

PROGRESS REPORT

2017-18 to 2018-19



NETWORK COORDINATING UNIT

All India Network Project on Vertebrate Pest Management
ICAR - Central Arid Zone Research Institute
Jodhpur 342 003

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CONTENTS

S.No.	Contents	Pages
1.	Coordinators report	1-4
Regular Centres		
2.	ICAR - Central Arid Zone Research Institute, Jodhpur	5-26
3.	Prof. Jayashankar Telangana State Agricultural University, Hyderabad	27-54
4.	Punjab Agricultural University (Rodent Control), Ludhiana	55 - 80
5.	Punjab Agricultural University (Agricultural Ornithology), Ludhiana	81- 122
6.	Anand Agricultural University, Anand	123 - 141
7.	University Of Agricultural Sciences, Bengaluru	142 - 157
8.	Kerala Agricultural University, Thrissur	158 - 181
9.	Acharya N G Ranga Agricultural University, APRRI, Maruteru	182 - 205
10.	Assam Agricultural University, Jorhat	206 - 229
11.	RARS, Assam Agricultural University, North Lakhimpur	230 - 238
Voluntary centres		
12.	Central Agricultural University, College Of Horti. & Forestry, Pasighat	239 - 241
13.	Odisha University Of Agriculture And Technology, Bhubaneswar	242 - 244
14.	Dr. B.S. Konkan Krishi Vidyapeeth, Dapoli	245
15.	ICAR-Indian Institute of Horticultural Research, Bengaluru	246
16.	Indian Institute of Science, Bengaluru	247 - 248

COORDINATOR'S REPORT

I am extremely happy to present the Progress Report of All India Network Project on Vertebrate Pest Management (VPM) for the Biennium (2017-19). This period started with the approval of SFC for the three year plan (2017-20). The SFC was approved in January 2018, therefore Project functioned with restructured mode from 2018-19 only. This Plan showed a major restructuring, as almost 50% of the manpower was reduced in order to cut establishment costs and increase the outlay for research contingencies. Secondly, five voluntary centers were phased out during 2017-18 due to various reasons. Thus only ten centers are functioning at seven state Agricultural Universities including the Coordinating Unit at CAZRI, Jodhpur. We are working with all the three major vertebrate groups, viz, problem birds and mammals like rodents and higher vertebrates.

I feel immense satisfaction that the project scientists have strived hard to achieve the mandates allotted to their centers during the Thrissur Meeting in 2017. The Project registered steady progress in identifying the current scenario of pest rodents, problem birds and higher vertebrates in selected agro-ecological regions of the country, evaluation of newer strategies of their management and transfer of technologies.

If we look at the salient achievements in respect of rodent component there are many highlights to mention here. Jodhpur center has completed the studies on rodent diversity in Narmada Canal command areas of western Rajasthan *vis a vis* changes in land use pattern from rainfed to irrigated cropping. Here replacement of xeric species viz, *Gerbillus Gleadowi* and *Meriones hurrinae* with sub-mesic and mesic species (*Mus booduga*, *Nesokia indica*, *Millardia meltada* and *Golunda elloiti*) and commensal species (*Rattus rattus* and *Mus musculus*) was noteworthy. *Mus booduga* and *Nesokia indica* were reported for the first time from Narmada Canal command areas. Likewise all centers studied rodent diversity and pestilence in one of the agro-climatic zones of their state, wherein the lesser bandicoot rat was the predominant species across the country. In the Hill zone of Assam, besides predominance of *Bandicota bengalensis* in all major cropping system, the squirrel; *Dremnomys lokriah* caused maximum damage to fruit and plantation crops.

Another milestone achievement was from Kerala where project scientists successfully used DNA barcoding techniques for the identification of four *Rattus* species viz., *R. ranjinae* (endangered since 2008, IUCN), *R. rattus*, *R. wroughtoni* and *R. norvegicus* at molecular level. The specimen details and sequences were submitted to BOLD database and a unique bar code was generated for each species. Based on the sequences generated a phylogenetic tree was constructed to analyze the similarity between these four *Rattus* sp. The blast searches showed 93 % identity for *R. rattus* and 94% for *R. norvegicus*. The phylogenetic tree showed that there is highest similarity between *R. rattus* and *R. ranjinae* (95%). *R. rattus* and *R. r. wroughtoni* (92.78%) and *R. ranjinae* and *R. r. wroughtoni* (88.05%).

In order to develop innovative techniques for rodent control, Ludhiana center worked on the repellent effect of eucalyptus oil and citronella oil against rodents using microencapsulation technique. Microencapsulated formulation with 5% conc eucalyptus oil proved effective for 7 days in laboratory and under simulated storage conditions. Evaluation of microcapsules containing citronella oil (5%) revealed significant anti-feedant effect on house rats and when it was sprinkled on bags containing wheat grains, showed a very high antifeeding index (av 75.6%) for 10-12 days. In another study the baits treated with methyl anthralinate (2.5%) also revealed antifeedant/repellent effect against house rats. Under field (storage) conditions this formulation prevented rodent attack up to a period of 28 days. Neem, though showed anti feedent effects on *B. bengalensis*, however a formulation of Neem seed alcoholic hexane (NSAH) extract showed

antifertility effect as well on both male and female lesser bandicoots. Studies are in progress at Ludhiana to increase the acceptance and application rate (depending upon rodent infestation) of formulated bait under field conditions. Similar studies undertaken by Jorhat center on botanicals like, *Azadirachta indica* seed kernel, *Capsicum chinense* and *Ricinus communis* indicated good repellent effect on *B. bengalensis*. The neem seed kernel showed strongest repellency index (>65%) followed by *C. chinense* (49%) and *R. communis* (31%). Studies on toxic effects of botanicals in Karnataka revealed that the *Strychnos nux-vomica* and *Gliricidia sepium*, was effective with the mean mortality periods of 9 and 10.6 days in *Millardia melitana*, 8.5 and 9.0 days in *Mus booduga* and 13.3 and 17.5 days under no choice condition with respective botanicals.

In the Godawari Delta region, our scientists evaluated an ecologically based rodent management techniques commonly referred as Trap Barrier System (TBS), which offered cent per cent protection of rice crop from *B. bengalensis*. The TBS system has shown effective potential in Kerala also. As far as developing rodent pest management modules, various centers came out with different modules. Like in Karnataka, application of zinc phosphide (2%) baiting at germination stage followed by burrow fumigation with aluminium phosphide at peg formation stage of groundnut yielded 82 per cent rodent control success with 1381 kg/ha yield in *Kharif* season. For Assam, the integration of different treatments like Cultural practices +spraying of castor oil (5%) on bunds at maximum tillering stage +Zinc phosphide baiting (2%) at panicle initiation stage + bamboo traps (30 traps /ha) at maturity stage) was found most promising treatment for rodent management in rice in Assam. In coconut, crown baiting with bromadiolone (0.005%) + trunk banding with Aluminum sheet recorded the highest rodent control success. Studies on development of rodenticidal baiting schedules for rodent management in groundnut and cumin crops in western Rajasthan are in progress. One year data revealed baiting with zinc phosphide (2%) and bromadiolone bait (on day 4th) followed by a third baiting with bromadiolone (0.005%) yielded 83.11 and 82.20% rodent control success, in cumin and ground nut, respectively. A novel low cost bait formulation was prepared by Maruteru center using the de-hulled maize cobs mixed in the jaggery. This bait recorded highest bait consumption (100%) as against 40% in control (broken rice) under no choice conditions by *Bandicota bengalensis*.

For management of rodents in pepper plantations at Chikkamagalur district Karnataka, use of snap trap @54/ha was found effective with 95 % rodent control success followed by bromadiolone baiting and/or zinc phosphide baiting (60-70% success). Likewise for management of rodents in areca plantations, the poison bait placement (on crown) proved superior over baiting at ground level. Ludhiana center evaluated the efficacy of two types of bait stations for delivery of zinc phosphide baits in rice crop. The bait stations made from used tyres installed @ 80 stations/ha yielded 77% rodent control. Studies on endo- parasites of rodents having zoonotic importance revealed maximum infected rats during tillering and dough stages. Major parasites included, *Cysticercus fasciolaris*, *Capillaria hepatica*, *Syphacia obvelata*, unidentified nematode larvae and *Trichuris muris* in concurrence with each other. Male rats were found to be more infected (60.7%) as compared to female rats (39.2%).

The Project scientists working on agricultural ornithology studied avian diversity and community structure at various locations across the country. Punjab center identified 10 species in paddy nurseries dominated by Cattle Egret, Bank Myna, Blue rock Pigeon and Ring Dove in the first fortnight of June in four districts. Based on the attractive tools like flower/ fruit/ flavor, 21 tree species were identified in Telanagana, of which *Bombax ceiba* (Adavi burugu) stands first in attracting 14 bird species in peak hours followed by *Butea monosperma* (moduga) - in attracting 12 bird species. In frugivorous category 12 species of birds were identified on *Ficus recimosa*

followed by *Cordia dichotoma* with 11 bird species. Among the birds Rose ringed parakeet was highly preferred on tree species like *Ficus religiosa*, *Butea monosperma* and *Pithecellobium dulce*. Assam center recorded 141 species of birds belonging to 47 families from Majuli – the biggest River Island of the world (in Assam) and prepared the ‘Bird checklist of the Island’. Oriental White Ibis *Threskiornis melanocephalus*, a Near Threatened (NT) bird was recorded for the first time from the island. Likewise Gujarat center studied the bird fauna in ground nut crop in Saurashtra region where 29 species were recorded from different villages. In wheat- bajra cropping system, 1036 birds of 19 different species were recorded. The Crested lark, *Galerida cristata* was dominant species in community (69.50 RA %). The Red-wattled lapwing, *Vanellus indicus* was occurred most frequently.

Purple moorhen (*Porphyrio* sp) is appearing to be one of the major emerging problem in paddy and kule rice fields (deep water rice) in Kerala. The bird caused 8.0 to 54.4% damage to tender culm of the seedling. Breeding season of the bird started in April-May and peaked in the rainy season. Deep water bodies with aquatic vegetation in the fringes of the field served as a perfect roosting site for the birds. Clearing the aquatic vegetation from the roosting sites (water bodies), metalized reflective ribbon, nylon net, cracker station, LED light flashes and bio bird repellents are common techniques used to minimize the damage caused by purple moorhen.

For management of depredatory birds several techniques were evaluated. Spraying egg solution @ 25 ml/l water in showed significantly higher protection from bird damage in sorghum and sunflower crops followed by castor oil spray @25ml/l, mixed oil spray @25ml/l), Azadirachtin @1500 ppm spray @25ml/l and salt solution spray @ 50g/l in Telangana. The demonstration on effectiveness of reflective ribbon conducted in 5000 sq. m. area of maize crop in Gujarat effectively deterred the visiting birds and thus managed the bird problem in the crop fields. Kerala center also evaluated various bird management practices in rice beds and reported that bio-bird repellent and carbon oxy chloride were equally effective registering 19.13 and 17.67% area damage as against 56.67% in control fields.

Gujarat center evaluated 78 nest boxes (designed as per size of entrance hole) for cavity nesting birds revealed 71% occupancy in the first year of installation. Majority of nest boxes (40) were occupied by common myna, two each were occupied by Brahminy starling and Oriental magpie-robin, and one was occupied by House sparrow. Interestingly 8 nest boxes were occupied by Squirrels. Assam center conducted large scale demonstration on role of insectivorous birds in suppression of insect pests in cereal and oilseed crops through installation of bird perches made of either bamboo or tree branch in the shape of ‘T’ @ 50/ha as a component of IPM and succeeded in controlling insect pests.

For suppression of insect pests on Sunflower in Telangana, combination of NPV and installation of bird perches reduced the *Spodoptera* population to the extent of (56%) followed by NPV alone (32%) and Azadirachtin, however in case of semi loopers (33%) and Hairy caterpillar (29%) population was reduced by using of Azadirachtin @ 1500ppm treated plot followed by NPV and bird perches (23% and 21%). Studies on use of bioacoustics in sorghum and bajra fields showed higher yields (2960 and 847 kg/ha) followed by expeller gun (2375.5 and 585 Kg/ha) and control (1987.5 and 377 Kg/ha).

Studies on higher vertebrates were carried out mainly by Hyderabad, Jodhpur, Bengaluru, Thiruvananthapuram centers. Some of the salient findings are; A total of 9935 of Rhesus macaque individuals were recorded in 204 troupe from five districts of Central Telangana Zone. The highest number of individuals (4513) were recorded from Khammam district and lowest in Siddipet (243). The per cent damage caused by monkeys was in range of 22-40% in maize cotton rice, sorghum and groundnut and 7- 20% in vegetables.

Wild boar in Kanakapura, Magadi and Chamarajanagara villages in Karnataka recorded maximum damage to banana (49.65 %) followed by ground nut (40.33 %), sweet potato (35.28 %) with an average of 5-10 raids per fortnight during the crop maturity stage. In Kerala 3-5 year old rubber trees experienced debarking damage by sambar deer and that of wild boar in banana, tuber crops vegetable etc. Demonstration of bio acoustics gadget against wild boar damage in different crops under taken in Rangareddy, Mahabubnagar and Nalgonda Districts exhibited its efficiency for a maximum of three months with complete protection from wild boar attack.

Area wide field trials in rubber plantation and fodder crop fields in Kerala showed that olfactory repellent (DeeRep) had effectively kept the sambar deer away from the vulnerable stage of the rubber plants. Among the different treatments, either cloth ribbon (2" width and 2-3 feet length) dipped in DeeRep solution (50ml per liter of water) tied around all rubber tree at 2' height above ground level or spraying DeeRep (50ml per liter of water) to all trees effectively protected the trees from debarking by the sambar deer. However, in the unprotected plots, the damage is 30 per cent.

For management of wild boars fencing with nylon net tied at a height of 120 cm with the support of poles and also spread over on the ground surface about 90 cm and fixed firmly to the ground and spraying Olfactory repellent (developed by the AINVPM centre, Thrissur) proved effective in deterring wild boars. Similar trials undertaken in maize and sun flower in Kammarreddy district of Telangana in the form of one, two tier and three tier systems revealed that plots treated with bioacoustic showed 100% check in entry of wild boar, while the other modules, viz., circular razor wire fence, fishnet with coconut coir & bio fence also showed promising results to the extent of only 2-4% damage as compared to control (80%). Barbed wire fencing and placement of HDPE nylon net in the boarder was most effective in managing wild boar problem in ground nut with yield of 1156.37 and 1086 kg/h, respectively compared to control (703.67 kg/ha).

I would conclude by highlighting a few spectacular feats achieved by the Project. For example scientists of AINP-VPM have filed three patents during this period. The IOT based bioacoustics gadget developed for wild animal management by PJTSAU center is being commercialized. In the first of this kind, AINP Kerala center is working on metagenomics and has undertaken molecular studies for the identification of four *Rattus* species and constructed the phylogenetic tree. Use of HDPE nylon nets as physical barrier for effective wild boar management is gaining popularity. Repellent formulation named as BoRep and DeeRep has been developed by Kerala center is in great demand in the state. Monitoring the changes in rodent pests in Narmada canal Command areas in Rajasthan has been completed that will serve as a baseline for future. Rodent management modules for various crops are refined and being popularized. All the centers have conducted large number of trainings and field demonstrations on VPM technologies. Capacity building on VPM technologies are being taken up by AINP and also in collaboration with DAC, NIPHM and State line departments.

At the end, I would like to express my deep sense of gratitude to Dr. T. Mohapatra, Secretary, DARE (GOI) and Director General, Indian Council of Agricultural Research (ICAR), Dr A.K. Singh, Dy. Director General (CS) and Dr P. K. Chakrabarty, former ADG (PP & B), and Dr Rajan, ADG (PP & B), ICAR, New Delhi for their support, guidance and encouragement and for providing financial assistance to the Project. Dr O. P. Yadav, Director, ICAR- Central Arid Zone Research Institute, Jodhpur deserves special thanks for his expert advice, guidance, constant encouragement and support to this Project. Special thanks are due to Dr V. Vasudeva Rao, PJTSAU, Hyderabad, the Cocordinator for his constant support in managing the AINP. I thank all the scientists and other staff members of all the cooperating centres for their untiring efforts in realizing the mandate of the Project. I am especially thankful to my colleagues at Coordinating

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ICAR-CENTRAL ARID ZONE RESEARCH INSTITUTE

JODHPUR-342 003

PART: I General Information

1. Name of the center	Network Coordinating Unit ICAR-Central Arid Zone Research Institute, Jodhpur
2. Sanction No	1-2/77-PP dated 02.09.1977
3. Date of start	1977-78
4. Date of Termination	Network Project of continued nature
5. Report period	2017-18 & 2018-19
6. Scientist In-charge	Dr. R.S. Tripathi

Staff Position*

Sr. No.	Name of post	No. of posts	Name of incumbent
1.	Network Co-ordinator	1	Dr R.S. Tripathi
2.	Principal Scientist	1	Dr Vipin Chaudhary
3.	Technical Officers	3	Mr. R.C. Meena, ACTO Dr. K.L. Gawadia, ACTO Mr. Surjeet Singh, ACTO
4.	Driver	1	Mr Zakir Hussain, TO
5.	Administrative	1	Mrs Rajni Mathur, UDC
6.	Supporting	1	Mr Babulal Dewasi, SSS

* At Institutes Strength

Part II. Work allotted

I. Multi location programmes

RM 1: Surveillance of pest rodents in predominant cropping systems

RM 2: Monitoring of rodent abundance and damage in selected agro-climatic zones of the region

RM 6: Bio-ecology of major rodent species (Habit, habitat, food, feeding /burrowing behaviour, population dynamics, reproduction & Breeding Biology etc.: *Tatera indica*

RM 7: Social Engineering Activity on Rodent Pest Management as Participatory Adaptive Research in adopted villages.

II. Location Specific programmes

a. Monitoring the spread of *Bandicota bengalensis* in arid zone

b. Rodent species composition in Narmada canal Command areas of Rajasthan

HV 1. Bio ecology and management of higher vertebrates in different crops

PART III: WORK DONE

I. MULTI LOCATION PROGRAMMES

RM 1: Surveillance of pest rodents in predominant cropping systems (Arid Horticulture)

Species Diversity: In CR farm of the institute a lot of changes in land use pattern have been witnessed over a period of time due to fragmentation of area into well establishment farming systems like Horticulture, Slvi-pasture and Agri-pasture etc. To monitor the impact of these changes on the composition of rodent diversity under a long term planned study surveys in the

three major systems viz, Horticulture, Silvi-pasture and Agri-pasture continued through monthly trappings. Indian gerbils, *Tatera indica* maintained its predominance during 2017 and 2018 with respective share of 63.46 and 45.31% followed by five striped squirrels, *Funambulus pennanti*, (Table 1). Other species trapped were *Golunda ellioti*, *Rattus rattus* and *Mus musculus* (Table 1). Indian gerbil, *T. indica* was predominant during 1970s also in the area but the other xeric species viz., *Meriones hurrianae*, *Gerbillus dasyurus indus* and *G. gleadowi* are totally absent in the area and not captured since long. Contrary to it, mesic species like, *R. rattus*, *M. musculus*, *M. booduga* are regularly captured from the area. This change in species composition in the area is an indication of species replacement due to change in land use pattern.

Trap Index: In all 52 and 64 individuals were trapped respectively, during 2017 and 2018. The rodent catch was comparatively less during the year 2017 and more during the year 2018 with a mean trap index of 1.20 and 1.48 rodents/100traps/day, respectively (Table 2). Overall trap index throughout the year varied between and 0.55-1.94 rodents/100 traps/night with maximum trapping during Feb-March in year 2017 and 0.83-2.22 rodents/100 traps/night with maximum trapping during May and October in year 2018 (Table 2).

Habitat Preference: The fruit orchards (horticulture) were preferred more by the rodents as highest rodent population (mean 46.28%) was recorded in the Horticulture system followed by Silva-pasture (mean 30.29%) and Agri-pasture (mean 23.44%). Amongst these, *F. pennanti* was mainly trapped from horticulture fields followed by silvi-pasture block, whereas *T. indica* was almost uniformly trapped from all the three habitats. The two commensal species (*R. Rattus* and *Mus musculus*) was trapped mainly near the boundary wall of CR farm (Table 3).

Table 1. Rodent species composition in CR Farm during 2017-18 & 2018-19

Rodent Species	1970	2017-18		2018-19	
		% Composition	Sex ratio (M:F)	% Composition	Sex ratio (M:F)
<i>Tatera indica</i>	43.80	63.46	0.44:1	45.31	1:1.42
<i>Funambulus pennanti</i>	0.82	28.85	0.88:1	40.63	1:0.37
<i>Rattus rattus</i>	0	5.77	1:0.5	4.69	-
<i>Mus musculus</i>	0	1.92	-	1.56	-
<i>Millardia meltada</i>	0.82	-	-	-	-
<i>Meriones hurrianae</i>	28.90	-	-	-	-
<i>Gerbillus gleadowi</i>	0.82	-	-	-	-
<i>G. nanus</i>	24	-	-	-	-
<i>M. booduga</i>	0	-	-	-	-
<i>Golunda ellioti</i>	0	Pr	-	7.81	1:0.67
<i>M. cervicolor</i>	0.82	-	-	-	-
<i>Hystrix indica</i>	-	Pr	-	-	-

Table 2. Monthly trap index (Rodents/100traps/day)

Months	2017	2018
January	1.38	1.94
February	1.94	1.67
March	1.66	1.67
April	1.11	0.83
May	1.38	2.22
June	0.55	1.39

July	1.11	1.11
August	1.38	1.11
September	0.55	1.39
October	1.38	2.22
November	1.11	0.83
December	0.83	1.39
Mean	1.20	1.48

Table 3. Relative abundance of rodents in different cropping system

Year	% Abundance		
	<i>Horticultural</i>	<i>Silvi-pasture</i>	<i>Crop fields & grasslands</i>
2017	51.92	23.08	25.0
2018	40.63	37.50	21.87
Mean	46.28	30.29	23.44

RM 2: Monitoring of rodent abundance and damage in selected agro-climatic zones of the region.

Four species of rodents viz., *M. meltada*, *G. ellioti*, *F. pennanti* and *R. rattus* were captured from villages Chidyawasa and Badvi, district Banswara. On the basis of appearance of soil mole hills on bunds especially in wheat crops, presence of *Nesokia indica*, was suspected in the region. Trapping in Khara and Uppplagarh villages of Tehsil Abu Road revealed the presence of five rodent species viz, *T. indica*, *M. meltada*, *G. ellioti*, *F. pennanti* and *R. rattus*.

RM 6: Bio-ecology of major rodent species (Habit, habitat, food, feeding /burrowing behaviour, population dynamics, reproduction & Breeding Biology etc.: *Tatera indica*

Indian gerbil, *Tatera indica* is most widely distributed and predominant rodent pest of India. Bio-ecological investigation on *T. indica* through monthly trapping in Jodhpur revealed predominance of Indian gerbil, as in every trapping session the *T. indica* trapped in maximum number in comparison of other species with a monthly average of 3.83 and 2.33 rodents respectively, during 2017 and 2018 (Table 4 and 6). A total of 46 and 28 individuals were trapped through 1440 trapping night each with maximum individual during September and May respectively, during 2017 and 2018. Only seven pregnant females with 15 number of sexually active females and four pregnant females with 09 sexually active females (vagina perforated) were trapped respectively, during 2017 and 2018 (Table 5 and 7). Mature males were encountered during most part of the year. Sex ratio was in favour of females. The mean body weight of trapped rodents was between 90.8-137.67g (Mean: 112.02g) and 79.00-182.00g (Mean: 111.01g) respectively, during 2017 and 2018 (Table 4 and 6). The trap index was in the range of 0.56 (April & June) to 1.67 (Sept.) and 0.83 (April and June-August) to 3.33 (Feb.) respectively, during 2017 and 2018 (Table 5 and 7).

Table 4. Mean body weight and other morphometric observations on *Tatera indica* collected from field during 2017

Trap Month	Body Wt.	HB	HF	Ear	Tail	♂	♀	Total Trapped
January	107	164	35.75	18.25	175.75	1	3	4
February	137.67	175.33	37.33	18.67	182.67	2	1	3
March	106.2	145.6	36.8	17.2	167	1	4	5
April	121.93	160.47	37.07	17.93	167.00	0	2	2
May	107.67	134.00	33.67	18.67	179.00	1	2	3

June	111	126.5	32	20.5	164	1	1	2
July	130.25	150.75	35.75	19.75	177.75	3	1	4
August	90.8	143.8	33.8	17.6	164	2	3	5
September	102	139.50	34.67	18.83	155.33	3	3	6
October	104.5	152	37.5	17.25	176.75	2	2	4
November	117.75	159	35.5	19.5	172.25	3	1	4
December	107.5	146	36.75	18.25	178.75	1	2	4
Mean	112.02	149.75	35.55	18.53	171.69	1.67	2.08	3.83
SEM±	3.73	3.92	0.50	0.29	2.36	0.28	0.29	0.34

Table 5. Trap index and reproductive status of *T. indica* collected from field during 2017

Trap Month	Trap index (Rodents/100 traps/night)	Sex ratio (M:F)	Breeding status				B. Wt. Range	
			♀			♂	♂	♀
			Preg-nant (Nos.)	Perfo-rated (Nos.)	Non-Perfo-rated (Nos.)	Scro-tal (Nos.)		
Jan.	1.11	0.33:1	1	2	0	1	95	95-132
Feb.	0.83	2:01	0	1	0	2	129-153	131
March	1.39	0.25:1	1	2	1	1	172	54-147
April	0.56	0	1	1	0	0	0	53-93
May	0.83	0.5:1	1	1	0	1	90	94-139
June	0.56	1:01	0	1	0	1	138	84
July	1.11	3:01	0	1	0	3	114-148	127
Aug.	1.39	0.67:1	1	1	1	2	96-108	65-110
Sept.	1.67	1:01	1	2	0	2	60-130	80-137
Oct.	1.11	1:01	1	1	0	2	90-95	66-167
Nov.	1.11	3:01	0	1	0	3	100-130	131
Dec.	1.11	0.5:1	0	1	1	2	109-149	85-87
Total	-	-	7	15	3	20	-	-

Table 6. Mean body weight and other morphometric observations on *Tatera indica* collected from field during 2018

Trap Month	Body Wt.	HB	HF	Ear	Tail	♂	♀	Total Trapped
January	136.33	162.33	37.33	183.33	18.33	1.00	2.00	3
February	124.00	154.50	36.25	186.50	17.50	1.00	3.00	4
March	97.00	148.50	36.50	188.50	16.50	1.00	1.00	2
April	105.00	156.00	39.00	194.00	18.00	0.00	1.00	1
May	89.80	136.40	35.60	169.20	15.80	2.00	3.00	5
June	79.00	140.00	37.00	180.00	18.00	1.00	0.00	1
July	128.00	160.00	39.00	190.00	19.00	1.00	0.00	1
August	182.00	164.00	38.00	208.00	20.00	0.00	1.00	1
September	102.00	154.50	39.00	168.50	18.50	0.00	2.00	2
October	113.00	155.00	35.67	175.67	18.33	1.00	2.00	3
November	86.00	150.00	35.50	176.00	16.50	1.00	1.00	2
December	90.00	141.67	36.33	181.00	17.33	0.00	3.00	3

Mean	111.01	151.91	37.10	183.39	17.82	0.75	1.58	2.33
SEM±	7.79	2.41	0.37	3.02	0.32	0.17	0.30	0.35

Table 7. Trap index and reproductive status of *T. indica* collected from field during 2018

Trap Month	Trap index (Rodents/100 traps/night)	Sex ratio	Breeding status					Body Wt. Range	
			♀				♂	♂	♀
			Pregnant (Nos)	Perforate d (Nos)	N.Perforated (Nos)	Pregnancy	Scrotal (Nos)		
January	2.50	1:2	1	1	0	50	1	131	110-168
February	3.33	1:3	1	2	0	33	1	83	110-177
March	1.67	1:1	0	0	1	-	1	125	69
April	0.83	0:1	0	1	0	-	0	0	105
May	4.17	1:1.50	1	0	2	33	2	61-113	53-149
June	0.83	1:0	0	0	0	-	1	79	0
July	0.83	1:0	0	0	0	-	1	128	0
August	0.83	0:1	1	0	0	100	0	0	182
September	1.67	0:2	0	2	0	-	0	0	101-103
October	2.50	1:2	0	1	1	-	1	137	88-114
November	1.67	1:1	0	1	0	-	1	59	113
December	2.50	0:3	0	1	2	-	0	0	70-112
Total	-	-	4	9	6		9	-	-

RM 7: Social Engineering Activity on Rodent Pest Management as Participatory Adaptive Research in adopted villages.

Training and demonstration on Rodent Pest Management was organized for farmers of villages, Padsala, Kapooria and Mangarea (Distt Jodhpur), Golasan and Chitalwana (Distt Jalore) and Jasrana (Distt Naguar). Under Tribal Sub Plan of AINP on VPM six field training on “Rodent Pest Management was conducted in the tribal villages at village Chidyawasa and Badvi of distt. Banswara (Rajasthan), Stakmo and Shang Villages of district Leh (J&K) and Khara and Uppplagarh of Distt Sirohi. More than seventy farmers attended the training at each village. Before, every training a questioner were supplied to farmers to understand the knowledge, attitude and practice (KAP) for rodent management. Besides, farmers from the adopted villages of KVK, Jodhpur visited the laboratory and were briefed about the importance of rodents in agriculture and management techniques. Lectures on Rodent Pest Management were delivered in on campus and off campus trainings organized by KVK and radio talks were delivered on AIR, Jodhpur.

Following off and on campus training in collaboration with KVK was organized on Rodent Pest Management in field and storages along with two demonstrations and one anti-rodent campaign.

A. On/ off campus training programme on Rodent Pest Management

2017-18

SN	Title of Training	Date	Village	No. of Participants
1.	Rodent management in fields.	19.06.2017	Lawaren P.S Sekhala	20
2.	Rodent management in fields.	15.09.2017	Rohicha Kalan P.S. Luni	19
3.	Rodent management in grain storages.	27.01.2018	Kakelao P.S. Luni	22
Off Campus Activity undertaken by Coordinating Unit				
SN	Activities	Date	Village	Participants
1.	Field based training on Rodent Pest Management	May 4, 2017	Koliwada, Ramnagar, Sonapura & Galthani, Summerpur	40 farmers
2.	Field based training on Rodent Pest Management	June 8, 2017	Aau (Phalodi)	30 farmers
3.	Field based training on Rodent Pest Management	June 29, 2017	Padsala (Jodhpur)	15 farmers
4.	Field based training on Rodent Pest Management	July 29, 2016	Jasrana (Nagaur)	35 farmers
5.	Field training on Rodent Pest Management in Narmada Canal Command areas	Oct. 06, 2017	Paldi (Jalore)	15 farmers
6.	Field based training on Rodent Pest Management	Oct.13, 2017	Sekhala	12 Farmers
7.	Field based training on Rodent Pest Management	Jan. 3, 2018	Deriya, Chamu, Rajsagar	35 farmers
8.	Rodent pest management in crops	Jan. 5, 2018	Golasan (Jalore)	40 farmers
9.	Rodent pest management in crops	Feb., 3, 2018	Kapooria (Jodhpur)	15 farmers

2018-19

SN	Title of Training	Date	Village	No. of Participants
1.	Rodent management in fields.	June 8, 2018	Rohicha kallan, PS Luni	31
2.	Pest Management in Seed Production	Feb. 2, 2019	Mangeria (Teh. Bhopalgarh)	138
Off Campus Activity undertaken by Coordinating Unit				
SN	Activities	Date	Village	Participants
1.	Field training on Rodent Pest Management in Narmada Canal Command areas	June 13, 2018 2017	Chitalwana (Jalore)	20 farmers

2.	Field based training on Rodent Pest Management	June 27, 2018	Padsala (Jodhpur)	17 farmers
3.	Role of rodents in Agriculture and their Management	July 18&19, 2018	Chidyawasa and Badvi (Banswara)	140 farmers
4.	Rodent pest management in crops	August 28, 2018	Golasan (Jalore)	40 farmers
5.	Role of rodents in Agriculture and their Management	Sept. 5&9, 2018	Stakmo and Shang (Leh-Ladakh)	140 farmers
6.	Field based training on Rodent Pest Management	Jan. 05, 2019	Kapooria (Jodhpur)	25 farmers
7.	Role of rodents in Agriculture and their Management	17&18 Feb., 2019	Khara and Uppplagarh (Sirohi)	140 farmers

B. Exhibitions on Rodent Pest Management

S.No.	Exhibition arranged	Date	Venue	Farmers visited
1.	Exhibition on Rodent Pest Management at Golasan village	Jan, 5, 2018	Golasan village	40 farmers
2.	Exhibition on Vertebrate Pest Management during Kisan Mela and Farmers Innovation Day, Jodhpur	Sept.24, 2017	CAZRI Campus	1800 farmers from 7 districts and 49 villages
3.	Exhibition on Vertebrate Pest Management during State level Kisan Mela and Farmers Innovation Day, Jodhpur	Sept.13-15, 2018	CAZRI Campus	5000 farmers
4.	Exhibition on Rodent Pest Management	July 182018	Chidyawasa Banswada	70 farmers
5.	Exhibition on Rodent Pest Management	July 19, 2018	Badvi village Banswada	70 farmers
6.	Exhibition on Rodent Pest Management	Sept. 5, 2018	Stakmo village Leh	70 farmers
7.	Exhibition on Rodent Pest Management	Sept. 9, 2018	Shang village Leh	70 farmers
8.	District level Kisan mela, Jodhpur	Jan. 28, 2019	CAZRI, Campus	2000 farmers
9.	Exhibition on Rodent Pest Management	Feb. 172019	Khara Abu Road (Sirohi)	70 farmers
10.	Exhibition on Rodent Pest Management	Feb 18,2019	Uppplagarh village Abu Road (Sirohi)	70 farmers

C. Exposure of Farmer and Student visitors group towards Rodent management technologies

S.No	Details of farmers visitor group	Date of visit	No.of farmers
1.	Farmers group of Tilwasni	21.11.2017	25
2.	Individual farmers form villages like, Jhalamand, Badla Basni, Khedi Salva, Utwalia, Pal, Basni, Balesar, Magra, Luni, Dawara, Jaiwal etc for technical know how	01.07.2017,2.09.2017,24.11.2017, 26.11.2017	15
3.	Farmers group of 07 Panchyat semities, Nagaur	24.02.2018	35

D. Demonstrations conducted on rodent management

S.No	Activity/ Problem	No. of demo.	Village	Result
1.	To reduce rodent damage in food grains. (Application of Zinc phosphide bait in rodent' burrows and also application of Bromodilone cake in grain storages in villages.)	10	Purkhawas P.S. Luni	Reduced 50 % rodent population in treated fields/ grain storages.

E. Exposure of Farmer and Student visitors group towards Rodent management technologies

S.No.	Details of farmers visitor group	Date of visit	No. of farmers
01.	Farmers group of Tilwasni	21.11.2017	25
02.	Individual farmers from villages like, Jhalamand, Badla Basni, Khedi Salva, Utwalia, Pal, Basni, Balesar, Magra, Luni, Dawara, Jaiwal etc for technical know how	01.07.2017, 2.09.2017, 24.11.2017, 26.11.2017	15
03.	Farmers group of 07 Panchayat semities, Nagaur	24.02.2018	35

F. Lecture during on/off campus training programmes

S. No	Topic	Date	Name of Training programme	No. of participants
1.	Rodent management in pulse crops.	03.08.2017	IPM in Kharif pulse crops. (2-3 Aug, 2017)	25
2.	Fasalon mein Choocha niyantran	24.08.2017	Training of Kisan Mitras of Baytoo (Barmer) by M power.	41
3.	Rodent management in crops and Grain storages.	06.11.2017	Scientific cultivation of arid fruit crops. (6-10 Oct, 2017)	36
4.	Rodent management in crops.	24.11.2017	Plant protection measures in chickpea and mustard crops. (23-24 Nov, 2017)	28
5.	Rodent management in pulse crops.	15.02.2018	Plant Protection measures in pulse crops. 12-16 Feb, 2018)	29
6.	Rodent management in grain storages.	13.02.2018	Plant Protection measures in pulse crops. 12-16 Feb, 2018)	29
7.	Fal and sabjiyon mein choohon se hone wale nuksan and roktham	June 29, 2018	Training on Nursery and Orchard Management	40
8.	Bagwani Faslon mein Choocha Niyantran	Dec. 19, 2018	Training on Livelihood security through arid horticulture (Dec 18-22, 2018)	36
9.	Nuksan pahuchane wali vibhinna choocha prajatiyan aur Bachav	Jan. 19, 2019	Training for Skill Development for Astt Gardeners (Jan 15- Feb. 04, 2019)	28
10.	Fasal Utpadan mein	Feb. 20, 2019	Plant Protection and other	32

	choohon se hone wale nuksan evam Roktham		techniques in crops (Feb 19-23, 2019)	
11.	Godamo evam gharon me chooha prabhandan	Feb. 23, 2019	Plant Protection and other techniques in crops (Feb 19-23, 2019)	32
12.	Udyaniki mein Choocha Niyantran	Feb. 27, 2019	Improved Production Technologies in Horticulture for Arid region (Feb 26-March 2, 2019)	30

G. Radio Talks

S.No.	Title	Date of Broadcast
1.	चूहों से खेत तथा घरों में होने वाला नुकसान व ईलाज	18.05.2017
2.	खेत खलिहानों में चूहा नियंत्रण कैसे	30.10.2017
3.	खेतों एवं भण्डार गृहों में चूहा नियंत्रण	23.02.2018
4.	सुरक्षित सामुहिक चूहा नियंत्रण कैसे	18.6.2018
5.	चूहों का प्रभवी नियंत्रण कैसे	5. 9.2018
6.	खेत खलिहानों में चूहा नियंत्रण	16.10.2018

II. TRAINING TO SCIENTISTS/STATE OFFICIALS/STUDENTS

SN	Nature of Training	Topics	Delivered By	Date
1.	Summer school on, "Developing strategies for doubling farmers income in low rainfall areas"	Management of Vertebrate Pests in Agriculture.	Dr R.S. Tripathi	Sept. 20, 2017
2.	MTC on Newer Options in arid horticulture for doubling farmers income	Efficient Management of rodents and other vertebrate pest in horticultural crops	Dr R.S. Tripathi	Nov 19.2017
3.	Training for Diploma in DAESI for Entrepreneurs Organised by KVK, Jodhpur	Godamon me chuha prabandhan	Dr R.S. Tripathi	Jan 14, 2018
4.	Training for Diploma in DAESI for Entrepreneurs Organised by KVK, Jodhpur	Hanikarak evam labhdayak keeto me bhed	Dr. Vipin Chaudhary	Jan. 28, 2018
5.	Training on rodent pest and its effective management to Diploma and Degree students of Nursing at Kuchaman City	Role of rodents in Agriculture	Dr. Vipin Chaudhary	Feb., 2, 2018
6.	Model Training Course on "Eco-friendly Integrated Pest Management in Arid Crops"	Efficient Management of vertebrate pest in Agricultures	Dr R.S. Tripathi	Feb., 16, 2018
7.	Model Training Course on "Eco-friendly Integrated Pest Management in	Efficient management of rodents in field crops	Dr. Vipin Chaudhary	Feb. 13, 2018

	Arid rops”			
8.	An Orientation course entitled ‘Agricultural Education, Research and Extension Management’ for Assistant Professors and SMS of Agriculture University, Jodhpur at AU, Jodhpur	Role of Rodents in Agriculture	Dr Vipin Chaudhary	June 30, 2018
9.	Green skill Developmental Program (GSDP), Certification course in Plantation Techniques and Utilization of Renewable Energy in Arid Zone Jodhpur	Rodent Management in Arid Zone	Dr Vipin Chaudhary	July 23, 2018
10.	An Orientation course entitled ‘Agricultural Education, Research and Extension Management’ for Assistant Professors and SMS of Agriculture University, Jodhpur at AU, Jodhpur	Managing Rodents in Agriculture	Dr Vipin Chaudhary	Aug. 20, 2018
11.	ICAR-Summer School on “Designing farming systems for enhanced income and resilience in low rainfall areas under climate change scenario”	Vertebrate Pests Management in Agriculture	Dr R.S. Tripathi	Sept. 12, 2018
12.	ICAR-Winter School on solar photovoltaic and thermal application for energy- water- food security in at Jodhpur	Vertebrate Pest of Agriculture and Solar Options in its Management	Dr Vipin Chaudhary	Oct. 4, 2018
13.	Exposure of 14 BSc (Ag) of Agril University, Jodhpur on Principles, Practices and Laboratory techniques on Rodent pest Management at Jodhpur	Principles, Practices and Laboratory techniques on Rodent Pest Management	Dr R.S. Tripathi and Dr Vipin Chaudhary	Nov.16, 2018
14.	ICAR-Winter school on “Recent approaches in horticultural development for enhancing farm income in environmentally constraints ecosystem” at Jodhpur	Efficient Management of Rodents and other Vertebrate pests in horticultural crops	Dr R.S. Tripathi	Dec 17,2018
15.	ICAR- Short Course on “Risk assessment and management of non-insect pests for sustainable Agriculture at NAU, Navsari	Bio ecology and management of rodents in India	Dr R.S. Tripathi	Jan. 7, 2019

16.	Trainers training for extension functionaries of State Department of Agriculture and Horticulture, Agriculture Development Agencies and KVK scientists of Punjab and adjoining states at Ludhiana	Higher vertebrate pests: damages caused and management strategies.	Dr Vipin Chaudhary	Jan. 30, 2019
17.	Model Training Course on Horticulture at Jodhpur	Effective Management of Rodents and other Vertebrate pests in Horticultural Crops	Dr R.S. Tripathi	Feb. 26, 2019

II. LOCATION SPECIFIC

a. Monitoring the spread of *Bandicota bengalensis* in arid zone

Population Dynamics: Bimonthly trapping to monitor the spread of introduced species of *Bandicota bengalensis* in urban and peri-urban limits of Jodhpur city revealed their partial withdrawal from Basni Mandi area as the population of house rat was at par with bandicoots in the area. However, at railway tracts in station area, hospitals and residential colonies it is predominant species. In the peri-urban cultivation activity of *B. bengalensis* was not observed and its spread along the waste water channel in these areas was also not recorded. The mean trap index ranged between 2.22-5.55 rodents/100 trap/day during the reporting years with a mean maximum population in during March (Table 8). The sex ratio in collections was in favour of female. The sexually mature male and females were available through the year. The pregnant females were trapped round the year.

Table 8. Relative incidence of lesser bandicoots during the last two years

Years	Trap index (Rodents/100 trap/day)					
	January	March	May	July	September	November
2017	5.0	6.66	3.33	5.0	2.77	1.66
2018	3.33	4.44	3.33	2.78	2.22	2.78
Mean	4.17	5.55	3.33	3.89	2.50	2.22

Body Weight: The mean body weight in the collection irrespective of year of collection ranged between 151.33-208.75 with lightest and heaviest female of 50 & 347g and male of 55 & 310g, respectively. Mean body weight of animals ranged from 151.33-208.75g and 161.00-196.38g during 2017 and 2018, respectively (Table 9a and b). There was no trend observed in the body weight of specimen collected throughout the year during the year 2017 and 2018 but the average weight was more during 2017 than 2018.

Morphometry: Various measurements of Head body (HB), Hind foot (HF), Tail (T) and Ear (E) lengths of *B. bengalensis* trapped from Jodhpur city are detailed in (Table 12a & b). Mean of various measurements of body during the year 2017, were HB: 177.71 HF: 35.70; Tail: 159.43; Ear: 17.26 mm and 2018 were HB: 168.98 HF: 34.98; Tail: 157.91; Ear: 16.20mm (Table 9a and b).

Table 9a. Mean body weight and other morphometric observations on *B. bengalensis* collected from Jodhpur during 2017

Trap Month	Body Wt.	HB	HF	Tail	Ear
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Jan. 17	198.22	181.78	35.89	165.0	16.11
March 17	208.75	193.58	36.83	172.92	18.83
May 17	196.00	167.83	35.83	148.33	17.0
July 17	201.11	171.33	35.78	155.11	17.67
Sep.17	184.80	181.40	36.20	155.20	17.60
Nov.17	151.33	170.33	33.67	160.00	16.33
Mean	190.04	177.71	35.70	159.43	17.26
SEM±	3.765	1.78	0.20	1.58	0.18

Table 9b. Mean body weight and other morphometric observations on *B. bengalensis* collected from Jodhpur during 2018

Trap Month	Body Wt.	HB	HF	Tail	Ear
January 18	163.67	174.67	35.00	158.17	17.00
March18	196.38	164.88	35.38	158.50	17.00
May 18	161.00	167.00	33.67	149.67	15.17
July18	162.20	174.40	35.40	170.60	16.40
September 18	178.25	166.75	35.25	154.50	15.25
November 18	172.00	166.20	35.20	156.00	16.40
Average	172.25	168.98	34.98	157.91	16.20
SEM±	3.93	1.26	0.19	2.03	0.24

Breeding Ecology: The sexually mature male and females was available through the year, as in every catch more than 50% collection constituted sexually mature individuals. Similarly pregnant females were trapped round the year except November, 2017 (Table 10).

Table 10. Seasonal Prevalence of Pregnancy (%) in lesser bandicoot rat

Years	Percent Pregnant females in the collection during months of					
	January	March	May	July	September	November
2017	50.00	42.80	25.00	40.00	50.00	0.00
2018	25.00	50.00	50.00	50.00	33.33	50.00
Mean	37.50	46.40	37.50	45.00	41.67	25.00

(b) Rodent species composition in Narmada canal Command areas of Rajasthan

2017-18

Survey of Narmada Canal command area to monitor the impact of canal irrigation on change in rodent fauna vis-a-vis land use was carried out in four habitats during kharif and rabi season. The main crops in the area (across the habitats) during kharif were groundnut, pearl millet, sesame, moong, moth, guar and castor, whereas during rabi wheat, barley, cumin (jeera), mustard, fennel, celery, fenugreek, were the main crops. The species of rodents encountered during both season were *Tatera indica*, *Millardia meltada*, *Rattus rattus*, *Golunda ellioti*, *Funambulus pennanti* and *Mus musculus*. *Meriones hurrianae* was trapped during rabi only (Table 11 and 13). Species composition during kharif was dominated by *F. pennanti* (36.84%), followed by *T. indica* (31.58%), *G. ellioti* (10.53%) and *R. rattus* (10.53%) *M. meltada* (5.26%) and *M. musculus* (5.26%). In rabi *T. indica* (26.93%) was predominant followed by *F. pennanti* (19.23%), *G. ellioti* and *M. hurrianae* (15.38% each) *M. meltada* (11.54%), *R. rattus* (7.69%) and *M. musculus*

(3.86%) (Table 11). The overall tarp index during kharif and rabi was 5.94 and 5.42 rodents/ 100 traps/night, respectively (Table 12).

Table 11. Rodent species composition in the canal command area during Kharif and Rabi

Rodent Species	Kharif		Rabi	
	% Composition	Sex ratio M : F	% Composition	Sex ratio M : F
<i>Tatera indica</i>	31.58	2:1	26.93	0.75:1
<i>Meriones hurrinae</i>	-	-	15.38	1:1
<i>Millardia meltada</i>	5.26	-	11.54	2:1
<i>Golunda elloiti</i>	10.53	-	15.38	3:1
<i>Rattus rattus</i>	10.53	1:1	7.69	1:1
<i>Funambulus Pennanti</i>	36.84	1.33:1	19.23	0.67:1
<i>Mus musculus</i>	5.26	-	3.86	-

Table 12. Habitat wise Trap index in Narmada canal command area during kharif and rabi

S. No.	Habitat	Trap index (rodents/100 traps/day)	
		Kharif	Rabi
1.	Cultivation of Irrigated Crops in vogue for >30 years	8.75	7.5
2.	Cultivation of Irrigated Crops in vogue for last 05 years	6.25	5.83
3.	Natural Fallow/Afforestation along the main canal	5.00	5.00
4.	Rain-fed crop (command/non- canal command area)	3.75	3.33

Table 13. Mean Body weight, sex ratio and morphometry of trapped rodents during Kharif and Rabi

Species	Season	B. Wt (g)	Sex ratio (M:F)	HB (mm)	Hf (mm)	T (mm)	E (mm)
<i>Tatera indica</i>	Kharif	97.50	1:0.67	137.33	34.17	150.83	18.83
	Rabi	102.14	1:1.33	154.57	35.14	170.71	18.00
<i>Meriones hurrinae</i>	Kharif	Pr	-	Pr	Pr	Pr	Pr
	Rabi	76.25	1:1	138.25	30.75	141.75	8.75
<i>Millardia meltada</i>	Kharif	70.00	-	110.00	23.00	100.00	16.00
	Rabi	71.00	1:0.5	121.67	27.67	104.00	16.33
<i>Gollunda elloiti</i>	Kharif	70.00	-	115.00	23.00	102.50	11.00
	Rabi	64.75	1:0.33	106.75	21.50	97.50	10.50
<i>Rattus rattus</i>	Kharif	99.50	1:1	156.50	32.00	184.00	19.00
	Rabi	107.00	-	170.00	32.50	185.00	21.00
<i>Funambulus pennanti</i>	Kharif	83.86	1:1	139.57	35.14	167.43	7.86
	Rabi	73.00	1:1.33	131.40	34.40	160.40	7.80
<i>Mus musculus</i>	Kharif	15.00	-	36.00	8.00	25.00	8.00
	Rabi	14.00	-	36.00	7.00	24.00	8.00

2018-19

Survey of Narmada Canal command area to monitor the impact of change in land-use due to canal irrigation on native rodent fauna was continued in four habitats during *Kharif*. Main kharif crop in the irrigated fields were groundnut, guar, bajra til and moong, however only bajra was sown as raifed. In fallows shrubs, bushes and tree were the main vegetation. Trapping in these habitats revealed the presence of nine species of pest rodents viz, *Tatera indica* and *Meriones hurrianae* (Gerbillinae); *Mallrdia meltada*, *Golunda ellioti*, *M. booduga* and *Nesokia indica*, *Rattus rattus*, and *Mus musculus* (Murinae) and *Funambulus pennanti* (Sciuridae), besides an insectivore *Suncus* sp. Two species viz., *M. booduga* and *N. indica* were trapped for first time from the Narmada canal command area in the habitats where cultivation of irrigated crops in vogue for more than 30 years and *M. musculus* was encountered in the habitat where cultivation of irrigated crops in vogue for more than 05 years. In all 67 individuals were trapped in 960 trapping nights. Like previous season Indian gerbil, *T. indica* (23.88%) was the predominant across the habitat followed by *G. elloiti* (20.90%) during this season also. However, among the habitats more individuals were trapped from the habitat where irrigated cropping is in vogue for more than 30 years (Trap index: 11.67 rodents/100 traps/night) followed by the habitats where irrigated cropping is under practice for more than 05 years (6.67), rain fed cropped areas (5.42) and fallow/afforestation areas (4.17). Survey of Narmada Canal command area to monitor the impact of change in land-use due to canal irrigation on native rodent fauna was continued in four habitats during *Kharif*. Main kharif crop in the irrigated fields were groundnut, guar, bajra til and moong, however only bajra was sown as raifed. In fallows shrubs, bushes and tree were the main vegetation. Trapping in these habitats revealed the presence of nine species of pest rodents viz, *Tatera indica* and *Meriones hurrianae* (Gerbillinae); *Mallrdia meltada*, *Golunda ellioti*, *M. booduga* and *Nesokia indica*, *Rattus rattus*, and *Mus musculus* (Murinae) and *Funambulus pennanti* (Sciuridae), besides an insectivore *Suncus* sp. Two species viz., *M. booduga* and *N. indica* were trapped for first time from the Narmada canal command area in the habitats where cultivation of irrigated crops in vogue for more than 30 years and *M. musculus* was encountered in the habitat where cultivation of irrigated crops in vogue for more than 05 years. In all 67 individuals were trapped in 960 trapping nights. Like previous season Indian gerbil, *T. indica* (23.88%) was the predominant across the habitat followed by *G. elloiti* (20.90%) during this season also (Table 14). However, among the habitats more individuals were trapped from the habitat where irrigated cropping is in vogue for more than 30 years (Trap index: 11.67 rodents/100 traps/night) followed by the habitats where irrigated cropping is under practice for more than 05 years (6.67), rain fed cropped areas (5.42) and fallow/afforestation areas (4.17) (Table 15). It indicated that the period of irrigated cropping had impacted rodent speciation as well as their population (Table 17).

Shannon Diversity index in various habitat revealed increased diversity in the fields with irrigation facilities i.e., with occurrence of seven species the diversity index was 1.89 and 1.77 from the habitat practicing irrigated cultivation for varying period as against rain-fed and fallow habitats (1.5 and 1.28, respectively) (Table 16). The relative abundance of different rodent species across the habitats ranged between 1.49-23.88 percent and the share of different species in the command area was, *Tatera indica* (23.88) *M. meltada* (8.96), *R. rattus* (8.96), *G. ellioti* (20.90), *F. pennant* (16.42), *M. hurrianae*, (7.46) *M. musculus* (1.49), *M. booduga* (4.48) and *N. indica* (7.46) (Table 14).

The study areas harboured rodent species of almost all sizes, with body weight ranging from 11 g (*M. booduga*) to 155 g (*N indica*). The heavier rodents like *N. indica* and *R. rattus* and the smallest (*M. booduga*) were recorded from irrigated crops only whereas, the fallow/

afforestation areas recorded only middle or small sized species. The only arboreal species, *F. pennati* with a mean body weight of 78.73 g was observed to inhabit trees growing in and around all the study habitats, whereas, the truly desert rodent fauna, *M. hurrianae* was also observed in all the habitats, except the fields with irrigation for over three decades (Table 18).

Table 14: The number of rodents caught and their relative abundance at four habitats in Narmada Canal Command area during Kharif 2018.

Species	Cultivation of Irrigated Crops >30 year		Cultivation of Irrigated Crops >5 year		Rain-Fed		Fallow & Afforestation		Total	
	Nos	RA (%)	Nos	RA (%)	Nos	RA (%)	Nos	RA (%)	Nos	RA (%)
<i>T. indica</i>	4	14.29	5	31.25	4	30.77	3	30.00	16	23.88
<i>M. hurrianae</i>	0	0.00	1	6.25	2	15.38	2	20.00	5	7.46
<i>M. melitad</i>	5	17.86	1	6.25	0	0.00	0	0.00	6	8.96
<i>G. ellioti</i>	6	21.43	3	18.75	4	30.77	1	10.00	14	20.90
<i>R. rattus</i>	3	10.71	2	12.50	1	7.69	0	0.00	6	8.96
<i>F. pennanti</i>	2	7.14	3	18.75	2	15.38	4	40.00	11	16.42
<i>M. musculus</i>	0	0.00	1	6.25	0	0.00	0	0.00	1	1.49
<i>M. booduga</i>	3	10.71	0	0.00	0	0.00	0	0.00	3	4.48
<i>N. indica</i>	5	17.86	0	0.00	0	0.00	0	0.00	5	7.46
Total	28	-	16	-	13	-	10	-	67	-
RA (%)	41.79	-	23.88	-	19.40	-	14.93	-	-	-

Table 15: Habitat wise Trap index in Narmada canal command area during kharif (2018)

S. No.	Habitat	Trap index (rodents/100 traps/day)
1.	Cultivation of Irrigated Crops in vogue for >30 years	11.67
2.	Cultivation of Irrigated Crops in vogue for >05 years	6.67
3.	Natural Fallow/Afforestation along the main canal	4.17
4.	Rain-fed crop (command area)	5.42

Table 16: Rodent Diversity in different habitat in Narmada canal command area during 2018

Diversity indices	Habitats			
	Cultivation >30 years	Cultivation last 05 years	Rain-fed crop	Natural Fallow/Afforestation
Number of species	7	7	5	4
Shannon index (H')	1.89	1.77	1.5	1.28
Species richness (d)	1.8	2.16	1.56	1.3
Evenness index (J)	0.97	0.91	0.93	0.92
Simpson's Index (D)	0.84	0.81	0.76	0.86
Species Heterogeneity (D-1)	0.16	0.19	0.24	0.14

Table 17: Variation of rodent abundance in different land-use categories in Narmada Canal Command Area during 2018

Habitat	R1	R2	R3	Average	SD±	SE±
Cultivation of Irrigated Crops >30 years	2.83	3.32	3	3.05**	0.25	0.14
Cultivation of Irrigated Crops >5 years	2.65	2.24	2	2.30	0.33	0.19
Rain-Fed	2.24	2	2	2.08	0.14	0.08
Fallow & Afforestation	1.41	2.24	1.73	1.79	0.42	0.24

CD at 0.05%=0.52

F Calculated (Treated): 8.94; F Table: at 5%: 2.3; at 1%:3.26; Df: 3.

Table 18: Rodent species with morphometry 2018

Species	Mean±SE					
		Body wt. (gm)	HB (mm)	HF (mm)	Tail (mm)	Ear (mm)
<i>T. indica</i>	Av	99.38	154.88	35.19	168.88	18.06
	SE±	5.48	2.51	0.48	1.84	0.41
<i>M. hurrinae</i>	Av	77.80	138.00	29.80	142.80	8.80
	SE±	3.23	2.94	0.91	1.32	0.20
<i>M. meltada</i>	Av	48.67	117.67	20.67	112.00	17.00
	SE±	6.63	5.71	2.11	1.26	0.97
<i>R. rattus</i>	Av	114.33	173.33	33.00	183.67	21.33
	SE±	2.56	1.05	0.37	1.52	0.42
<i>G. elloiti</i>	Av	64.43	113.79	21.86	99.75	11.71
	SE±	3.03	3.84	0.46	2.29	0.38
<i>N. indica</i>	Av	155.00	181.80	34.20	121.40	12.60
	SE±	14.64	4.54	0.80	3.89	0.24
<i>M. booduga</i>	Av	11.00	68.67	11.67	65.67	8.00
	SE±	1.00	1.86	0.33	0.33	0.00
<i>F. pennanti</i>	Av	78.73	133.00	34.09	158.73	7.82
	SE±	3.19	0.99	0.37	2.37	0.12

HV 1. Bio ecology and management of higher vertebrates in different crops

2017-18

(i) Nilgai: Incidence of nilgai and wild boar was severe in villages of Jodhpur and Nagaur districts. 24 heard of nilgai in the fallows located near crop fields with a heard size ranging from 1-22 was recorded in villages of Nagaur and Jodhpur districts (Table 19). Electrical fencing of crop fields proved quite effective in preventing nilgai damage. Electrical fencing of 12 ha costs around Rs. 4500/- which includes cost of machine (battery and pulsating current device) and GI wire. After installation of electric fencing the farmers realized Rs. 50,000/- in 2017 from the sale of carrot of 0.17 ha as against Rs 25000/- when the area was not fenced in 2016. Likewise, the production of Isabgol has increased to 600kg from 1500kg in 0.75 hectare and that of wheat to 3500kg from 400 kg in a hectare after installation of the machine.

(ii) Wild boar: Wild boar activity was also observed in the area. The field of sonf, cumin, methi and wheat crops, which were at vegetative growth stage was moved by wild boar through its snout at several places. In the process plants in the area were uprooted. The farmers of the area are using phorated mix bajara for killing wild boar. They placed the phorate mix bajra at places where

activity of wild boar was noticed in the field in the polythene sheets. They observed that boar died after consuming the bajra due to flatulence and subsequent busting of abdomen. In one field we observed that to capture the boar farmer dug a ditch at the entry point and covered it with debris. Electrical fencing to check the entry of wild boar and nilgai were laid by 4-5 farmers in the area. In each field about 2-3 hectare area sown with castor, cumin, wheat crop was fenced. In one field fencing around pomegranate was also laid, wild boar devoured most of the fruits of pomegranate in the field. After laying electrical fencing the entry of wild boar was checked in the field. Farmers in the area were finding electrical fencing very effective and economic. For electrifying the fence around 2-3 ha area about 25 kg GI wire and one instrument is required. It costs Rs. 8-9 thousand only. The battery of instrument can be charged through solar energy or domestic electricity.

Table 19. Size and composition of herd of Nilgai

Location	Herd size	Composition		
		Adult Male	Adult Female	Calves
Rool	6	4	-	2
	9	-	4	5
	12	2	4	6
Faroda	11	1	6	4
	5	5	-	-
	6	4	-	2
Tarnau	6	6	-	-
	7	7	-	-
	8	-	6	2
	8	5	-	3
Sandila	5	2	3	-
	7	-	5	2
	4	4	-	-
Badi Khatu	5	1	3	1
Nagaur (outskirt)	10	1	5	4
	8	4	3	1
Panchla	10	1	6	3
	1	1	-	-
	6	-	4	2
	1	1	-	-
Kaporla	22	3	10	9
	2	2	-	-
	1	1	-	-
	5	-	3	2

2018-19

Incidence of Higher Vertebrate Pests: Incidence of nilgai and wild boar was severe in villages of Jodhpur and Jalore districts. 12 heard of nilgai in the fallows located near crop fields with a heard size ranging from 2-11 were recorded in villages of Jalore and Jodhpur districts (Table 20). Severe infestation of wild boar was observed in Narmada canal command area in castor and bajra crop. Electrical fencing 30 cm above ground level proved quite effective in checking the menace of wild boar.

Table 20. Size and composition of herd of Nilgai 2018

Location	Herd size	Composition		
		Adult Male	Adult Female	Calves
Padasla	7	4	-	3
	11	-	6	5
Bagardina ki Dhani	7	7	-	-
	2	2	-	-
	5	-	3	2
Phadpura	6	6	-	-
	7	7	-	-
Golasan	3	-	3	-
	7	-	5	2
Chitalwana	8	-	6	2
	11	-	7	4
Piparli	5	5	-	-

TSP ACTIVITIES

The activities under TSP was organized in villages of Banswara, Leh and Sirohi districts, two trainings each at Chidyawasa and Badvi of Distt. Banswara (Rajasthan), Stakmo and Shang Villages of District Leh (J&K) and Khara and Uppplagarh of Distt Sirohi. From each village 60 farmers in the ratio of 40:60 (40% men and 60% women) participated in the trainings on rodent pest management. Initially evaluation of farmers' knowledge about rodent damage in agricultural crops and strategies adopted by them to control the rodents through set questionnaire was made. Later training on role of rodents in agriculture was given. Farmers were informed about the various behavioural traits of the rodents along with the role of rodents as pest in agriculture and storage in hot and cold arid agriculture. Detailed account of economically rodents along with rodents was presented. Various non-chemical and chemical methods of rodent pest management were explained in detail. Information on acute and chronic poison used in rodent control was imparted along with precautions to be taken while their use in various conditions. Demonstrations on techniques of poison bait preparation and bait placement along with correct use of traps were also imparted. A total of 360 farmers participated in the training and benefited from the training. Farmers were also distributed bait containers (PVC) and information folders. A total of 360 bait containers were distributed among farmers for preparation of poison bait for rodent control.

Output	Details of output and unit	Target (No)	Achievements (No)	% achievement
Output 1	Bait container (PVC) 120 Nos	360 Farmers	360 Farmers	100%
Output 2	Training on Rodent Pest Management	06	06	100%
	Demonstration of poison bait preparation and administration technique	06	06	100%

RESOURCE GENERATION

A sum of Rs. **4060313.00** was generated during the year 2017-18 and 2018-19 from contract service on anti-rodent testing, as detailed in following Table.

Title of consultancy	Client	Amount (Rs)
Anti-Rodent Testing of DWC (Double Wall Corrugated) HDPE Ducts (Sizes 90/77mm, 125/108mm and 180/153 mm)	M/S Tirupati Plastomatics Pvt. Ltd.	3,41,029.00
Evaluation of Anti-Rodent Treated Plastic (PBT) Tubes Against Rodent Attack Supplied M/S KiTEC Industries India Ltd. Silvassa, UT of D & N. H.	M/S KiTECH Industries (India) Limited, Borivali (West) Mumbai-400 103	3,37,417.00
Evaluation of Rodent Repellent Additive for Pipes and Cables against Rodent attack	M/S NICHEM Solutions, Plot No. Wagle Industrial Estate, Thane (W), Maharashtra, India	4,20,129.00
Anti-rodent testing of rat repellent corrugated tube manufactured by M/s Hyundai Motor India ltd. Tamil Nadu	M/S Hyundai Motor India Ltd. Kancheepuram Diist. Tamil Nadu-602 117	3,71,991.00
Anti-rodent testing of DWC (Double wall Corrugated)Ducts of Dura-Line India Pvt. Ltd., (Szes 50mm, 63mm, 75 mm, 110 mm, 120 mm, 180mm & 200mm Oranges and Blue Colour	M/S Dura-Line India Pvt. Ltd., Mahbubnagar District-509 325, Telangana	5,13,935.00
Anti-rodent testing of DWC (Double wall Corrugated) HDPE ducts of M/s Tirupati Plastomatics Pvt. Ltd (Sizes 53/38mm, 63/50mm & 110/96mm)	M/S Tirupati Plastomatics Pvt. Ltd., (Nit-II), B-141-A, Road No. 9-D VKI. Jaipur (Rajasthan) India	3,49,042.00
Anti-rodent testing of DWC (Double wall Corrugated) ducts	Dura-Line India Pvt. Ltd., RIICO Industrial Area, Neemrana, Alwar, Rajasthan, India	4,02,356.00
Anti-rodent testing of HDPE DWC (Double wall Corrugated) ducts of Creator Poly Extrusions LLP (Sizes 50mm, 63mm, 75mm, 90mm, 110mm, 120mm and 160mm)	Creator Poly Extrusions Ltd., Plot NO. 107, Sector Ecotech XII, Greater Noida, G. B. Nagar (UP) India	4,78,249.00
Anti-rodent testing of HDPE DWC (Double wall Corrugated) ducts of Dura Line India Pvt., Ltd., Alwar (Sizes 160mm, 120mm, 50mm, orange and Blue)	Dura-Line India Pvt Ltd., RIICO Industrial Area, Neemrana, Alwar, Rajasthan, India	4,06,773.00
Anti-rodent testing of DWC (Double wall Corrugated) ducts of Dura-Line India Pvt. Ltd., Alwar	Dura-Line India Pvt Ltd., RIICO Industrial Area, Neemrana, Alwar, Rajasthan, India	4,39,392.00

PUBLICATIONS

Papers in Research Journals

- Chaudhary, V., Tripathi R S, Koodi, H L and Singh L. 2017. Diversity and distribution of Rodent community in cold arid ecosystem of Leh, Jammu and Kashmir, India. *J. Exp. Zool. India* 20(1): 1371-1376.
- Chaudhary, V., Tripathi, R. S. 2019. First record of Little Indian field mouse, *Mus booduga* (Gray, 1837*) (Rodentia: Muridae) from cold arid region of Leh-Ladakh, Jammu & Kashmir, India. *Mammalia* 83(1):97-99.
- Chaudhary, V. Tripathi, R S, Singh S. and Raghuvanshi, M S 2017. Distribution and population of Himalayan marmot, *Marmota himalayana* (Hodgson, 1841) (Mammalia Rodentia Sciuridae) in Leh-Ladakh, Jammu and Kashmir, India. *J. Threatened Taxa*. 9 (11): 10886-10891.
- Chaudhary, V. and Tripathi, R.S. 2016-17. Depredation of pomegranate (*Puccnia granatum*) by rodents and its management in arid region of Rajasthan. *Rodent Newsletter* 40&41(1-4): 2-3.
- Chaudhary, V. and Tripathi, R.S. 2019. Critical timings of rodenticidal application for rodent pest management in mixed crop of bajra, moth and gaur. *Annals of Plant and Soil Research* 21(1): 19 – 24.
- Singh, B. and Tripathi, R.S. 2017. Effect of rodenticides on seed yield of Rabi crops in arid zone. *Annals of Arid Zone*. 56 (3&4): 125-128.
- Vasudeva Rao, V. Naresh, B., Tripathi, R.S. Sudhakar, C and Ravinder Reddy, V. 2017. Reduction of wild boar (*Sus scrofa* L.) damage in maize (*Zea mays* L.) by using castor (*Ricinus communis* L) as barrier. *J. Entomology and Zoology Studies*. 5(6):426-428.

Papers in Seminar/ Symposia/Workshops etc

- Chaudhary, V. And Tripathi, R.S. 2017. Effect change in land use pattern and urbanization on rodent community in an arid ecosystem. National Conference on Behavioural Ecology: Responses to Changing Climate & 41st Annual Conference of the Ethological Society of India organised by GUIDE, Kuchchh, Gujarat from 24-25 Nov., 2017 (Abstract Submitted).
- Chaudhary, V and Tripathi, R.S. 2017. Toxicity and acceptability of Difenacoum a second anticoagulant rodenticide against murid rodents. International Conference on “Global Research Initiative for Sustaining Agricultural and Allied Sciences”, held at MPUAT, Udaipur during 2-4 Dec, 2017 (Presented by senior author).
- Tripathi, R.S. 2018. Rodent Management under Changing Land Use Pattern Scenario in India. XVI AZRA International Conference on “Applied Zoological Research for Sustainable Agriculture and Food Security” during February 09-11, 2018 at BHU, Varanasi. Abstract Book pp 125. (Presented as Lead paper).
- Chaudhary, V. And Tripathi, R.S. 2018. “Critical timings of rodenticidal application for rodent pest management in mixed crop of bajra, moth and guar in arid zone. (Abstract Book) National Conference “Managing Natural Resources for Sustainable Agriculture. GKV (December 8-9, 2018) pp 20.
- Tripathi, R.S. and Chaudhary, V. 2019. Rodent pest management in vegetable crops. (Abstract Book) First Vegetable Science Congress on Emerging Challenges in Vegetable Research and Education (VEGCON-2019). Indian Society of Vegetable Science, Agriculture University and ICAR-Indian Institute of Vegetable Research, (1-3rd February, 2019) pp 204.
- Tripathi, R.S., Chaudhary, V and Gawaria KM. 2019. Bioefficacy of two second generation anticoagulant rodenticides against rodent pests. (Abstract Book) International Conference on Dryland Development: Converting dryland areas from Grey into Green. IDDC and AZRAI, (Feb 11-14, 2019) pp 235.

Chaudhary, V. Tripathi, R S., Singh, S. and Meena, RC. 2019. Effect of habitat alteration on diversity, distribution and abundance of rodents in Narmada canal command areas of Western Rajasthan. (Abstract Book) International Conference on Dryland Development: Converting dryland areas from Grey into Green. IDDC and AZRAI, (Feb 11-14, 2019) pp 240.

Technical Bulletins

- Chaudhary, V., Tripathi, R.S. Singh, S and Meena, R.C. 2017. Rodents of cold arid region of Leh-Ladakh. Technical Bulletin (No 19). AINP on Vertebrate Pest Management, Central Arid Zone Research Institute, Jodhpur. Pp 1-12.
- Singla, N, Chaudhary, V. and Tripathi, R.S. 2017. Current Status of Rodent problem in Indian Agriculture. Technical Bulletin (No 20). AINP on Vertebrate Pest Management, Central Arid Zone Research Institute, Jodhpur. Pp 1-62.
- Singla, N., Babbar, B.K., Singh, R., Kaur, N. and Tripathi, R.S. 2017. Bio-ecology of Indian gerbil, *Tatera indica* (Hardwicke, 1807). Technical Bulletin, AINP on Vertebrate Pest Management, Punjab Agricultural University, Ludhiana. Pp 1-20.

Popular articles

- Tripathi, R.S. 2017. Efficient management of rodents and other vertebrate pests in horticultural crops. In. Model Training Course on 'Newer Options in Arid Horticulture for doubling farm income' CAZRI, Jodhpur.
- Tripathi, R.S. 2018. Efficient management of vertebrate pests in Field Crops. In *Ecofriendly Integrated Pest Management in Arid Crops* (Eds, Jadon, KS; Patel, N. and Choudhary, KB) Central Arid Zone Research Institute, Jodhpur. Pp 58-65.
- Tripathi, R. S; Vipin Chaudhary and A.S. Tomar (2018). *Dalhani fasalon me chuha prabandhan*. Training Manual on "Dalhani fasalon me poudh sanrakshan". Published from KVK, CAZRI, Jodhpur. Pp 40-42.
- Chaudhary, Vipin; R.S.Tripathi and A.S. Tomar (2018). *Godawn ve Gharon me chuha prabandhan*. Training Manual on "Dalhani fasalon me poudh sanrakshan". Published from KVK, CAZRI, Jodhpur. Pp 60-68.
- Tripathi, R.S (2018). *Godawon me chuha prabandhan*. Training Manual on "One year Diploma in DAESI from Nov, 2017 to Nov, 2018". Published from KVK, CAZRI, Jodhpur.
- Chaudhary, V (2018). *Fasalon ke hanikarak evem mitre (मित्र) keet*. Training Manual on "One year Diploma in DAESI from Nov, 2017 to Nov 2018". Published from KVK, CAZRI, Jodhpur.
- Chaudhary, V. 2018. Efficient management of rodents in field crops. In *Ecofriendly Integrated Pest Management in Arid Crops* (Eds, Jadon, KS; Patel, N. and Choudhary, KB) Central Arid Zone Research Institute, Jodhpur. Pp 63-68.
- Tripathi, R.S. and Chaudhary, V. 2018. Rodent management in Arid Regions. *Indian Farming*, 68(9): 79-84.
- Singh, J.P., Saha, D. and Tripathi, R.S. 2018. Rehabilitation of *Orans* (sacred groves) in Western Rajasthan. *Desert Environment Newsletter*. 20 (3-4).6-9.
- Tripathi, R.S 2018. फल एवं सब्जि उत्पादन में चूहों से होने वाले नुकसान व रोकथामा नर्सरी एवं बगीचा प्रबंधन per prashikshan pustika. Published from KVK, CAZRI, Jodhpur. Pp 65-69.
- Chaudhary, V., Tripathi, R.S. and Tomar, A.S. 2018). *Dalhani fasalon me chuhon ki samasaya evem pravandhan*. Dalhani Fasalon me Keet ve Rog pravandhan per prashikshan pustika 27-28 July, 2018. Published from KVK, CAZRI, Jodhpur. Pp 27-29.
- Chaudhary, V, Tripathi, R.S. and Tomar, A.S. 2018. *Gowdamon mevem Gharon me Chuha pravandhan*. Fasalon me poudh Sanrakshan 19-23 Feb, 2019. Published from KVK, CAZRI, Jodhpur. Pp 31-33.

- Tripathi, R.S 2019. *Fasal Utpadan me Chuhon se hone vala nuksan evem Roktham*. Fasalon me poudh Sanrakshan 19-23 Feb, 2019. Published from KVK, CAZRI, Jodhpur. Pp 25-30.
- Tripathi, R.S 2019. फल एवं सब्जि उत्पादन में चूहों से होने वाले नुकसान व रोकथाम। Skill Deployment training per prashikshan pustika. Published from KVK, CAZRI, Jodhpur. pp 103-108.

Book Chapters

- Tomar, A. S., Tripathi, R. S., Sharma, S. K., Meghwal, R. R. and Chaudhary, M. 2017. Fasalon mein Deemak ka Samanvit Prabandhan. In *Shushk Kshetra mein Jalvayu Samuthansheel krishi Taknikiyan* (Eds SK Sharma, Poonam kalash, DV Singh, N. Patel and RK Goyal); ICAR- Central Arid Zone Research Institute, Jodhpur. Pp49-51.
- Tripathi R.S. 2018. Integrated management of rodent pests in agriculture. In: Chattopadhyay, C.; Tanwar, R.K.; Sehgal, M.; Birah, A.; Bhagat, S.; Ahmad, N.; Mehta, N. (eds), *Handbook of Integrated Pest Management*. Indian Council of Agricultural Research, pp. 153-162.
- Tripathi, R.S. 2018. Vertebrate Pest Management in Agriculture. In Designing Farming Systems for low rainfall areas (Eds Tanwar, SPS, Singh, A., Khapte, PS and Kachhawaha). Compendium of Summer School (August 26-September 17 2019) ICAR- Central Arid Zone Research Institute, Jodhpur. Pp 223-233.
- Tripathi, R.S. 2018. Efficient management of vertebrate pests in Field Crops. In *Eco-friendly Integrated Pest Management in Arid Crops* (Eds, Jadon, KS; Patel, N. and Choudhary, KB) Central Arid Zone Research Institute, Jodhpur. Pp 58-65.
- Chaudhary, V. 2018. Rodent pest Management in Arid Zone. In Training Manual on “Plantation Techniques and Utilization of Renewable Energy in Arid Zone” Green Skill Development Programme (MOEF&CC), GOI, New Delhi Singh, (Eds Singh, J.P., Tripathi, R. S., Saha, D., Santra, P., Singh, A.; Das, T.; Goyal, S.). ENVIS, ICAR- Central Arid Zone Research Institute, Jodhpur. Pp 120-127.
- Chaudhary, V and Tripathi, R.S. 2019. Faunal Diversity of Thar Desert, India. In: Drylands, Biodiversity, Management and Conservation (Eds: Victor, R. Squires, Mahesh Gaur and Salah Attia-Ismail) Nova Sciences Publisher Inc. New York. Pp 25-40.

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	12.93	0	8.08	2.7	0	0	10.78
2018-19	25.77	0.00	10.90	4.07	6.13	1.23	22.33

**PROFESSOR JAYASHANKAR TELANGANA STATE AGRICULTURAL UNIVERSITY,
HYDERABAD-500 030**

Part 1. General Information

1. Name of the center	Prof. Jayashankar Telangana State Agricultural University, Hyderabad
2. Sanction no.	11-1/81PP dated 29/01/1982
3. Date of start	September 1982
4. Date of Termination	Network Project of contd nature
5. Report period	2017-18 to 2018-19
6. Scientist Incharge	Dr V. Vasudeva Rao

7. Staff Position

Sr. No	Name of post	No. of posts sanctioned	Name of incumbent	Date of Joining	Date of Leaving
1	Principal Scientist & Head	1	Dr. V. Vasudeva Rao	15/02/2000	-
2	Senior Scientist	1	Dr. V. Ravinder Reddy	16/02/2000	-
3	Scientist	2	Dr. V. Sunitha	26/02/2014	-
			Vacant	-	-
4	Technical Asst.	2	P. Venkateswarlu	27/10/2010	-
			A.V.L.N. Ramalingeswara Rao	27/10/2010	-
5	Attender	1	Korani Naveen	19/04/2010	-

Part II: Work allotted (Technical Programme)

I. Multi location Programmes

BM 1. Surveillance of depredatory birds in predominant cropping systems. (Rice/rice, maize, sorghum, bajra and sunflower)

BM 2. Community structure of birds and their diversity in relation to crop stages in different agroecological zones of the region. PJTSAU, Hyderabad Southern Telangana

BM 3. To identify, develop and evaluate eco-friendly bird management techniques
a) Evaluation of different botanicals as feeding deterrents in the captivity and fields
b) Evaluation of chemical/ non chemicals as deterrents in the fields (all centers)
c) Field evaluation of different management methods in various crops in farmers' fields/universities/ university farms/ government farms). (Maize, bajra, sorghum and sunflower)

BM 4. Exploitation of beneficial birds for the suppressing of insect pests (Sunflower/Tomato)

BM 5. Evaluation of fruiting / flowering trees to attract insectivorous / omnivorous / Depredatory birds to the agricultural land scape.

BM 6. Farmers' participatory research on bird management

II. Location specific programmes

- a) Fruit bat damage pattern and development of management methods in Horticultural crops.
- b) Bio ecology, extent of crop damage and management of Indian palm squirrel
- c) Biodiversity in agricultural landscape with relevance to conservation

(C) HIGHER VERTEBRATES

HV 1: Bio ecology and management of higher vertebrates (Wild boar and *Rhesus macaque*) in different crops.

Part III. Work Done

BM 1. Surveillance of depredatory birds in predominant cropping systems.

- Bird damage to different crops varied significantly with respect to stage of the crop. The values of crop losses are of individual fields and not for particular crop or the entire state.
- The damage to crops by birds vary from region to region, season to season, depending on number of factors like number of depredatory species and their density, area under crop, ecology of the area, concentration of migrants, their food habits as well as the physiological status of birds involved.
- Assessment of losses due to birds to different crops viz., sorghum, maize, pearl millet, paddy, sunflower, safflowers, and groundnut was done in farmers field's of different agro climatic zones of the state. All the crops were susceptible to bird damage during sowing, seedling stage and ripening stage. The damage to the crops of smaller grains such as pearl millet and sorghum was more serious as compared to that in large size grains. Isolated fields were always prone to bird damage and similarly, early (or) late maturing fields were highly susceptible to bird damage. The overall percent incidence of damage by depredatory birds on different crops revealed that high incidence of damage recorded on sunflower during milky stage (18-46%) followed by sorghum (20-44%), Pearl millet (18-35%), safflower (09-15%), maize (05-31%), and paddy (03-05%). Whereas, during sowing and sprouting stage, the incidence of damage was high in Maize (20-46%) and sunflower (2 - 5%) (**Table 1**).

Table: 1. Per cent incidence of damage by depredatory birds in different crops.

S.No	Crop	Per cent damage	
		Sprouting stage	Milky stage
1	Sunflower	02 – 05	18 - 46
2	Sorghum	-	20 - 44
3	Pearl millet	-	18 - 35
4	Safflower	-	09 - 15
5	Maize	22 – 46	05 - 31
6	Paddy	-	03 - 05

BM 2. Community structure of birds and their diversity in relation to crop stages in different agro- ecological zones based on cropping systems.

During the period, community structure of birds and their diversity in relation to crop stages are studied in and around fields of Rajendranagar in three cropping systems *i.e.*, paddy followed by paddy, paddy followed by maize and paddy followed by red gram. In all cropping systems, species richness was highest in vegetative state except in red gram, the species richness was high in post harvesting stage. Species richness was predominant in vegetative stage (56sps)

followed by nursery stage (51sps), post harvesting stage (32sps), milky stage (22sps) harvesting (23sps) and least recorded in transplanting stage (21sps), while in other crops in post harvesting stages the species richness was more or less same (**Table.2**). Among the crops, the relative abundance of common bird species were observed in paddy cattle egret was high abundant (22.83%) in Maize Ashy Preenia was highly abundant (20.90%) and in red gram spotted Munia was highly abundant (21.60%) (**Table 3**). In all the three cropping systems total 69 species are recorded. The species richness was high (69%) during different growth stages of paddy followed by maize (30) and pulses (16) (**Table.4**).

The mean occurrence of birds were high in paddy /paddy 3.87 ± 0.52 with a range of 01-38 birds followed by Maize 1.68 ± 0.23 with a range of 01-09 birds and pulses 0.83 ± 0.09 with a range of 01-05 birds. Bird activity was recorded in different crops, the data showed that high number of species were utilizing paddy crop for feeding (47%), followed by Maize for perching (63%) and redgram for moving (36%) purpose (Fig 1). The overall bird activity in relation to different crops showed that 38% of bird species were recorded for perching followed by 29% for feeding, 13% for moving, 7% calling, 06% flying and 1% playing (Fig.2). Foraging guild of bird species in different crops were recorded and observed, the occurrence of insectivorous birds were high in all crops (Paddy 28 sp, Maize 14 sp and Redgram 06 sp), followed by omnivorous birds (Paddy 18 sp, Maize 06 sp and Redgram 04 sp) (**Table 5**) .

Table 2: Species richness in relation to crop stages

Crop stage	Crop type		
	Paddy (n=132)	Maize (n=90)	Red gram (n=180)
Nursery	51	-	-
Transplant	21	-	-
Germination	-	16	19
Vegetative	56	33	21
Flowering			15
Milky	22	12	-
Cob	-	23	-
Fruiting	-	-	22
Ripening		-	-
Harvesting	23	10	7
Post harvesting	32	23	25

Table 3: Relative abundance of top 10 bird species in relation to different crops

Paddy	% RA	Maize	% RA	Red gram	% RA
Cattle egret	22.83%	Common myna	2.41%	Spotted munia	21.60
Spotted munia	14.65	Indian robin	13.40	Baya weaver	19.22
Open bill stork	8.46	Rose ringed parakeet	14.8	Silver bill munia	18.25
Baya weaver	11.64%	Baya weaver	10.49%	Rose ringed parakeet	13.50
Plain prinia	5.57	Pied bush chat	18.34%	Spotted dove	9.61
Common myna	9.22%	Small green bee eater	7.485	House crow	6.05
Common sand piper	14.03%	Indian roller	4.26	Common myna	4.64
Black Drongo	6.58%	House crow	3.58	Blue rock pigeon	3.89
Small green bee eater	4.65	Yellow billed	4.31%	Yellow billed babbler	1.94

		babbler			
Pied bush chat	3.28%	Ashy prinia	20.90%	Black drongo	1.73
Yellow billed babbler	9.67				

Table 4: Mean, Species richness and diversity indices of birds (n=63)

Cropping system	Mean $\pm$ S.E	Shannon H'	Species Richness	Range
Paddy/Paddy	3.87 $\pm$ 0.52	1.54	63	01- 38
Paddy/Maize	1.68 $\pm$ 0.23	1.21	28	01-09
Paddy/Pulses	0.83 $\pm$ 0.09	1.04	10	01-05

Table.5: Per cent occurrence of different birds and their foraging guild in relation to crops

Foraging guild	Paddy	%	Maize	%	Red gram	%
Carnivorous	06	09	02	07	02	10
Frugivorous	02	03	01	04	01	5
Granivorous	12	18	04	14	05	25
Insectivorous	28	42	14	50	06	30
Nectarivorous	01	01	01	04	02	10
Omnivorous	18	27	06	21	04	20
Total	67	100	28	100	20	100

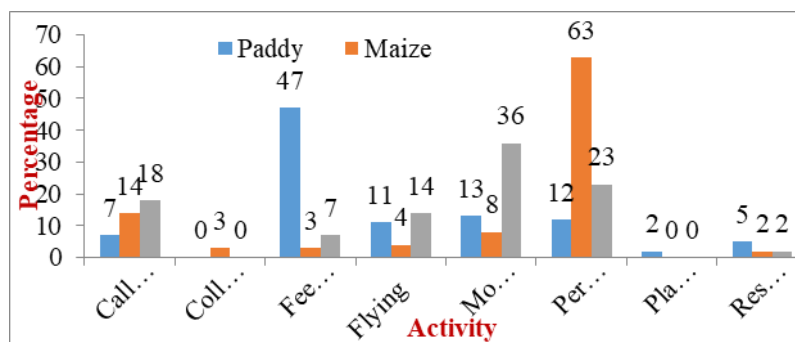


Fig.1: Bird activity pattern in relation to different crops

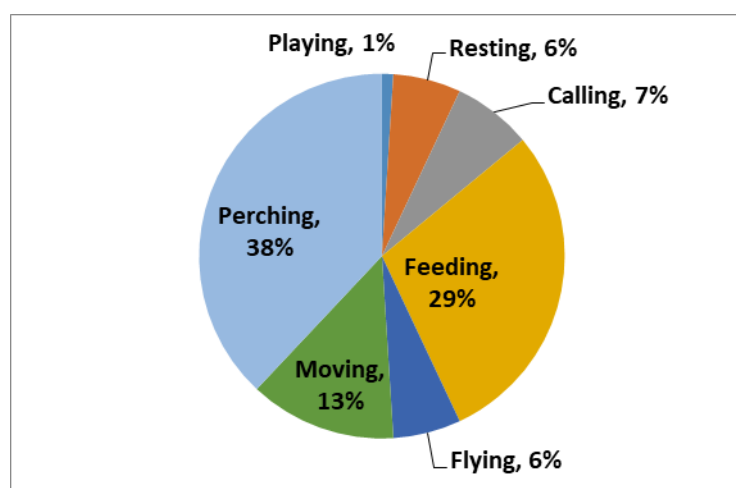


Fig.2: The overall bird activity in different crops recorded during the study period

BM 3. To identify, develop and evaluate eco-friendly bird management practices for crop protection.

During the period 2017-19 in Kharif season to protect the Maize crop from birds at sowing stage among the treatments ribbon showed highest germination with 81.61%, 71.25% followed by egg solution @ 2% (77.8%), Azadirachtin @25ml/l (70.92%) and Methyl anthanilite @ 0.2% (62.67%) showed on par germination against control (49.69%, 42.78%). In Rabi season at sowing stage among the treatments ribbon showed highest germination with 71.25% followed by egg solution @ 2% (70.35%) and Azadirachtin @25ml/l (62.51%) and Methyl anthanilite @ 0.2% (55.11%) showed on par germination against control (42.78%)(**Table.6**).

During the period 2017-19 to protect the Bajra crop from birds among the treatments salt solution @25gm/l (20.19%) followed by castor oil @25ml/l (25.98 %)and Deepam Oil @ 25ml/l (28.2%) showed less damage and Ginger and garlic @30ml/l (30.47%) and neem oil @ 25ml/l (31.51%) showed on par results against control (68.99%) (**Table 7**).

During Rabi season at ARS, Tandur to reduce bird damage in Bajra among the treatments imposed egg solution spray (25ml/l) showed higher yield (944 Kg/ha) followed by ribbon (815 Kg/ha), sorghum border (801Kg/ha), Mixed oil spray(25ml/l) (741 Kg/ha), castor oil spray (25ml/l) (717Kg/ha) and salt solution spray (50gm/l) (627 Kg/ha) compared to control (394 Kg/ha) (**Table.8**).

During Rabi season at ARS, Tandur to reduce bird damage in Sorghum among the treatments imposed, egg solution spray @25ml/l showed higher yield (2593.54 Kg/ha) followed by castor oil spray @25ml/l (2423.17 Kg/ha), mixed oil spray @25ml/l (2353.8Kg/ha), Azadirachtin @1500 ppm spray @25ml/l (2059.28.28 Kg/ha) and salt solution spray @ (50gm/l (1683.35 Kg/ha) compared to control (953.71 Kg/ha) (**Table.9**).

In Rabi at ARS, Tandur to reduce bird damage in Safflower among the treatments imposed, egg solution spray @25ml/l showed higher yield (1444 Kg/ha) followed by ribbon (1216 Kg/ha), Strychnus spray (1163 Kg/ha), mixed oil spray @25ml/l (1074 Kg/ha), Castor oil spray @25ml/l (858 Kg/ha) and salt solution spray @50gm/l (842 Kg/ha) compared to control (533 Kg/ha) (Table.10).

In Rabi at ARS, Tandur to reduce bird damage in Sunflower among the treatments imposed egg solution spray (25ml/l) showed higher yield (1408.64 Kg/ha) followed by castor oil spray @25ml/l (1238.64 Kg/ha), mixed oil spray @25ml/l (1086.42 Kg/ha), Azadirachtin @1500 ppm spray @25ml/l (917.28 Kg/ha) and salt solution spray @ 50gm/l (722.22 Kg/ha) compared to control (358.02 Kg/ha) (**Table.11**).

In Rabi sorghum at ARS, Tandur compared the bioacoustics and expeller gun with control. Among the treatments bioacoustics showed higher yield (2960 Kg/ha) followed by expeller gun (2375.5 Kg/ha) and control (1987.5 Kg/ha). Similarly in Bajra also bioacoustics plot was recorded higher yield (847 Kg/ha) followed by expeller gun (585 Kg/ha) and control (377 Kg/ha) (**Table.12**).

In all the above crops bird instances were recorded from milky stage to harvesting stage. In all the experimental fields the bird instances were drastically reduced after treatment (80%) and noticed less damage pattern in the crops to the extent of 63-80%.

Table.6 Effectiveness of different methods to reduce bird damage in Maize crop at sowing & sprouting stage during Kharif & Rabi at Rajendranagar(2017-18&2018-19)

Treatments	Kharif	Rabi
T1: Azadirachtin 1500ppm @25ml/l	70.92	62.61

T2: Methly anthranilite @0.2%	62.67	55.11
T3: Whole egg solution @2%	77.8	70.35
T4: Ribbon	81.64	71.25
T5: Control	49.69	42.78
CD	13.59	5.49
SE(d)	4.767	2.344
CV	6.95	4.75

Table 7: Effectiveness of different methods to reduce bird damage in Bajra during *Kharif* 2017-18 & 2018-19

Treatments	Damage %	Yield (Kg/ha)
T1: Azadirachtin 1500ppm @25ml/lt	31.51	1,745.23
T2: Ginger and Garlic @30ml/lt	30.47	2,063.30
T3: Deepam Oil @ 25ml/lt	28.2	2,397.00
T4: Salt solution @100gm/lt	20.19	2,630.33
T5: Castor oil @ 20ml/Lt	25.98	2,469.85
T6: Control	68.99	1,285.60
C.D.	4.271	260.209
SE(d)	1.892	115.293
C.V.	6.773	6.729

Table 8. Effectiveness of different methods to reduce bird damage in Bajra crop during *Rabi* at ARS-Tandur

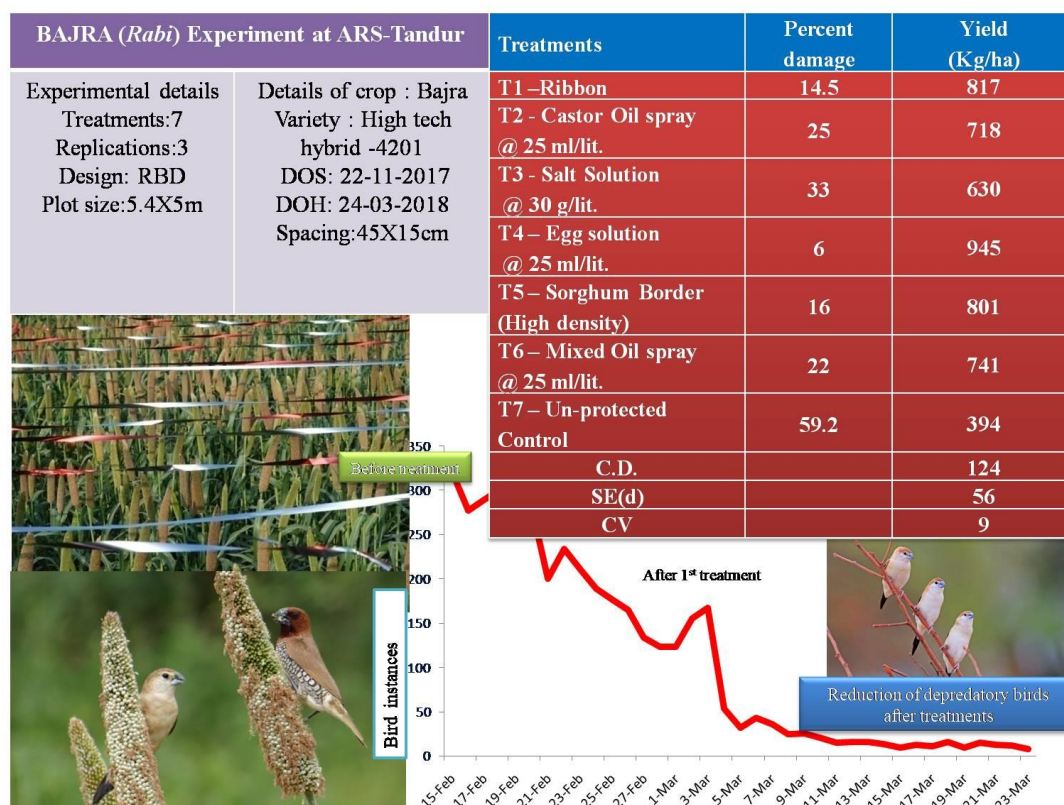


Table.9 Effectiveness of different methods to reduce bird damage in Sorghum crop during Rabi at ARS- Tandur

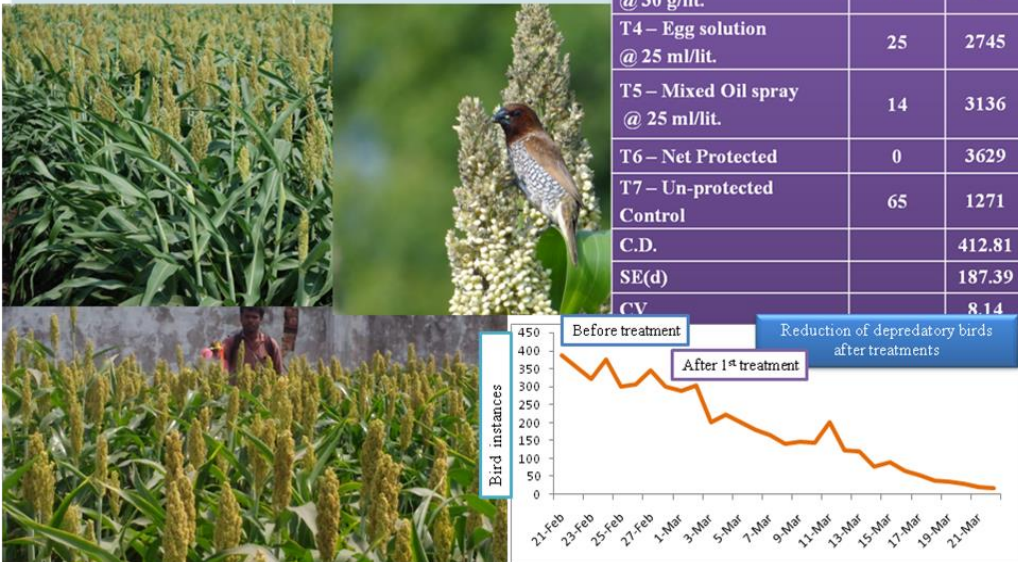
SORGHUM (<i>Rabi</i>) Experiment at ARS- Tandur		Treatments:	Percent damage	Yield (Kg/ha)
Experimental details : Treatments:7 Replications:3 Design: RBD Plot size:5.4X5m	Details of crop : Sorghum Variety :Mahindra male C-43 DOS: 09-11-2017 DOH: 22-03-2018 Spacing:45 X15	T1 –Ribbon	5	3458
		T2 - Castor Oil spray @ 25 ml/lit.	39	2245
		T3 - Salt Solution @ 30 g/lit.	11	3231
		T4 – Egg solution @ 25 ml/lit.	25	2745
		T5 – Mixed Oil spray @ 25 ml/lit.	14	3136
		T6 – Net Protected	0	3629
		T7 – Un-protected Control	65	1271
		C.D.		412.81
		SE(d)		187.39
		CV		8.14
				

Table. 10 Effectiveness of different methods to reduce bird damage in Safflower crop during Rabi at ARS-Tandur

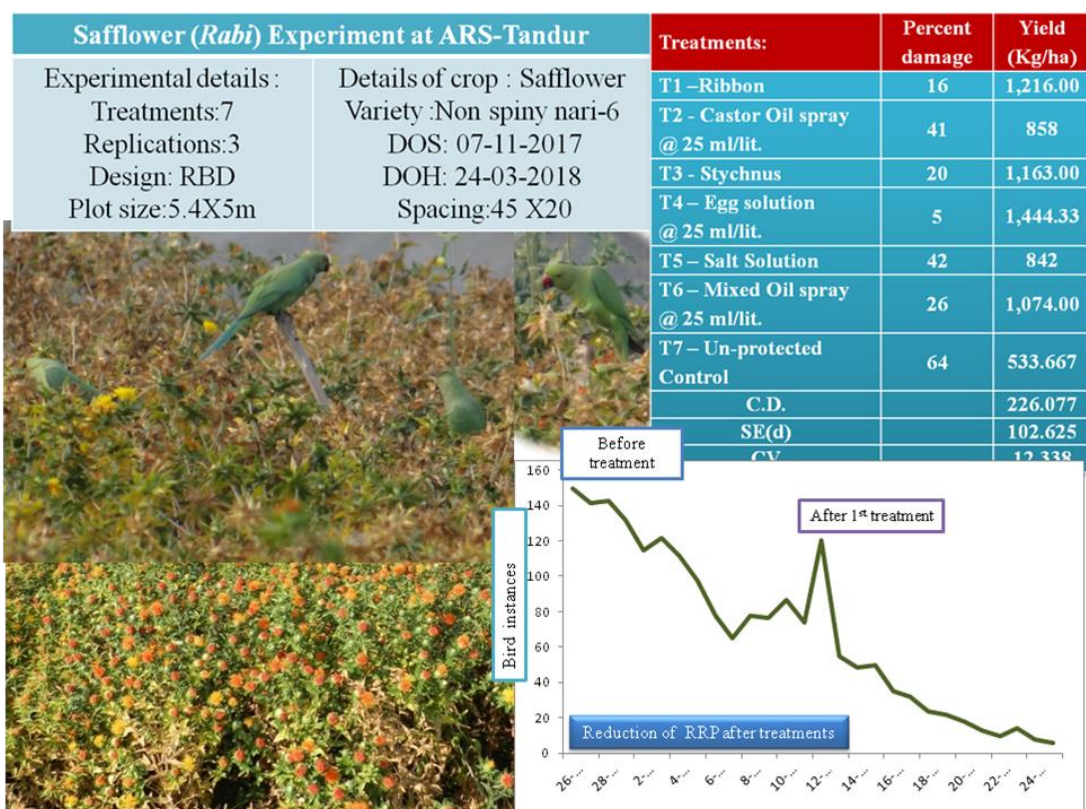


Table 11 Effectiveness of different methods to reduce bird damage in Sunflower crop during *Rabi* at ARS-Tandur

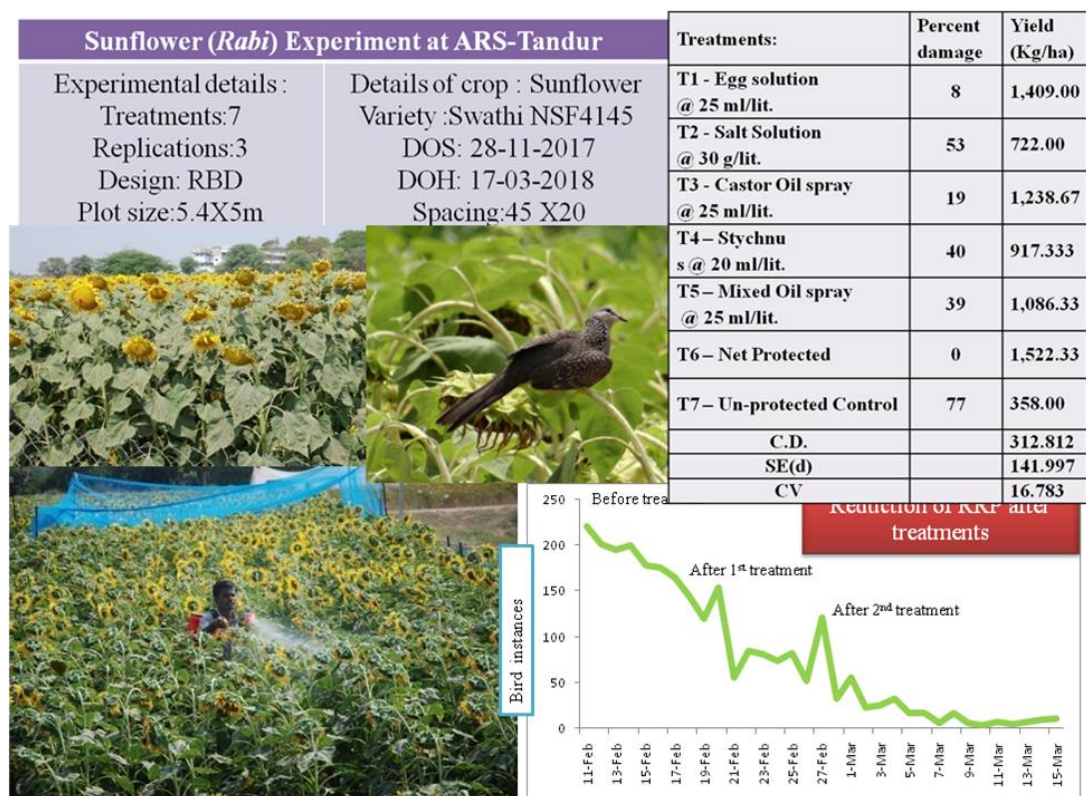


Table 12. Demonstration of Mechanical devices to reduce bird damage in Sorghum and Bajra at ARS- Tandur during *Rabi*

	Rabi Sorghum	% damage	Yield Kg/ha
	T1: Acoustic sounds	3	2960
	T2: Expeller	11	2637.5
	T3: Control	33	1987.5

	Bajra	% damage	Yield (Kg/ha)
	T1: Acoustic sounds	5	847
	T2: Expeller	27	622
	T3: Control	56	377

BM 4. Exploitation of beneficial birds in suppression of insect pests

(a) Vegetable crop; (b) Sunflower

During the period 2017-19 Sunflower crop was raised at AINPVPM office premises. Hairy caterpillar, Tobacco caterpillar and semi looper pests were observed. Pest density data was taken alternate day and also recorded the bird activity in relation to larval density. Bird species composition was also recorded. Treatments were given when the pest has reached ETLs, pest density and bird density was recorded before and after treatments. In suppression of insect pest on Sunflower, among the treatments combination of NPV and Bird perches reduce the *spodoptera* population followed by NPV and Azadirachtin @1500ppm. But in case of semilooper and Hairy caterpillar population reduced in Azadirachtin @1500ppm treated plot followed by NPV and Bird perches. The insect population was reduced and ranges from 25-30%. The per cent utilization of T perches by Black Drongo, Ashy prinia, Indian robin and Pied bush chat were high ranging between 36-71% (Table 13).

Table 13. Role of beneficial birds in suppression of insect pests in Sunflower

Treatment	Tobacco caterpillar		Semilooper		Hairy caterpillar	
	BT	AT	BT	AT	BT	AT
	5.7	7.265	7.183	9.083	7.498	8.383
	6.033	4.317	7.6	3.083	7.605	3.267
	6.217	2.9	7.633	8.317	7.75	8.317
	6.283	1.767	7.25	3.717	7.417	3.933
	6.333	1.233	7.315	1.233	7.833	2.033
	6.4	7.233	7.367	9.017	7.467	8.198
CD	N/A	0.541	N/A	0.52	N/A	0.661
SD	0.346	0.24	0.441	0.231	0.387	0.293
CV	6.877	7.127	7.31	4.919	6.233	6.303

BM 5. Identification of Fruiting/ flowering trees to attract insectivorous/ omnivorous birds to the agricultural landscape

For evaluation of fruiting/flower trees which attract insectivores/omnivorous birds to agriculture habitat, studies were conducted at tribal areas of Goleti, Kothagudem, areas of Adilabad Bejjur and Achampet of Mahabubnagar, Miryalaguda of Nalgonda and Eturunagaram of Bhupalapally districts during the period 2017-19. A total of 21 tree species were identified based on the their attractive tools (flower), of which *Bombax ceiba* (Adavi burugu) stands first in attracting 16 bird species in peak hours followed by *Butea monosperma* (14) and *Gliricidia sepium* (11). *Syzygium cumini*, *Melia azedarach* L. *Madhuca indica* these three species attracting 10m species of birds (Table 14).

Total 16 species of the plants were identified in frugivorus category. Among the species *Pithecellobium dulce*, *Phoenix sylvestris* and *Ficus racemosa* are attracting highest number of birds 16,14 and 13 respectively (Table 15). Rose ringed parakeet stands high with occurrence of 34 on *Ficus religiosa*, *Butea monosperma* (22) and *Pithecellobium dulce* (21). Least number of rose ringed parakeet observed on *Ficus racemosa* and *Ceiba pentandra* (Fig. 3). Phenological events of different trees indicated utilization of birds throughout the year either for flower or fruit trees (Fig.4). It is also observed that the red flowers are highly preferred by the birds when compared to other colours (Fig.5).

Table.14 Important Flower Bearing Trees & Utilization pattern by birds

S.No.	Scientific name	Telugu Name	Phenology	No. of Sp.	Count	Mean
1	<i>Bombax cieba</i>	Adavi Bhuruga	March - April	16	221	11.2
2	<i>Butea monosperma</i>	Moduga	Feb-March	14	141	9.2
3	<i>Gliricidia sepium</i>	Seema ganuga	Jan-March	11	132	8.1
4	<i>Pongamia pinnata</i>	Adavi Ganuga	April - June	8	110	6.5
5	<i>Syzygium cumini</i>	Neredu	April-May	10	98	5.8
6	<i>Delonix regia</i>	Gulmohar	April-Jun	9	95	5.6
7	<i>Senna siamea</i>	Chettu Tangedu	year	8	91	5.4
8	<i>Bauhinia variegata</i>	Deva kanchanam	Aug-Oct	7	88	5.2
9	<i>Cassia fistula</i>	Rela	March - April	8	85	5.0
10	<i>Erythrina suberosa Roxb.</i>	Mulla moduga	March-July	8	85	5.0
11	<i>Sterculia foetida</i>	Adavi badam	March-Aug	7	85	5.0
12	<i>Melia azedarach L.</i>	Turakavepa	March-July	10	85	5.00
13	<i>Wrightia tinctoria</i>	Akupala	Feb-Jun	9	82	4.8
14	<i>Jacaranda mimosaefolia</i>	Agnipoolu	April-Oct	9	76	4.5
15	<i>Albazia saman</i>	Nidra ganneru	Feb-March & Sep.-Oct.	7	72	4.2
16	<i>Couroupita guianensis</i>	Nagamalli	April-Oct	9	67	3.9
17	<i>Spathodea campanulata</i>	Yerra neru budda	July-Sep	9	78	3.9
18	<i>Madhuca indica</i>	Ippa	Feb-Jun	10	61	3.6
19	<i>Adansonia digitata</i>	Bobool	April-Oct	6	58	3.4
20	<i>Careya arborea</i>	Budadharmi	March-Aug	7	54	3.2
21	<i>Millingtonia hortensis</i>	Kada malli	April-May & Oct.- Nov.	9	52	2.1

Table.15 Important Fruit Bearing Trees & Utilization pattern by birds

S.No.	Scientific name	Telugu Name	Phenology	No. of Birds	Count	Mean
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1	<i>Pithecellobium dulce</i>	Sima chintha	March-Sep	16	421	26.06
2	<i>Phoenix sylvestris</i>	Eetha	Dec.-April	14	366	25.88
3	<i>Ficus racemosa</i>	Medi	Feb-April, Sep-Nov	13	378	22.75
4	<i>Cordia dichotoma</i>	Nakkera	Jun.-Jan	11	225	11.06
5	<i>Ficus benghalensis</i>	Marri	Dec.-March	7	221	13.81
6	<i>Muntingia calabura</i>	Nakkaraegu	Dec-Jan	9	214	13.38
7	<i>Buchanania cochinchinensis</i>	Chinnamori	Dec.-April	9	198	12.38
8	<i>Cordia dichotoma</i>	Nakkera	Nov.-Jan	8	185	11.56
9	<i>Tamarindus indica</i>	Chintha	Feb.-April	9	184	11.50
10	<i>Morinda pubescens</i>	Thogari	May-Oct	8	165	10.31
11	<i>Ficus religiosa</i>	Ravi	May-June	7	157	9.81
12	<i>Salvadora persica</i>	Chekkera chettu	Nov-April	6	145	9.06
13	<i>Annona squamosa</i>	Seethapalam	April-Nov	8	143	8.94
14	<i>Grewia flavescens</i>	Jana	Jun-May	9	127	7.94
15	<i>Zizyphus oenoplia</i>	Parigi	July.Sep.	5	121	7.56
16	<i>Zizyphus mauritiana</i>	Regu	Aug-Jan	8	98	6.13

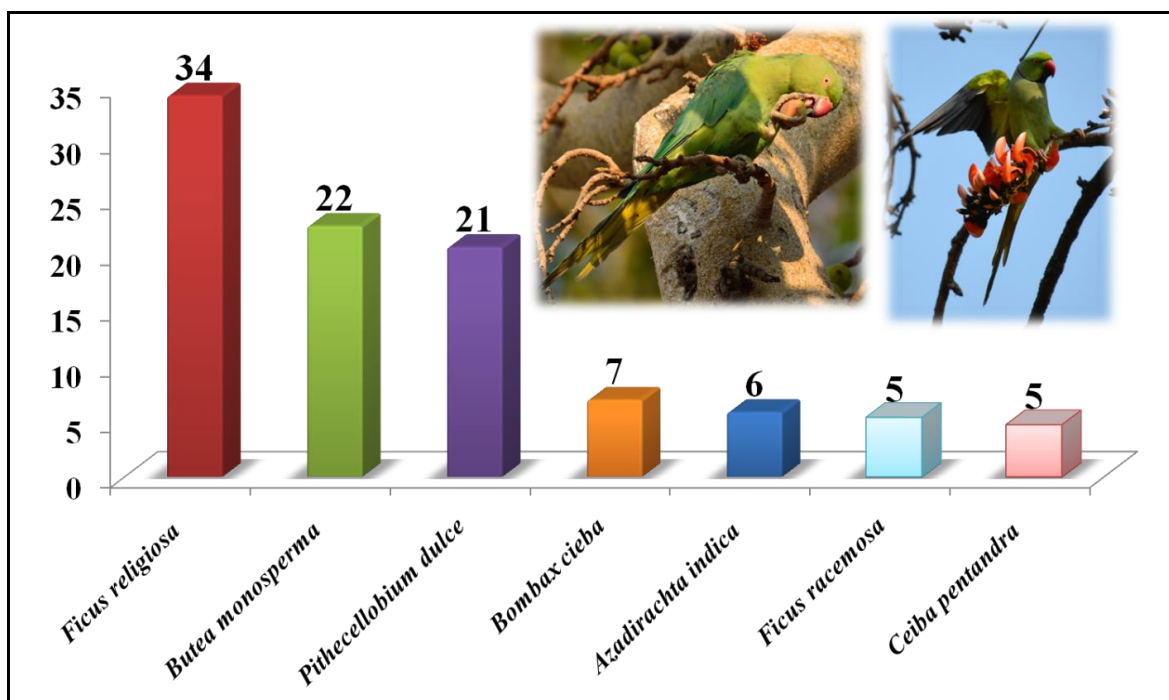


Fig.3 List of trees preferred by Rose ringed parakeet with count

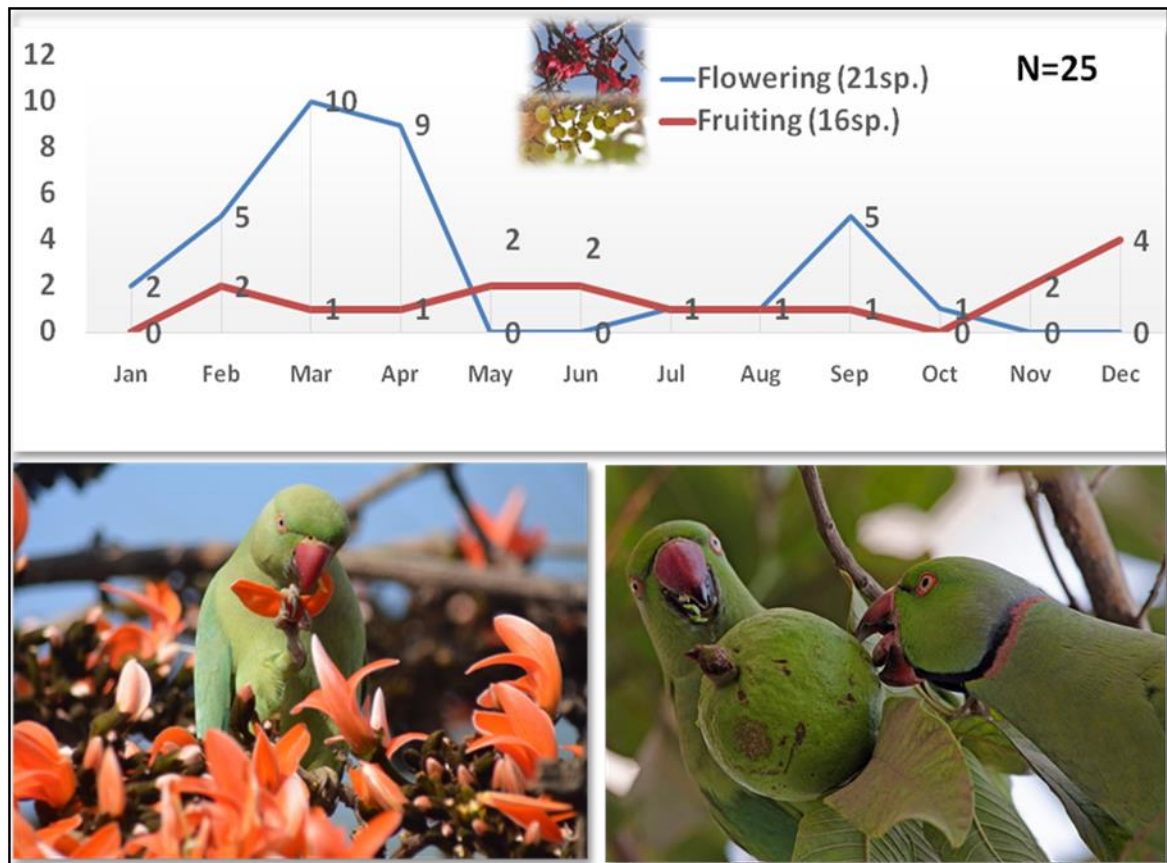


Fig.4 Phenological events recorded during the study period

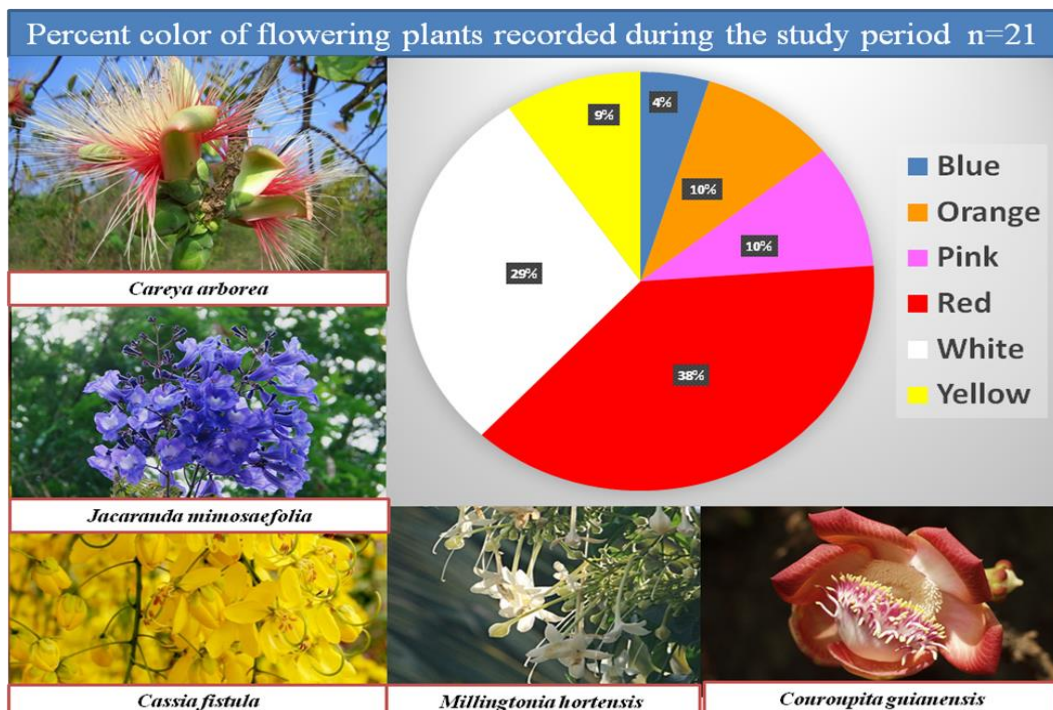


Fig.5 Percent color of flowering plants recorded during the study period

BM. 6. Farmers' participatory research on bird management.

II. Location specific programmes.

a). Fruit bat damage pattern in horticultural crops and development of management methods: During the period 2017-19 a total of in 8 Mandals of Rangareddy and Mahabubnagar districts were surveyed and recorded 3 species of fruit bats with a population of 6840. Among the species Indian flying fox (5827) recorded maximum number, followed by Fulvous fruit bat (485) and Greater short nosed fruit bat (446).

Table 16: Population details of three species of fruit bats in R.R. district

Name of the locations	Indian Flying Fox (<i>Pteropus giganteus</i>)	Fulvous Fruit bat (<i>Rousettus leschenaulti</i>)	Greater Short-nosed Fruit Bat (<i>Cynopterus sphinx</i>)	Total Location
Hayathnagar	731	95	77	903
Manchal	712	110	41	863
Yacharam	961	22	0	983
Vikarabad	371	27	56	454
Dharur	457	23	59	539
Navabpet	891	76	73	1040
Doma	1403	57	70	1530
Gandeed	301	75	67	443
Total	5827	485	446	6840

15 important trees were identified as preferred roosts for the three species of bats (Fig.6).

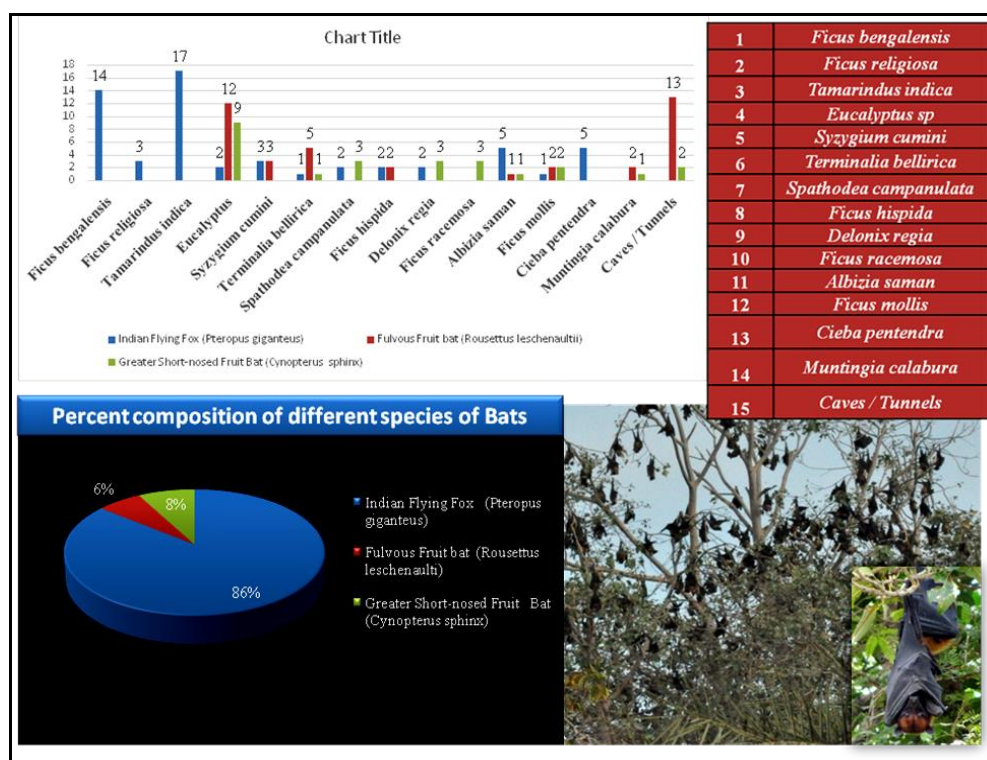


Fig. 6. Important roosting trees preferred by three species of fruit bats

Extent of area under horticultural crops in STZ consisting of 58341 ha. Out of this Mango area is predominant covering 30590ha followed by sweet orange 24366 ha (Table.17). The roosting sites are observed with in the 5 -10 km radius in relation to orchards (Fig.7). The extent of damage in fruit orchards ranges between 5-20% (Fig.8). Among the crops guava was recorded an

average of 219.3 damage per plant followed by Mango 143.8 and sweet orange 66.7 per plant (Table.18)

Table.17 & Fig.7 Extent of area under horticultural crops in STZ and distribution of roosting sites of bats in relation to crops

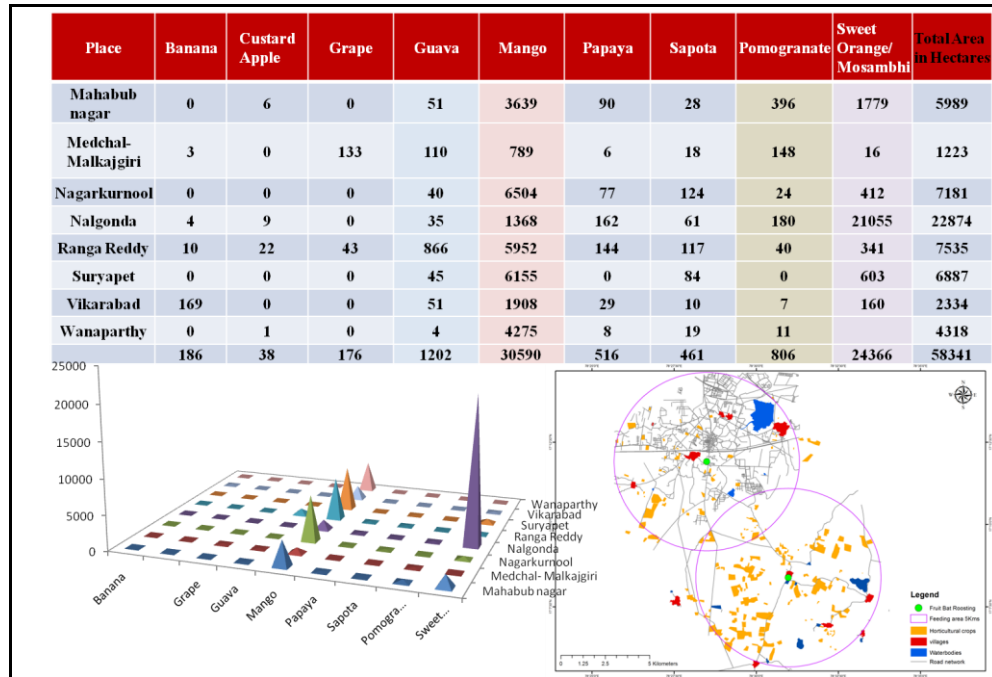
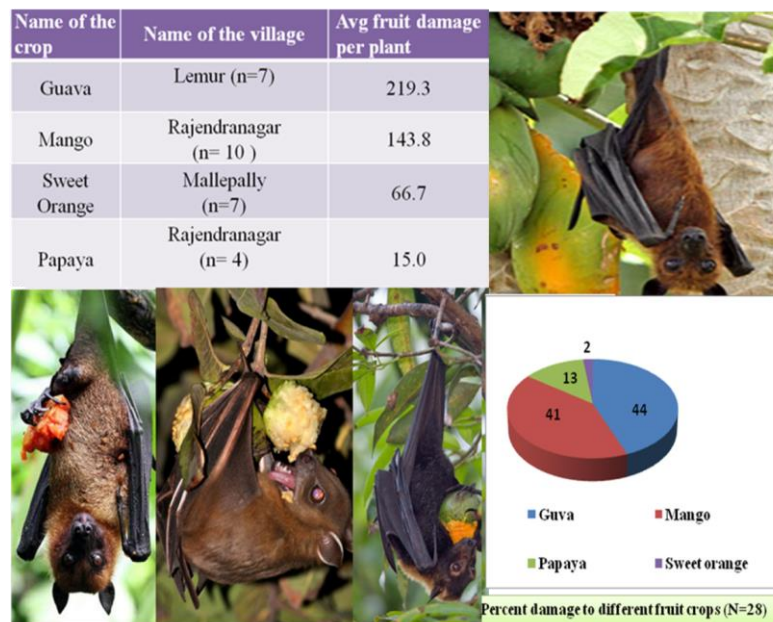


Table.18 & Fig.8 Extent and percent damage by fruit bats in different fruit crops



b). Ecology and management of Indian squirrel in agricultural crops: Population of Indian palm squirrel was estimated in maize, paddy, vegetable garden and grape garden. Among the crops, highest number of squirrels were found in grape garden (20/acre) followed by maize (18/acre) and vegetable garden (18/acre). Least population was recorded in paddy field (8/acre) (Fig 9). The following food materials were consumed by Indian palm squirrel viz., insects (21%), seeds (18%), leaves (16%), fruits (11%), flower buds (11%), flowers (9%), bark (8%) and pith (6%) (Fig 10). In

maize at sprouting stage recorded squirrel damage as 80-93%. In case of sunflower at sprouting stage causes 59-69% damage (Table 19).

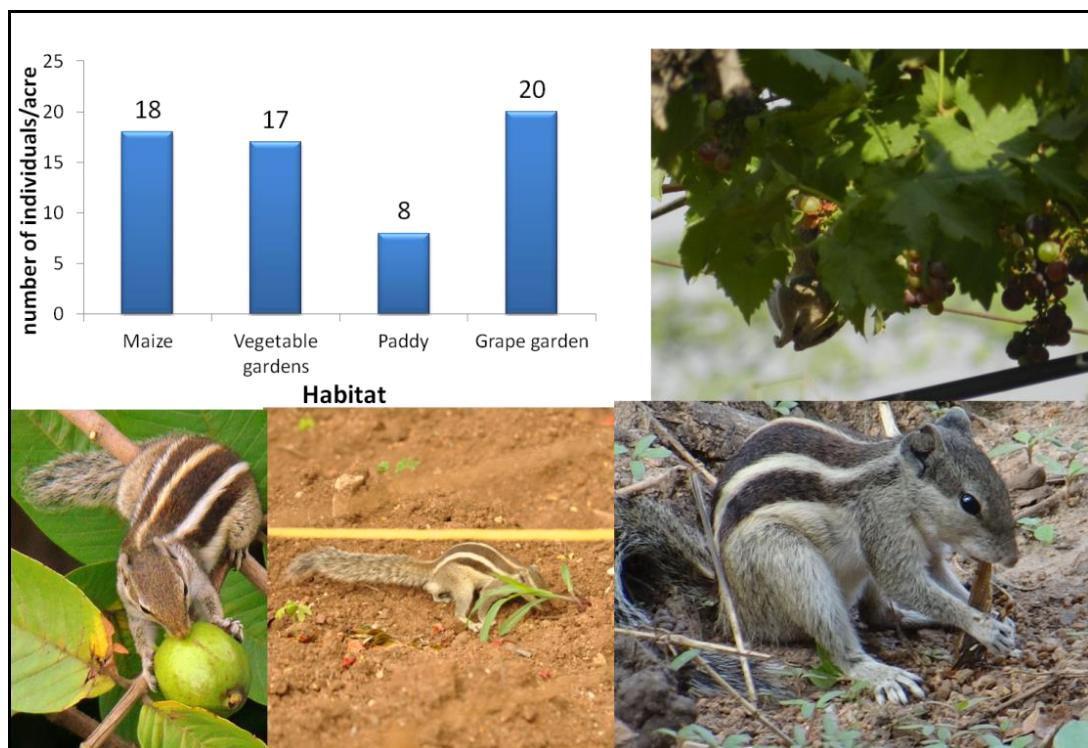


Fig. 9. Crop wise population details of Indian Palm Squirrel

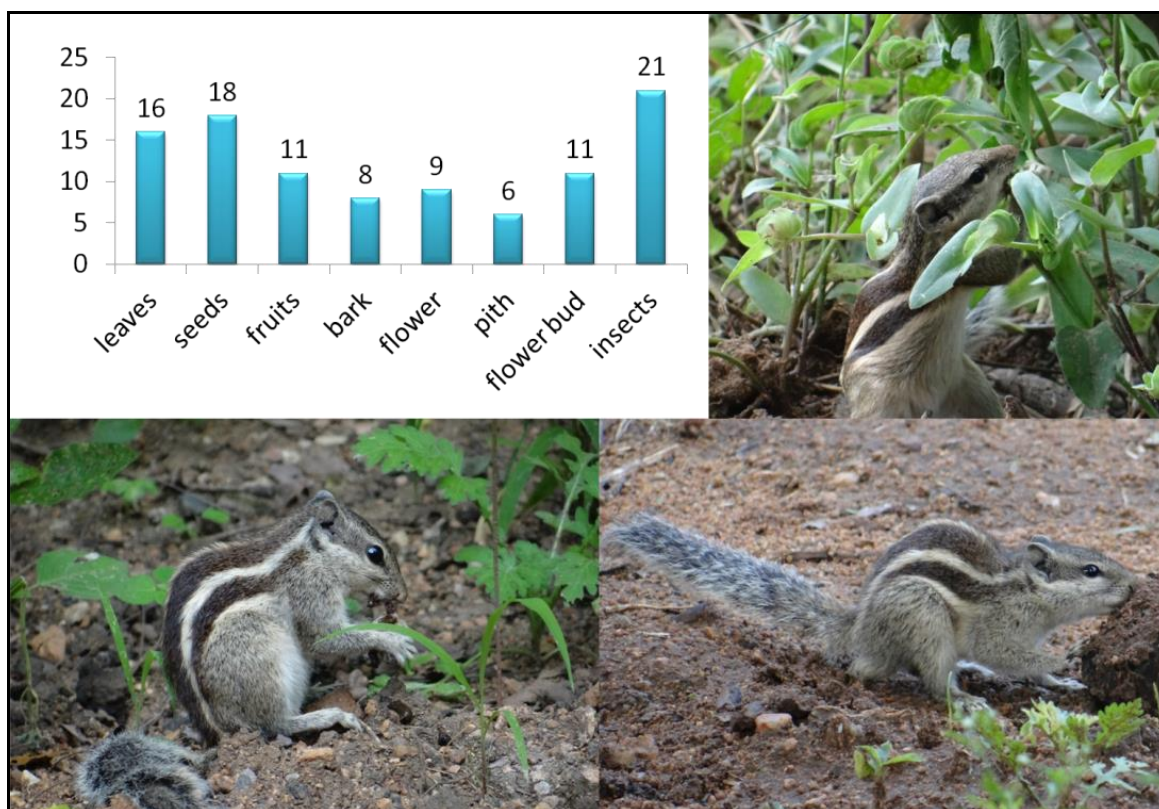


Fig. 10. Type of food material consumed by Three Striped Palm Squirrel

Table 19. Squirrel damage Per cent in Maize and Sunflower crops at Sowing stage

	Maize (DHM-117)		Sunflower (DRSH-1)	
	No. of plants damaged	Damage %	No. of plants damaged	Damage %
Plot 1	233/288	80	234/360	65
Plot 2	248/288	86	214/360	59
Plot 3	233/288	81	231/360	64
Plot 4	214/288	74	243/360	68
Plot 5	269/288	93	249/360	69



c). Bio-diversity in agricultural landscape with relevance to conservation: During *Kharif* intensive surveys were under taken at STZ ,NTZ and CTZ recorded bio diversity in crops like paddy, cotton, maize, sorghum ground nut and pulses. Salient findings are briefed as under

- Total 364 floral species belonging to 231 genera of 86 families were recorded in all six crops (Fig.11).
- Of these 364 sps, 211 sps are indigenous and 134 sps are wild sps (Fig.8).
- In all the crops, the life forms i.e., Trees, shrubs, and herbs varied significantly in relation to different crops. The Trees, shrubs, and herbs were recorded highest in paddy (131 sps) followed by Maize (76 sps), Sunflower (64 sps), Sorghum (58 sps), Cotton (56 sps) and groundnut (42 sps) (Fig.11).
- The diversity indices floral component was showed high at NTZ (1.72) with species richness 245 while in STZ the species diversity was 1.43 with 285 species. Among the native exotic plant distribution indigenous wild represented with 181 species followed by exotic wild with 96 species (**Table.20**).
- The faunal composition showed high occurrence of Aves followed by Invertebrates, Herpetofauna and Mammals. The species composition in relation to crops are showed high in Paddy (220), followed by Cotton (143), Maize(127), Sorghum (127), Groundnut (100) and Sunflower (100) (Table.21).
- Highest faunal composition was observed in STZ with 196 species followed by CTZ (168) and NTZ (160).

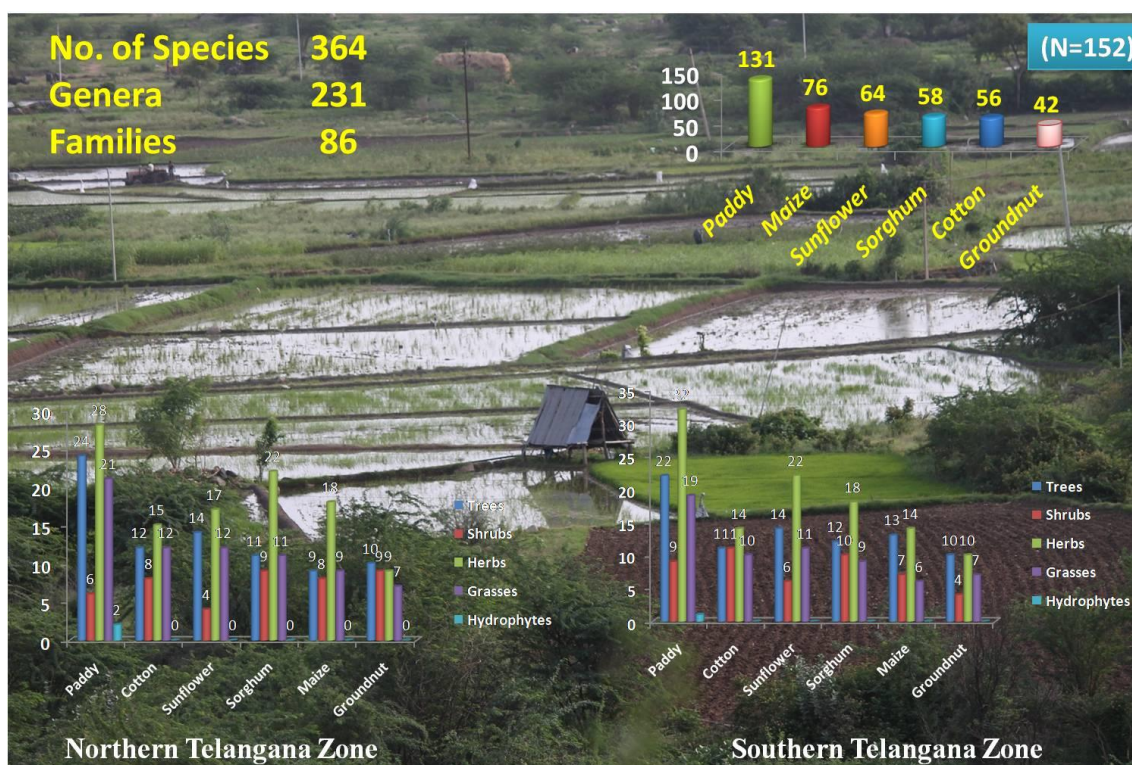


Fig.11. Zone wise floral composition in different crops

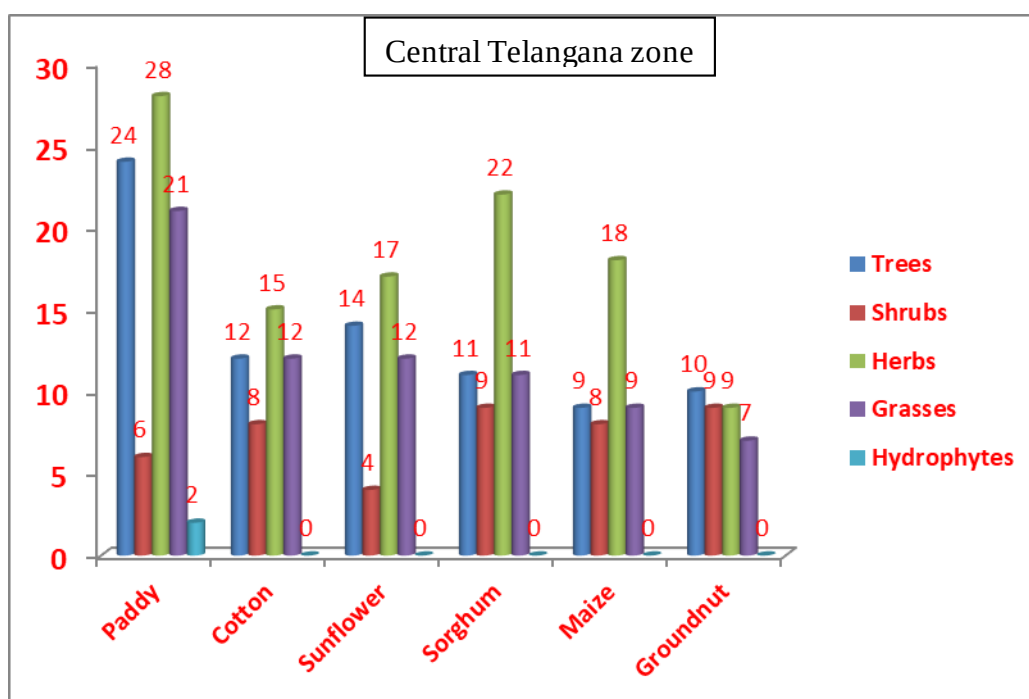


Table.20. Diversity indices of floral components and distribution of native & exotic plant species during study period

Study area	Shannons	Simpsons	Species richness
NTZ	1.72	0.98	245
STZ	1.47	0.97	287
CTZ	1.74	0.98	246

Table.20 a. Native and exotic plant distribution

Type	Trees	Shrubs	Herbs	Species richness	Indigenous/ Exotic
Indigenous wild	25	20	136	181	211
Indigenous/Planted	22	7	1	30	
Exotic/wild	3	14	79	96	134
Exotic/Planted	29	7	2	38	

Table.21 Zone wise faunal composition & species richness in different crops

Crop	NTZ	STZ	CTZ
Paddy	160	196	168
Cotton	108	139	73
Sunflower	85	85	112
Sorghum	0	106	105
Maize	108	116	112
Ground nut	0	77	81
Pulses	0	0	0

Table.21 b. Faunal composition & species richness in different crops

Taxa	Paddy	Maize	Cotton	Sorghum	Sunflower	Ground nut
Mammals	10	7	8	5	2	8
Aves	120	59	72	56	45	51
Herpeto	18	10	12	7	8	10
Invertebrates	72	51	51	59	45	31
Total	220	127	143	127	100	100

(C) Higher vertebrates**1. Integrated Management of Wild boar (*Sus scrofa*) in different agricultural crops at STZ**

Demonstrated integrated management methods to control wild boar in maize with the following modules.

- **Single tire:** 1) **T1** Physical barrier – circular blade wire, **T2**) Biofence using castor **T3**) HDPE Fishnets **T4**) Treated coconut coir with pig oil /sulphur and **T5**) Bioacoustics
- **Two Tier:** 1) **T6** (Biofence + human hair), 2) **T7** (Fishnet + Treated coconut coir with pig oil /sulphur) and 3) **T8** (Biofence + Acoustic system).
- **Three Tier:** 1) **T9** (Biofence + Treated coconut coir (pig oil /sulphur) + human hair) and 2) **T10** (Fishnet + Treated coconut coir (pig oil /sulphur) + Bioacoustics).

Pretreatment damage to the extent of 30% was recorded in maize crop. Among all the modules the extent of post treatment damage in bioacoustic plot showed 100% check in entry of wild boars. The other modules i.e., Circular razor wire fence, Fishnet with coconut coir & bio fence with coconut coir were showed promising results to the extent of 2-4% damage when compared to control (80%). Castor crop as border crop yielded 214 to 265 Kg/Ac (Table.22).

Table. 22 Pre and post damage pattern by wild boar during *Kharif* at D Dharmaram

Treatment	Farmer Name	Pre treatment damage	Post treatment damage	Yield kg/acre	Yield from Biofence kg/acre
T1(Physical barrier – circular blade wire)	Vudutha Naresh	9.4	0	1176	-
T2(Biofence using castor)	Srikanth reddy	0	3.4	593.75	244.4
T3(HDPE Fishnets)	Vudutha Naresh	11	2.8	1083	-
T4(Treated coconut coir with pig oil /sulphur)	Vudutha Naresh	17	3.4	869	-
T5Bioacoustics	N. Dasaratham	30	0	884	-
T6 (Biofence + human hair)	Srikanth reddy	0	2.4	718.75	257.72
T7 (Fishnet + Treated coconut coir with pig oil /sulphur)	Vudutha Naresh	9.1	0	969	-
T8 (Biofence + Acoustic system)	B. Mallesham	0	0	1167	214.35
T9 (Biofence + Treated coconut coir (pig oil /sulphur) + human hair)	Srikanth reddy	0	1.6	745.4	265.2
T10(Fishnet + Treated coconut coir (pig oil /sulphur) + Bioacoustics)	N. Mahesh	7	0	1428	-
T11(Control)	A. Balamani	20	80	180	-

During Rabi season, implemented different treatments in Maize and Sunflower crops before damage caused by wild boar. Among all the tested modules, bioacoustic treated plot showed 100% control in entry of wild boar. The other modules, Circular razor wire fence, Fishnet with coconut coir & bio fence with coconut coir were showed promising results to the extent of 2-4% damage when compared to control (80%). Castor crop as border crop yielded additionally 180 to 203 Kg/Ac (Table.23).

Table.23 Pre and post damage pattern by wild boar during *Rabi* at D Dharmaram

Treatment	Farmer Name	Crop	Pre treatment damage	Post treatment damage	Yield kg/acre	Yield from Biofence
T1(Physical barrier – circular blade wire)	Golla Yadagiri	Maize	0	0	2100.6	-
T2(Biofence using castor)	B. Mallesham	Sunflower	0	1.3	437.5	180.3
T3(HDPE Fishnets)	Golla Yadagiri	Maize	0	0	2125.11	-
T4(Treated coconut coir with pig oil /sulphur)	Golla Yadagiri	Maize	0	2.8	2111.0	-
T5 Bioacoustics	Vudutha Naresh	Sunflower	0	0	584.32	-
T6 (Biofence + human hair)	B. Mallesham	Sunflower	0	0	466.7	195.5
T7 (Fishnet + Treated coconut coir with pig oil /sulphur)	Golla Yadagiri	Maize	0	0	2166.5	-
T8 (Biofence + Acoustic system)	Dom mata Ramaiah	Sunflower	0	0	582.17	167.2
T9 (Biofence + Treated coconut coir (pig oil /sulphur) + human hair)	B. Mallesham	Sunflower	0	0	450.34	203.4
T10 (Fishnet + Treated coconut coir (pig oil /sulphur) + Bioacoustics)	Vudutha Naresh	Sunflower	0	0	613.0	-
T11(Control 1)	Masaipet swamy	Maize	18	53	976.0	-
T11(Control 2)	B. Mallesham	Sunflower	4	21	327	-

2. Population estimation and development of management strategies to reduce Rhesus macaque (*Macaca mulatta*) crop damage in different districts of Telangana.

Population surveys and behavioral activities on Rhesus macaque (*Macaca mulatta*) were conducted in different districts of Central Telangana Zone. A total of 9935 individuals of Rhesus macaque were recorded in 204 troops from five districts of CTZ where, highest number of individuals (4513) were recorded from Khammam district, followed by Medak (3521), Warangal (1350), Sangareddy(308) and Siddipet (243) (Table.24). Among the 9935 individuals recorded, the highest number of individuals were recorded from the category adult females (3090), followed by juveniles (2338), sub adult females (1829), infants (978), adult males (864) and sub adult males (836). The troop size varied from 2-232 individuals (Table.25).

Male, Female sex ratio is between 2 – 3 females for a single male, which is the normal population trend. Since it is in normal condition *R. Macaque* population is constantly increasing in agricultural fields due to availability of nutritious food. The percent damage caused by monkeys in various agricultural crops showed highest damage in Maize (40.4%) followed by Cotton (34.6%), Paddy (26.8%), Sorghum (24.3), Groundnut (22.6%), Tomato (19.5%), Brinjal (17.4%), Ridge gourd (14.8%), Water melon (13.7%) and Bitter gourd (7.9%)(Table.26). The peak feeding observations of monkeys were noticed between morning (6.00 to 10.00 hrs) and evening hours (16.00 to 18.00 hrs) (Fig.12&13).

Table.24 Rhesus macaque (*Macaca mulatta*) population, Mean group size and number of troops in different districts

District	Mean troop Size	Total population	No. of troops	Range
Khammam	47.05 ± 3.80	4513	94	2-211
Medak	42.15 ± 4.03	3521	66	2-232
Siddipet	29.10 ± 3.78	243	8	3-82
Sangareddy	19.10 ± 3.16	308	10	3-65
Warangal	28.01 ± 3.04	1350	26	1-157
Overall	32.28 ± 3.56	9935	204	1-232



Table.25 Social structure of Rhesus macaque in different districts

District	Adult Male	Adult Female	Sub Adult Male	Sub Adult Female	Juvenile	Infant	Total
Khammam	408	1417	367	814	1083	424	4513
Medak	300	1087	308	621	847	358	3521
Sangareddy	26	77	16	54	47	23	243
Siddipet	32	98	20	64	63	31	308
Warangal	98	411	125	276	298	142	1350
Grand Total	864	3090	836	1829	2338	978	9935



Male, Female sex ratio is between 3 – 4 females for a single male, which is the normal population trend. Since it is in normal condition *R. Macaque* population is constantly increasing in agricultural fields due to nutritious food

Table 26. Extent of damage (%) caused by Rhesus macaque in different crops

S. No	Crops	% Damage
1	Maize (n=42)	40.4
2	Cotton (n=38)	34.6
3	Paddy (n=40)	26.8
4	Sorghum (n=15)	24.3
5	Groundnut (n=25)	22.6
6	Tomato (n=20)	19.5
7	Brinjal (n=14)	17.4

8	Ridge guard (n=18)	14.8
9	Watermelon (n=5)	13.7
10	Bitter guard (n=8)	7.9

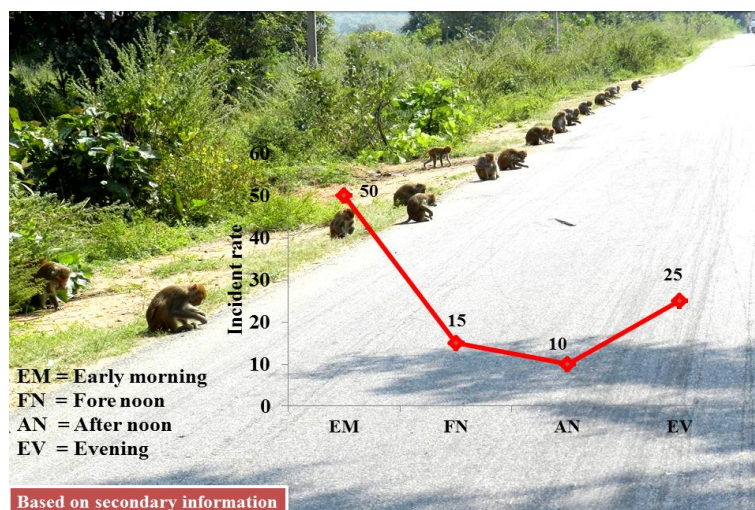


Fig.12 Incidence of crop-raiding in different times of the day

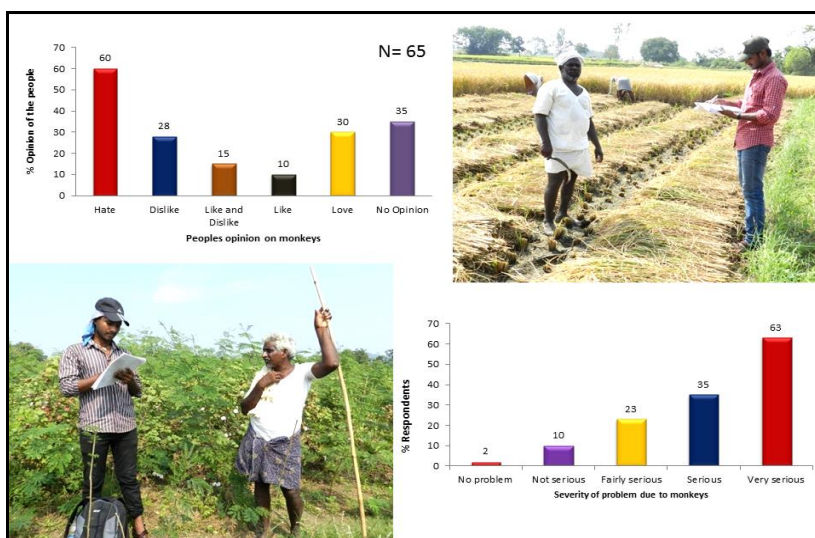


Fig.13 People's perception towards monkeys and its damage

Tribal Sub – Plan Activities (2017-19)

Keeping in view of the severity of wild boar damage in different crops considered as main criteria to use Bio acoustic device for reducing the extent of damage by wild boars and Monkeys in the selected tribal villages at 5 districts of Telangana consisting of --- villages --- beneficiaries. The districts selected having more than 40% of ST population, economically very poor, low yields in agriculture, having very less knowledge in controlling wild boar and Monkey issues. This information was gathered in collaboration with DAATTC centers located in the above districts.

The locations were surveyed and identified the impact of wild boar damage on different crops. Interacted with the farmers by conducting meetings and gathered their view points with respect to wild boar issues. During the interactions it is clearly evident that the tribal farmers do not have any knowledge about the population of Birds, wild boar, rodents and Monkeys, sex ratio, habitat preference, food habits, seasonal behavior and extent of damage in different growth stages

of the crop. The only attitude they have to kill and eradicate wild boars and Monkeys from the region.

Training were given how to install and operation procedures of the bio acoustic gadget, HDPE Nylon net, Ribbons, Wonder traps and Agri canon during vulnerable stages of the crops (Maize, Sorghum, Soybean, Paddy and other vegetables) and also distributed pamphlets in local languages.

The activities undertaken by PJTSAU center under TSP are briefed as under;

The activities undertaken by PFTB/IC center under PFT are entered as under,					
SN	Budget allocated	Expenditure	Details of out put	Target/ beneficiaries	Achievements
2017-18					
1	Rs 4.0 lakhs	Rs 4.0 lakhs	1) Bio acoustic units (24) to reduce wild boar damage in tribal areas of Telangana.	24 units (Farmers benefitted 24)	100%
2			6 trainings on bird & wild boar management in crops	(Farmers benefitted : 246)	100%
2018-19					
	Rs 6.39 lakhs	Rs 6.39 lakhs	1) Bio acoustics to reduce wild boar damage in tribal areas of Telangana.	5 units (Farmers benefitted: 5)	100%
			2) Nine trainings on bird & wild boar management in crops	Nine (Farmers benefitted: 630)	100%
			3)Agri canon to reduce monkey menace in agricultural crops	Farmers benefitted: 45	100%
			4)HDPE nylon net to control wild boar problem in agricultural landscape	Farmers benefitted: 45	100%
			5) Bird scaring ribbons	Farmers benefitted: 25	100%
			6)Wonder traps for rodent management	Farmers benefitted: 30	100%

Impact of the programme: In general the net annual incomes of TSP farmers in the above areas are very meager and ranging approximately between Rs.20, 000-25,000 per year. Apart from the pest diseases the TSP farmers are encountered severe problem of Birds, wild boar, rodents and monkeys in the region. This results very low yields of the crops and sometimes farmers are not interested in raising the crops.

By using Bio acoustic gadget, HDPE Nylon net, Ribbons, Wonder traps and Agri canon there is a 20-30% increase in yield of different crops (Maize, Sorghum, Paddy and other vegetables). The income generated by TSP farmers after using the Bio acoustics, HDPE Nylon net Ribbons, Wonder traps and Agri canon was satisfactory and they are very happy to continue to use the equipment in future. The feedback from farmers indicated that the equipment protected the crop

fields completely leading to reduction in the crop damage by wild boar and Increased yields. They were ready to use and spread the utility of the equipment to other farmers.

	
Interactive meetings and field visit with TSP farmers in Mahaboobnagar district	Demonstration of Bioacoustic gadget at TSP farmer field at Lingapur of Kumarambheem district.
	
HDPE Nylon net for reducing Wild boar menace	Farmer using Agri Canon to scare the monkeys

EXTENSION ACTIVITIES

(a) Radio / TV Programmes

S.N.	Name of the Faculty	Title of the Programme	TV/ Radio	Date
1	Dr. V. Vasudeva Rao	Vertebrate Pest Management	DD Saptagiri	20.02.2019
2	Dr. V. Sunitha	Adavi pandulu mariyu pakshulu nundi pantala yajamanyam	T-SAT	18.02.2019
3	Dr. V. Sunitha	Adavi pandulu mariyu pakshulu nundi pantala yajamanyam	All India Radio	28.02.2019
4	Dr. V. Sunitha	Adavi pandulu mariyu kothula nundi pantala yajamanyam	ETV, Jaikisan	18.03.2019
5	Dr. V. Sunitha	Adavi pandulu mariyu kothula nundi pantala yajamanyam	ETV, Jaikisan	21.03.2019
6	Dr. V. Sunitha	Management of Monkeys with monkey scaring gun	Rythu nestham You tube channel	28.05.2019
7	Dr. V. Sunitha	Management of wild boars with Bioacoustics	Rythu nestham You tube	31.05.2019

			channel	
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(b) Guest Lectures delivered

S N	Name of Faculty	Topic	Date	Venue
1	Dr. V. Vasudeva Rao	GAP for management of vertebrate pests	25.10.2018	NIPHM, Hyderabad
2	Dr. V. Vasudeva Rao	Bird Pest Management for SOP preparation	24.11.2018	MANAGE, Hyderabad
	Dr. V. Vasudeva Rao	Refresher training on “On-farm production of bio-control agents and Microbial bio-pesticides	28.11.2018	
3	Dr. V. Vasudeva Rao	Refresher training on “Major Bird Pest species and their management in urban environs”	17.12.2018	NIPHM, Hyderabad
4	Dr. V. Vasudeva Rao	Stored Grain Pest Management Birds Management in Godowns	21.01.2019 & 25.01.2019	NIPHM, Hyderabad
5	Dr. V. Sunitha	Wild boar and Monkey management at Srirampur village Karimnagar Dist.(for farmers)	16.03.2019	Srirampur vill. Karimnagar Dist.
6	Dr. V. Sunitha	Birds and wild boar management in Maize crop (for farmers) under SC Sub plan	29.03.2019	MRC, ARI, Rajendranagar
7	Dr. V. Sunitha	Birds and wild boar management in Maize crop (for farmers) under SC Sub plan	30.03.2019	MRC, ARI, Rajendranagar
8	Dr. V. Vasudeva Rao	GAP for management of vertebrate pests	07.02.2019	NIPHM, Hyderabad
9	Dr. V. Sunitha	Lecture on wild boar management to farmers during Kisan mela organized by ATMA and Department of Agriculture	16.02.2019	CRIDA, Hyderabad
10	Dr. V. Vasudeva Rao.	Addressed the farmers on wild boar and Monkey management (Kisan mela organized by ATMA and Deptt. of Agriculture	23.02.2019	Siddipeta
11	Dr. V. Sunitha	Addressed the farmers on wild boar and Monkey management (Kisan mela organized by ATMA and Department of Agriculture	28.02.2019	Ramagiri killa
12	Dr. V. Vasudeva Rao	Participated and displayed AINPVPM technologies Internl. Biodiversity Day	22.05.2019	Nampally
13	Dr. V. Vasudeva Rao & Dr. V. Sunitha	Seed Mela	24.05.2019	Hyderabad

(c) Other Events

- Attended Krishi Unnathi mela at New Delhi from 19.03.2016 to 20.03.2016 and displayed usable technologies of AINP on VPM
- Prepared action plan for Rajasthan and Gujarat states from 30.11.2016 to 2.11.2016
- Attended National Equipment Policy Workshop ASPIRE, DST from 09.02.2017 to 10.02.2017

- Attended Directors VC conference at New Delhi from 14.02.2017 to 15.02.2017.
- An action plan for management of wild animal entry into the agricultural crops of Rajasthan and Gujarat States, India.
- Submitted provisional patent bearing number TEMP/E-1/16937/2016-CHE Dated 04-06-2016

Seminars / Workshops / Meetings/ Training programmes attended

S. N.	Name of the Faculty	Place	Duration	Purpose
1	Dr.V. Sunitha	NIRD, Hyderabad	Nov 13-15, 2018	ToT on Biodiversity Governance
2	Dr.V. Vasudevarao & Dr.V. Sunitha	PJTSAU Hyderabad	Nov 27, 2018	Brain storming session on “Present status of fall army worm and its management strategies in Telangana”
3	Dr.V.Vasudevarao Dr.V. Ravinder Reddy & Dr.V. Sunitha	PJTSAU Hyderabad	Dec 10-12,2018	National symposium on Advances in Entomology
4	Dr.V. Sunitha	PJTSAU, Hyderabad	March 12, 2019	Attended Guest lecture on “Exquisite Galls and Intelligent Insects” by Prof. Raman Ananthanarayanan and “Lessons from Global patterns of Resistance to Bt crops for Managing Pink boll worm in India” by Bruce Tabashnik at College of Agriculture Rajendranagar, Hyderabad
5	Dr.V.Vasudevarao Dr.V.Sunitha	PJTSAU Hyderabad	Jan 19,2019	Microsoft in Agriculture
6	Dr.V.Vasudevarao Dr.V.Ravinder Reddy & Dr.V.Sunitha	PJTSAU Hyderabad	May 15-16, 2019	SLTP
7	Dr.V.Vasudevarao	PJTSAU Hyderabad	May 17, 2019	Subash Palekar Natural farming meeting

Provisional Patents: 2 Nos (Kethi Rakshak, Agri Canon)

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To
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Vampagada Village, Kapra Municipality,
Secunderabad - 500062

Date/Time 2019/10/08 11:03:46

Userid: Sreenivas

CBR Detail:

Sr. No.	Ref. No./Application No.	App. Number	Amount Paid	C.R.R. No.	Form Name	Remarks
1	20194164621	TEMPLE-14307924018-CITE	8000	23817	FORM 1	Integrated IoT based Biosensitic Solution for deterring animals from Agricultural crop fields.

TransactionID	Payment Mode	Customer Identification Number	Amount Paid	Head of A.C.No.
N-6080545222	Online Bank Transfer	60101910003736	8000.00	147901020000001

Total Amount : ₹ 8000
Amount in Words: Rupees Eight Thousand Only
Received from INKOLLU SREENIVAS MURTHY the sum of ₹ 8000 on account of Payment of fee for above mentioned Application/Form.
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500062 Email: sreenivas@ipindia.gov.in

Date/Time 2019/10/08 11:03:46

Sr. No.	Ref. No./Application No.	App. Number	Amount Paid	C.R.R. No.	Form Name	Remarks
1	20194164621	TEMPLE-14307924018-CITE	8000	23817	FORM 1	Integrated IoT based Biosensitic Solution for deterring animals from Agricultural crop fields.

TransactionID	Payment Mode	Customer Identification Number	Amount Paid	Head of A.C.No.
N-6080545222	Online Bank Transfer	60101910003736	8000.00	147901020000001

Total Amount : ₹ 8000
Amount in Words: Rupees Eight Thousand Only
Received from INKOLLU SREENIVAS MURTHY the sum of ₹ 8000 on account of Payment of fee for above mentioned Application/Form.
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Publications

- Sailu, G., Laxmi Narayana, B., Deepak Ramaiyan, Naresh, B, Vasudeva Rao, V., Harikrishna Adepu, Rajeev Khandelwal, Pariksheet Devulapalli and Phani Krishna. 2017. Faunal diversity of Ameenpur Lake, Telangana state, India: A biodiversity heritage site. *Journal of Entomology and Zoology Studies*. 5(1): 512-526.
- Laxmi Narayana, B., Swamy, K., Surender, and V. Vasudeva Rao. 2017. An observation on parenthood of Red-vented Bulbul *Pycnonotus cafer*. *Ambient Science*. DOI: 10.21276/ambi.2017.04.2.nn03. 4(2): 1-2.
- Hanumantha Rao. V , Rao, A.V.L.N, **Vasudeva Rao. V**, Baleeshwar Reddy, A. and Sarala, C. 2017. *Ecology, Environment and Conservation*.23: 26-31.
- Vasudeva Rao V, Naresh B, Tripathi R.S., Sudhakar, C. and Ravinder Reddy, V.2017.Reduction of wild boar (*Sus scrofa*) damage in maize (*Zea mays L.*) by using castor (*Ricinus communis L.*) as barrier. *Journal of Entomology and zoology studies*. 5(6):426-428.

- Naresh, B., Laxmi Narayana, Swamy, K. and Vasudeva Rao, V. 2017. Telangana state's first records of breeding Black-winged and the occurrence of nest predation by feral dogs. *Stilt*. 71:42-44.
- Laxmi Narayana, B., Chethan Kumar, G., Naresh, B. and Vasudevarao, V. 2017. *J. Bombay Nat. Hist. Soc.* Doi:10.17087/jbnhs/2017/v114/109359. 114:8-11.
- Laxmi Narayana, B., Surender, G. and Vasudeva Rao, V. 2017. Diversity, distribution, and conservation status of herpetofauna of the sherpalli-a proposed site for uranium mining project at nalgonda district, Telangana State, India. *International Conference on current challenges in conservation of biodiversity*. 66-67.
- Laxmi Narayana, B. Vasudeva rao, V. and Venkateshwara reddy, V. 2017. Status, distribution and diversity of birds in agricultural landscapes of Peddagattu and Sherpaqlly area: AQ proposed uranium mining sites in Nalgonda District of Telangana State, India. *International Conference on current challenges in conservation of biodiversity*. 51-52.
- Naresh, B. and Vasudeva Rao, V. 2017. Population size and social structure of Rhesus macaque (*Macaca mulatta*) in Telangana State, India *International Conference on current challenges in conservation of biodiversity*. 156-157.
- Hanumantha Rao V, Vasudeva Rao V. and Sarala C. 2017. Potential Tradable Plant Resources of Southern Telangana, India. *3rd International Conference on Environmental Management*. (JNTU Hyderabad) DOI: [10.13140/RG.2.2.22717.77283](https://doi.org/10.13140/RG.2.2.22717.77283).
- Hanumantha Rao V, Vasudeva Rao V. and Sarala C. 2017. Plant Species Composition, Utilization and Conservation of Rock Outcrops in Southern Telangana, India. *Indian Biodiversity Congress- 2017. Pondyichery central University*. Conference: Volume: 4.
- Supriya, G.B., Singh, T.V.K., Sunitha, V., Vinod, S.K and Narendrareddy, C. 2018. Life Table Study of Tobacco Caterpillar *Spodoptera litura* (F.) (Noctuidae: Lepidoptera) on Different Bt Cotton Hybrids During 120-150 DAS (Days after Sowing). *Int.J.Curr.Microbiol.App.Sci*. 7(6): 2367-2386
- Supriya G.B., Singh T.V.K., Sunitha, V and Vinod, S.K. 2018. Age-specific life table, fecundity table, life parameters, stable age distribution and life expectancy of *Spodoptera litura* (F.) on cotton hybrids during 90-120 DAS. *Journal of Entomology and Zoology*. 6(3): 477-486.
- Laxminarayana, B., Vasudevarao, V. and Venkateshwar Reddy, V. 2018. Composition of Birds in Agricultural landscape of Peddagattu and Sherpally Area: A proposed Uranium mining sites in Nalgonda, Telangana, India. *Proceedings of Zoological Society, Kolkata, India*. 72 (4):380-400.
- Hanumantharao, V., Vasudevarao, V., Baleeshwar Reddy, A. and Satyanarayana Raju, V. 2018. The status assessment of *Corynandra viscosa* subsp. *nagarjunakondensis* (Magnoliopsida: Cleomaceae), Endemic to Nagarjunakonda, Andhra Pradesh, India. *Journal of Threatened Taxa*. 1(9):12210-12217.
- Surender, G., Vasudevarao, V., Mahesh, S.S, Tripathi, R.S. and Swamy K. 2018. Unusual Depredatory Birds in Sunflower and Sorghum, Entomology, Ornithology & Herpetology. *Entomology, Ornithology & Herpetology: Current Research*. 7: 2.
- Vasudevarao V, Sunitha, V, Ravinder Reddy, V, Venkateshwarlu, P and Ramalingeswar Rao, A.V.L.N. 2019. Insectivorous birds as bio control agents to control insect pests in Okra. *Entomology 2018: Advances and Challenges Souvenir*. Pp 48-49.
- Venkateshwarlu, P, Vasudevarao V, Sunitha, V, Ravinder Reddy, V and Ramalingeswar Rao, A.V.L.N. 2018. Spotted owl (*Athena brama brama* T) – A potential bio control agent in agricultural landscape. *Entomology 2018: Advances and Challenges Souvenir*. Pp 67-68.
- Supriya, G.B., Singh, T. V. K., Sunitha, V and Vinod., S, K. 2018. Demographic parameters of Tobacco caterpillar *Spodoptera litura* (Fabricius) on Castor (*Ricinus communis*) under Lab conditions. *Research Journal of Agricultural Sciences*. 9 (4). 775-779.
- Supriya, G.B., Singh, T. V. K., Sunitha, V and Vinod., S, K. 2018. Study on food consumption parameters of *Spodoptera litura* (Fab.) (Noctuidae: Lepidoptera) on different Bt cotton hybrid plant parts. *Journal of Entomological Research*. 42 (4): 529-535.

- Teja, N. V Ramesh Babu V Sunitha, V Ramesh Babu and Satyanarayana, J.2018. Effect of variable temperature on the toxicity of novel insecticides against diamondback moth, *Plutella xylostella* (Linn.) *Journal of Entomology and Zoology Studies*. 6(5).409-412.
- Supriya, G. B., Singh, T. V. K, Sunitha, V. and Vinod, S. K. 2018. Age-specific survivorship, life-fertility table studies of *Spodoptera litura* (Fabricius) on Bt-I and Bt-II Cotton hybrids under laboratory conditions. *Journal of Experimental Zoology India*. 21, 2, 1093-1102.
- Teja, N. Sunitha, V., Ramesh Babu, V and Satyanarayana, J 2018. Toxicity and persistency of novel insecticides against Diamondback moth, *Plutella xylostella* Linn. Souvenir of *National Symposium on Entomology 2018: advances and Challenges*. Pp 125-126.
- Supriya, G.B., Singh, T.V.K., Sunitha, V and Vinod, S.K. 2018. Age-specific life table, fecundity table, life parameters, stable age distribution and life expectancy of *Spodoptera litura* (F.) on cotton hybrids during 90-120 DAS. *Journal of Entomology and Zoology Studies*. 6(3): 477-486.
- Mahesh, S.S., Vasudevarao, V., Surender, G., Kiran kumar, D.A. and Swamy. K. 2019. Distress feeding of depredatory birds in Sunflower and Sorghum protected by Bioacoustics. *Cold Spring Harbor Perspectives in Biology*. 10.1101/200097
- Teja, N. Sunitha, V., Ramesh Babu, V and Satyanarayana, J. 2019. Evaluation of novel insecticides and their persistency against diamondback moth, *Plutella xylostella* Linn. *Journal of Entomology and Zoology Studies*. 7(3): 338-341.

Budget Utilization

CC Unit, PJTSAU, Hyderabad							
Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	7.00	0.00	6.00	1.00	0.00	0.00	7.00
2018-19	12.00	0.00	11.00	0.28	0.00	0.00	11.28
PJTSAU centre, Hyderabad							
Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	88.60	88.56	2.40	0.19	0.00	4.00	95.15
2018-19	119.32	85.21	13.00	0.08	5.11	6.39	109.79

PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA
(Rodent Control)

Part: I General Information

1. Name of the center	Punjab Agricultural University, Ludhiana Department of Zoology
2. Sanction no.	1-2/77-pp dated 2.7.1977 and 7-1/85pp dated 29.10.1988
3. Date of start	20.1.1978
4. Date of Termination	Network project of continued nature
5. Report period	2017-2019
6. Scientist Incharge	Dr. Neena Singla

7. Staff Position

Sr. No.	Name of post	No. of posts sanctioned	Name of incumbent	Date of Joining	Date of Leaving
I.	Zoologist (Rodents)	1	1. Dr. Neena Singla Sr. Zoologist (Rodents) Rs.37,400-67,000 +10,000 GP	28.07.2000	Continued
II.	Assistant Zoologist (Rodents)	3	1. Dr. B. K. Babbar Assistant Zoologist (Rodents) Rs.15,600-39,100 + 8000 GP 2. Dr. Rajwinder Singh Assistant Zoologist (Rodents) Rs. 15,600-39,100 + 6000 GP 3. Dr Navdeep Kaur Assistant Zoologist (Rodents) Rs. 15,600-39,100 + 6000 GP	28.12.2005 01.06.2012 11.11.2013	Continued Shifted w.e.f. 01.04.2018 Shifted w.e.f. 01.04.2018
II	Agricultural Sub Inspectors (ASI)	3	1. Ms. Baljit Kaur Rs. 10,300-34,800+3600 GP 2. Mr. Ram Prasad Rs. 10,300-34,800+3200 GP 3. Mr. Inderbir Singh Rs.10,300-34,800+3200 GP	22.09.2012 01.03.2013 22.12.2016	Technical Assistant ASI Shifted w.e.f. 01.04.2018

Part II: Work allotted (Technical Programme)

Multi-location programs

- RM-1. Surveillance of pest rodents in Rice-Wheat-Vegetable cropping system of Punjab.
- RM-2. Monitoring of rodent abundance and damage in Western zone of Punjab.
- RM-3. Evaluation of botanicals against rodent pests for antifeedant/deterrent/ attractant/sterilant effects
- RM-4. Evaluation of chemical compounds for toxic and anti-fertility properties for data generation on Indian rodents.
- RM-5. Development of rodent management technologies under storage conditions.
- RM-6. Bio-ecology of *Tatera indica*.
- RM-7. Development/Refinement of rodent pest management modules in predominant crops/cropping systems.
- RM-8. Field evaluation of Cinnamic aldehyde formulations as repellent/antifeedant in storage
- RM-9. Social engineering activity on rodent pest management as participatory adaptive research in adopted villages.
- RM-10. Studies on predatory potential of barn owls and its utilization for bio-control of rodent pests.
- RM-11. Collection and cataloguing of ITKs for management of higher vertebrates.

Location Specific:

- a) Behavioural studies on predominant rodent species.
- b) Field evaluation of triptolide for rodent population regulation through IRPM.
- c) Studies on potential of predatory cues for bio control of rodent pests.

Part III: Work done

I Multi Location programs

RM-1. Surveillance of pest rodents in rice-wheat-vegetable cropping system of Punjab

Surveillance of rodent pests in rice-wheat-vegetable cropping system at village Barewal Dogra, Distt Ludhiana revealed predominance of *Bandicota bengalensis* followed by *Tatera indica*, *Mus booduga* and *Golunda ellioti*. During the whole year trap index varied from 5.10 to 37.50. The lowest trap index was recorded in the month of October, 17 and highest in August, 17. *G. ellioti* was trapped during the month of October only. Trapping of rats having body weight lower than 100g almost throughout the year indicated that these species breed all the year around. Maximum number of burrows was observed during the month of April, 17 in wheat crop (34.12/ha) and minimum during November, 17 (14.15/ha) in lean period.

Trapping of rodent pests in wheat crop at KVK Bahawal, district Hoshiarpur revealed the predominance of *Tatera indica* whereas in villages of district Ludhiana, there was predominance of *Bandicota bengalensis*. Trapping from fish market near Sidhwan canal, Ludhiana and other commensal areas such as Circuit house, PAU library, grocery store, chicken plaza and ESIC Hospital in Ludhiana revealed the coexistence of *Rattus rattus* and *B. bengalensis*.

Survey of pre-harvest rodent damage to wheat crop sown with Happy Seeder (surface mulching) conducted (April) in village Sajuma, district Sangrur and villages Bagga Khurd and Lathowal Seed Farm of PAU in district Ludhiana revealed 0.59 to 1.58% cut tillers thus indicating that rodent infestation is not totally dependent upon surface mulching. Record of rodent infestation at germination stage (December) revealed low rodent population in happy seeder sown wheat fields with and without stubbles at village Noorpur Bet, district Ludhiana. However at villages Barnhara, Malikpur and Saleempur, district Ludhiana and in village Bulle, district Ferozepur where stubbles were standing, rodent population was moderate to high but in villages Gandhi Vind

and Chamba Kalan Hawelian, district Taran Taran Sahib, rodent population was very high and there was need to control rodent population. It therefore indicates that rodent population in such fields is more location specific rather than due to agronomic practices.

Record of rodent burrows in village Talwandi Kalan, district Ludhiana where one farmer had used different methods for sowing and management of paddy stubbles revealed negligible burrows in all the blocks of wheat crop. Reason may be again be due to location specificity or due to the presence of large dog population in the village because of the presence of a slaughter house.

RM-2. Monitoring of rodent abundance and damage in western zone of Punjab

A survey of pre-harvest rodent damage to wheat crop was conducted in selected villages of districts Bathinda, Muktsar and Moga during April, 2017 under western zone of Punjab State. Mean per cent cut tillers and yield loss (kg/ha) recorded in three districts were 0.77 and 52.85; 0.61 and 43.07; 1.13 and 60.04, respectively. In district Bathinda, there was predominance of *B. bengalensis* (33.60) followed by *M. booduga* (16.37) and *T. indica* (6.66) with mean total burrow count (per ha) of 56.65. In district Muktsar, there was predominance of *B. bengalensis* (19.16) followed by *Millardia meltada* (4.99) and *M. booduga* (4.17) with mean total burrow count (per ha) of 23.88. In district Moga, there was predominance of *B. bengalensis* (22.77) followed by *T. indica* (11.66) and *M. booduga* (6.94) with mean total burrow count (per ha) of 48.33.

A survey of pre-harvest rodent damage to rice crop was conducted in selected villages of districts Hoshiarpur, Shaheed Bhagat Singh (SBS) Nagar (Nawan Shahar) and Roopnagar during October, 17. The mean per cent cut tillers and damage (kg/ha) recorded to rice crop in three districts were 1.01 and 83.64; 0.86 and 61.78; 0.33 and 27.55, respectively. In district Hoshiarpur, there was predominance of *B. bengalensis* (33.32) followed by *M. booduga* (22.77), *T. indica* (12.50) and *M. meltada* (3.60) with mean total burrow count (per ha) of 72.21. In district SBS Nagar there was predominance of *B. bengalensis* (36.94) followed by *M. booduga* (19.98), *M. meltada* (10.81) and *T. indica* (4.16) with mean total burrow count (per ha) of 71.93. In district Roopnagar, there was predominance of *B. bengalensis* (14.99) followed by *M. booduga* (5.27) with mean total burrow count (per ha) of 20.27.

RM-3. Evaluation of botanicals against rodent pests for antifeedant/deterrent/attractant/sterilant effects

Short term repellent effect (1-2 days) of eucalyptus against *R. rattus* has been given in previous reports. The biological action of the oil can be wiped out by volatilization of active components via the act of oxidation, high temperatures and UV light. Microencapsulation is the technique by which solids, fluids or even vapours containing the required characteristics may be encircled in enormously miniscule quantities in microscopic particles having thin coverings of wall material with some degree of permeability. The ultimate objective of microencapsulation is to decrease the degree of vaporization of the oil, increase shelf life and have controlled release of the active components for a longer period of time. Naturally occurring polymers such as alginate and chitosan are widely used in biomedical and pharmaceutical fields in various forms such as nanoparticles, microcapsules and emulsions. Evaluation of microcapsules containing three different concentrations of eucalyptus oil (3, 5 or 7%) for persistence of antifeedant and repellent effect revealed a highest antifeedant effect with microcapsules containing of 5% concentration of the oil and mixed at 20% concentration. Repellent effect was also found highest at 5% concentration of the eucalyptus oil (79.67%).

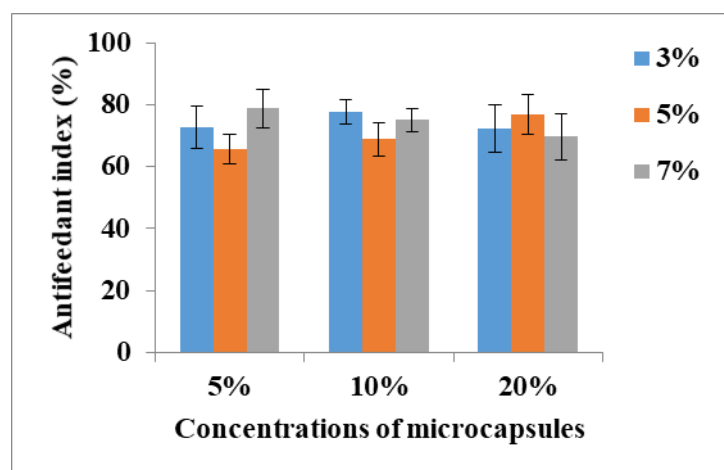


Fig. 1. Comparison of antifeedant index of microcapsules containing 3, 5 and 7% eucalyptus oil against *R. rattus*. Bars containing different superscripts (a-c) indicate significant difference

Antifeedant index of microcapsules containing 3, 4 and 5% citronella oil mixed in WSO bait at 5, 10 and 20% concentrations against *R. rattus* was found to be 61.7 to 78.7% at all the three concentrations of microcapsules containing 3% oil; 72.3 to 83.4% at 4% oil and 77.5 to 90.6% at 5% oil. A significant difference was found in mean daily consumption between treated and untreated baits and antifeedant index (Fig. 2) at all the three concentrations of eucalyptus oil (3, 4 and 5%) and all the three concentrations of microcapsules (5, 10 and 20%) on all the 7 days of treatment. Apparently the antifeedant index was highest at 5% concentration of oil at 20% concentration of microcapsules on all the 7 days of treatment.

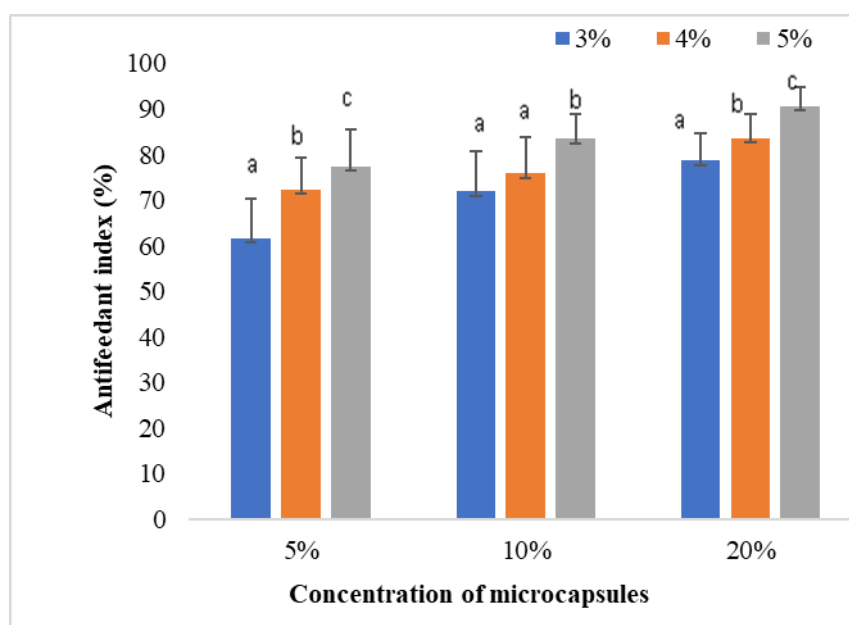


Fig. 2. Comparison of antifeedant index of microcapsules containing 3, 4 and 5% citronella oil against *R. rattus*. Bars containing different superscripts (a-c) indicate significant difference

Per cent repellency with microcapsules containing 3% citronella oil was maximum on day 2 (94.4%) of exposure which decreased to nil by day 6. The overall repellency was 77.0%. Per cent repellency (Table 1) with microcapsules containing 4% citronella oil was maximum on day 3

(96.8%) of exposure. The overall repellency was 87.3%. Per cent repellency with microcapsules containing 5% citronella oil was maximum on day 2 (99.5%) of exposure which decreased significantly to 77.7% by day 7 of exposure. The overall repellency was 92.2%. The repellency with microcapsules containing 4 and 5% citronella oil was observed on all the seven days of exposure.

Table 1. Per cent repellency with microcapsules containing different concentrations of citronella oil against *Rattus rattus*

Days of treatment	Per cent repellency		
	3%	4%	5%
1	81.5±3.8	94.9±1.9	97.9±1.9
2	94.4±1.3	96.3±1.3	99.5±0.5
3	89.5±2.7	96.8±1.2	97.1±1.1
4	72.1±4.4	92.0±1.1	94.4±1.0
5	47.7±10.2	87.3±1.4	92.9±0.6
6	-	77.6±2.0	86.1±1.5
7	-	66.1±3.0	77.7±2.5
Average	77.0±7.5	87.1±4.7	92.2±3.2

Exposure to WSO bait containing 1, 2, 3, 4 and 5 % capsicum oleoresin (containing 0.14% capsaicin) extracted from moderately pungent red chili powder (Hybrid CH 27, *Capsicum annum*) to rats for 15 days revealed antifeedant index of as 40.90, 43.95, 54.68, 51.78 and 49.54%, respectively. Highest antifeedant effect was observed at 3 and 5% concentrations. The antifeedant index was maximum in the initial 4-5 days which later decreased (Fig. 3).

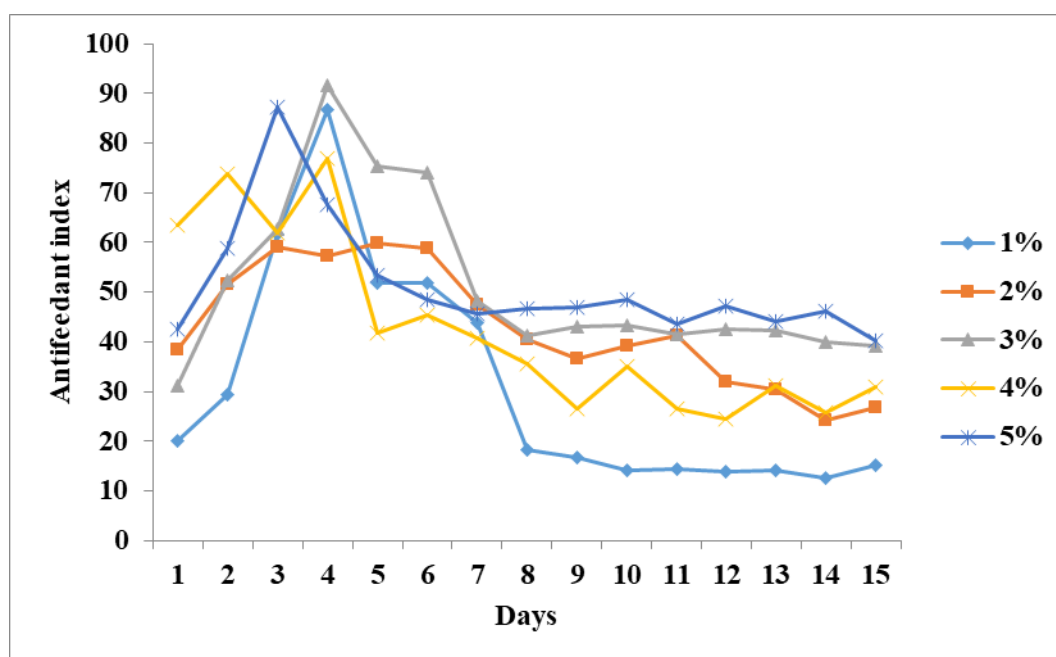


Fig. 3. Comparison of antifeedant index at five different concentrations of capsicum oleoresin against *B. bengalensis* in laboratory experiment

Under Laboratory conditions, 2.5% methyl anthranilate (MA) was found to have antifeedant and secondary repellent effect against *R. rattus* which was retained for the experimental period of 30 days. Rats completely avoided treated baits during first hour of their

exposure to treated bait indicating primary/olfactory repellent effect of MA. After that rats started eating treated bait. Results revealed that 2.5% MA is effective as antifeedant against rodents if provided with alternative food sources. Feeding of 2.5% MA in no-choice had severely affected the epithelial lining of stomach. The number of different cells of intestinal mucosa reduced significantly in no-choice group of rats except stem cells and lymphocytes whose number was increased. Reduction in number of different cells of intestinal glands might have caused reduction in secretion of intestinal juice and hormones secreted by neuroendocrine cells of intestinal gland causing indigestion in rats. There was also significant effect of treatment on tongue papillae. Application of microcapsules containing 2.5% MA on small stacks of wheat bags prevented rodent attack for 28 days (Table 2).

Table 2. Antifeedant index and consumption of plain bait and bait treated with 2.5% MA for 30 days in bi-choice feeding tests

Sex	Days	Body weight (gm)	Consumption of bait (g/100gbw)		Antifeedant index (%)
			Plain	Treatment	
Male	1-5	123.25±5.49	10.36±0.78	0.44±0.14	91.53±2
	6 - 10		10.15±0.93	0.78±0.12	84.49±3.40
	11-15		9.56±1.09	1.12±0.23	78.39±5.14
	16-20		9.64±0.71	0.92±0.21	85.37±3.12
	21-25		8.45±0.19	0.72±0.18	85.61±1.48
	26-30		9.46±0.58	0.82±0.16	88.84±1.05
	Mean±SE		9.60± 0.24	0.8±00.08*	85.70±1.65
Female	1-5	132.25±3.54	8.77±0.23	0.34±0.16	89.66±6.57
	6 - 10		9.03±0.56	0.56±0.22	91.14±3.08
	11-15		9.35±0.93	0.71±0.14	88.24±1.66
	16-20		8.37±0.82	1.03±0.37	78.93±6.22
	21-25		8.01±0.24	0.59±0.13	85.70±3.17
	26-30		8.50±0.92	0.54±0.03	88.84±1.05
	Mean±SE		8.67±0.17	0.62±0.08*	86.88±1.52

*Significantly less bait consumption from treated side

Six different doses (1.5, 3, 4.5, 6, 7.5 and 9 ml) of Neem seed alcoholic (NSA) extract were tested in laboratory under bi-choice condition. Maximum antifeedant index was 72.61% in female rats and 89.13% in male rats at 9ml dose of NSA extract (Table 3). Rats completely avoided all the treated baits during first hour of their exposure indicating primary/olfactory repellent effect. After that rats started eating treated bait but consumption remained depressed indicating Secondary repellent effect which might have occurred because of development of gastrointestinal malaise. Antifeedant or secondary repellent effect of NSA extract was more (89.16 to 94.41%) with 7.5 and 9 ml treated baits in female and male rats as compared to 1.5ml treated bait and the effect was retained for experimental period of 30 days in both sexes.

Table 3. Antifeedant index of neem seed alcoholic extract and consumption of bait during treatment period by *B. bengalensis*

Sex	Doses (ml)	Body weight (g)	Consumption of bait (g/100 bwt)		Antifeedant
			Treatment period		Index (%)
			Plain	Treated	
	1.5	241.00±6.84	6.25±0.23 ¹	3.35±0.25 ^{3*}	31.79±3.17 ^a
	3	242.33±10.62	5.59±0.48 ¹	2.28±0.41 ^{3*}	42.92±1.50 ^a

Male ^A	4.5	242.66±6.86	6.02±0.19 ¹	2.50±0.20 ^{3*}	43.17±2.43 ^a
	6	244.33±4.90	6.21±0.44 ¹	2.20±0.19 ^{3*}	51.05±6.63 ^a
	7.5	245.00±4.49	6.09±0.01 ¹	2.64±0.14 ^{3*}	41.91±2.32 ^a
	9	245.66±31.36	5.49±0.60 ¹	0.34±0.07 ^{2*}	89.13±1.03 ^b
Female ^A	1.5	257.33±16.22	4.21±0.35 ^a	1.13±0.42 ^{d*}	54.99±15.10 ¹
	3	261.00±41.52	6.89±1.56 ^a	2.03±0.14 ^{de*}	44.40±7.89 ¹
	4.5	257.33±16.22	5.83±0.55 ^a	1.67±0.24 ^{d*}	54.64±4.41 ¹
	6	261.12±43.52	7.30±1.15 ^a	1.92±0.58 ^{d*}	61.55±4.83 ¹
	7.5	258.13±17.92	9.43±0.53 ^b	3.05±0.27 ^{e*}	51.12±6.41 ¹
	9	260.66±34.95	11.01±1.15 ^c	1.94±0.61 ^{d*}	72.61±9.46 ²

Significant difference in consumption between plain and treated bait during treatment period
Different superscripts along the columns for male and female rats showing significant difference among consumption of baits and antifeedant indices

Male *B. bengalensis* were exposed to treatment baits containing three different concentrations (2, 3 and 5%) of ripe papaya seed powder in WSO bait. The acceptance of treatment bait varied from 36.44 to 44.21% and 35.18-37.07% in groups of rats treated for 15 and 30 days durations, respectively. The total active ingredient ingested after 15 and 30 days of treatment with different concentrations of papaya seed powder was 7.14-18.15 and 13.74-41.25 g/kg bwt, respectively. Pregnancy was found reduced to 33.33 and 16.67% in female rats paired with male rats treated with 5% papaya seed powder for 15 and 30 days duration. Overall, there was significant effect of treatment on sperm parameters and reproductive organs which was not recovered after 30 days of treatment withdrawal.

For studying antifertility property of neem seed alcoholic hexane (NSAH) extract, its different formulations F3 to F7 were prepared. Maximum consumption of bait was having formulation 7 of NSAH extract. Female rats administered oral dose of NSAH extract were not fertile and did not deliver pups. Normal follicles were completely absent in ovaries of group 2 rats. There was a significant difference in number of primordial and secondary follicles between rats of untreated group 1 and treated groups 2, 3 and 4 indicating maximum effect of treatment on primordial and secondary follicles. Comparison of atretic follicles among different groups of female rats revealed that these follicles were maximum in rats of groups 2 and 3. In group 2 rats, all follicles were atretic (Table 4).

Table 4. Effect of NSAH extract and F7 formulation on percent atresia in follicles in ovary of female *B. bengalensis*

Group	Primordial follicles	Primary follicles	Secondary follicles	Pre-antral follicles	Antral follicles	Graffian follicles
1 (untreated)	33.92	63.66	50	53.65	0	0
2 (0.8ml NSAH for 15 days)	100	100	100	100	-	-
3 (F7 for 20 days and dissected immediately)	98.82	96.55	88.96	100	100	-
4 (F7 for 20 days and dissected after 15 days)	81.10	73.73	71.50	0	0	100
5 (F7 at ESIC	47.74	61.57	50	33.33	0	-

hospital)						
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A significant effect of NSAH extract was observed on sperm motility (%), sperm viability (%), sperm count (millions/ml) and sperm abnormality (%) in the cauda epididymal fluid of male rats of groups II, III & IV. No pups were delivered by females paired with group II male rats, indicating 100 % breeding failure. A significant effect was observed on spermatogenesis.

RM-4. Evaluation of chemical compounds for toxic and antifertility properties for data generation on Indian rodents.

20 different formulations of zinc phosphide were tested against both sexes of *B. bengalensis*. Already recommended bait of 2% zinc phosphide and 19 new formulations of zinc phosphide were prepared by mixing different ingredients to get a best formulation for rodent control. Percent mortality in rats exposed to fresh formulation of 2% zinc phosphide was 100% as compared to only 20% mortality after 15 days and no mortality after 30 days of exposure clearly indicating reduction in effectiveness with time. No mortality was observed with freshly prepared formulations 2(a), 2(c), 4, 5, 7 and 10. While 15-80% mortality was observed with formulations 2 (b), 6, 9, 11 and 16. However, with formulation 20, percent mortality was 80-100% even after 30 days of preparation indicating its edge over already recommended formulation of 2% zinc phosphide.

Three different concentrations of quinestron (0.01, 0.02 and 0.03%), a synthetic estradiol were tested against male *B. bengalensis*. None of the untreated male rats paired with male rats fed on bait containing 0.03% quinestron for 10 days became pregnant. Results revealed partial improvement in breeding success of male rats treated with 0.01% after 15 days, of those treated with 0.02% quinestron after 30 days of treatment withdrawal and in those treated with 0.03% quinestron, no breeding success was observed even after 30 days of treatment withdrawal. Autopsy of male rats treated with 0.02 and 0.03% quinestron after 15 and 30 days of treatment withdrawal revealed a significant decrease in weight of reproductive organs and sperm parameters as compared to rats of untreated group and rats of group treated with 0.01% quinestron. The highest effect of treatment was observed in rats treated with 0.03% quinestron and there was no reversibility in antifertility effects.

RM-5. Development of rodent management technologies under storage conditions.

Sprinkling of bags with microcapsules containing 5% eucalyptus oil under simulated store condition, revealed a significant difference in mean daily consumption of wheat grains between treated and untreated sides from day 2 to 15. The average repellency observed in 15 days was 64.7% (Table 5). Spillage of grains started on both treated and untreated sides from day 2 onwards but was comparatively more on untreated side as compared to treated side. Average mean daily spillage of grains in 15 days from treated side was significantly low (4.7 g/100g bwt) than that observed on untreated side (9.0 g/100g bwt). No cuts to bags were found on either side on day 1. Average mean daily cuts on bags in 15 days from treated side were significantly lower (1.3) than that observed on untreated side (2.3). The size of cuts of the bags was small on treated side as compared to untreated side.

Sprinkling of bags with microcapsules containing 5% citronella oil under simulated store condition, revealed a significant difference in mean daily consumption of wheat grains between treated and untreated sides from day 2 to 10. Highest per cent repellency was found on day 2 (100%) of treatment after which it decreased slowly to 0% by day 13. The repellent effect was thus

observed for 10-12 days with overall average per cent repellency of 75.62%.

Table 5. Effect of microcapsules containing 5% eucalyptus oil on consumption of wheat grains by *Rattus rattus* and percent repellency under simulated store conditions

Days of treatment	Mean daily consumption of grains (g/100 gbwt)		Percent repellency
	Treated side	Untreated side	
Day 1	0.00±0.00	0.00±0.00	0.00±0.00
Day 2	0.30±0.30	4.50±1.38*	75.00±20.41
Day 3	0.66±0.39	7.39±0.82*	91.67±3.93
Day 4	1.57±0.16	7.74±0.62*	79.58±1.40
Day 5	1.11±0.38	10.10±0.74*	88.69±3.11
Day 6	2.20±0.16	11.46±0.95*	80.62±0.88
Day 7	2.09±0.28	10.90±0.47*	80.62±2.39
Day 8	2.20±0.83	10.68±1.13*	77.15±7.21
Day 9	3.26±0.51	11.54±0.91*	71.86±3.18
Day 10	3.10±0.40	12.99±0.90*	76.51±1.79
Day 11	3.98±0.48	10.79±1.81*	60.81±5.15
Day 12	4.80±1.10	11.85±0.91*	59.20±8.33
Day 13	5.86±0.71	12.40±1.59*	51.10±6.21
Day 14	6.23±0.87	11.13±1.49*	46.59±7.93
Day 15	8.65±0.87	12.46±1.15*	30.69±1.25
Average	3.07±1.23	9.73±1.76*	64.67±12.24

Seven different formulations (F1-F7) using 2.5% MA were prepared and tested in outdoor grain stores. Presence of rat pellets on bags and consumption of plain WSO bait kept below stacks revealed the presence of rats in all the grain stores throughout the observation period but number of cuts were not observed on the bags up to 9 days of treatment from all the four stacks treated with different formulations. There were no faecal pellets on wheat bags treated with F2 and F3 up to 14 days of treatment and up to 21 days on bags treated with F4 and up to 28 days on bags treated with F1 (Table 6). Overall, rats avoided treated stacks for up to 14 days and treated bags for up to 21 days.

Cost of one stack of wheat bags is Rs 20 lakh and rodents are responsible for causing damage to lower two layers of stacks costing about two lakh. Cost of one time treatment of one stack with MA capsules is Rs 500, which can protect a stack from rodent attack for one month. Therefore, cost effectiveness of MA formulation in grain stores depends upon the value of crop stored, level of damage without MA application and percent damage reduced after MA application. So effectiveness of MA increased with increase in crop value and anticipated damage due to rodents. Moreover, as MA formulations are more effective under bi-choice conditions, availability of alternative untreated food can further reduce damage to treated stored food.

Table 6. Percent consumption of WSO bait kept under large and small stacks

Stacks	Treatment	Consumption of plain WSO bait (g/100g)				
		7 DAT	14 DAT	21 DAT	28 DAT	35 DAT
SS1	F1	0.00±0.00	0.00±0.00	1.33±0.27	3.33±0.54	4.66±0.54
LS1	Untreated	70.00±8.47	78.75±3.72	82.5±2.93	77.5±2.33	60.0±3.95
SS2	F2	0.00±0.00	0.00±0.00	2.50±0.95	4.33±0.27	5.33±0.54
LS2	Untreated	100.00±0.00	92.5±3.85	75.00±4.67	87.75±3.75	87.5±3.42
SS3	F3	0.00±0.00	0.00±0.00	2.33±0.72	4.66±0.54	-----
LS3	Untreated	68.75±2.75	70.00±2.50	60.00±9.55	62.50±6.31	-----

SS4	F4	0.00±0.00	0.00±0.00	0.66±0.54	1.33±0.27	-----
LS4	Untreated	67.5±4.23	67.75±4.56	62.5±4.23	57.77±4.20	-----
SS5	Untreated	60.00±4.71	63.33±2.72	53.33±2.72	73.33±5.44	70.00±4.71
LS5	Untreated	70.00±3.06	68.75±4.82	76.66±7.20	75.0±0.58	71.42±0.19

Testing of formulations F1 (prepared by mixing effective dose 7.5 ml of NSA extract slurry and emulsifier in 1:2 ratio to prepare nanoemulsion) and F2 (prepared by mixing 7.5 ml NSA extract slurry and emulsifier in 1.5:1 ratio. To this solution, tert-butyl-hydroquinone solution was also added) at experimental rattery under simulated storage condition revealed no cut on treated bags for 2 days after treatment with F1 and 7 days after treatment with F2 thus indicating the potential of F2 in preventing rodent damage for considerably long time.

Spraying of formulations I and II consisting of 3 and 5% concentrations of capsicum oleoresin, respectively on wheat bags under simulated storage conditions revealed potential of both the formulations in reducing damage caused by rats on all the 15 days of exposure period. Spraying of both the formulations on soil in non-crop field area also revealed a significant effect in reducing bait consumption from treated area. Spraying of formulation II on soil in mung bean crop field area revealed a significant effect in reducing rodent damage.

RM-6. Bio-ecology of *Tatera indica*.

Male and female gerbils (32 of each sex) live trapped from different crop fields in villages Partap Pura and Ladhawal, district Ludhiana, Punjab were divided into two groups based on their body weights to study the growth pattern. Morphometric measurements were taken at weekly intervals of head+ body length, tail length, length of fore and hind limbs, eye and ear length, length of largest whiskers and length of scrotum of male and female gerbils. The tail was found to be slightly longer or shorter or almost equal to head+body length.

Examination of vaginal smear of mature female gerbils revealed duration of each stage in one estrous cycle to be 0.38, 0.62, 1.37 and 0.61 days, respectively with total average duration of one cycle to be 2.99 days. When the male rats were kept with the female rats after parturition, the female resumed estrous cyclicity immediately or within a day and came to heat resulting in mating with the male. This resulted in back to back pregnancy. The difference in two parturitions was found to be 21-23 days. The second litter was born just at the same time, the first litter was weaned. The litter size during second parturition was found reduced (3.00 ± 0.71) compared to that during first parturition (6.50 ± 0.50). Moreover, the pups of second litter were observed to be weak which may be because of stress on the mother.

For the establishment of breeding colonies, total twenty five breeding pairs (consisting of one male and one female) were formed. The male and female gerbils selected in each breeding pair were collected from different locations and breeding success was found to be 88% i.e. twenty two pairs bred successfully. Average litter size per breeding pair was found to be 5.14 ± 1.58 with range 3-8. The average number of male pups (2.91 ± 0.73) delivered was generally more as compared to female pups (2.23 ± 1.08). The gestation period of female gerbils was found to vary from 21-24 days.

Evaluation of female gerbils of different age groups (30 days, 45 days, 60 days, 75 days, 90 days, 105 days and 120 days) revealed a significant increase in body weight and weight of ovaries and uterus from day 30 to day 120 after birth indicating their development. Primordial follicles predominated in the cortex region at the age of 30 days. Development of primary follicles started at the age of 30 days and increased at 45 days after birth. Development of secondary follicles and pre-antral follicles along with one antral follicle was found in gerbils of age 45 days. More number of pre-antral and mature antral follicles was found at the age of 60 to 75 days. The follicles started becoming atretic at the age of 90 days onwards. Simultaneously there was ovulation from 90 days onwards leading to formation of corpora lutea at ages 105 days and 120

days. Overall, study depicted that the sexual maturity in female gerbils is attained at the age of 3-4 months.

RM-7. Development/Refinement of rodent pest management modules in predominant crops/cropping systems.

Experiment conducted in rice crop fields at Lathowal Seed Farm of PAU to compare the efficacy of paper bait and tyre bait stations for application of zinc phosphide revealed higher percent control success (77.38) in block with tyre bait stations installed @80 stations/ha. The percent cut tillers and yield loss were found to be less in treated fields as compared to control fields. Rodent control in wheat crop fields sown with Happy Seeder at Lathowal University Seed farm of PAU, Ludhiana as per the recommendation made resulted in successful management of rodent pests throughout the crop season.

RM-8. Field evaluation of cinnamic aldehyde formulations as repellent/antifeedant in storage conditions.

Study concluded in 2017

RM-9. Social engineering activity on rodent pest management as participatory adaptive research in adopted villages

Three villages were selected during rice and wheat crop periods 2017-18. These were categorized as (i) Maintenance area (village Barewal Dogra), (ii) Neglected area (village Kutbewal Gujran) and (iii) Survey area (village Ladiyan Kalan). Three villages were selected during wheat and rice crop periods in district Ludhiana during 2018-19 were categorized as (i) Maintenance area (Village Barnhara), (ii) Neglected area (village Jainpur) and (iii) Survey area (Village Malikpur). In maintenance area, proper education and training was imparted to the farmers along with distribution of rodenticides bait. In neglected area also proper education and training was imparted but poison bait was not distributed among the farmers. The survey area was kept as reference area where neither education was provided nor was rodenticide bait distributed. The survey was conducted in all the villages before and after providing education. Results revealed increase in percent farmers adopting different strategies for control of rodents. Overall, the number of burrows and per cent cut tillers decreased among maintenance and neglected villages as compared to the survey village in wheat and rice crop fields. This indicates that timely education and training of farmers on rodent control along with the distribution of poison bait are the key factors responsible for success of a rodent control programme.

Rodent control technology was also transferred to the end users by other modes like through TV/radio talks, training camps, field/office visits, kisan melas, extension workshops, lectures in various training programmes etc. Strong linkages have been developed and have actively collaborated with i) Agriculture departments of Punjab and Himachal states and officers of MARKFED, PUNGRAIN and FCI in collaboration with NIPHM, Hyderabad, ii) Department of Extension Education of PAU, Ludhiana by acting as resource person in different training programmes and kisan melas organized for better awareness creation among the farmers. Also organized stalls and Exhibitions during kisan melas for better transfer of technology, iii) With department of Extension Education of Guru Angad Dev Veterinary and Animal Sciences University (GADVASU), Ludhiana by acting as resource person in different training programmes organized for the benefit of farmers, iv) With KVKs under PAU, Ludhiana by acting as resource person in different training programmes organized by them for better awareness creation among the farmers, v) With IGMRI at PAU campus by acting as resource person in different training programmes organized by them for better awareness creation among food supply officers/inspectors, vi) With PAMETI (Punjab Agricultural Management and Extension Training

Institute) at PAU campus by acting as resource person in different training programmes organized by them for better awareness creation among ADOs/HDOs and farmers and vii) With Northern Railways by organizing one day training programme on rodent pest management along with practical demonstrations for officers of Northern Railways under Ferozepur Division.

RM-10. Studies on predatory potential of barn owls and its utilization for bio-control of rodent pests.

Study concluded in 2017.

RM-11. Collection and cataloguing of ITKs for management of higher vertebrates.

Farmers of villages Noorpur Bet, Gorsian Hakam Rai, Gara, Rajapur, Burj Labra, Khaira Bet, Chahal, Bagga Kalan, district Ludhiana reported that blue bull is causing damage in fields. More blue bull population and damage was reported between the area of Budha Nullah and Sutlej river. After the establishment of Ladhawal seed farm of PAU and Borlaug Institute of South Asia (BISA) at Ladhawal, district Ludhiana which are near to Sutlej river, blue bulls and wild boars were forced to abandon their habitat. BISA had also installed fencing at a height of about 7 feet. They also employed security guards for beating drums and forcing wild animals to leave their area. As a result, these blue bulls and wild boars migrated in above villages and started attacking agriculture fields for want of their food. Moreover, as these villages are located near water resources, these animals preferred to stay near these villages. Previously these animals preferred to stay away from human beings but now they got habituated and started attacking humans.

Female bulls attack dogs, other animals and human beings to protect their calves. However this attacking behaviour is rare in males. These animals prefer to feed upon maize, bajra, carrot, cauliflower, guava, sugarcane, fodder etc. Farmers reported nearly 100% damage to vegetables in their fields. Bulls prefer to live near water and fields having poplar trees. They also cause more damage in wheat crop sown with Happy Seeder during germination. The surface mulching of paddy straw in these fields may be providing them warmth in winter season. They attack wheat crop at maturity stage but do not prefer paddy and turmeric crops much. They attack crops after midnight in herds of 15-20 in number. They also remove bark of immature eucalyptus and poplar trees. Percent damage to poplar trees recorded was 25 to 37%. One female gave birth to two young ones at a time. Their gestation period is 250 days. Male lives in herd with calves and females and stays near the female at the time of delivery. Male is grayish black to bluish grey in colour with horns while female is camel coloured. Female gives birth to young ones in a protected place. They have scent glands on legs and feet to mark territory. They also mark their territory with heaps of dung. One animal in herd keeps vigilance, gives alarm calls and all animals start running in different directions to confuse their predator. Farmers reported that blue bulls run too fast and while running they destroy crop fields coming in their way. Farmers had adopted following methods for the management of these animals to prevent their entry in fields. But all the methods were a complete failure.

1. They installed fencing up to a height of 1-3 feet with electric current. However, blue bulls cross this fencing and enter into the fields. They were suggested to increase the height of fencing up to seven feet.
2. They sprayed egg solution (24 eggs solution for 14 acre area) around the crop but blue bulls were not repelled even for 24 hours.
3. They also sprayed dung solution in their fields after collecting dung of herds living in nearby villages to repel blue bulls from their fields, which was again a failure.
4. They also seek help from Forest department, which provided wire on subsidy to farmers of Kandi area but not to the farmers of this area. Farmers suggested that these animals can be translocated to forest at village Matewal. This forest is surrounded by fencing of about 13

feet height. Therefore once translocated, they will not attack village fields and residential areas.

5. They also sprayed a weedicide (Roundup) around the crops which provided protection against wild boar but not the blue bull
6. They also fed them wheat flour mixed with sulphur and stones, which is not an ethical and humane method for their management.
7. Scare crow and human dummy also could not repel them from their fields.
8. One farmer suggested that to prevent damage to eucalyptus is to paint it with mixture of copper sulphate and chuna (calcium hydroxide).
9. Farmers felt that fencing is not cost effective and only way to prevent damage is their translocation to a protective area.
10. They can also be repelled with Thimet (pesticide) or diesel.
11. Fencing can be done with ecodon soaked rope to repel wild boar.
12. Beating drums and exploding crackers is another way to repel them.

Blue bull population was also observed at villages Sudhar, Atiana, Rajoana, Mullanpur, and Chack Kalan, district Ludhiana. Farmers of these villages were educated about methods of management.

II. Location Specific Programs

a) Behavioural studies on predominant rodent species.

In maze experiment, the behaviour of rats was recorded in response to their exposure to microcapsules containing 5% eucalyptus (Table 7) and citronella oils (Table 8). Results revealed the efficacy of microcapsules for first 2 days. The total duration of mobility was found to significantly less in treated zone than that in untreated zone. The animal tracking data in two zones of I-Maze revealed comparatively less animal tracks in treated zone.

Table 7. Behaviour of *Rattus rattus* in response to microcapsules containing 5% eucalyptus oil exposed in bi-choice test in I-Maze

Parameters	Treatment days	Treated zone	Untreated zone
In zone frequency	Day 1	26.75±24.75	50.5±31.79
	Day 2	217±166.87	228.5±165.37
	Day 3	432±426.68	438.5±426.51
	Average	225.25±101.38	239.17±97.11
In zone total duration (s)	Day 1	95.3±44.44	4379.55±908.15
	Day 2	569.5±497.15	3798.85±1206.21
	Day 3	663.15±646.97	3793.4±1236.50
	Average	442.65±152.22	3990.6±168.43
In zone latency of first occurrence (s)	Day 1	47.05±18.17	34.8±18.34
	Day 2	2.1±1.84	18.3±11.69
	Day 3	49.25±24.05	20.45±7.29
	Average	32.8±13.30	24.52±4.49
Total distance moved (cm)	Day 1	1008.48±847.19	44630.49±27293.71
	Day 2	18346.22±17034.31	38951.15±11166.06
	Day 3	44092.04±43688.23	71997.73±34443.72
	Average	21148.91±10839.05	51859.79±8834.821
Velocity (cm/s) of movement	Day 1	10.67±4.21	23.87±3.09
	Day 2	25.52±5.90	61.9±48.45
	Day 3	32.84±13.67	63.08±42.83

	Average	23.01±5.65	49.61±11.15
Total duration of mobility (s)	Day 1	90.7±40.97	4272.5±888.30
	Day 2	538.35±466.83	3552.05±1290.62
	Day 3	453.15±436.97	3752.35±1226.08
	Average	360.73±118.85	3858.97±185.94

Table 8. Behaviour of *Rattus rattus* in response to microcapsules containing 5% citronella oil exposed in bi-choice test in I-Maze

Parameters	Treatment days	Treated zone	Untreated zone
In zone frequency	Day 1	9.75±6.76	68.5±42.46
	Day 2	1.50±0.29	33.5±12.98*
	Day 3	4.25±2.95	65.25±42.05
	Average	5.17±2.10	55.75±9.67*
In zone total duration (s)	Day 1	907.95±889.29	2692±889.27
	Day 2	22.60±9.59	4477.25±903.30*
	Day 3	14.20±5.45	3585.8±5.45*
	Average	314.92±256.80	3585.02±446.31*
In zone latency of first occurrence (s)	Day 1	769.25±728.89	268.45±262.52
	Day 2	442.05±302.57	67.85±49.27
	Day 3	14.20±13.28	4.4±18.96
	Average	408.50±189.32	113.57±68.92
Total distance moved (cm)	Day 1	5234.65±5016.76	18295.63±7031.85
	Day 2	112.69±71.45	17384.81±10403.13
	Day 3	317.39±207.88	22566.67±4448.83*
	Average	1888.24±1449.94	19415.70±1383.28*
Velocity (cm/s) of movement	Day 1	11.72±3.05	71.06±53.57
	Day 2	7.76±2.66	19.17±4.35
	Day 3	16.23±9.15	18.11±1.20
	Average	11.90±2.12	36.11±15.13
Total duration of mobility (s)	Day 1	228.80±218.47	872.55±338.47
	Day 2	6.00±3.14	1766.15±1322.49
	Day 3	6.60±2.23	1152.15±334.20*
	Average	80.47±64.23	1263.62±228.55*

Tatera indica of both the sexes were live trapped at different growth stages (tillering, panicle initiation, dough stages, pre-harvest and post-harvest periods) of rice and wheat crop fields at village Barewal Dogra, District Ludhiana. The population dynamics of *T. indica* was studied by recording the number of live burrows of *T. indica* as well as by calculating trap index. In rice crop, the no. of burrows (29) and population size (17) of *T. indica* was maximum during tillering stage. 100% mature gerbils were collected during initial growth stages. Total trap index was maximum during tillering stage i.e. 23.61. During transplanting and tillering stages all gerbils were observed to be cyclic. The cyclic gerbils showed normal estrous cycle with mean duration from 3.98 to 4.47 days.

The average body mass of female gerbils was found to be maximum during dough (169.33g) stage. Maximum weight of ovaries was observed during tillering stage indicating that the gonadal activity of female gerbils was high during the tillering stage of rice crop. The maximum weight of uterus was observed during dough stage. The number of primordial follicles was highest in panicle initiation stage indicating more number of ova reserves in the ovaries of gerbils. However, the number of pre-antral and antral and atretic follicles were highest during the tillering.

The maximum average body mass of male gerbils were observed during tillering stage. Maximum average weight of testes was observed during dough stage. The maximum average weight of epididymis (0.46g/100g bwt) and seminal vesicles (1.51g bwt) was observed during panicle initiation stage. The maximum average weight of prostate gland was observed in tillering (0.10g/100g bwt) stage. The maximum average sperm viability (94.50%) and sperm abnormalities were observed during tillering stage (6.25%) followed by panicle initiation stage.

The average diameters of seminiferous tubules in testes of male gerbils were found to be highest during panicle initiation (218.24 μ m) stage of rice crop. Similarly, the diameters of lumen were found to be highest during tillering stage (90.99 μ m). The numbers of seminiferous tubules showing complete spermatogenesis were maximum during tillering and panicle initiation stages as indicated by the presence of maximum number of round spermatids. Thus to control the population of gerbils in rice crop fields, rodenticides should be applied before their breeding peaks i.e. in the month of June.

In wheat crop, the no. of burrows/acre was maximum during sowing (13) and tillering stage (14). The total trap index (11.11%) was also found to be maximum during the sowing and tillering growth stages of wheat crop. However, only 37.5% gerbils were found to be mature during these growth stages. All the gerbils were cyclic during dough stage of the wheat crop. Minimum percentage of non-cyclic gerbils i.e. 25% gerbils were observed during pre-harvest stage. 66.67% of gerbils were found to be non-cyclic during panicle initiation. The gerbils presented normal estrous cycle with mean duration ranging from 3.63 to 4.03 days.

The maximum average body mass of the females was observed during lean period (150.50g) during tillering (112.83g) stage of the crop. The average weight of ovaries was found to be highest during pre-harvest stage and lean period (19.00mg/100g bwt) of wheat crop and minimum during sowing stage (6.00mg/100gbw). The maximum weight of the uterus was observed during dough stage (51.00mg/100g bwt).

The histomorphological studies of ovaries revealed that the number of primordial, primary, secondary, antral, atretic follicles and corpus luteum were less during initial growth stages i.e. sowing, tillering, panicle initiation stage and higher during later growth stages i.e. dough, pre-harvest stage and lean period. The maximum number of primordial follicles was recorded during dough stage (16.75).

The maximum body weight of male gerbils was observed during pre-harvest stage (150.5 g). The maximum weight of testes and epididymes was observed during pre-harvest stage. The weight of seminal vesicles was maximum during dough stage (0.92/100g bwt) and minimum the maximum weight of the prostate gland was observed during panicle initiation stage (0.10g/100g bwt). The maximum value of sperm motility was recorded during dough stage (89.67%). The sperm viability was found to be maximum during dough stage (92.67%). The maximum value of sperm count was recorded during pre-harvest stage (131.75 millions/ml).

The diameters of seminiferous tubules and lumen were highest during pre-harvest stage of

the wheat crop. The maximum number of elongating spermatids (88.5) and elongated spermatids (89.50) was observed during pre-harvest stage which indicated active process of spermatogenesis. The breeding activity of *T. indica* in later growth stages of wheat crop was due to favourable temperature conditions as well as proper food availability. Thus to control their population in the wheat crop fields, rodenticides should be applied in the months of January-February (tillering/panicle initiation stage).

Study on burrowing behaviour of *B. bengalensis* in relation to different soil parameters and different crop stages was carried out in wheat crop. During different growth stages (tillering, panicle initiation, dough stages, pre-harvest and post-harvest periods) of wheat crop, the length of burrow ranged from 172.40-200.80cm and depth of burrow ranged from 53.53-68.9cm. Results revealed that to keep the environment of the burrow optimum the rat decreases the depth and increases the length of burrow during tillering stage and increases depth and reduces length of burrow during lean period.

The lesser bandicoot rat, *B. bengalensis* of both the sexes were live trapped at different growth stages of wheat crop in village Dhatt, District Ludhiana to study their reproductive biology. No pregnant female was trapped during the tillering, panicle initiation and lean period of the wheat crop. This may be due to the limited food availability during these growth stages of the crop. The maximum pregnant rats (66.7%) were observed during pre-harvest stage (April) of wheat crop followed by dough stage (March) with 50% pregnant females. The maximum litter size observed was 9 in one rat during the dough stage of the wheat crop, thus indicating the maximum reproductive potential or the population rebuild up by the bandicoot rats during this stage. The estrous cyclicity of the female bandicoot rats was observed daily by collecting the vaginal smears from each animal for 12-15 days. The minimum duration of estrous cycle (3.51 days) and the highest duration of estrus phase (0.82 days) were observed during the pre-harvest stage of the wheat crop. The sperm parameters such as sperm motility (%), sperm viability (%) and sperm count (millions/ml) were determined in cauda epididymal fluid. The maximum values of these parameters were recorded during pre-harvest stage (74.0%, 79.4%, 176.7 million/ml, respectively), however, there was no significant difference during different growth stages. The maximum population of the bandicoot rats was recorded during pre-harvest stage of the wheat crop. So to control their population in the crop fields at pre-harvest stage, rodenticides should be applied at the tillering/panicle initiation stage of wheat crop i.e. in the months of January and February when low and reproductively less active population of rats was present.

To observe parasitic infections found in *B. bengalensis* at different growth stages of wheat crop, rats of both sexes were sacrificed. Liver and intestine were examined for endoparasitic infection. Total 28 (17 males and 11 females) rats were examined at different stages of wheat crop. The parasitic infection recorded at tillering, panicle initiation, dough, pre-harvesting stages and lean period was 75.0, 0.0, 71.4, 75.0 and 60.0%, respectively. The maximum infected rats were found during tillering and dough stages which were infected with *Cysticercus fasciolaris*, *Capillaria hepatica*, *Syphacia obvelata*, unidentified nematode larvae and *Trichuris muris* in concurrence with each other. Male rats were found to be more infected (60.7%) as compared to female rats (39.2%).

b) Rodents as reservoirs of parasites of zoonotic importance and risk assessment

To observe parasitic infections found in *B. bengalensis* at different growth stages of wheat crop, rats of both sexes were sacrificed. Liver and intestine were examined for endoparasitic infection. Total 28 (17 males and 11 females) rats were examined at different stages of wheat crop.

The parasitic infection recorded at tillering, panicle initiation, dough, pre-harvesting stages and lean period was 75.0, 0.0, 71.4, 75.0 and 60.0%, respectively. The maximum infected rats were found during tillering and dough stages which were infected with *Cysticercus fasciolaris*, *Capillaria hepatica*, *Syphacia obvelata*, unidentified nematode larvae and *Trichuris muris* in concurrence with each other. Male rats were found to be more infected (60.7%) as compared to female rats (39.2%).

Till the last decade, wild rodent pest species, *B. bengalensis* was predominant in agricultural landscapes in Punjab, India. The species still constitutes more than 70% of the rodent population in crop fields. This species has also now migrated to urban areas and is a potential threat to humans and domestic animals, being reservoir of different parasites of zoonotic importance. In present study, we live trapped rodents at monthly intervals from commensal habitats such as residences, street food stores, flour mills, poultry farms and fish market at Ludhiana, Punjab and collected sixty five *B. bengalensis* in addition to other species i.e. *R. rattus* and *M. musculus*. In the laboratory, the lesser bandicoot rats were sexed, weighed and examined for their ecto and endoparasitic fauna. Investigation of skin and fur revealed 61.3% (46) rats infested with one or more of ectoparasites such as insects i.e. rat flea (*Xenopsylla cheopis*) and lice (*Polyplax* sp. and *Mallophaga* sp.) and arachnids i.e. tick (*Hemaphysalis* sp.) and mites (*Ornithonyssus bacoti* and *Liponyssoides sanguineus*). The fleas and lice were the most common ectoparasites that infested the lesser bandicoot rat. After necropsy, liver, small and large intestine of 78.4% (51) rats were found infested with different endoparasites such as, cestodes i.e. *C. fasciolaris*, *Hymenolepis nana* and *Hymenolepis diminuta*, nematodes i.e. *T. muris*, *Heterakis spumosa*, *Strongyloides ratti*, *Syphacia muris*, *Aspicularis tetraptera* and *C. hepatica* and acanthocephalan i.e. *Moniliformis moniliformis*. There was also an effect of season on prevalence of ecto and endoparasites on rats. Among different parasitic species identified, many are of zoonotic importance and pose a potential health risk to the inhabitants. Hence, managing rodent population in these commensal areas and generating awareness among people about the risk of disease transmission through rodents seems to be entirely necessary.

EXTENSION ACTIVITIES OTHER THAN ADOPTION OF VILLAGE (2017-019)

a) Trainings organized at PAU campus:

S. no.	Name of training	Date	No. of participants
1	One day training programme was organized for officers of Indian Railways Department belonging to different railway stations along with demonstration	15.03.2018	16 Officers of Indian Railways Department belonging to railway stations Ludhiana, Jalandhar, Amritsar, Ferozepur, Pathankot, Katra and Jammu
2	Five Days Training Programme on Vertebrate Pest Management organized in the Department of Zoology, PAU, Ludhiana as Course Director in collaboration with NIPHM, Hyderabad	28 th Jan-01 Feb, 2019	20 participants among KVK Scientists, ADOs, HDOs of Punjab and Himachal Pradesh and officers of FCI, PUNGRAIN and MARFED.

b) Trainings organized outside PAU campus:

S. No.	Name of programme and place	Date	No. of participants
1	Training camp on rodent control in	09.08.201	25 farmers of village

	paddy crop was organized at village Manava, District Moga.	7	Manava, District Moga
2	In response to news in 'Ajit' Newspaper dated 31.05.18, a training camp was organized in association with scientists at FASC Barnala to tackle rodent problem in cotton crop.	13.06.2018	12 farmers of village Khudi Khurd, District Barnala News appeared in Newspaper and PAU website.
3	Demonstration on preparation and application of rodenticide bait in bottle gourd crop grown at organic farm of a farmer was given after survey regarding rodent infestation and damage.	24.07.2018	One farmer of village Gholia, Distt Moga
4	Lecture cum demonstration on methods of rodent control and Nilgai management was given to farmers in a training camp organized on 16 th January, 2019.	16.01.2019	40 farmers of village Aitiana district Ludhiana

c) Demonstration on methods of rodenticide bait preparation and application:

Sr. no.	Village/participants	Date	No. of farmers
1	Village Manava, District Moga	09.08.17	25
2	Young farmers' training on Integrated Crop Production organized by Directorate of Extension Education, PAU at KKG from 01.08.17 to 31.10.17	11.10.17	18
3	Training camp for young farmers at KKG, PAU	08.03.18	25
4	Railway station, Ludhiana	15.03.18	16
5	Village Khudi Khurd, District Barnala in collaboration with FASC Barnala	13.06.18	12
6	Organic farm at Village Gholia, district Moga	24.07.18	1
7	Training on <i>in situ</i> management of crop residue organized by KVK Kapurthala	23.08.18	25
8	Training on Vermicomposting, rodent pests and bird management under organized by PAMETI, PAU campus from 27 th Aug-01 September, 2018	27.08.18	15
9	-do-	28.08.18	15
10	Training on <i>in situ</i> management of crop residue organized by KVK Kapurthala	31.08.18	25
11	Training on <i>in situ</i> management of crop residue organized by KVK Kapurthala	17.09.18	44
12	Training camp of three months duration for young farmers at KKG, PAU	23.10.18	36
13	Village Atiana district Ludhiana	16.01.19	40
14	KVK Scientists, ADOs, HDOs of Punjab and Himachal Pradesh and officers of FCI, PUNGRAIN and MARFED	28 th Jan-01 Feb, 19	20

d) Presentation at workshops as resource person:

Sr. no.	Name of Workshop	Date	Activity
1	Research & Extension Specialists Workshop on Kharif crops held at PAU from 27-28 Feb, 2017.	28.02.17	Presented research findings on Rodent control in outdoor grain storage
2	Research & Extension specialists' workshop for Vegetables, Floriculture and Sericulture along with Post harvest management, Farm Power and Machinery, Food Technology and Agricultural Economics held from 31 May-01 June, 2017 at PAU.	01.05.17	Presented research findings related to Rodent problems and their control in vegetable crops
3	Research & Extension Specialists' Workshop for Vegetables, Floriculture and Sericulture along with Post harvest management, Farm Power & Machinery, Food Technology & Agricultural Economics held at PAU from 31st May-1st June, 2017.	01.06.17	Presented research findings related to Rodent problems and their control in vegetable crops
4	Research & Extension Specialists Workshop for Rabi Crops held at PAU, Ludhiana from 31 st August to 1 st September, 2017.	31.08.17	Presented research findings related to Rodent control in wheat crop sown under rice residue management
5	Research & Extension Specialists' at Workshop for Kharif Crops held at PAU from 21-22 February, 2018.	22.02.18	Presented on the topic Rodent control in kharif crops
6	Research & Extension Specialists' Workshop for Vegetables, Floriculture and Sericulture along with Post Harvest Management, Farm Power & Machinery, Food Technology & Agricultural Economics held at PAU from 10-11 May, 2018.	11.05.18	Presented on the topic Rodent damage and control in vegetable crops
7	Training cum Workshop of Crop PAU-Residue Manager's Association (PAU-CRMA) held at PAU, Ludhiana on 20.12.2018.	20.12.2018	Presented on the topic Rodent control in wheat crop sown under rice residue management

e) Exhibitions organized:

Sr. no.	Particulars of exhibition	Name of the event	Place of exhibition	Display methodology chart/model/live/any other
1	Rodent pest management	Research and extension specialists' workshop for Kharif crops	PAU, Ludhiana on 28th Feb, 2017	Charts, live specimens and model
2	Rodent pest management	Research and extension specialists' workshop for Kharif crops	PAU, Ludhiana on 22nd Feb, 2018	Charts, live specimens and model

3	Rodent pest management	Training cum Workshop of Crop PAU-Residue Manager's Association (PAU-CRMA held at PAU, Ludhiana on 20.12.2018.	PAU, Ludhiana on 20.12.2018	Charts, live specimens and model
4	Rodent pest management	Research and extension specialists' workshop for Kharif crops	PAU, Ludhiana on 27th Feb, 2019	Charts, live specimens and model

f) Lecturers delivered in different training programmes:

Sr.no.	Title of lecture	Organizing agency	Participants	Date(s)
1.	Methods of rodent control at post harvest stage	Directorate of Extension Education, PAU, Ludhiana	Training course on preservation and storage of food grains for officers of MARKFED, Punjab (40)	07.04.2017
2.	Rodent control methods in poultry farms	Department of Veterinary and Animal Husbandry Education, GADVASU	Special training course for poultry farmers (30)	28.04.2017
3.	Rodents, their biology and control methods during post harvest stage	IGMRI, PAU Campus	Food supply officers from different states (25)	23.06.2017
4.	Rodents, their biology, identification and control measures	Training organized by IGMRI, PAU campus from 20-22 September, 2017	20 (Food supply officers from Punjab state)	22.09.2017
5.	Rodent control in kharif crops	Young farmers' training on Integrated Crop Production organized by Directorate of Extension Education, PAU at KKG from 01.08.17 to 31.10.17	18 (Young farmers) who attended 3 months young farmers' training course at KKG, PAU, Ludhiana	11.10.2017
6.	Rodent control in wheat sown with Happy Seeder"	Training course on 'Crop Residue Management' organized by PAMETI, PAU from 06-10 Nov, 2017	16 (Extension staff of state agriculture and allied departments)	06.11.2017
7.	Rodent pest management in fields under rice residue incorporation	Training course on 'Conservation Agriculture and Soil Health' organized Under the auspices of Centre of Advanced Faculty	17 (Scientists of different state agricultural universities and ICAR Institutes)	17.11.2017

		Training by Department of Soil Science, PAU, Ludhiana from 01-21 Nov, 2017		
8.	Rodent control methods in poultry farms	Special Training course on poultry farming organized by Department of Veterinary and Animal Husbandry Education, GADVASU from 20.11.17 to 01.12.17	53 (Poultry farmers)	27.11.2017
9.	Rodents, their biology, identification and control measures	Training organized by IGMRI, PAU campus from 27.11.17 to 22.12.17	20 (Food supply officers from different states)	12.12.2017
10.	Rodents, their biology, identification and control measures	Training organized by IGMRI, PAU campus from 12-16 Feb, 2018	18 (Food supply officers from different states)	15.02.2018
11.	Rodent control in field crops	Training camp for young farmers at KKG, PAU	25 young farmers	08.03.2018
12.	Rodent control in wheat sown with Happy Seeder	Training course on 'Alternatives for Crop Residue Management' organized by PAMETI from 09-12 April, 2018	18 (Extension staff of state agriculture and allied departments)	11.04.2018
13.	Rodent control in wheat sown with Happy Seeder	Training on alternatives for crop residue management organized by PAMETI, PAU campus from 09-12 April, 2018	25 Extension officers	11.04.2018
14.	Rodent control methods in poultry farms	Special Training course on poultry farming organized by Department of Veterinary and Animal Husbandry Education, GADVASU	28 (poultry farmers)	26.04.2018
15.	Rodent control in wheat sown with Happy Seeder	Training on <i>in situ</i> management of crop residue organized by KVK Kapurthala	25 farmers	23.08.2018
16.	Rodent pests, their behaviour and economic importance along with demonstration	Training on Vermicomposting, rodent pests and bird management under organized by PAMETI,	15 farmers	27.08.2018

	on identification of different species, rodent damage and population assessment methods	PAU campus from 27 th Aug-01 September, 2018		
17.	Preventive and non-chemical methods of rodent management	-do-	15 farmers	28.08.2018
18.	Diseases transmitted by rodents and chemical control of rodent pests and along with methods of rodenticide bait preparation and application	-do-	15 farmers	28.08.2018
19.	Rodent control in wheat sown with Happy Seeder	Training on <i>in situ</i> management of crop residue organized by KVK Kapurthala	25 farmers	31.8.2018
20.	Rodent control for <i>in situ</i> rice residue management	Training course on rice residue management organized by PAMETI	25 farmers	31.08.2018
21.	Rodent control in wheat sown with Happy Seeder	Training on <i>in situ</i> management of crop residue organized by KVK Kapurthala	44 farmers	17.09.2018
22.	Rodents, their biology, identification and control measures	Training organized by IGMRI, PAU campus	25 (Food supply officers from PUNGRAIN)	11.09.2018
23.	Rodent control in Organic Farming	Training on Organic Farming and Production of Medicinal and Aromatic Plants organized by PAMETI, PAU campus from 08-13 October, 2018	16 Young men and women	10.10.2018
24.	Rodent control in field crops	Training camp of 3 months for young farmers at KKG, PAU	36 young farmers (119 th batch)	23.10.2018
25.	Rodent control in wheat sown with Happy Seeder	World Soil Day celebrated on 5th December 2018 at KVK, Langroya	More than 200 farmers	05.12.2018
26.	Rodent and other pest management	Skill Development Programme on Small Poultry Farmer	15 farmers	17.12.2018

		organized by Department of Veterinary and Animal Husbandry Education, GADVASU from 04 Dec 2018 to 08 Jan 2019		
27.	Rodent control methods in poultry farms	Special Training course on poultry farming organized for poultry club members by Department of Veterinary and Animal Husbandry Education, GADVASU	50 farmers	19.12.2018
28.	Rodents, their biology, identification and control measures	Training organized by IGMRI, PAU campus	22 (Food supply officers from PUNGRAIN)	31.12.2018
29.	Rodent management in happy seeder sown crops	Training under a scheme (<i>in-situ</i> management of crop residues) of Agriculture Department, Punjab.	36 farmers of village Chak Kalan, distt Ludhiana	08.2.2019
30.	Rodents, their biology, identification and control measures	Training organized by IGMRI, PAU campus	20 (Food supply officers from PUNGRAIN)	21.02.2019

g) TV Talks:

Sr. no.	Topic	Name of expert	Date of telecast/recording
1	TV recording on 'Rodent control in kharif crops' by FAST WAY Channel Ludhiana	Dr. Neena Singla	Recording on 30.08.17 and telecast on 31.08.17
2	Live Radio talk on 'Animal Biodiversity' on ' International Biodiversity Day ' for programme ' Khabarsar ' of AIR FM Gold Ludhiana at 100.1 mHz	Dr. Neena Singla	
3	TV recording on rodent damage and management in vegetables Fastway Channel	Dr.B.K. Babbar	On 25.05.18
4	TV recording related to 'Rodent control in wheat crop sown with Happy Seeder' by Jalandhar Doordarshan Kendra for ' Mera Pind Mere Khet ' Programme	Dr. Neena Singla	Recording on 14.12.18 and telecast on 21.12.18

h) Participation in Kisan Melas:

Involved in **organization of exhibitions** and **providing education** on ‘Methods of Rodent Control’ to hundreds of farmers from throughout the Punjab state visiting the Kisan Melas held at PAU campus, Ludhiana **twice (for two days each) a year in the months of March and September**. An expert guidance on rodent pests, reasons for failure of control operations and recommended methods of management is provided.

i) Helpline/other queries attended:

- Provided **technical guidance** on control of **rodents in berseem crop** to a farmer of village Bhawanigarh, district Sangrur in May, 2017.
- Provided **technical guidance** on control of **rodents in sugarcane crop to a progressive farmer of village Noorpur Bet**, district Ludhiana in June, 2017.
- Provided **technical guidance** on control of **rodents in lemon orchard and turmeric crop** to a farmer in Pathankot on 04.01.17.
- Provided technical guidance **regarding problem of rodent menace in meritorious school, Ghabdan, District Sangrur** in response to request received from **Director General School Education-cum-State Project Director Sarva Shiksha Abhyas Authority, Punjab** in Sep-Oct, 2017. Actual control was done using traps and rodenticide baits. Also **suggested precautions and care to be taken in future to prevent increase in rodent population**.
- Provided **technical guidance** on control of **rodents in kinnow orchard** to a farmer near Mullanpur, Ludhiana on 15.01.18.
- Provided **technical guidance** on control of **rodents** in cotton crop to farmers at village Daliyawali, Distt Mansa on 12.06.18.
- Provided **technical guidance** on reduction in **rodent damage** to bags containing maize silage in fields to farmers at village Bangla, near Samrala, Ludhiana on 05.07.18.
- Provided **technical guidance** on control of **rodents in ESIC Hospital, Ludhiana** on 18.01.18.
- A complaint was received regarding rodent problem in ESIC Model Hospital, Ludhiana on 21.5.2018. Given technical guidance to staff of ESIC hospital regarding rodent management in premises from 24.5.18 to 11.9.18. They are now managing rats at their own level.
- Provided technical guidance for **control of squirrels in PAU nursery** on 06.08.18. Conducted control using formulation of an antifeedant.
- **Technical guidance on control of rodents** outside as well as inside the building of **Circuit House, Ludhiana** was provided in 2018. Conducted actual control operation by trapping rats from both inside and outside, using rodenticide baits outside the building and using a safe repellent spray inside the kitchen area to repel rodents. Also **suggested precautions and care to be taken in future to prevent increase in rodent population**.
- Involved in providing individual level **technical guidance** for ‘Management of rats, mice and squirrels’ in laboratories, library, offices, computer centres, residential areas, kitchen garden, orchards and crop fields in PAU and GADVASU campuses and farmer fields to non-teaching staff, scientists, students and farmers.
- Submitted advisories for dissemination through ‘**Kheti Sandesh**’ regarding ‘rodent control in wheat crop fields sown with Happy Seeder’ as and when required through Additional Director Communication and Directorate of Extension Education, PAU.

J) Extension/popular articles/News:

1. **Singla N** (2017). Manage rodent pests in field crops. *Progressive Farming* **53**(8): 21-23.
2. **Singla N** (2017). Phaslan vich chuhiyan de roktham. *Changi Kheti* **53**(8): 21-23.
3. **Singla N** and Babbar B K (2017) Rats consume food grains worth crores of rupees every year throughout the country: *Punjab Kesari* (Ludhiana Edition) dated 17.04.2017, pp 02 (In Hindi). (News item)
4. **Singla N** (2017). PAU chkayaegi chuhiyan diyan puchhan. *Punjabi Tribune* (Ludhiana Edition) dated 09.09.2017. (News item)

5. **Singla N** and Babbar BK (2018). Rodent control in wheat crop sown with Happy Seeder. *Progressive Farming* **54**(1): 4.
6. **Singla N** and Babbar BK (2018). Happy Seeder nal bijae kanak de khetan vich chuhiyan de roktham. *Chengi Kheti* **54**(1): 15
7. Gupta RK, **Singla N** and Gill RS (2018). Management of wheat crop sown with Happy Seeder. *Progressive Farming* **54**(11): 13-14.
8. **Singla N**, Gill RS and Gupta RK (2018). Happy Seeder nal bijae kanak da vadh jhar kivaen kariya. *Chengi Kheti* **54**(11): 12-13.
9. Gupta RK, **Singla N** and Gill RS (2019). Happy Seeder nal biji kanak da vadhare jhar lain layi jaruri nukte. *Krishi Jagran* **21**(2): 60-63.

PUBLICATION (2017-2019)

1.	Singla N and Kaur R (2017). Increasing efficacy of eucalyptus oil as repellent against <i>Rattus rattus</i> by controlled release through encapsulated wax blocks. <i>Proceedings of the National Academy of Sciences India (Biological Sciences)</i> 87 (4): 1407-13.	2250-1746 (NAAS rating 2016 = 6.00)
2.	Singla N , Dhar P and Gupta K (2017). Effect of nifedipine on fertility of male lesser bandicoot rat (<i>Bandicota bengalensis</i>). <i>Applied Biological Research</i> 19 (1): 79-88.	5.07
3.	Garg N, Singla N , Jindal V and Babbar BK (2017). Studies on bromadiolone resistance in <i>Rattus rattus</i> populations from Punjab, India. <i>Pesticide Biochemistry and Physiology</i> 139 : 24-31.	9.44
4.	Singh R, Singla N and Kaur N (2017). Determination of method and timings of rodent control in direct seeded and transplanted basmati rice crops. <i>The Bioscan</i> 12 (2): 697-701.	5.26
5.	Kaur R, Singla N , Bansal N and Pathak D (2017). The biological effects of red chilli containing capsaicin on small intestine of rats. <i>Indian Veterinary Journal</i> 94 (9): 35-37.	4.42
6.	Malhotra R, Singla N and Babbar BK (2017). Diet composition of Barn Owl, <i>Tyto alba</i> as determinant for its potential as biocontrol agent of rodent pests in Punjab, India. <i>Indian Journal of Ecology</i> 44 (3): 583-89.	4.96
7.	Kaur J and Babbar BK (2017) Studies on repellent and feeding behaviour of house rat, <i>Rattus rattus</i> , in response to cinnamamide. <i>Applied Biological Research</i> 19 (2): 220-25.	5.07
8.	Kaur N and Singla N (2017) Burrow structure of rodents in different crop fields of Punjab. <i>Environment and Ecology</i> 36 (2): 381-86.	4.18
9.	Kaur R and Singla N (2017) Effectiveness of pure capsaicin as aversive agent against house rat, <i>Rattus rattus</i> . <i>Biopesticides International</i> 13 (2): 149-53.	4.82
10.	Kaur R, Singla N , Bansal N. And Pathak D (2017). Light and electron microscopic studies on papillae of rat tongue in response to ingestion of red chilli. <i>Indian Journal of Veterinary Anatomy</i> 29 (2): 59-61.	4.42
11.	Kaur A and Babbar BK (2018) Effect of cinnamic aldehyde as repellent on behaviour and gastrointestinal tract of house rat, <i>Rattus rattus</i> . <i>Indian Journal of Experimental Biology</i> 56 :803-11	6.00
12.	Kaur R and Singla N (2018). Potential of red chilli and capsicum oleoresin sprays as aversive agents against house rat (<i>Rattus rattus</i>) under simulated store conditions. <i>Agricultural Research Journal, PAU</i>	4.71

	55(3): 554-59.	
13.	Kaur R, Singla N , Bansal N and Pathak D (2018). Post-ingestional effects of red chilli powder containing capsaicin in stomach of house rat, <i>Rattus rattus</i> : histomorphological and histoenzymic studies. <i>Indian Journal of Animal Research</i> 52 (10): 1416-21.	6.20
14.	Sachdeva S and Singla N (2018). Antifeedant and repellent potential of alginate based microcapsules containing eucalyptus oil against house rat, <i>Rattus Rattus</i> . <i>Journal of Entomology and Zoology Studies</i> 6 (2): 608-17.	5.53
15.	Kaur N, Singla N and Singh R (2018) Efficacy of rodenticide bait application for rodent pest management in potato crop. <i>Journal of Entomology and Zoology Studies</i> 6 (2): 2149-52.	5.53
16.	Singla N and Kaur S (2018) Rodenticide baits of cholecalciferol, bromadiolone and their combinations against lesser bandicoot rat, <i>Bandicota bengalensis</i> . <i>Pesticide Research Journal</i> 30 (1): 85-91.	5.90
17.	Malhotra R and Singla N (2018). Analysis of regurgitated pellets of Spotted Owlet <i>Athene brama</i> (Temminck, 1821) (Aves: Strigiformes: Strigidae) from Punjab, India. <i>Journal of Threatened Taxa</i> 10 (6): 11717-24.	5.10
18.	Bala B and Babbar BK (2019) Development and testing of methyl anthranilate based formulations against rodents. <i>Journal of Entomology and Zoology Studies</i> 7 (1): 1586-95.	5.53
19.	Sandhu KK and Singla N (2019) Postnatal development and attainment of sexual maturity in male Indian gerbil, <i>Tatera indica</i> Hardwicke: morphometric, biochemical, spermatoc and histological evaluation. <i>Journal of Experimental Zoology India</i> 22 (1): 41-49.	5.51

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	54.60	51.89	2.19	0.41	0.00	0.00	54.49
2018-19	58.3	37.54	15	0.08	5.00	0.00	57.62

PUNJAB AGRICULTURAL UNIVERSITY, LUDHIANA-141004
(AGRICULTURAL ORNITHOLOGY)

Part I: General Information

1.	Name of the centre	:	Punjab Agricultural University, Ludhiana
2.	Sanction No.	:	11-1/81-PP dated 29.1.1982
3.	Date of Start	:	19.1.1983
4.	Date of termination	:	Network project of continuous nature
5.	Report period	:	2017-19
6.	Scientist-in-charge	:	Dr. Tejdeep Kaur Kler

7. Staff Position

Name of the post sanctioned	No. of posts	Name of incumbent	Date of joining	Status
Sr. Ornithologist (Rs. 37,400- 67,000)	1	Dr. Tejdeep Kaur	25.05.1996	Continuing
Assistant Ornithologist (Rs. 15,600-39,100)	1	Dr. Manoj Kumar	04.03.2010	Continuing
Tech. Assistant	1	Mr. Avtar Singh	02.01.2017	Continuing

Part II. Work Allotted (Technical Programme)

I. Multi locational Programmes

- BM 1 Surveillance of depredatory birds in predominant cropping systems (Rice/Wheat, Oilseed/Cereals).
- BM 2 **Community structure of birds and their diversity in relation to crop stages in different agro ecological zones of the region (Western Zone Punjab)**
- BM 3 To identify, develop and evaluate eco-friendly bird management techniques
- BM 4 Exploitation of beneficial birds for the suppressing of insect pests (Mustard/Berseem)
- BM 5 Evaluation of fruiting/ flowering trees to attract insectivorous/ omnivorous/ Depredatory birds to the agricultural landscape.
- BM 6 Farmers participatory research on bird management

II. Location Specific programmes:

- Biodiversity in agricultural landscape with relevance to conservation
- HV 1 Bio ecology and managements of higher vertebrates in different crops

Part III. Work Done

I. Multi location Programmes

BM 1. Surveillance of depredatory birds in predominant cropping systems (Rice/Wheat, Oilseed/Cereals).

Surveillance of depredatory birds in predominant cropping systems of Punjab was done for the given period. The observations were recorded as per the mandate in Rice, Wheat, Oil Seeds / Cereal Crops for depredatory bird species count, extent of damage at different growth stages and roosting sites. During the survey of wheat, rice and mustard crop field in different agro-climatic zones a total of 11 depredatory bird species were observed. Blue Rock Pigeon and House Crow were the most predominant species during the year 2017-18 and 2018-19 respectively.

Table 1: Observations on depredatory bird species presence and extent of damage at different growth stages of crops

Crop		Rice			Wheat			Mustard		
		Crop Stage			Crop Stage			Crop Stage		
S. No.	Depredatory bird Species	Nurse ry /Initial stage	Vegetati ve stage	Ripeni ng stage	Initia l stage	Vegetati ve stage	Ripeni ng stage-	Initia l stage	Vegetati ve stage	Ripeni ng stage
1	House Crow	✓	-	-	✓	-	-	✓	-	-
2	Rose-ringed Parakeet	-	-	-	-	-	-	-	-	✓
3	Indian Peafowl	-	-	-	✓	✓	-	✓	✓	-
4	Blue Rock Pigeon	✓	-	✓	✓	-	✓	✓	-	✓
5	Eurasian Collared-Dove	✓	-	✓	✓	-	✓	✓	-	✓
6	Common Myna	-	-	-	✓	-	-	✓	-	-
7	Spotted Munia	-	-	✓	-	-	-	-	-	✓
8	White-throated Munia	-	-	✓	-	-	-	-	-	✓
9	Purple Moorhen	-	✓	-	-	-	-	-	-	-
10	Common Moorhen	-	✓	-	-	-	-	-	-	-
11	House Sparrow	✓	-	✓	✓	-	✓	✓	-	✓
Extent of Damage		2-5%	1-5%	0.5-5%	2-6.5%	0%	1-5%	3.5-6%	0%	5-15%

(✓) Observed; (-) not observed

Table 1 shows the variation in bird species in different crops with different stages. Maximum damage was found in maturing stage of mustard. In vegetative stage, there was less damage to the crops but in the rice fields, the presence of Purple Moorhen and Indian Moorhen may causes up to 5.00% damage to the crop. In case of wheat the maximum damage occurred in initial stage of the crop.

BM 2: Community Structure of Birds and their Diversity in relation to crop stages in western Zone of Punjab

As per the mandate the community structure of birds and diversity was studied in different crops in western zone of Punjab. The observations of the community structure in different crops are given in Table 2.

Table 2: Bird community structure observed in Wheat crop (2017-18) and their diversity in relation to stages in western agro-climatic zone of Punjab

SN	Bird Species	% Abundance at different growth stage of wheat crop		
		Initial stage	Vegetative stage	Maturing stage
1.	House Crow	1.49	7.14	
2.	Common Myna	11.11	16.08	9.23
3.	White Wagtail	5.55	-	-

4.	Red-wattled Lapwing	20.00	14.29	4.61
5.	Grey Wagtail	20.38	-	-
6.	Cattle Egret	7.78	8.92	3.08
7.	Black Kite	0.74	1.79	1.53
8.	Large Pied Wagtail	4.08	3.58	-
9.	Black Drongo	4.08	1.79	1.53
10.	Blue Rock Pigeon	6.67	1.79	69.23
11.	Bank Myna	1.11	3.58	-
12.	Black Ibis	2.60	5.35	-
13.	Citrine Wagtail	0.74	-	-
14.	Eurasian Collared-Dove	12.22	5.35	6.15
15.	Indian Roller	0.38	1.79	-
16.	Paddyfield Pipit	1.11	5.35	4.61
17.	Plain Prinia	-	3.58	-
18.	Rose-ringed Parakeet	-	5.35	-
19.	White-breasted Waterhen	-	1.79	-
20.	Small Bee-eater	-	5.35	-
21.	Jungle Babbler	-	5.35	-
22.	Pied Bushchat	-	1.79	-

During the survey of wheat crop field in western agro-climatic zone, a total of 22 bird species were observed. Grey Wagtail and Red-wattled Lapwing were most abundant during the initial stages of the crop with an abundance of 20.38 and 20.00. Blue Rock Pigeon was the most predominant at maturing stage (69.23%) during the year 2017-18. Commonly abundant bird species were House Crow, Common Myna, Red-wattled Lapwing, Cattle Egret, Black Kite, Large Pied Wagtail, Black Drongo, Blue Rock Pigeon, Bank Myna, Black Ibis, Eurasian Collared-Dove in wheat fields.

Table 3: Bird community structure observed in Wheat crop (2018-19) and their diversity in relation to stages in western agro-climatic zone of Punjab

Wheat (Per cent abundance of birds)				
S No	Bird Species	Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Black Kite	1.44	-	-
2.	Black Drongo	5.80	4.44	8.33
3.	Common Myna	10.14	13.33	8.33
4.	Blue Rock Pigeon	15.45	10.00	23.33
5.	White Wagtail	3.87	2.22	1.67
6.	House Crow	1.93	2.22	5.00
7.	Red-wattled Lapwing	23.68	24.44	8.33
8.	Large Pied Wagtail	5.80	2.22	-
9.	Black Ibis	3.39	-	-
10.	Cattle Egret	11.11	22.22	3.33
11.	Citrine Wagtail	1.44	-	-
12.	Red-vented Bulbul	1.44	3.33	-
13.	Grey wagtail	9.18	-	-
14.	Black-winged Stilt	2.41	-	-
15.	Bank Myna	1.44	-	-

16.	Indian Roller	0.49	-	1.67
17.	Eurasian Collared-Dove	0.97	2.22	8.33
18.	Greater Coucal	-	1.11	1.67
19.	Small Bee-eater	-	3.33	3.33
20.	White-breasted	-	-	1.67
21.	Paddyfield Pipit	-	-	11.67
22.	Plain Prinia	-	8.89	-
23.	Rose-ringed Parakeet	-	-	13.33

During the survey of wheat crop field in western agro-climatic zone, a total of 23 bird species were observed in 2018-19. Red-wattled Lapwing and Blue Rock Pigeon were most abundant during the initial stages of the crop with an abundance of 23.68 and 15.45 respectively. Blue Rock Pigeon was the most predominant depredatory bird species at initial stage and maturing stage. Rose-ringed Parakeet was observed during the maturing stage of the crop. Commonly abundant bird species were Black Drongo, Common Myna, Blue Rock Pigeon, House Crow, Red-wattled Lapwing, Eurasian Collared-Dove in wheat fields in crop year 2018-19.

Survey was conducted to study the bird community structure in Pearl millet crop (2017) and their diversity in relation to various stages of crop fields. A total of 17 bird species were observed in 2017. Common Swallow was most abundant during the initial stages of the crop with an abundance of 54.55%. Red-wattled Lapwing and Cattle Egret were most abundant during the vegetative phase. Maximum bird diversity was observed at the maturing stage of the crop as maximum of 14 species were observed during this phase. Blue Rock Pigeon was observed during the maturing stage of the crop with relative abundance of 18.33%.

Table 4: Bird community structure observed in Pearl millet crop (2017) and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Pearl millet (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Greater Coucal	9.09	2.78	-
2.	Small Bee-eater	27.27	-	5.00
3.	House Crow	9.09	-	1.67
4.	Common Swallow	54.55	-	-
5.	Common Myna	-	13.89	8.33
6.	Black Drongo	-	13.89	1.67
7.	Red-wattled Lapwing	-	30.56	1.67
8.	Cattle Egret	-	27.78	5.00
9.	Eurasian Collared-Dove	-	8.33	6.67
10.	Rose-ringed Parakeet	-	2.78	5.00
11.	Baya Weaver	-	-	8.33
12.	Spotted Munia	-	-	6.67
13.	White-throated Munia	-	-	6.67
14.	Paddy field Pipit	-	-	10.00
15.	Black Kite	-	-	3.33
16.	Jungle Babbler	-	-	11.67
17.	Blue Rock Pigeon	-	2.78	18.33

Table 5 Bird community structure observed in Pearl millet crop (2018) and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Pearl millet(Per cent abundance of birds)			
	Bird Species	Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Small Bee-eater	11.65	7.14	2.04
2.	House Crow	2.78	-	4.09
3.	Common Myna	19.44	17.86	10.21
4.	Greater Coucal	5.55	-	-
5.	Cattle Egret	33.33	35.72	22.44
6.	Black Drongo	8.33	7.14	4.09
7.	Red-wattled Lapwing	2.78	7.14	10.20
8.	Common Swallow	5.55	-	-
9.	Eurasian Collared-Dove	5.55	10.72	-
10.	White-breasted Kingfisher	-	3.58	-
11.	Bank Myna	-	7.14	6.12
12.	Indian Roller	-	3.58	2.04
13.	White-throated Munia	-	-	8.60
14.	Rose-ringed Parakeet	-	-	6.12
15.	Rufous-fronted Prinia	-	-	2.04
16.	Blue Rock Pigeon	5.02		22.01

Survey was conducted to study the bird community structure in Pearl millet crop (2018) and their diversity in relation to various stages of crop fields. A total of 16 bird species were observed in 2018. Cattle Egret followed by Common Myna was found most abundant during the initial stages of the crop with an abundance of 33.33% and 19.44% respectively. Cattle Egret were most abundant during the vegetative phase with relative abundance of 35.72%. Maximum bird diversity was observed at the maturing phase of the crop and 12 species were found during this phase. Cattle Egret and Blue Rock Pigeon were observed maximum during the maturing stage of the crop with relative abundance of 22.44% and 22.01% respectively.

Table 7: Bird community structure observed in Mustard crop (2017-18) and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Mustard (Per cent abundance of birds)			
	Bird Species	Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Blue Rock Pigeon	40.38	-	13.79
2.	Red-wattled Lapwing	21.15	8.33	-
3.	Common Myna	3.85	14.58	13.79
4.	Eurasian Collared-Dove	19.23	4.17	10.34
5.	White Wagtail	3.85	8.33	-
6.	Large Pied Wagtail	1.92	-	-
7.	Bank Myna	7.69	-	-
8.	Black Drongo	1.92	4.17	-
9.	House Crow	-	8.33	6.90
10.	Cattle Egret	-	12.50	-
11.	Black-winged Stilt	-	6.25	-
12.	White-breasted Kingfisher	-	2.08	-
13.	Jungle Babbler	-	14.58	24.13

14.	Common Hoopoe	-	2.08	-
15.	Paddyfield Pipit	-	-	6.90
16.	Black Redstart	-	2.08	-
17.	Spotted Munia	-	-	10.34
18.	Plain Prinia	-	12.50	-
19.	Rose-ringed Parakeet	-	-	13.79

During the survey period of Mustard 2017-18 for studying the bird community structure and their diversity in relation to various stages of crop fields. A total of 19 bird species were observed in 2017-2018. Blue Rock Pigeon was found most abundant during the initial stages of the crop with relative abundance of 40.38%. Common Myna, Jungle Babbler and Cattle Egret were most abundant during the vegetative phase with relative abundance of 14.58%, 14.58% and 12.50%. Jungle Babbler was found maximum during the maturing stage of the crop with relative abundance of 24.13%.

Table 8: Bird community structure observed in Mustard crop (2018-19) and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Mustard (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Common Myna	25.42	20.31	21.43
2.	Blue Rock Pigeon	40.68	-	29.76
3.	House Crow	3.39	1.56	-
4.	Eurasian Collared-Dove	6.78	7.81	16.67
5.	Red-wattled Lapwing	16.95	18.75	-
6.	Ashy Prinia	3.39	-	3.17
7.	Jungle Babbler	-	14.06	8.33
8.	Plain Prinia	-	14.06	-
9.	Indian Chat	-	6.25	-
10.	Rose-ringed Parakeet	-	1.56	13.09
11.	Spotted Dove	-	1.56	-
12.	Black Drongo	-	6.25	-
13.	Cattle Egret	3.39	7.81	-
14.	Asian Pied Starling	-	-	2.38
15.	Black Redstart	-	-	4.96

During the survey period of mustard 2018-19 for studying the bird community structure and their diversity in relation to various stages of crop. A total of 15 bird species were observed in 2018-2019. Blue Rock Pigeon was found most abundant during the initial stages of the crop with relative abundance of 40.68%. Common Myna and Red-wattled Lapwing were most abundant during the vegetative phase with relative abundance of 20.31% and 18.75%. Relative abundance of Blue Rock Pigeon was found maximum during both the years and found causing maximum damage in the field.

Table 9: Bird community structure observed in Potato 2017 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Potato (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Common Myna	25.26	17.24	35.48

2.	Red-wattled Lapwing	15.26	44.83	12.90
3.	Black Drongo	10.53	10.34	6.45
4.	House Crow	12.63	6.90	12.90
5.	Plain Prinia	-	10.34	-
6.	White Wagtail	10.00	-	12.90
7.	Large Pied Wagtail	-	-	6.45
8.	Cattle Egret	26.31	10.34	12.90

Table 10: Bird community structure observed in Potato 2018 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Potato (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Red-vented Bulbul	5.26	-	14.28
2.	Common Myna	26.31	32.14	23.81
3.	House Crow	10.53	3.57	4.76
4.	Black Drongo	10.53	7.14	4.76
5.	Red-wattled Lapwing	15.79	14.28	9.52
6.	Common Hoopoe	-	-	4.76
7.	White Wagtail	15.79	7.14	9.52
8.	Large Pied Wagtail	-	3.57	9.52
9.	Grey Wagtail	-	10.71	19.05
10.	Paddyfield Pipit	-	10.71	-
11.	Cattle Egret	15.79	10.71	-

Survey was conducted for the period of 2017 and 2018 for studying the bird community structure and their diversity in relation to various stages of potato crop fields. In case of potato crop, only eight species in 2017 and 11 species in 2018 were observed. In potato crop, Common Myna was most predominant species in both the years initial stages of potato crop. Other mostly observed species in potato field were Red-vented Bulbul, House Crow, Black Drongo, Red-wattled Lapwing and White Wagtail.

Table 11: Bird Community Structure observed in Paddy 2018 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Paddy (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Cattle Egret	25.33	5.88	-
2.	House Crow	2.67	-	3.92
3.	Indian Pond-Heron	10.67	11.76	-
4.	Common Myna	8.67	11.76	3.92
5.	Blue Rock Pigeon	4.00	-	5.88
6.	Asian Pied Starling	4.67	5.88	-
7.	Bank Myna	8.67	-	19.61
8.	Red-wattled Lapwing	9.33	5.88	9.80
9.	Black Ibis	1.33	-	-
10.	Greater Coucal	0.67	5.88	1.96
11.	Black Kite	0.67	-	-
12.	White-breasted	0.67	-	1.96

13.	White-necked Stork	0.67	-	-
14.	Small Bee-eater	8.00	8.82	-
15.	Indian Roller	0.67	-	1.96
16.	Shikra	0.67	-	1.96
17.	Paddyfield Pipit	4.00	11.76	-
18.	Eurasian Collared-Dove	2.67	-	-
19.	Plain Prinia	-	8.82	3.92
20.	Black Drongo	-	5.88	3.92
21.	Common Swallow	-	14.70	3.92
22.	Red-vented Bulbul	-	-	25.49
23.	Spotted Munia	-	-	3.92
24.	White-breasted	-	12.94	7.84
25.	Black-winged Stilt	6.03	-	-

During the survey of paddy crop field, a total of 25 bird species were observed in 2018. Cattle Egret and Indian Pond Heron were abundant in initial stage with relative abundance of 25.33% and 10.67% respectively whereas Red-vented Bulbul and Bank Myna were abundant in maturing stages of the crop with relative abundance of 25.49% and 19.61%.

Table 12: Bird community structure observed in Berseem 2017- 18 and their diversity in relation to stages in western agro-climatic zone of Punjab

Berseem (Per cent abundance of birds)				
S No	Bird Species	Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	House Crow	15.38	3.85	2.70
2.	Red-wattled Lapwing	15.38	21.79	16.22
3.	Black Drongo	7.69	5.12	6.76
4.	Cattle Egret	15.38	19.23	24.32
5.	Black Ibis	7.69	1.28	2.70
6.	Common Stonechat	-	2.56	-
7.	Common Myna	30.77	32.05	21.62
8.	White-breasted Kingfisher	7.69	0.64	-
9.	Bank Myna	-	8.33	-
10.	Black-winged Stilt	-	3.20	2.70
11.	White Wagtail	-	1.28	-
12.	Large Pied Wagtail	-	0.64	-
13.	Small Bee-eater	-	-	8.11
14.	Spotted Munia	-	-	8.11
15.	Eurasian Collared-Dove	-	-	6.76

Table 13: Bird community structure observed in Berseem 2018-19 and their diversity in relation to stages in western agro-climatic zone of Punjab

Berseem (Per cent abundance of birds)				
S No	Bird Species	Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Greater Coucal	2.94	5.33	-
2.	Eurasian Collared-Dove	2.94	-	-
3.	Indian Chat	2.94	2.67	-
4.	Red-wattled Lapwing	26.47	45.33	19.23
5.	Red-vented Bulbul	5.88	5.33	-
6.	Spotted Munia	8.82	6.67	13.46
7.	Common Myna	17.65	-	23.08

8.	Blue Rock Pigeon	5.88	-	13.46
9.	Bank Myna	8.82	4.00	5.77
10.	Large Pied Wagtail	11.76	-	-
11.	White-breasted Kingfisher	2.94	-	1.92
12.	Black Drongo	2.94	4.00	3.85
13.	Cattle Egret	-	9.33	3.85
14.	Indian Pond-Heron	-	2.67	-
15.	White Wagtail	-	4.00	-
16.	Rufous-backed Shrike	-	1.33	1.92
17.	Paddyfield Pipit	-	5.33	-
18.	House Crow	-	2.67	3.85
19.	Black Ibis	-	1.33	1.92
20.	Small Bee-eater	-	-	7.69

Relative abundance of Common Myna and Red-wattled Lapwing was found maximum during the study period in both the years in berseem crop. A total of 15 species observed in 2017-18 while 20 species were observed in 2018-19 crop season respectively.

Table 14: Bird community structure observed in Moong 2018 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Moong (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Small Bee-eater	23.07	5.06	-
2.	Plain Prinia	15.38	10.09	-
3.	Common Myna	15.38	17.18	17.67
4.	Red-wattled Lapwing	14.38	6.06	24.00
5.	Blue Rock Pigeon	8.69	25.24	24.00
6.	Black Drongo	6.69	6.06	9.33
7.	Eurasian Collared-Dove	-	7.06	9.33
8.	House Crow	-	5.06	-
9.	Rose-ringed Parakeet	-	11.12	15.67
10.	Bank Myna	16.38	10.09	-

Table 15: Bird community structure observed in Moong 2019 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Moong (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Small Bee-eater	21.07	6.06	-
2.	Plain Prinia	15.38	9.09	-
3.	Common Myna	17.38	18.18	16.67
4.	Red-wattled Lapwing	15.38	6.06	25.00
5.	Blue Rock Pigeon	7.69	24.24	25.00
6.	Black Drongo	7.69	6.06	8.33
7.	Eurasian Collared-Dove	-	6.06	8.33
8.	House Crow	-	6.06	-
9.	Rose-ringed Parakeet	-	12.12	16.67
10.	Bank Myna	15.38	9.09	-

Moong is a pulse crop having high nutritional value. The abundance study of birds in this crop fields was taken for two years. Ten species of birds were observed in moong crop fields during both the years 2018 and 2019. Small Bee-eater was most dominating species in both the years at initial stage while Blue Rock Pigeon was more abundant at vegetative stage in both years. Red-wattled Lapwing and Blue Rock Pigeon were most abundant during the maturing stages of the crop with an abundance of 24.00% in 2017-18 and 25.00% in 2018-19 respectively for both the species.

Table 16: Bird community structure observed in Summer Squash 2018 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Summer Squash (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Red-wattled Lapwing	13.33	14.29	14.29
2.	Cattle Egret	20.67	9.52	-
3.	Common Myna	26.00	14.29	21.43
4.	Black-winged Stilt	13.33	-	-
5.	House Crow	13.33	4.76	14.29
6.	Black Drongo	-	9.57	7.14
7.	Red-vented Bulbul	-	4.76	7.14
8.	Plain Prinia	-	19.05	14.29
9.	Small Bee-eater	-	-	14.29
10.	White-breasted Kingfisher	6.67	-	-
11.	Paddyfield Pipit	-	9.52	-
12.	Ashy Prinia	-	9.52	7.14
13.	Asian Pied Starling	6.67	-	-
14.	Common Hoopoe	-	4.76	-

Table 17: Bird community structure observed in Summer Squash 2019 and their diversity in relation to stages in western agro-climatic zone of Punjab

S No	Bird Species	Summer Squash (Per cent abundance of birds)		
		Growth stage of crop		
		Initial stage	Vegetative stage	Maturing stage
1.	Common Swallow	18.75	-	-
2.	Bank Myna	18.75	-	19.05
3.	Red-wattled Lapwing	12.50	12.50	9.52
4.	Cattle Egret	6.25	8.33	-
5.	House Crow	12.50	4.17	9.52
6.	Common Myna	31.25	29.17	19.05
7.	Red-vented Bulbul	-	8.33	4.76
8.	Plain Prinia	-	12.50	19.05
9.	Small Bee-eater	-	-	9.52
10.	Black Redstart	-	4.17	4.76
11.	Jungle Babbler	-	20.83	-
12.	White-breasted Kingfisher	6.25	-	4.76

In 2018, Common Myna was found most abundant species with relative abundance of 26.00%, 21.43% at initial and maturing stage respectively. In 2019, Common Myna, Bank Myna and Plain prinia were found with most relative abundance of 19.05% at maturing stage to on the other hand Black Redstart, White-breasted Kingfisher and Red-vented Bulbul was found as least abundant species at maturing stage if Summer squash with relative abundance of 4.76% each.

Table 18: Relative abundance of different bird species observed in Maize fields (2018-19)

Village Species  	Mirzapur	Sheikhupur	Rasoolpur	Gehal Mazari
Red-wattled Lapwing	15.38	-	20.0	40.0
House Crow	30.77	23.08	-	-
Green Bee-eater	15.38	-	-	-
Crow Pheasant	7.69	-	-	-
Black Drongo	7.69	2.56	-	20.0
Little Brown Dove	23.08	-	-	-
Common Myna	-	15.38	-	40.0
Tailor Bird	-	5.13	-	-
Common Swallow	-	33.33	-	-
Rose-ringed Parakeet	-	10.26	-	-
Bank Myna	-	5.13	13.33	-
Ring Dove	-	5.13	-	-
Cattle Egret	-	-	46.67	-
Black Winged Stilt	-	-	20.0	-

The community structure of birds in Maize fields of three villages falling in Districts namely Mohali (Mirzapur), Kapurthala (Sheikhupur), Ferozpur (Rasoolpur) and SBSN (Gehal Mazari) was recorded. A total of 14 species were recorded. House Crow was the most dominant species in the fields of Mirzapur whereas Common Swallow and Cattle Egret were the dominant species found in fields of Sheikhupur and Rasoolpur villages respectively. Community structure of birds in village Gehal Mazari, district SBSN consisted of three species. Red-wattled Lapwing and Common Myna were equally dominant species with relative abundance of 40.0%.

Table 19: Relative abundance of different bird species observed in Maize fields (2017-18)

Villages Species  	Malowal	ParjainKalan	Rautan	Shahkot	Malsian
Common Plain Warbler	41.67	-	44.4	0.77	-
House Crow	8.33	35	22.2	2.15	26.67
Grey Hornbill	8.33	-	-	-	-
Red Vented Bulbul	16.67	-	-	-	-
Rose Ringed Parakeet	25	-	22.2	1.08	-
Common Swallow	-	30	-	89.61	-
Green Bee-eater	-	30	-	6.09	-
Crow Pheasant	-	5	-	0.36	-
Blue Rock Pigeon	-	-	11.11	-	-
Common Myna	-	-	-	-	20
Pied Myna	-	-	-	-	13.33
Cattle Egret	-	-	-	-	13.33
White Throated Munia	-	-	-	-	26.67

The community structure of avian species in Maize field of 5 villages under district Jalandhar consisted of 13 avian species. Common Swallow was abundant with relative abundance of

89.61%. Common Plain Warbler was predominantly abundant with relative abundance of 44.4%. House Crow was found with relative abundance of 35%.

Table 20: Relative abundance of different bird species observed in Sugarcane Field of Khan Khana village (2017-18)

Villages → Species ↓	Khan Khana
Ring Dove	13.33
Baya Weaver	13.33
Crow Pheasant	6.66
House Crow	26.67
Common Babbler	40

The community structure of bird species in Sugarcane field of village Khan Khana of District Shaheed Bhagat Singh Nagar consisted of 5 avian species. Common Babbler was most abundant with relative abundance of 40% followed by House Crow with relative abundance of 26.67%.

Table 21: Relative abundance of different bird species observed in Sugarcane Field of selected villages (2017-18)

Villages → Species ↓	Kala (Jalandhar)	Bakra (Hoshiarpur.)	Pind (Hoshiarpur.)	Bassijalal (Hoshiarpur)
Ring Dove	30.00	-	-	-
Common Babbler	60.00	-	-	-
House Crow	10.00	-	-	50.00
Red-wattled Lapwing	-	16.67	-	33.33
Crow Pheasant	-	33.33	-	-
Black Drongo	-	16.67	-	-
Cattle Egret	-	33.33	-	-
Indian Roller	-	-	-	16.67

The community structure of bird species in sugarcane field of village Kala Bakra under district Jalandhar, Beas pind and Bassijalal under district Hoshiarpur. Common Babbler was the most abundant species found in Kala Bakra with relative abundance of 60% whereas Crow Pheasant and Cattle Egret was equally dominant 33.33% species in Beas pind. House Crow was the dominant species found in village Bassijalal.

Table 22: Relative abundance of different bird species observed in Sugarcane fields in Mohali and Kapurthala Districts (2018-19).

Village → Species ↓	Palanpur	Chaheru
Crow Pheasant	12.5	4.54
Ring Dove	25.00	9.09
Baya weaver	50.00	-
House Crow	12.50	9.09
White-throated Munia	-	9.09
Indian Roller	-	4.54
Common Babbler	-	63.63

The community structure of birds in Sugarcane fields of two villages falling in Districts namely Mohali (Palanpur) and Kapurthala (Chaheru) was recorded. Baya Weaver was the dominant

species found in fields of Palanpur whereas Common Babbler was the dominant species dominant species found in Chaheru fields.

BM 3: To identify, develop and evaluate eco-friendly bird management techniques

Table 23: Field evaluation of different management methods in various crops

Material Used	Name of the Crop	Purpose	Remarks
Insect solar Light trap	Tomato, Chilies	Used to collect harmful insect-pests especially lepidopteran pests, hemipteran, coleopteran and dipteran pests causing damage to fruits and foliage	There is significant reduction in fruit damage after trap installation as compared to control plots thus reduction pesticide usage and also during dusk and dawn hours the bird activity was also high for feeding on trap catch
Bird protection net	Peas, cucurbits seedlings	To prevent the crop from damage by birds especially the crows as they feed on the growing media and seedlings when the plug trays are kept in open for proper growth of plants and also the birds cause damage to seed crop of peas.	100.00% protection from bird damage to seedlings and seed crop was observed.
Nylon net	Muskmelon, pumpkin, capsicum	Protection of crop from damage by birds, insect-pests and environmental factors like high or low temperature	The crops raised used nylon net cages is protected from bird damage and also protected from abiotic and biotic factors resulting in high growth and yield
Reflecting tape	Peas, Tomato, chilies, Mustard,	Reflective tapes scare away the birds especially at seedling stage of the crop as well as at seed maturation stage of the crop	90-95% protection was observed in peas at seed maturation phase.
Cue lure Chemical	Bitter gourd, sponge gourd, water melon, muskmelon, pumpkin	Used in preparation of fruit fly traps	The use of cue lure trap is beneficial for non-chemical pest management.

Various different botanical, chemical and non chemical as deterrents in the fields were installed, Insect solar light trap caused significant reduction in fruit damage after trap installation as compared to control plots. the bird activity was also high during the dusk and dawn hours for feeding on trap catch. There was 100% protection of crop in bird protection net and nylon nets for pea, cucurbits, muskmelon, pumpkin, and capsicum. Reflective tape was used in pea, tomato, chili and mustard and was found up to 95% effective.

Table 24: Different bird species observed in experimental (reflective ribbon) and control field of Mustard crop (2017-18) during seed setting to maturity stage

S. No.	Bird Species	Crop Field with reflective ribbon	Control Field
1	Common Myna	38.33	20.61
2	Jungle Babbler	33.33	6.87
3	Paddyfield Pipit	13.33	-
4	Red-wattled Lapwing	-	9.16
5	Plain Prinia	11.66	21.38
6	Spotted Munia	-	2.29
7	Indian Chat	-	4.58
8	Rose-ringed Parakeet	-	9.16
9	Eurasian Collared-Dove	-	6.11
10	Spotted Dove	-	1.53
11	Black Drongo	-	3.05
12	Cattle Egret	-	3.82
13	House Crow	-	9.16
14	Asian Pied Starling	3.33	-
15	Ashy Prinia	-	2.29

It was observed that Common Myna and Jungle Babbler were not affected by the installation of reflective ribbons. Total of 5 species were observed in the field with reflective ribbon where as 13 Species were observed in the control field. No Depredatory bird species was noted in mustard crop field.

Table 25: Comparative damage assessment observed in experimental (reflective ribbon) and control field (2017-18) of Mustard crop during seed setting to maturity stage

Sample No	Field with reflective ribbon		Control Field	
	Total number of Pods	Total No of Damaged Pods	Total number of Pods	Total No of Damaged Pods
1	290	7	333	23
2	285	6	269	18
3	330	8	246	26
4	249	6	289	25
5	296	9	216	19
	1450	36 (2.48 %)	1353	111 (8.20%)

In maturity stage of mustard crop, reflective ribbon was found effective and reduced the damage to 2.48% from 8.20% (Control field).

Table 26: Different bird species observed in experimental (reflective ribbon) and control field of Mustard crop (2018-19) during seed setting to maturity stage

S. No.	Bird Species	Crop Field with reflective ribbon	Control Field
1	Jungle Babbler	35.00	16.87
2	Common Myna	35.00	21.38
3	Paddyfield Pipit	14.33	-
4	Red-wattled Lapwing	-	8.16
5	Plain Prinia	15.66	-
6	Spotted Munia	-	3.29
7	Indian Chat	-	4.58
8	Rose-ringed Parakeet	-	10.15
9	Eurasian Collared-Dove	-	5.12
10	Grey Wagtail	-	2.50
11	Black Drongo	-	2.05

12	Cattle Egret	-	7.82
13	House Crow	-	15.86
14	Ashy Prinia	-	2.29

It was observed that Common Myna and Jungle Babbler were not affected by the installation of reflective ribbons. Total of four species were observed in the field with reflective ribbon where as 12 species were observed in the control field.

Table 27: Comparative damage assessment observed in experimental (reflective ribbon) and control field of Mustard crop (2018-19) during seed setting to maturity stage

Sample No	Field with reflective ribbon		Control Field	
	Total number of Pods	Total No of Damaged Pods	Total number of Pods	Total No of Damaged Pods
1	280	6	330	25
2	295	7	265	17
3	320	8	244	25
4	244	5	282	24
5	285	8	225	20
	1424	34 (2.38 %)	1346	111 (8.25%)

In maturity stage of mustard crop, reflective ribbon was found effective and reduced the damage to 2.38% from 8.25% (Control field).

Table 28: Different bird species observed in experimental (reflective ribbon) and control field of Tomato crop (2017-18) during fruiting stage.

S. No.	Bird Species	Crop Field with reflective ribbon	Control Field
1.	Common Myna	32.35	7.20
2.	Red-wattled Lapwing	13.33	6.20
3.	White Wagtail	13.33	5.55
4.	Paddyfield Pipit	-	9.20
5.	Ashy Prinia	-	4.25
6.	Plain Prinia	-	6.55
7.	Black Drongo	-	6.58
8.	Large Pied Wagtail	-	4.08
9.	Common Starling	20.0	6.55
10.	Jungle Babbler	13.34	-
11.	Common Hoopoe	-	4.28
12.	Pied Bushchat	-	1.50
13.	House Crow	7.65	38.06

Table 29: Comparative damage assessment observed in experimental (reflective ribbon) and control field of Tomato crop (2017-18) during fruiting stage

	Field with reflective ribbon		Control Field	
	Total no of Fruit	Total Damaged Fruit	Total no. of Fruit	Total Damaged Fruit
1	15	2	20	3
2	12	1	22	4
3	20	1	18	2
4	19	1	19	3
5	22	0	20	2
	88	5 (5.68%)	99	14 (14.14%)

(*Sample Size =1 Plant)

In tomato crop, the reflective ribbon was found effective at fruiting stage. It was observed that the relative abundance of House Crow was decreased to 7.65% from 38.06%. In the experimental field, the damage was recorded to be decreased to 5.68% from 14.14% (Control field).

Table 30: Different bird species observed in experimental (reflective ribbon) and control field of Tomato crop (2018-19) during fruiting stage

S. No.	Bird Species	Crop Field with reflective ribbon	Control Field
1.	House Crow	6.67	36.06
2.	Red-wattled Lapwing	13.33	8.20
3.	Common Myna	13.33	8.20
4.	Paddyfield Pipet	-	8.20
5.	Black Drongo	-	6.55
6.	Plain Prinia	6.67	6.55
7.	Rufous-fronted Prinia	-	3.28
8.	White Wagtail	13.33	6.55
9.	Large Pied Wagtail	6.67	3.28
10.	European Starling	20.0	6.55
11.	Common Hoopoe	6.67	-
12.	Grey Wagtail	6.67	3.28
13.	Pied Bushchat	6.67	3.28

Table 31: Comparative damage assessment observed in experimental (reflective ribbon) and control field of Tomato crop (2018-19) during fruiting stage

S. No	Field with reflective ribbon		Control Field	
	Total no of Fruit	Total Damaged Fruit	Total no. of Fruit	Total Damaged Fruit
1	19	2	20	4
2	13	0	22	4
3	22	2	18	2
4	16	0	16	4
5	25	1	11	3
	95	5 (5.2%)	87	11(12.6%)

(*Sample Size =1 Plant)

In tomato crop, the reflective ribbon was found effective at fruiting stage. It was observed that the relative abundance of House Crow was decreased to 6.67% from 36.06%. In the experimental field, the damage was recorded to be decreased to 5.2% from 12.6% (Control field). House Crow was found causing maximum damage to the crop in both the seasons.

Table 32: Comparative damage assessment observed in experimental (Nylon Net) and control field of mustard crop (2017-18) at germinating stage

Sample No	Field with Jute Ropes			Control Field		
	Total number of Plants	Total No of Damaged Plants	% Damage	Total number of Plants	Total No of Damaged Plants	% Damage
1	218	-	-	261	35	13.40
2	234	-	-	199	24	12.06

3	220	-	-	248	36	14.52
4	258	-	-	257	39	15.18
5	239	-	-	262	37	14.12
			0.00 %			13.86%

Nylon nets were installed in Mustard crop during the germinating stage to check for comparative damage assessment of Nylon net with control field. There was nil damage in the experimental field whereas 13.86% damage was recorded in control field.

Table 33: Comparative damage assessment observed in experimental (Nylon Net) and control field of mustard crop (2017-18) at germinating stage

Sample No	Field with Jute Ropes			Control Field		
	Total number of Plants	Total No of Damaged Plants	% Damage	Total number of Plants	Total No of Damaged Plants	% Damage
1	205	4	1.95	219	28	12.79
2	250	5	2.00	214	44	20.56
3	270	8	2.96	258	32	12.40
4	262	5	1.90	260	29	11.15
5	238	4	1.68	240	33	13.75
			2.10%			14.13%

During the comparative analysis of using jute rope in the mustard crop at germinating stage for preventing the damage from peafowl it was observed that jute ropes were significantly effective in reducing the damage at germinating stage. The damage was reduced to 2.10% from 14.13% (Control field).

Table 34: Comparative damage assessment observed in experimental (Nylon Net) and control field of mustard crop (2018-19) at germinating stage

Sample No	Field with Jute Ropes			Control Field		
	Total	Total No of	% Damage	Total	Total No of	% Damage
1	215	-	-	250	36	14.4
2	225	-	-	200	25	12.5
3	230	-	-	250	38	15.2
4	240	-	-	234	34	14.53
5	235	-	-	220	36	16.36
			0%			14.60

For the crop year 2018-19, Nylon nets were installed in Mustard crop during the germinating stage to check for comparative damage assessment of Nylon net with control field. There was nil damage in the experimental field whereas 14.60% damage was recorded in control field.

Table 35: Comparative damage assessment observed in experimental (Jute Rope) field for the control of Peafowl damage to mustard crop (2018-19) at germinating stage

Sample No	Field with Jute Ropes			Control Field		
	Total number of Plants	Total No of Damaged Plants	% Damage	Total number of Plants	Total No of Damaged Plants	% Damage

1	215	3	1.39	220	30	13.63
2	240	5	2.08	215	42	19.53
3	265	7	2.64	255	35	13.72
4	263	5	1.90	258	30	11.63
5	225	5	2.22	251	32	12.75
			2.04%			14.25%

During the comparative analysis of using jute rope in the mustard crop at germinating stage for preventing the damage from peafowl it was observed that jute ropes were significantly effective in reducing the damage at germinating stage. The damage was reduced to 2.04% from 14.25% (Control filed).

BM4: Exploitation of beneficial birds for the suppressing of insect pests (Mustard/Berseem)

Table 36: Observations of beneficial birds in the field of Berseem 2017-18 exploiting resources (T-Perches) in agriculture landscape for suppressing of insect pests

Berseem										
S No	Bird Species	Initial Stage			Vegetative Stage			Maturing Stage		
		Crop Field	On 'T' Perches	Over head Electric Cable	Crop Field	On 'T' Perches	Over head Electric Cable	Crop Field	On 'T' Perches	Over head Electric Cable
1.	Red-wattled Lapwing	15.00	-	-	26.42	-	-	28.57	-	-
2.	House Crow	20.00	33.33	16.67	11.32	-	25.00	9.52	-	13.33
3.	Cattle Egret	10.00	-	-	7.55	-	-	9.52	-	-
4.	Common Myna	15.00	33.33	33.33	13.21	16.67	8.33	14.29	14.29	13.33
5.	Blue Rock Pigeon	10.00	-	-	-	-	16.67	9.52	-	20.00
6.	Black Drongo	-	-	16.67	-	16.67	8.33	-	14.29	-
7.	White Wagtail	15.00	-	-	7.55	8.33	-	-	-	-
8.	Large Pied Wagtail	5.00	-	-	3.77	-	-	-	-	-
9.	Red-vented Bulbul	-	-	-	-	16.67	-	4.76	28.57	-
10.	Bank Myna	-	-	33.33	5.66	8.33	8.33	-	-	-
11.	Asian Pied Starling	-	-	-	3.77	-	-	-	-	13.33

12	Black-winged Stilt	10.00	-	-	-	-	-	-	-	-
13	White-breasted Kingfisher	-	33.33	-	-	-	8.33	-	--	-
14	Greater Coucal	-	-	-	1.89	-	-	-	-	-
15	Common Stonechat	-	-	-	1.89	8.33	-	-	-	-
16	Paddyfield Pipit	-	-	-	3.77	8.33	-	14.29	14.29	-
17	Common Swallow	-	-	-	-	-	25.00	-	-	13.33
18	White-throated Munia	-	-	-	-	-	-	9.52	-	26.67
19	Small Bee-eater	-	-	-	-	16.67	-	-	28.57	-

Table 37: Observations of beneficial birds in the field of Berseem 2018-19 exploiting resources (T-Perches) in agriculture landscape for suppressing of insect pest

		Berseem								
		Initial Stage			Vegetative Stage			Maturing Stage		
S No	Bird	Crop	On 'T'	Over	Crop	On 'T'	Over	Crop	On 'T'	Over
1.	Eurasian	2.56	-	4.00	-	-	13.33	-	-	16.67
	Indian Chat	2.56	-	-	-	30.00	6.67	-	-	-
3.	Red-wattled	43.59	-	-	16.98	-	-	25.64	-	-
4.	Red-vented	10.26	20.00	-	-	10.00	13.33	-	21.43	-
5.	Common	-	-	8.00	24.50	40.00	-	7.69	-	16.67
6.	Spotted	-	-	32.00	-	-	13.33	-	-	16.67
7	House Crow	7.69	-	4.00	33.96	-	13.33	10.26	-	-
8	Blue Rock	5.13	-	28.00	-	-	13.33	5.13	-	33.33
9	Bank Myna	-	20.00	8.00	5.66	-	-	7.69	-	16.67
10	Large Pied	10.26	20.00	4.00	1.89	10.00	-	-	-	-
11	White-	-	20.00	-	-	-	-	-	7.14	-
12	Black	-	20.00	8.00	-	-	-	-	21.43	-
13	Greater	7.69	-	-	-	-	-	2.56	-	-
14	Cattle Egret	2.56	-	-	5.66	-	-	10.26	-	-
15	Indian	2.56	-	-	-	-	-	-	-	-
16	Indian	-	-	4.00	-	-	-	-	-	-
17	White	-	-	-	5.66	10.00	-	7.69	7.14	-
18	White-	-	-	-	1.89	-	-	-	-	-
19	Rufous-	-	-	-	-	-	6.67	-	7.14	-
20	Common	-	-	-	-	-	6.67	-	-	-
21	Paddyfield	-	-	-	3.78	-	-	5.13	7.14	-
22	Black Ibis	-	-	-	-	-	13.33	7.69	-	-
23	Small Bee-	-	-	-	-	-	-	10.26	28.57	-

Observations were recorded for the exploitation of “T” perches and overhead electric cables by the birds. In the barseem crop, it was observed that a total of 19 bird species were recorded in 2017-18 and 23 bird species in 2018-19. It was observed that mostly Bank Myna,

Large Pied Wagtail, White-breasted Kingfisher, Black Drongo and Red-vented Bulbul were using the T perches installed in the crop fields during the initial stages of crop. Whereas Black Drongo, Red-vented Bulbul and Small Bee-eater were exploiting the “T” perches during the maturation of crop. Overhead electric wires were mostly exploited by Common Myna and House Crow during the surveyed period.

Table 38: Observations of beneficial birds in the field of Mustard 2017-18 exploiting resources (T-Perches) in agriculture landscape for suppressing of insect pests

Mustard									
S No	Bird Species	Initial Stage			Vegetative Stage			Maturing Stage	
		Crop Field	On ‘T’ Perches	Over head Electric Cable	Crop Field	On ‘T’ Perches	Over head Electric Cable	Crop Field	Over head Electric Cable
1	Eurasian Collared-Dove	8.57	-	10.00	-	-	18.18	8.57	15.38
2	Indian Chat	2.86	20.00	-	3.64	12.50	-	5.71	-
3	Red-wattled Lapwing	8.57	-	-	3.64	-	-	-	-
4	Red-vented Bulbul	-	-	10.00	0.00	12.50	9.09	-	7.69
5	Common Myna	20.00	20.00	20.00	14.55	25.00	27.27	5.71	23.08
6	House Crow	11.43	-	20.00	7.27	-	18.18	11.43	15.38
7	Blue Rock Pigeon	17.14	-	30.00	-	-	-	17.14	30.77
8	Bank Myna	5.71	-	-	-	-	-	5.71	-
9	Large Pied Wagtail	5.71	20.00	-	3.64	12.50	-	-	-
10	White-breasted Kingfisher	-	-	-	-	-	9.09	-	-
11	Black Drongo	-	40.00	10.00	-	-	18.18	-	7.69
12	Greater Coucal	2.86	-	-	1.82	-	-	-	-
13	Cattle Egret	5.71	-	-	5.45	-	-	-	-
14	Indian Roller	-	-	-	-	12.50	-	-	-
15	White Wagtail	5.71	-	-	9.09	-	-	-	-
16	Rose-ringed Parakeet	0	-	-	7.27	-	-	5.71	-
17	Black Ibis	5.71	-	-	-	-	-	-	-
18	Jungle Babbler	-	-	-	12.73	-	-	17.14	-
19	Black Redstart	-	-	-	5.45	-	-	-	-
20	Plain Prinia	-	-	-	16.36	25.00	-	14.29	-
21	Ashy Prinia	-	-	-	3.64	-	-	2.86	-
22	Common Tailorbird	-	-	-	5.45	-	-	3.01	-
23	Black Kite	-	-	-	-	-	-	2.70	-

Table 39: Observations of beneficial birds in the field of Mustard 2018-19 exploiting resources (T-Perches) in agriculture landscape for suppressing of insect pests

Mustard									
		Initial Stage			Vegetative Stage			Maturing Stage	
S No	Bird Species	Crop Field	On 'T' Perches	Over head Electric Cable	Crop Field	On 'T' Perches	Over head Electric Cable	Crop Field	Over head Electric Cable
1	Eurasian Collared-Dove	10.34	-	15.00	-	-	20.00	6.25	16.38
2	Indian Chat	-	10.00	-	4.17	11.50	-	6.25	-
3	Red-wattled Lapwing	10.34	-	-	4.17	-	-	-	-
4	Red-vented Bulbul	-	10.00	5.00	-	13.50	10.00	-	7.69
5	Common Myna	17.24	15.00	30.00	14.58	20.00	30.00	6.25	22.08
6	House Crow	13.79	-	10.00	8.33	-	20.00	9.38	14.38
7	Blue Rock Pigeon	20.69	-	25.00	-	-	-	15.63	32.77
8	Bank Myna	3.45	5.00	-	-	-	-	6.25	-
9	Large Pied Wagtail	-	10.00	-	4.17	17.50	-	-	-
11	Black Drongo	-	50.00	15.00	-	-	20.00	-	6.69
12	Greater Coucal	3.45	-	-	2.08	-	-	-	-
13	Cattle Egret	6.90	-	-	6.25	-	-	-	-
14	Indian Pond-Heron	3.00	-	-	-	-	-	-	-
15	White Wagtail	6.90	-	-	10.42	-	-	-	-
16	Rose-ringed Parakeet	-	-	-	4.17	-	-	9.38	-
17	Black Ibis	3.90	-	-	-	-	-	-	-
18	Jungle Babbler	-	-	-	14.58	-	-	15.63	-
19	Black Redstart	-	-	-	6.25	-	-	-	-
20	Plain Prinia	-	-	-	14.58	25.00	-	18.75	-
21	Ashy Prinia	-	-	-	4.17	12.50	-	3.13	-
22	Common Tailorbird	-	-	-	2.08	-	-	3.13	-

Observations were recorded for the exploitation of “T” perches and overhead electric cables by the birds. In the Mustard crop, it was observed that a total of 23 bird species were recorded in 2017-18 and 22 bird species were noted in 2018-19. It was observed that Common Myna exploited all type of resources present in the agricultural landscape and was present in all type of stages of crop. Relative abundance of Black Drongo was maximum on T perches in both the seasons at initial stages of crop. Overhead electric wires were mostly exploited by Common Myna, Blue Rock Pigeon and House Crow during the surveyed period.

BM 5: Evaluation of fruiting/ flowering trees to attract insectivorous/omnivorous/Depredatory birds to the agricultural landscape

Table 40: Bird community characteristics in transect 1 and transect II of Punjab Agricultural University for the period of 2017-2019

S No	Bird Species	Relative Abundance (%)		Trophic group
		Transect I	Transect II	
1.	Ashy Prinia	1.14	0.14	I
2.	Asian Koel	-	0.30	F/I
3.	Asian Pied Starling	0.77	0.49	I/F
4.	Black-crowned Night-Heron	-	0.12	I/SI
5.	Black Drongo	1.30	3.08	I
6.	Black Ibis	0.49	-	I/G
7.	Black Kite	1.77	3.25	I/SV
8.	Black Redstart	0.24	-	I
9.	Black-shouldered Kite	0.06	-	I/SV
10.	Blue Rock Pigeon	0.26	0.88	G
11.	Brown-headed Barbet	-	0.29	I/F
12.	Cattle Egret	4.91	11.94	I/SI
13.	Common Babbler	3.97	1.52	I/F
14.	Lesser Golden-backed Woodpecker	0.03	-	I
15.	Common Hoopoe	0.80	0.72	I
16.	Common Lesser Whitethroat	0.02	-	I/F
17.	Common Myna	7.74	15.50	I/F/P/SI
18.	Common Swallow	-	0.77	I
19.	Common Tailorbird	0.43	0.17	I/P
20.	Eurasian Collared-Dove	4.25	1.11	G
21.	Franklin's Prinia	0.10	-	I
22.	Great Tit	0.23	-	I/SI
23.	Greater Coucal	1.49	0.07	I/SI/SV
24.	Grey Francolin	0.82	0.07	G/I/SI/SV
25.	Grey Wagtail	0.14	-	I/F
26.	House Crow	18.46	29.06	I/F/G/SV
27.	House Sparrow	0.17	-	G/I
28.	Indian Chat	0.24	0.16	I
29.	Indian Grey Hornbill	0.12	-	F/I
30.	Indian Peafowl	0.06	0.86	G/P/I/SV
31.	Indian Pond-Heron	-	0.06	I/SV
32.	Indian Robin	0.03	0.06	I
33.	Indian Roller	0.12	0.17	I
34.	Indian Treepie	0.17	0.94	I/SV
35.	Jungle Babbler	0.07	-	I/F
36.	Oriental Magpie-Robin	0.51	-	I
37.	Oriental White-eye	0.11	-	I/N
38.	Paddyfield Pipit	0.32	0.09	I/P
39.	Pied Bushchat	0.31	0.04	I
40.	Pied Crested Cuckoo	0.07	-	I
41.	Plain Prinia	0.73	-	I
42.	Purple Sunbird	1.42	0.84	N
43.	Red-vented Bulbul	8.24	1.60	I/P/F

44.	Red-wattled Lapwing	1.84	1.53	I/SI
45.	Rufous-fronted Prinia	0.42	-	I
46.	Rose-ringed Parakeet	16.89	17.38	F/P/G
47.	Rosy Starling	0.03	-	F/G/N/I
48.	Small bee-eater	2.27	2.71	I
49.	Spotted Munia	2.75	-	I/G
50.	Spotted Owlet	0.37	0.06	I/SV
51.	Stone-Curlew	0.27	-	I/SI
52.	Tawny Eagle	0.11	0.15	I/SV
53.	White-breasted Kingfisher	0.37	0.09	I/SV
54.	White-breasted Waterhen	-	0.13	I/SI/P
55.	White-browed Fantail-Flycatcher	0.04	-	I
56.	White-throated Munia	12.72	1.87	I/G
57.	Wire-tailed Swallow	0.52	1.87	I
58.	Yellow-legged Green-Pigeon	-	1.27	F
59.	Yellow Wagtail	0.15	-	I/SI

G- grains, F- fruits, I- insects, P- plants, SI- small invertebrates, SV- small vertebrates, N- nectar
Z- 0.294 (NS), Z is the coefficient of Mann- Whitney U test, NS- Difference is non-significant

The present study was carried out to assess food and foraging niches of carnivorous bird species in mixed fruit orchard selecting two transects I and II at Punjab Agricultural University campus. There were observed 12 and 11 carnivorous bird species out of total 52 and 38 bird species recorded in transect I and II respectively. Habitat features consisting of hedgerows, uncemented water channel, irrigation schedules, fruit developmental stages etc seemed to attract carnivorous bird species. Statistical method of Mann- Whitney U test has shown no significant difference between the relative abundance of total bird species and dominance of carnivorous species in transect I and transect II.

Table 41: Insectivorous/omnivorous/Depredatory birds to the agricultural landscape and trees attracting these birds

S No	Name of The Bird	Relative abundance (%)	Feeding Habits	Trees Preferred
1.	Black Ibis (<i>Pseudoibis papillosa</i>)	3.45	Carnivorous	Eucalyptus, Poplar, Silver Oak,
2.	Indian Peafowl (<i>Pavo cristatus</i>)	1.81	Carnivorous	Mango, Peepal, Banyan
3.	Black Kite (<i>Milvus migrans</i>)	2.07	Carnivorous	Silver Oak, SaptParni, Eucalyptus, Sheesham, Peepal
4.	Indian Roller (<i>Coracias benghalensis</i>)	0.63	Carnivorous	Toot, Poplar
5.	Cattle Egret (<i>Bubulcus ibis</i>)	28.87	Carnivorous	Kikar, Beri, Pilkhan
6.	Tawny Eagle (<i>Aquila rapax</i>)	0.57	Carnivorous	Eucalyptus, Poplar
7.	Little Egret (<i>Egretta garzetta</i>)	2.45	Carnivorous	Kikar, Beri, Pilkhan
8.	Greater Coucal (<i>Centropus sinensis</i>)	0.25	Carnivorous	Mulberry, Dek

9.	Oriental White Ibis (<i>Threskiornis melanocephalus</i>)	0.07	Carnivorous	Eucalyptus, Poplar, Silver Oak,
10.	Spotted Owlet (<i>Athene brama</i>)	0.04	Carnivorous	Toot, Dek, Eucalyptus, Silver Oak, Mango
11.	Common Babbler (<i>Turdoide scaudatus</i>)	3.76	Insectivorous	Toot, Dek, Tahli, Mango
12.	Great Tit (<i>Parus major</i>)	2.12	Insectivorous	Kikar, Beri, Pilkan
13.	Black Drongo(<i>Dicrurus macrocerus</i>)	1.42	Insectivorous	Kikar, Beri, Pilkan
14.	Small Bee-eater (<i>Merops orientalis</i>)	0.51	Insectivorous	Toot, Dek, Kikar
15.	Red-vented Bulbul (<i>Pycnonotus cafer</i>)	0.79	Insectivorous	Mango, Guava, Ashoka
16.	Stone-Curlew (<i>Burhinus oedicnemus</i>)	6.06	Insectivorous	Shrubs
17.	Grey Wagtail (<i>Motacilla cinerea</i>)	0.26	Insectivorous	Agricultural Fields
18.	Black Redstart (<i>Phoenicurus ochruros</i>)	0.44	Insectivorous	Guava, Pears
19.	Wire-tailed Swallow (<i>Hirundo smithii</i>)	0.59	Insectivorous	Shrubs
20.	Oriental Tree Pipit (<i>Anthus hodgsoni</i>)	0.31	Insectivorous	Mulberry, Dhek, Kikar
21.	Citrine Wagtail(<i>Motacilla flava</i>)	0.35	Insectivorous	Agricultural Fields
22.	Red-wattled Lapwing (<i>Vanellus indicus</i>)	0.93	Insectivorous	Agricultural Fields
23.	Asian Koel(<i>Eudynamys scolopacea</i>)	0.28	Insectivorous	Mango, Sheesham
24.	Plain Prinia(<i>Prinia inornata</i>)	0.18	Insectivorous	Bushes, Small Plants,
25.	Ashy Prinia(<i>Prinia socialis</i>)	0.04	Insectivorous	Bushes, Small Plants,
26.	Common Hoopoe(<i>Upupa epops</i>)	0.54	Insectivorous	Agricultural Fields, Grape wines
27.	Paddyfield Pipit (<i>Anthus rufulus</i>)	0.09	Insectivorous	Agricultural Fields
28.	Rufous-fronted Prinia(<i>Prinia buchanani</i>)	0.07	Insectivorous	Agricultural Fields, Citrus, Shrubs
29.	Indian Chat (<i>Cercomela fusca</i>)	0.18	Insectivorous	Shrubs
30.	Common Swallow (<i>Hirundo rustica</i>)	0.46	Insectivorous	Shrubs
31.	Lesser Golden-backed Woodpecker (<i>Dinopium benghalense</i>)	0.12	Insectivorous	Silver Oak, Pinus, Pilkhan
32.	White Wagtail (<i>Motacilla alba</i>)	0.08	Insectivorous	Agricultural Fields
33.	Large Pied Wagtail (<i>Motacilla maderaspatensis</i>)	0.13	Insectivorous	Agricultural Fields
34.	House Crow (<i>Corvus splendens</i>)	16.9	Omnivorous	Sheesham, Euclyptus, Poplar, Mango, Peepal, Banyan
35.	Common Myna (<i>Acridotheres tristis</i>)	6.37	Omnivorous	Euclyptus, Poplar, Mango, Peepal, Banyan
36.	Grey Francolin (<i>Francolinus pondicerianus</i>)	0.1	Omnivorous	Shrubs, orchards
37.	Indian Treepie (<i>Dendrocitta</i>	0.38	Omnivorous	Sheesham, Mango,

	<i>vagabunda</i>)			Peepal, Banyan
38.	Indian Grey Hornbill (<i>Ocyrceros birostris</i>)	0.07	Omnivorous	Pilkhan, Sheesham, Euclyptus, Poplar, Mango, Peepal, Banyan
39.	Brown-headed Barbet (<i>Megalaima zeylanica</i>)	0.12	Omnivorous	Goolar
40.	Purple Sunbird (<i>Nectarinia asiatica</i>)	0.22	Nectarivorous	Bushes
41.	Rose-ringed Parakeet (<i>Psittacula krameri</i>)	15.09	Frugivorous	Guava, Mango, Dhek, Mulberry
42.	Eurasian Collared-Dove (<i>Streptopelia decaocto</i>)	0.2	Granivorous	Mulberry, Dhek, Neem,
43.	Blue Rock Pigeon (<i>Columba livia</i>)	0.18	Granivorous	Peepal, Banyan, Goolar
44.	Black Francolin (<i>Francolinus francolinus</i>)	0.07	Granivorous	Shrubs, orchards

Evaluation of fruiting/flowering trees to attract insectivorous/ omnivorous/ Depredatory birds to the agricultural landscape was taken during the surveyed period. A total of 44 bird species were studied to check the preferred tree species for various purposes.

As the agro-forestry is very well established in Punjab so the bird diversity and abundance was recorded for five selected exotic tree species i.e. Safeda (*Eucalyptus tereticornis*), The Silver Oak (*Grevillea robusta*), Poplar (*Populus deltoides*), The Monkey Puzzle (*Araucaria araucana*) and Bottle Brush (*Callistemon viminalis*). Mainly Poplar and Safeda are dominant tree species used for agro-forestry purposes. These exotic tree species are indigenous to Australia.

Table 42: Avian species recorded in reference to exotic trees (2017-18)

	Common Name↓	Bottle Brush		The Silver Oak		Poplar		Safeda		Monkey Puzzle	
	Locations→	L I	L II	L I	L II	L I	L II	L I	L II	L I	L II
1	Ashy Prinia	2.77	-	-	-	-	-	-	-	-	-
2	Asian Koel	-	-	-	-	4.05	-	3.57	-	-	-
3	Asian Pied Starling	-	-	1.25	-	-	-	-	-	-	-
4	Baya weaver	4.16	-	-	-	-	-	-	-	-	-
5	Black Drongo	-	-	3.12	-	2.70	-	-	-	-	-
6	Black Ibis	-	-	-	-	-	-	2.67	-	-	-
7	Black Kite	-	-	1.87	-	-	-	8.03	6.45	-	-
8	Blue Rock Pigeon	2.77	-	14.37	-	5.40	18.18	3.57	-	-	-
9	Common Golden-backed Woodpecker	-	-	3.12	-	-	-	-	-	-	-
10	Common Hoopoe	2.77	-	-	-	-	-	-	-	-	-
11	Common Myna	4.16	-	13.12	16.66	14.86	40.90	12.5	22.58	30	75
12	Common Tailorbird	4.16	-	-	-	-	-	-	-	-	-
13	House Crow	5.55	6.66	18.75	44.44	35.13	27.27	41.96	45.16	50	25
14	Indian Grey Hornbill	-	-	-	-	-	-	1.78	-	-	-
15	Jungle Babbler	25	20	10.625	-	9.45	-	-	-	20	-
16	Little Brown Dove	4.16	-	11.875	-	4.05	-	5.35	-	-	-
17	Purple Sunbird	19.44	33.33	-	-	-	-	-	-	-	-

18	Red-vented Bulbul	5.55	-	1.875	5.55	4.05	4.54	-	-	-	-
19	Rose-ringed Parakeet	9.72	40	17.5	33.33	17.56	9.09	20.53	25.80	-	-
20	Small Bee-eater	-	-	1.25	-	-	-	-	-	-	-
21	Spotted Owlet	8.33	-	1.25	-	-	-	-	-	-	-
22	Verditer Flycatcher	1.38	-	-	-	-	-	-	-	-	-
23	White-breasted Kingfisher	-	-	-	-	2.70	-	-	-	-	-
	Species richness	14	4	13	4	10	5	9	4	3	2

A total 23 species of birds were recorded belonging to 11 orders (Table 1). Highest species richness (14) was recorded on Bottle Brush tree. Common Myna (*Acridotheres tristis*), Rose-ringed Parakeet (*Psittacula krameri*), House Crow (*Corvus splendens*), Blue Rock Pigeon (*Columba livia*) were the abundant species observed during the study on exotic trees under study. The order Passeriformes was the dominant order of bird species observed. In overall study it was found that House Crow (*Corvus splendens*) was the dominating species. House Crow is adaptable to all type of vegetation. Lowest species richness (2) was found on Monkey puzzle (*Araucaria araucana*).

BM 6: Farmers participatory research on bird management

Table 43: Recommendations and distribution of nests to farmers in various districts of Punjab

District	Village	No of Farmers recommended for various management practices	Distribution of Wooden Nest boxes and Earthen Nests to farmers (No of Nest)
Barnala	Karamgarh	25	Copy of designs given to farmers
	Sanghera	15	Copy of designs given to farmers
Ludhiana	LadianKhurd	20	Copy of designs given to farmers
	Baranhara	25	10
	Kaind	15	10
	Alamgir	10	10
	Birmi	15	Copy of designs given to farmers
	Pakhowal	23	Copy of designs given to farmers
	Sarabha	28	Copy of designs given to farmers
	Dangon	25	Copy of designs given to farmers
Sangrur	Dheri	20	10
	Rampur channa	24	10
Patiala	Dargapur	15	10
	Rauni	20	5
Jalandhar	KotliGajran	21	10
Moga	KotIse Khan	25	10
Ferozpur	Haraj	9	10
	Vaa	10	5
	Toot	15	5
Ropar	Fatehpur	25	5
	Mukarabpur	20	5

	Manjitpur	19	5
Chandigarh	Gharuan	24	5

During the survey of various districts of Punjab, interviews, seminars and informal talks were organized and various recommendations were given as per the problems faced by the farmers to manage the crop damage done by the farmers. Wooden and earthen nests were also distributed to increase the diversity of farmer friendly bird species.

II Location Specific programmes: Biodiversity in agricultural landscape with relevance to conservation

Table 44: Different bird species observed on and in surroundings of selected high voltage electric towers

S. No	Bird species	Site I		Site II		Site III		Site IV		Site V	
		On tower	Other	On tower	Other	On tower	Other	On tower	Other	On tower	Other
1.	Blue Rock Pigeon	66.15	35.40	55.72	8.39	-	52.91	42.10	61.35	66.04	38.46
2.	House Crow	-	4.42	-	17.48	37.50	10.58	-	9.20	-	10.49
3.	Common Myna	3.85	8.85	-	20.98	37.50	8.99	-	11.04	7.55	10.49
4.	Bank Myna	-	22.12	-	-	-	-	-	-	-	-
5.	Cattle Egret	-	3.54	-	3.50	-	4.23	-	-	-	3.50
6.	Rose-ringed Parakeet	-	13.27	-	-	-	6.35	-	7.98	-	19.58
7.	Red-wattled Lapwing	-	10.62	-	7.69	-	2.12	-	4.91	-	7.69
8.	Black Kite	-	1.77	17.24	-	25.00	2.12	5.26	0.61	-	-
9.	Eurasian Collared-Dove	30.00	-	20.69	-	-	-	10.53	0.61	5.66	-
10.	White Wagtail	-	-	-	2.10	-	-	-	-	-	-
11.	Small Bee-eater	-	-	10.34	4.20	-	-	21.05	-	-	-
12.	Asian Pied Starling	-	-	-	3.50	-	-	-	-	15.09	4.20
13.	Indian Chat	-	-	-	1.40	-	-	-	-	-	-
14.	Jungle Babbler	-	-	-	10.49	-	2.12	-	-	-	0.70
15.	Plain Prinia	-	-	-	2.10	-	-	-	-	-	-
16.	Common Hoopoe	-	-	-	2.10	-	5.82	-	-	-	-
17.	Ashy Prinia	-	-	-	2.80	-	-	-	-	-	-
18.	Purple Sunbird	-	-	-	2.10	-	-	-	-	-	-
19.	Brown-headed Barbet	-	-	-	0.70	-	-	-	-	-	1.40

20.	Indian Peafowl	-	-	-	2.10	-	-	-	3.07	-	-
21.	Common Tailorbird	-	-	-	2.80	-	1.05	-	-	-	0.70
22.	Black Ibis	-	-	-	3.50	-	-	-	-	-	-
23.	Asian Koel	-	-	-	2.10	-	1.05	-	-	-	-
24.	Red-vented Bulbul	-	-	-	-	-	0.53	26.32	-	-	-
25.	Indian Treepie	-	-	-	-	-	1.05	-	-	-	-
26.	Spotted Owlet	-	-	-	-	-	1.05	-	-	-	-
27.	Black Drongo	-	-	-	-	-	-	-	1.23	5.66	-
28.	Paddyfield Pipit	-	-	-	-	-	-	-	-	-	1.40
29.	Little Brown Dove	-	-	-	-	-	-	-	-	-	1.40

Different bird species were observed on and in surroundings of selected high voltage electric towers during the surveyed period and it was observed that 29 bird species were present near electric towers. It was also observed that most of the bird species does not prefer to sit on the electric towers. Blue Rock Pigeon, Common Myna, Eurasian Collared- Dove, Small Bee-eater, Black Kite were the main species which exploited the electric towers present in the agricultural landscape.

Table 45: Different bird species observed on and in the surroundings of selected mobile towers

S. No.	Bird species	Site I		Site II		Site III		Site IV		Site V	
		On tower	Other	On tower	Other	On tower	Other	On tower	Other	On tower	Other
1.	Black Kite	66.67	1.16	20.00	1.10	80.00		36.36	4.52	18.18	2.59
2.	Common Myna	20.00	13.84	-	24.18	10.00	14.73	54.55	4.18	36.36	12.07
3.	Rose-ringed Parakeet	-	14.73	-	7.69	-	-	-	10.80	18.18	15.52
4.	House Crow	13.33	13.39	40.00	9.89	10.00	13.95	-	0.70	9.09	11.21
5.	Jungle Babbler	-	17.86	-	24.18	-	16.28	-	8.01	-	7.76
6.	Alexandrine Parakeet	-	2.23	-	-	-	-	-	-	-	-
7.	Indian Peafowl	-	5.81	-	-	-	-	-	3.48	-	-
8.	Small Bee-eater	-	0.89	-	-	-	-	-	4.53	-	-
9.	Eurasian Collared-Dove	-	4.02	20.00	7.69	-	8.53	-	-	-	3.45
10.	Blue Rock Pigeon	-	10.27	-	21.98	-	13.18	-	1.05	-	41.38

11.	Ashy Prinia	-	1.79	-	-	-	-	-	-	-	-
12.	Indian Grey Hornbill	-	1.34	-	-	-	-	-	-	-	-
13.	Common Hoopoe	-	0.45	-	-	-	-	-	-	-	0.86
14.	Black Drongo	-	0.45	-	-	-	-	9.09	-	-	-
15.	Red-vented Bulbul	-	1.79	-	-	-	-	-	-	18.18	5.17
16.	Indian Chat	-	-	-	1.10	-	-	-	-	-	-
17.	Oriental Magpie-Robin	-	-	-	2.20	-	-	-	-	-	-
18.	Lesser Golden-backed Woodpecker	-	-	-	-	-	-	-	-	-	0.86
19.	Red-wattled Lapwing	-	-	-	-	-	10.85	-	13.94	-	-
20.	Little Brown Dove	-	-	-	-	-	8.53	-	-	-	-
21.	Spotted Dove	-	-	-	-	-	2.33	-	-	-	-
22.	Common Tailorbird	-	-	-	-	-	1.55	-	-	-	-
23.	Paddyfield Pipit	-	-	-	-	-	7.75	-	-	-	-
24.	White Wagtail	-	-	-	-	-	2.33	-	1.75	-	-
25.	Grey Francolin	-	-	-	-	-	-	-	-	-	-
26.	Plain Prinia	-	-	-	-	-	-	-	1.05	-	-
27.	Common Sandpiper	-	-	-	-	-	-	-	4.18	-	-
28.	Indian Moorhen	-	-	-	-	-	-	-	9.06	-	-
29.	White-breasted Waterhen	-	-	-	-	-	-	-	5.92	-	-
30.	Black-winged Stilt	-	-	-	-	-	-	-	13.94	-	-
31.	Purple Sunbird	-	-	-	-	-	-	-	1.05	-	-
32.	Asian Pied Starling	-	-	-	-	-	-	-	11.15	-	-
33.	Greater Coucal	-	-	-	-	-	-	-	0.35	-	-
34.	Yellow-legged Green-	-	-	-	-	-	-	-	0.35	-	-

	Pigeon									
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Different bird species were observed on and in surroundings of selected Mobile Towers during the surveyed period and it was observed that 34 bird species were present near selected Mobile Towers. It was observed that the relative abundance of Black Kite was maximum on towers. The other species exploited mobile towers were Common Myna and House Crow. It was observed that only tree species exploited mobile tower where as maximum bird species present near the towers were not exploiting these towers.

Table 46: Different bird species observed at major wetlands of Punjab.

S. No.	Bird species	Ropar wetland	Harike wetland	Kanjli wetland
1.	Brahminy Shelduck	✓	✓	-
2.	Bar-headed Goose	✓	-	-
3.	Little Grebe	✓	✓	-
4.	Common Swallow	✓	-	-
5.	Greater Coucal	✓	-	-
6.	Common Sandpiper	✓	✓	-
7.	Little Cormorant	✓	✓	-
8.	Great Cormorant	✓	✓	-
9.	Little Egret	✓	✓	-
10.	Black-winged Stilt	✓	✓	-
11.	White Wagtail	✓	✓	-
12.	Common Teal	✓	-	-
13.	Indian Moorhen	✓	-	✓
14.	Indian Pond-Heron	✓	-	✓
15.	River Tern	✓	✓	-
16.	Darter	✓	-	-
17.	Common Coot	✓	✓	-
18.	Lesser Pied Kingfisher	✓	✓	-
19.	Blue Rock Pigeon	✓	-	-
20.	White-breasted Kingfisher	✓	-	✓
21.	Stone-Curlew	✓	-	-
22.	Great Crested Grebe	✓	-	-
23.	Indian Shag	✓	-	-
24.	Common Pochard	✓	-	-
25.	River Lapwing	✓	-	-
26.	Cattle Egret	-	✓	-
27.	Common Myna	✓	-	-
28.	Rose-ringed Parakeet	-	-	-
29.	House Crow	✓	-	✓
30.	Pintail	-	✓	-
31.	Spoon bill	-	✓	-
32.	Purple Moorhen	-	✓	-
33.	Median Egret	-	✓	-
34.	Northern Shoveller	-	✓	-
35.	Grey Heron	-	✓	-
36.	Glossy Ibis	-	✓	-
37.	Spot-billed Duck	-	✓	-

(✓) Observed (-) Not Observed

Survey was conducted at major wetlands of Punjab. A total of 37 species were observed at the major wetlands, which is very less as compare to earlier estimates of the bird diversity observed at these sites.

Table 47: Different bird species observed in different village ponds in different districts of Punjab

S. No.	Bird species	Jagerha (Ludhiana)	Bassian (Ludhiana)	Apra (Jalandhar)
1.	Common Moorhen	72.73	8.27	25.81
2.	Cattle Egret	3.03	2.76	0.54
3.	Spot-billed Duck	3.03	6.21	-
4.	Black-winged Stilt	6.06	42.75	3.23
5.	House Crow	3.03	-	-
6.	Little Grebe	6.06	8.96	3.76
7.	White-breasted Waterhen	3.03	2.76	1.61
8.	Red-wattled Lapwing	3.03	18.62	4.30
9.	Northern Shoveller	-	4.83	39.25
10.	Common Coot	-	1.38	18.82
11.	Little Cormorant	-	-	1.61
12.	White Wagtail	-	-	1.08
13.	Median Egret	-	0.69	-
14.	Grey Heron	-	0.69	-
15.	Little Egret	-	0.69	-
16.	Indian Pond-Heron	-	1.38	-

Table 48: Avian species recorded in reference to water bodies (village pods) of selected villages in district Sangrur (2017-18)

Village Species → ↓	Badshahpur	Ghnauri Kalan	Katron
Asian Koel	-	2.5	-
Blue Rock Pigeon	-	10	-
Brown Rock Chat	-	7.5	-
Cattle Egret	-	3.75	4.35
Common Babbler	-	6.25	-
Common Myna	-	15	-
House Crow	-	21.25	-
House Sparrow	-	7.5	-
Indian Moorhen	80.70	-	69.56
Indian Moorhen	-	2.5	-
Lesser whistling Duck	1.75	-	-
Little Brown Dove	1.75	-	-
Little Grebe	12.28	-	-
Pond Heron	1.75	-	17.39
Purple Sunbird	-	6.25	-
Red-wattled Lapwing	-	11.25	-
Ring Dove	1.75	3.75	-
Rose-ringed Parakeet	-	2.5	-
White-breasted Waterhen	-	-	8.69

The community structure of bird species in village Pond of villages under district Sangrur consisted of 19 avian species. Indian Moorhen was found abundant with relative abundance of 80.70%. House Crow was found with relative abundance of 21.25% followed by Little Grebe with relative abundance of 12.28%. The community structure of bird species in village Pond at Katron consisted of 4 bird species. Most abundant species found was Indian Moorhen with relative abundance of 69.56%.

Study on breeding biology of the Indian Pond Heron was conducted from in village Karamgarh (district Barnala) considered as location I and Punjab Agricultural University, Ludhiana as location II. The study revealed a total of 23 nests with highest numbers of nests in the months of August and September. The nest type was twig nests, comprising of an open untidy flat platform of loosely arranged twigs. The most preferred tree species for nesting were *Ficus benghalensis*, *Ficus religiosa* and *Melia azedarach*. Clutch size varied between 2 to 5. The average feeding frequency was 1.55 times/hour at location I and 1.63 times/hour at location II. The higher tree diversity and large number of ponds at location I seemed to support breeding activities of Pond Heron.

Table no. 49: Tree preference and number of nests of Indian Pond Heron

Nesting site	Name of the trees	No. of trees used for nesting	No. of nests of Indian Pond Heron	Nests of other bird species	Mean Height of Nest	Average Clutch Size
Location I						
Nest Site 1	<i>Acacia nilotica</i>	1	2	5	6.7	4
Nest Site 2	<i>Ficus religiosa</i>	2	3	2	15.8	3
Nest Site 3	<i>Cordia oblique</i>	1	1	-	7.0	3
Nest Site 4	<i>Syzygium cumini</i>	1	1	-	9.0	3
Nest Site 5	<i>Melia azedarach</i>	1	2	-	7.2	4
Nest Site 6	<i>Dalbergia sissoo</i>	2	2	-	8.5	2
Nest Site 7	<i>Ficus benghalensis</i>	5	7	4	13.6	3
Location II						
Nest Site 8	<i>Callistemon</i>	1	2	-	7.9	3
Nest Site 9	<i>Melia azedarach</i>	1	3	-	10.3	4

Studies on Indian Robin: Studies on change in landuse patterns and habitat alterations of Indian Robin were carried out in the campus of Punjab Agricultural University (PAU), Ludhiana considered as location I, village Baranhara (district Ludhiana) as location II and village Ladiankhurd (district Ludhiana) as location III. The breeding season of Indian Robin extended from March to July at studied locations. Both the parents participated in the nest formation. The clutch size varied from 2 to 4, but clutches of 3 eggs were more frequent. Eggs were pale greenish in the background with specks and small reddish brown blotches. The female was noted to incubate the eggs while the male were observed to guard the nests against the predators. Indian Robin was found close to human habitation and perched on the rooftops, water tanks, wooden poles and electric wires. It was noted that the average incubation period was 11.5 ± 0.22 days. The hatching and fledging success of eggs of Indian robin was studied in 16 clutches at the studied locations. A total of 51 eggs were laid during the breeding season, out of which only 44 eggs hatched. It could be inferred from the present study that Indian Robin showed adaptive nesting preferences at the buffer zone of developing colonies and village outskirts.

Table 50: Type of nests and nesting sites of Indian Robin at studied transects

Transects	Number of nests	Type of nests		Nesting sites
		Ground nest	Cavity nest	
I	1	√	-	In undergrowth of hedge near roadside
II	2	√	-	In undergrowth of hedge near roadside
III	1	√	-	In undergrowth of hedge near roadside
IV	2	√	-	On ground in wild bushes
V	1	√	-	On ground in wild bushes
VI	3	-	√	On the terrace of under constructed buildings
VII	2	-	√	On the terrace of under constructed buildings
VIII	4	-	√	In crevices of under constructed buildings
IX	2	-	√	In crevices of under constructed buildings

Table 51: Hatching and fledging success of Indian Robin at studied location

Transect s	Nest Number	Clutch Size	Incubation Period (Days)	Number of eggs hatched	Hatching success (%)	Nestling Period (Days)	Number of young fledged	Fledging success (%)
I	1	2	11	2	100	7	2	100
II	2	4	12	3	75	8	2	66.67
III	3	4	10	3	75	9	3	100
IV	4	3	11	2	66.67	6	2	100
	5	3	12	3	100	8	3	100
V	-	-	-	-	-	-	-	-
VI	6	3	10	3	100	11	3	100
	7	3	11	3	100	11	2	66.67
	8	3	12	2	66.67	10	2	100
VII	9	4	12	2	50	9	2	100
	10	3	13	3	100	9	3	100
	11	4	13	4	100	12	4	100
VIII	12	4	12	4	100	12	4	100
	13	3	11	3	100	10	3	100
	14	2	12	2	100	11	2	100
IX	15	3	11	3	100	11	3	100
	16	3	11	2	66.67	9	2	100

Breeding biology of Black Drongo: The study on the nest-site selection and breeding activities of Black Drongo in relation to habitat features was carried out for one year from January 2017 to December 2017 in the campus of Punjab Agricultural University (PAU), Ludhiana i.e. location I, village Baranhara (district Ludhiana) i.e. location II and village Ladian khurd (district Ludhiana) i.e. location III. The breeding season of Black Drongo extended from May to August at all the studied locations. Detailed observations on 18 nests of Black Drongo were made on its breeding parameters and egg characteristics. The clutch size varied from 3-4 eggs. The average incubation period was of 13 ± 0.34 days. The hatching and fledging success of Black Drongo were noted. Tree

species specificity (four indigenous and one exotic) of Black Drongo for nesting preferences was recorded. The data generated on breeding biology of Black Drongo along with habitat characteristics could provide impetus to conservation efforts of this species in agricultural ecosystem.

Table 52: Various parameters of breeding biology of Black Drongo

Transects	Nest Number	Clutch Size	Incubation Period (Days)	Number of eggs hatched	Hatching success (%)	Nestling Period (Days)	Number of young fledged	Fledging success (%)
I	1	4	12	3	75.00	18	2	66.67
	2	4	11	3	75.00	20	2	66.67
II	3	4	13	4	100.00	21	4	100.00
	4	4	13	4	100.00	21	4	100.00
III	5	4	16	3	75.00	22	2	66.67
IV	6	3	14	3	100.00	19	3	100.00
V	7	4	13	4	100.00	17	4	100.00
	8	3	15	3	100.00	20	2	66.67
	9	3	12	3	100.00	20	3	100.00
VI	10	4	14	3	75.00	19	3	100.00
	11	4	14	2	50.00	18	2	100.00
VII	12	4	12	4	100.00	20	4	100.00
	13	4	11	4	100.00	19	3	75.00
	14	4	13	4	100.00	20	4	100.00
VIII	15	3	15	3	100.00	21	3	100.00
	16	3	12	2	66.67	20	2	100.00
IX	17	4	11	4	100.00	19	3	75.00
	18	3	13	3	100.00	19	3	100.00

Breeding biology of Cattle Egret: The study on the nest-site selection and breeding activities of Cattle Egret in was carried out for the surveyed period in the various locations of Punjab. The breeding season of Cattle Egret extended from April to July at all the studied locations. Detailed observations on 132 nests of Cattle Egret were studied under 5 heronries made. The clutch size varied from 2-4 eggs. The hatching and fledging success of Cattle Egret was 55-60%. Tree species specificity of Cattle Egret for nesting preferences was Kikkar. The data generated on breeding biology of Black Drongo along with habitat.

Table 53: Cattle Egret heronries observed during survey of different sites in different districts of Punjab

Site	Tree	No. of nests	Location of heronry	Age of heronry	Water source near by
Malakpur (Ludhiana)	<i>Kikkar</i>	18	At the outer skirts of the village, on main road	3-5 years	Paddy fields
BarewalDogra (Ludhiana)	<i>Kikkar</i>	33	At the outer skirts of the village, on main road	8-10 years	Paddy fields, River Satluj
Ucha bet (Kapurthala)	<i>Kikkar</i>	48	On main road	6-7 years	Paddy fields, drain channel
Fattudhinga (Kapurthala)	<i>Kikkar</i>	19	On main road	7-8 years	Paddy fields, River Beas
Rajewal (Kapurthala)	<i>Kikkar</i>	14	On main road	3-5 years	Paddy fields

HV 1: Bio ecology and managements of higher vertebrates in different crops

Table 54: Status of Wild Boar and its distribution, habitat, feeding, crop damage, management practices in different villages of Punjab

Sample No	District Name	Name of Village	Crop Damage	% Damage	Management Method
1	Mohali	Mirzapur, Gocher, Kubaheri, Singriwala	Maize, Wheat, Sugarcane	10-50	Barbed fencing, Hanging colored cloth, Drum Beating, Crackers, Making raised platform
2	Kapurthala	Butala, Mugalchak, Miani	Maize, Wheat, Sugarcane	5-10	Barbed fencing, Drum Beating
3	Barnala	Jhaloor, Sekhna	Maize, Wheat, Sugarcane	5-10	Barbed fencing, Drum Beating
4	Ludhiana	Ladowal, Aitiana, Khehra Bet	Maize, Wheat, Sugarcane	5-15	Drum Beating, Barbed fencing,
5	Gurdaspur	Kirhi Afghana, Bhait	Sugarcane	10-20	Barbed fencing, Drum Beating
6	SBS Nagar	Bulalowal, Rattewal,	Maize, Sugarcane	10-25	Barbed fencing, Drum Beating, Making raised platform
7	Hoshiarpur	Khanni, Jejjon	Maize	10-20	Barbed fencing
8	Amritsar	Beas	Maize, Wheat	5-15	No management practice applied
9	Ropar	Bhojey Majra, Raipur,	Maize, Sugarcane	5-15	No management practice applied

Survey was conducted in 9 districts (Mohali, Kapurthala, Barnala, Ludhiana, Gurdaspur, SBS Nagar, Hoshiarpur, Amritsar, Ropar) (21 villages) of Punjab to assess the damage causes by Wild Boar in the different crop fields.

Wild Boar was found to causing maximum damage to Maize, Wheat and Sugarcane. Mostly the farmers were not using any management techniques for Wild Boar. The most common techniques were Barbed fencing, drum beating, hanging colored cloth, crackers, making raised platforms.

Studies & management on vertebrate pest of crops other than birds & rodents

The Indian Wild Boar (*Sus Scrofa* L.) is wide spread animal. The present study involves the observations on the prevalence of Indian Wild Boar and its damage in agricultural crops in selected locations of Punjab (Site-1 New Orchard Area (PAU), Site-2 BISA and Seed Farm of Ladhowal and Site-3 Regional Research Station for Kandi areas of Ballawal Saunkhri. The study period ranges from December 2016- April 2018. They were found in all three selected locations. They are major vector of many parasitic diseases which transfers to domestic and wild animals as well as to human beings. The life activity of Indian Wild Boar was varied with seasons, conditions and availability of natural resources. Like, nocturnal activity during summer and diurnal activity in winter. The present time the population and damage of wild boar was more observed in those areas, which present near the forest areas, water resources and uncultivated areas. Increase the number of human population and decrease the area for sheltering is play an important role to increase the damage of agriculture crops.

A total 16 casts of pug marks of Indian Wild boar were prepared by the help of Plaster of Paris. So, on the basis of dimension of these casts of pug marks the different life stages of animals become categories. The size of pug-marks ranges from 4.0 cm X 3.7 cm (minimum) to 8.0 cm X 7.5 cm (maximum). The average Pug- Marks size of Indian Wild boar varies from 4-8cm length and 4-6

cm width. Out of total casts of pug-marks (n=16) prepared, presence of juvenile (18.75%), sub-adult (25.0%) and adult (56.25%) individuals was revealed.

Table 55 : Measurements of the Pug-marks of Indian Wild Boar (2017-18)

Sr. No.	Length (cm)	Width (cm)	Life Stage of Individual
1.	4.9	5.1	Sub- adult
2.	4.1	4.8	Juvenile
3.	4.0	3.7	Juvenile
4.	5.8	5.5	Adult
5.	4.6	5.0	Sub- adult
6.	5.3	4.2	Adult
7.	5.1	4.7	Adult
8.	5.5	4.6	Adult
9.	5.0	4.4	Adult
10.	5.3	4.3	Adult
11.	4.8	4.2	Sub- adult
12.	5.8	4.4	Adult
13.	4.3	4.6	Sub- adult
14.	4.5	4.0	Juvenile
15.	6.5	5.3	Adult
16.	8.0	7.5	Adult
Mean	5.21	4.76	

The study also revealed that on an average 15-20% of the crop were damaged by Indian Wild boar. More damage was observed to maize (*Zea mays*), Jawar (*Sorghum vulgare*), Rice (*Oryza sativa*), *Brassica spp.* and vegetables crops. On the basis of survey report 56% farmers agreed with moderate amount of damage (20-25%), 91% farmers agreed with more damage to crops which were present near the forest areas and 98% farmers agreed with the use of the traditional management methods to minimize the damage of animals.

Table 56 : Questionnaire used for collecting the information about the vertebrate pests (2017-18)

1.	Identification about wild animals coming in crop fields.		
	Less (2%)	Moderate (13%)	More (85%)
2.	Loss caused by wild animals to agricultural crops.		
	Less (4%)	Moderate (58%)	More (38%)
3.	All the wild animals cause damage to agricultural crops.		
	Agree (44%)	Disagree (46%)	Not known (10%)
4.	Its possible, the animal harmful in one way but beneficial in another way.		
	Agree (12%)	Disagree (45%)	Not known (43%)
5.	Before inflorescence stage of crop damage of harmful animal over the agricultural crops become manageable necessary.		
	Agree (100%)	Disagree (0%)	Not known (0%)
6.	Animals cause more damage to those crops which are present near the habitat / river/ forest area.		
	Agree (91%)	Disagree (3%)	Not known (6%)
7.	The use of management methods yield of agricultural crops increase.		
	Agree (93%)	Disagree (6%)	Not known (1%)

8.	After crop harvesting, the animal cause the damage?		
	Agree (79%)	Disagree (20%)	Not known (1%)
9	Traditional methods are the best method for management of crops from harmful animals.		
	Agree (98%)	Disagree (2%)	Not known (0%)
10.	The management of harmful animals successfully possible.		
	Agree (78%)	Disagree (20%)	Not known (2%)
11.	The management of harmful animal is possible at own level.		
	Agree (80%)	Disagree (18%)	Not known (2%)
12.	The management of harmful animals possible at village level.		
	Agree (100%)	Disagree (0%)	Not known (0)
13.	The efforts and policies of scientists and government play some role in managing the effect of harmful animals over the crops.		
	Agree (100%)	Disagree (0%)	Not known (0%)
14.	The farmers take the proper knowledge from authorities / damage controlling programs, they becomes control the damage of animals its own level.		
	Agree (100%)	Disagree (0%)	Not known (0%)
15. The farmers easily control the effect of harmful animals when using some of the following methods e.g. :-			
1. Use of Barbed Fencing.			
	Agree (80%)	Disagree (18%)	Not known (2%)
2. Use of Electric Fencing.			
	Agree (100%)	Disagree (0%)	Not known (0%)
3. Scaring of wild animal from crop field.			
	Agree (100%)	Disagree (0%)	Not known (0%)
16.	Create irritation in Respiration System by use of human hairs.		
	Agree (74%)	Disagree (9%)	Not known (17%)
17.	Growing of thorny bushes around the crop field.		
	Agree (62%)	Disagree (33%)	Not known (5%)
18.	Digging the trench around the crop field.		
	Agree (65%)	Disagree (27%)	Not known (8%)
19.	Hunting / Killing of wild animals are legally prohibited.		
	Agree (100%)	Disagree (0%)	Not known (0%)

The (88%) farmers of different areas of selected areas adopt the different traditional methods for control the damage of wild animals over the different agricultural crops i.e. - Electric fencing, Spike fencing, Chain-Linked fencing, Planting of thorny plants, building of wall, using of local dogs for scaring of dogs and other traditional methods for protecting of agricultural crops from the damage of Indian Wild boar to the agricultural crops in the selected areas of Punjab.

Study of acoustic signals of House Crow (*Corvus splendens*) in agricultural ecosystem (2018-19)

The study and analysis of acoustic signals of House Crow (*Corvus splendens*) was performed by recording the acoustic signals of the House Crow in morning and evening hours at selected fields in Punjab Agricultural University, Ludhiana and Ahmedgarh, District Sangrur. Recorded calls were analyzed by using Raven Pro software of Cornell University, Ithaca, NY. Spectrograms of audio recordings were created. Study shows variations in the calls of House Crow recorded at both the locations.

Table 57: Total bird species observed in the Agriculture landscape of Punjab

S No	Bird Species	S No	Bird Species	S No	Bird Species
1	Cattle Egret	41	Barn Owl	81	Baya Weaver
2	Bank Myna	42	Common Starling	82	Glossy Ibis
3	Common Myna	43	Jungle Babbler	83	Oriental White Ibis
4	Black Ibis	44	Black Partridge	84	Indian Cuckoo
5	Citrine Wagtail	45	Little Stint	85	Himalayan Bulbul
6	Black Drongo	46	Large Egret	86	Jungle Crow
7	Eurasian Collared-Dove	47	Rufous-fronted Prinia	87	Little Stint
8	Red-wattled Lapwing	48	Grey Francolin	88	Lesser Pied Kingfisher
9	House Crow	49	House Sparrow	89	Eurasian Spoonbill
10	Indian Roller	50	Spotted Munia	90	Brahminy Starling
11	White Wagtail	51	Asian Pied Starling	91	Ashy Prinia
12	Black Kite	52	Spotted Dove	92	House Swift
13	Grey Wagtail	53	Spot-billed Duck	93	Eastern Skylark
14	Large Pied Wagtail	54	White-throated Munia	94	Red-rumped Swallow
15	Paddyfield Pipit	55	Greenish Leaf-Warbler	95	Little Brown Dove
16	Black-winged Stilt	56	Pied Bushchat	96	Gadwall
17	White-breasted Kingfisher	57	Indian Chat	97	Streaked Fantail-Warbler
18	Common Hoopoe	58	Purple Moorhen	98	Oriental White-eye
19	Common Stonechat	59	Small Bee-eater	99	Gull-billed Tern
20	Rose-ringed Parakeet	60	Blue-tailed Bee-eater	100	River Tern
21	Purple Sunbird	61	Northern Shoveller	101	White-necked Stork
22	Red-vented Bulbul	62	Common Moorhen	102	Great Tit
23	Spotted Owlet	63	Common Coot	103	Tawny Eagle
24	Brown-headed Barbet	64	Little Cormorant	104	Mallard
25	Indian Grey Hornbill	65	Little Grebe	105	Indian Greater Horned Owl
26	Alexandrine Parakeet	66	Black Redstart		
27	Asian Koel	67	Median Egret		
28	Plain Prinia	68	Great Cormorant		
29	Indian Grey Hornbill	69	Black-shouldered Kite		
30	Indian Peafowl	70	Rufous-backed Shrike		
31	Common Tailorbird	71	Eurasian Golden Oriole		
32	Greater Coucal	72	Stone-Curlew		
33	White-breasted Waterhen	73	Citrine Wagtail		
34	Common Swallow	74	Little Egret		
35	Wire-tailed Swallow	75	Northren Pintail		
36	Indian Pond-Heron	76	Brahminy Shelduck		
37	Blue Rock Pigeon	77	Common Sandpiper		
38	Indian Treepie	78	Common Redshank		

39	Oriental Magpie – Robin	79	Shikra	
40	Yellow-legged Green-Pigeon	80	Lesser Golden-backed Woodpecker	

OTHER ACTIVITIES

S.No.	Activities	Agency/ Departments
1.	Provided information of management of birds for farmer's portal in December 2017. Resource Person: Dr. Tejdeep Kaur Kler	Department of Extension Education, PAU, Ludhiana
2.	Artificial nests handed over to scientists working at KVK Kapurthala and FASC Kapurthala for farmer level demonstration in 2018. Resource Person: Dr. Tejdeep Kaur Kler	KVK Kapurthala and FASC Kapurthala
3.	Two five day training programme from 20 th -24 th August, 2018 and 27 th -31 st August on "Avoid residue burning to save birds for natural balance" in- situ management of crop residue at KVK Kapurthala were organized. Lectures were delivered in Punjabi to participating farmers. Resource Person: Dr. Tejdeep Kaur Kler	KVK Kapurthala
4.	Training programme on "Vermicomposting, rodent pest and bird management" under STRY from 27 August-01 September, 2018 organized in association with PAMETI under The Ministry Of Agriculture and Farmer's Welfare, Government Of India . Lectures, field practical's and literature (in Punjabi) were given to farmers. Resource Person: Dr. Tejdeep Kaur Kler	PAMETI and The Ministry Of Agriculture and Farmer's Welfare, Government Of India
5.	Attended the first brainstorming session conducted by 'The Food and Agriculture Organization of the United Nations (FAO, UN) and PAMETI ' and to discuss "Bird Diversity" on 17.10.2018 at Chandigarh. Resource Person: Dr. Tejdeep Kaur Kler	The Food and Agriculture Organization of the United Nations (FAO, UN) and PAMETI'
6.	Dr Manoj Kumar, Assistant Ornithologist visited Bioacoustics Research Programme Lab, The Cornell Lab of Ornithology, Cornell University, Ithaca, New York, USA . "Sound Analysis Workshop (October 15 – October 19, 2018)" was also attended at the Cornell Lab of Ornithology . Resource Person: Dr. Manoj Kumar	The Cornell Lab of Ornithology, Cornell University, Ithaca, New York, USA
7.	Integrated module of birds, weeds and insect management formulated and forwarded to Air Force Station, Halwara (Ludhiana) and Air Force Station, Adampur (Jalandhar) in 2018. Resource Person: Dr. Tejdeep Kaur Kler	Air Force Station, Halwara (Ludhiana) and Air Force Station, Adampur (Jalandhar)
8.	Participated in meetings chaired by National Green Tribunal NGT with Punjab Pollution Control Board official to discuss the animal diversity along rivers in 2018 and 2019 (Buddha Nullah and River Beas). Resource Person: Dr. Tejdeep Kaur Kler	National Green Tribunal, New Delhi, Punjab State Pollution Control Board
9.	Attended a National level meeting called by World Wildlife India WWF and Department of Forests and Wildlife Preservation, Punjab to work out the conservation strategy for Indus River Dolphin and wildlife in Beas Conservation	World Wildlife India WWF, Department of Forests and Wildlife

	Reserve in 2018 and 2019. Resource Person: Dr. Tejdeep Kaur Kler	Preservation, Punjab
10.	Participation of M.Sc. Student Navleen Kaur (L-2017-BS-326-M) working under major advisor Dr Tejdeep K Kler, Senior Ornithologist in the Asian Waterbird Census, 2019 organized by Wetlands International in New Delhi from 14-17 January, 2019.	Asian Waterbird Census, Bird Life International
11.	Agricultural Development Officer's workshop for <i>Rabi</i> crops held on August 26-27, 2018. Agricultural Development Officer's workshop for <i>Kharif</i> crops held on February 26-27, 2019. Research and Extension Specialists Workshop For Horticultural Crops, 27-28 May, 2019. Resource Person: Dr. Tejdeep Kaur Kler	Director Agriculture, Directorate of Horticulture (Punjab), Agricultural Development Officers, Horticulture Development Officers.
12.	'International day for Biological Diversity' organized by Agricultural Technology Management Agency (ATMA) and Department of Agriculture and Farmer's Welfare, District Moga in village Pando khosa (Moga) on 22.05.2019. Resource Person: Dr. Tejdeep Kaur Kler	Department of Agriculture and Farmer's Welfare, ATMA, PAMETI, Punjabi University (Patiala), Village Panchayat
13.	Member Punjab State Committee Constituted by The Honorable Chief Minister of Punjab for Conservation of Birds especially Passerines Resource Person: Dr. Tejdeep Kaur Kler	Subject Matter Specialist in Punjab State Committee along with Chief Conservator Forests

LIST OF VILLAGES SURVEYED

The survey was carried out at 131 villages of 15 Districts of Punjab. A total of 105 bird Species were observed during the surveyed period.

S. No.	District	Villages
1.	LUDHIANA	Sahauli, Halwara, Bhundri, , Malakpur, Valipur kalan, Valipur khurd, Chakar, Jhorhran, Bilaspur, Rama, Kaleran, Bassian, Raikot , Barewal dogra, Bhatha dhua, Baranhara, Ladhowal, Ladian, , Gagra Aitiana, Gurhe, Chowkiman, Sidhwan, Agwarh Ladhe, Aligarh, chuharhpur, Isewal, Humbran, Abbuwal, Rajeana, Hasanpur
2.	JALANDHAR	Adampur, Dhilwan, Mehatpur, Parjian kalan, Malsian, Kala Bakra, Beas pind, Noorwal, Nagar, Thala, Rasoolpur, Rautan, Mallowal
3.	SANGRUR	Dhuri, Badshahpur, Ghnauri kalan, Katron, Mohali, Bagrian, Guara
4.	ROPAR	Katli, Ropar, Chak dhera, Dakala, Patiala, Marhauli, Chtamala
5.	SHAHEED BHAGAT SINGH NAGAR	Gehal mazari, Gunachaur, Khan khana, Moron, Banga, Palli jhikki, Jasso mazara, Rahon, Garcha, Lasarha, Ballowal, Rattewal, Bullowal, Kular,
6.	HOSHIARPUR	Talwara, Mukerian, Jejjon doaba, Rampur, Jhanjwal ,Chaulang, Bassi jalal, Pull pakka
7.	BARNALA	Handiaya, Roorheke kalan, Pakho kalan, Sanghera, Dadhahoor, Sehjarha, Mehal kalan,
8.	MANSA	Aklia, Joga, Ralla, Atla kalan, Khiala khurd
9.	MOHALI	Mirzapur, Gocher, Pallanpur, Abhipur, Kubaheri
10.	KAPURTHALA	Dham, Miani, Paharhipur, Sheikhpur, Fattu dhinga, , Chaherhu,

		Kanjli, Birk, Mehtan, Mundi, Khojewala, Ucha bet, Rajewal
11.	FEROZEPUR	Lehra bet, Peer Muhammad, Rasoolpur, Makhu
12.	FARIDKOT	Cahnd baja, Tehna, Kotkapura, Moranwali
13.	MOGA	Pando khosa, Abbu shah buker, Chuha chak, Muhar, Ajitwal, Lohara
14.	TARANTARAN	Chamba, Gandiwind, Goindwal, Harike
15.	GURDASPUR	Bhait, Bithwan, Kirhi Afgana, Kot kishan, Ghumaan,

a) Significant achievements during this plan period so far

The surveys were carried out in 131 villages of 15 Districts of Punjab which revealed a total of 105 bird species in agricultural areas (including crop fields and rural residential habitats).

Depredatory Bird Species: During the survey of wheat, rice and mustard crop fields in different agro climatic zones, a total of 11 depredatory bird species were observed. Blue Rock Pigeon and House Crow were the most predominant species during the year 2017-18 and 2018-19 respectively. In selected rice fields, the presence of Purple Moorhen and Indian Moorhen was found to cause damage up to 5%.

Community Structure of Birds and their Diversity:

Community structure in different crops: The observations on bird community structure in different crops were undertaken in different crops in western zone of Punjab. A total of 23, 17, 19, 25, 20 bird species were observed in wheat, pearl millet, mustard, paddy and berseem respectively.

Pulses Moong: Moong is a pulse crop having high nutritional value. Observations have shown ten species of birds in moong crop fields during both the years 2018 and 2019.

Vegetable Summer Squash: Bird community structure of summer squash crop had shown less biodiversity. Common Myna was followed by Cattle Egret in abundance in year 2018. Common Myna was found having maximum relative abundance followed by Bank Myna and Common Swallow in the field at initial stage as well as at maturing stages of the crop in the year 2019.

Insect solar Light trap were found effective to collect harmful insect-pests especially lepidopteran pests, hemipteran, coleopteran and dipteran pests causing damage to fruits and foliage in tomato and chilies.

Bird protection net: In Peas and cucurbits at seedling stage, bird protection net was found 100% effective in preventing the bird damage.

Nylon net: Nylon Net was used to protect the crop from damage by birds, insect-pests and environmental factors like high or low temperature in muskmelon, pumpkin and capsicum crops; high growth and yield was also noted.

Reflecting tape: Reflective tapes were used to scare away the birds especially at seedling stage of the crop as well as at seed maturation stage of the peas, tomato, chilies and mustard crops. 90-95% protection from bird damage was observed in peas at seed maturation phase.

Cue lure Chemical: To prevent damage from fruit flies to different vegetable crops like Bitter gourd, sponge gourd, water melon, muskmelon, pumpkin: Cue lure chemicals were tested in collaboration with Department of Vegetable, the use of cue lure trap was found 100% beneficial for non-chemical pest management.

Installation of reflective ribbon was evaluated and tested in Mustard and Tomato crop fields:

Bird damage estimation was done in mustard fields and tomato fields with reflective ribbon. Damage values were 2.48% damage in protected fields; whereas 8.20% damage was observed in

control fields in mustard. The reflective ribbon was found effective at fruiting stage in tomato crop. It was observed that the relative abundance of House Crow had shown decrease from 36.06% to 6.67%. In the experimental field, the damage was recorded to be decreased to 5.2% from 12.6% (Control field).

Exploitation of “T” perches: Observations were recorded for the exploitation of “T” perches and overhead electric cables by the birds. In the berseem crop, it was observed that a total of 19 bird species were recorded in 2017-18 and 23 bird species in 2018-19. Maximum bird species used ‘T’ perches in vegetative and maturing stage of crop in years 2017-18 and 2018-19 (8 and 7) respectively. Simultaneously in mustard crop a total of 23 and 22 bird species were observed crop season 2017-18 and 2018-19 respectively. A total of five and six insectivorous bird species were used ‘T’ perches in maximum number in 2017-18 and 2018-19 respectively.

Wild Boar: Survey was conducted in 21 villages of 9 districts (Mohali, Kapurthala, Barnala, Ludhiana, Gurdaspur, SBS Nagar, Hoshiarpur, Amritsar, Ropar) of Punjab to assess the damage caused by Wild Boar in the different crop fields. It was observed that Wild Boar was causing maximum damage to Maize, Wheat and Sugarcane. Mostly the farmers were not using any management techniques for Wild Boar. A few farmers were using barbed fencing, hanging of colored cloth, drum beating, crackers and making raised platforms.

Bird Tree Preferences: Detailed studies have shown 44 bird species in association with different tree species in the agricultural landscape during the surveyed period. There were 22 insectivorous, 10 carnivorous, 6 omnivorous, 3 granivorous, 1 nectarivorous and 1 frugivorous bird species as per their feeding habits. Mango, Mulberry, Acacia, Eucalyptus, Silver Oak, Melia and Poplar trees were found preferred for nesting and roosting purposes.

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	43.10	45.09	1.60	0.30	0.00	0.00	47.00
2018-19	54.3	33.25	15.00	0.21	3.23	0.00	51.69

ANAND AGRICULTURAL UNIVERSITY, ANAND

PART: I General Information

1. Name of the center	Anand Agricultural University, Anand Department of Entomology
2. Sanction no.	Sanction Order No.11-1/81 PP dated 29.11.1982
3. Date of start	29.11.1982
4. Date of Termination	Network project of continued nature
5. Report period	2017-2019
6. Scientist In charge	Dr. C.K. Borad

7. Staff position

Sr. No.	Name	Designation	Position	Pay Scale
1	Dr. C. K. Borad	Ornithologist	Filled	37400-67000
4	Dr. J. G. Dulera	Jr. Ornithologist	Filled	15600-39100
5	Shri. A. H. Nayi	Technical Assistant	Filled	9300-34800

Part II. Work Allotted (Technial Programme)

I. Multi Location programmes

- BM 1. Surveillance of depredatory birds in predominant cropping systems.
BM 2. Community structures of birds and their diversity in relation to crop stages in different agro- ecological zones of the region.
BM 3. To identify, develop and evaluate eco-friendly bird management techniques
BM 4: Exploitation of beneficial birds for suppressing insect pests
BM 5. Evaluation of fruiting / flowering trees to attract insectivorous / omnivorous / Depredatory birds to the agricultural land scape.
BM 6. Farmer's participatory research on bird management

II. Location specific programmes

- BM 7. Biodiversity in agricultural landscape with relevance to conservation
HV 1: Bio-ecology and Management of higher vertebrates in different crop

PART III. Work done

I. Multi-location Programmes

BM 1. Surveillance of depredatory birds in predominant cropping systems

1.1: Community structure of birds in Groundnut crop fields of Saurashtra region: The work was undertaken with the objective to evaluate the impact of cropping system on avian diversity. Study was conducted during December 2017 to February- 2018 in agricultural landscape of Sojitra taluka. We established transect route with effective 500 m long strip and 50 m width to determine the relative abundance, species richness in agro-ecosystem. Ten transects laid randomly in

different villages of Sojitra taluka during different crop stages. The observations were made on encounter of bird species and number of birds. Details of microhabitat were noted. In all 29 species and 1136 number of birds were recorded from different villages visiting total 30 transect sites during Rabi 2017-18. Results presented in table reveal that cattle egret was dominant bird species during different crop stages. Black drongo, cattle egret, common myna and jungle babbler were abundant species. Relative abundance of black drongo (6.81), cattle egret (23.6), common myna (7.16) and jungle babbler (10.1) was maximum during milky stage. Activity of rose ringed parakeet was observed only during milky stage. Species richness was 15, 24 and 28 during seedling, vegetative and milky stage of crop.

1.2: Evaluation of bird predation on honey bees/pollinators: The objective of the programme was (i) To identify avian predators of various honey bee species and work out community structure of birds feeding on honey bees and (ii) (2) To study the bird predation on honey bee. Study was carried out during April 2017 to February 2018. Naturally occurring and artificial bee hives in AAU- apiary and outside apiary were monitored for the activity of predatory birds on honey bees. The regurgitated pellets of green bee eater (Table 1) fallen on the ground below perch sites were collected. The collected pellets were kept separately in small plastic bottles and labeled for further studies. The prey fragments were identified using a microscope on the basis of various body parts in the remains of the diet. Insect remains in each pellet were identified up to order level by looking at some of the most important exoskeletons such as head capsules, elytra, legs, wings etc. (Table 2). Necessary photographs of prey items were also taken.

Total 99 Regurgitated pallets of green bee eater fallen on the ground below roosting sites were collected from AAU campus. Total 1186 individual of various prey items were recovered from pellet. Mean number of prey per pellet ranged from 2 to 23 with an average of 11.98 ± 6.61 . The proportion of identified prey in different order was hymenoptera (86.26 %) > odonata (7.34 %) > coleoptera (6.41 %).

Table 1. Morphometry of green bee eater regurgitated pellets (n=50) (2017-18)

	Length (cm)	Width (cm)	Weight (g)
Min	1.3	0.4	0.043
Max	2.1	0.8	0.179
Mean $\pm$ SD	1.65 ± 0.22	0.63 ± 0.11	0.089 ± 0.031

Table2. Frequency and percent composition of various prey items in the diet of the green bee-eater (n=99)

Prey items	Frequency	% composition	Mean	Rank
Hymenoptera (Bees, wasps)	1023	86.26	10.33 ± 6.27	I
Odonata (Dragonflies)	87	7.34	0.88 ± 1.54	II
Coleoptera (Beetles)	76	6.41	0.77 ± 1.54	III
Total	1186	-		-

BM 1.3: Effect of roosting of Rose-ringed Parakeet on agricultural crops

This study was undertaken to assess the damage of Rose-ringed Parakeet on agricultural crops in relation to distance from its roost site. Damage assessment was done following rapid damage assessment method for bajara. Extent of damage by Parakeet to bajara crop at maturity stage was assessed with reference to distance from the roosting site i.e. at 2-3, 3-5, 5-7 and 7-9 km distance. At each distance minimum five fields were assessed. From each field, 200 earheads were sampled and categorized as healthy and damaged. Damaged earhead per cent was calculated.

Damaged surface area was work out using polynomial equation ($Y = 0.8954 - 0.0279X + 0.0102X^2$) Where Y=% surface area, X=% ear head damaged)

The study was carried out on effect of distance of roosting site of Rose- ringed parakeet on extent of damage to bajara crop. The study was conducted around Vallbhavidhyanagar, Anand parakeet roost site during summer 2017-18. The mean percent earhead damage of five fields were 19.2 ± 5.81 , 16.4 ± 3.65 , 12.0 ± 3.94 and 6.4 ± 3.21 with respect to distance from roosting site i.e. 2-3, 3-5, 5-7, 7-9 km distance. Surface area damaged (%) were calculated as 1.61, 1.35, 1.09, 0.94 by using polynomial equation of damage assessment method (Table3). It was revealed that the extent of damage is decrease with increasing the distance of crop field from roost site.

Table 3. Effect of distance of roosting site of Rose-ringed Parakeet on extent of damage to bajara crop in summer season

Distance From roosting site (Km)	Village name	Total no. of earhead damaged/ 1000 earheads	Mean earhead damage (%)	Surface area damaged (%)
2-3	Mogri	96	19.2 ± 5.81	1.61
3-5	Gana	82	16.4 ± 3.65	1.35
5-7	Meghwal	60	12.0 ± 3.94	1.09
7-9	Napa	32	6.4 ± 3.21	0.94

Table 4. Effect of distance of roosting site of Rose-ringed Parakeet on extent of damage to bajara crop in kharif season

Distance From roosting site (Km.)	Village name	Total earhead damaged / 1000 earheads	Mean earhead damage (%)	Surface area damaged (%)
5-6	Sandesar	279	27.9 ± 12.22	1.05
6-8	Napa	91	9.1 ± 2.70	0.79

Total extent of damage per five fields were assessed as 279 and 91 number of 1000 earhead of field with reference to 5-6, 6-8 Km distance. The data presented in table that mean percent earhead damage of five fields were 27.9 ± 12.22 and 9.1 ± 2.70 with respect to distance from roosting site i.e. 5-6, 6-8 km distance. Surface area damaged (%) were calculated as 1.05 and 0.79 by using polynomial equation of damage assessment method (Table 4).

1.4: Studies of community structure of birds in wheat-bajra agroecosystem

The Study was conducted during year 2018-19 and onwards in agricultural habitats of Anand district to evaluate the impact of cropping system on avian diversity. The observations were made using 10 × 50 binoculars. Transect routes was established with effective 500 m long strip and 50 m width to determine bird density/abundance. Ten transects will be laid randomly in Middle Gujarat region. The data were collected at fifteen days interval.

Total 1036 birds of 19 different bird species were recorded in year 2018-19. The Crested lark, *Galerida cristata* was dominant species in community (69.50 RA %). The Red-wattled lapwing, *Vanellus indicus* was occurred most frequently (Table 5).

Table 5. Bird community structure in wheat agro ecosystem

Bird species	Frequency Occurrence	Occurrence (%)	Total birds Occurrence	Relative abundance (%)
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Bird species	Frequency Occurrence	Occurrence (%)	Total birds Occurrence	Relative abundance (%)
Bay-backed shrike	3	60	3	0.29
Black drongo	2	40	5	0.48
Black ibis	2	40	15	1.45
Cattal egret	4	80	25	2.41
Crested lark	3	60	720	69.50
Green bee eater	3	60	12	1.16
Grey francolin	4	80	23	2.22
House sparrow	3	60	8	0.77
Indian roller	2	40	2	0.19
Jungle babbler	2	40	15	1.45
Purple sun bird	2	40	6	0.58
Red-vented bulbul	3	60	16	1.54
Red-wattled lapwing	5	100	48	4.63
Rose-ringed parakeet	2	40	11	1.06
Rosy starling	1	20	21	2.03
Sarus crane	3	60	8	0.77
Spotted dove	2	40	6	0.58
Wire-tailed swallow	2	40	60	5.79
Yellow wagtail	2	40	32	3.09
Grand Total	50		1036	100.00

1.5: Depredatory birds in guava orchard: The 9 guava growers of Anand districts were visited and interviewed for their view on birds role in guava cultivation during year 2018.. The information on birds visiting guava plantation, damage, predation on pest, perception of damage caused by bird was collected and verified by rowing survey field. Total nine locations of middle Gujarat were observed to record guava fruit damage by parakeet. The status of the plantation was 4 to 15 year old. After observed twenty hectare area of guava orchard and communication with farmers, we recorded five per cent damage due to parakeet. The farmers use man power and nylon net to manage parakeet depredations

1.6: Assessment of Rose- Ringed Parakeet (*Psittacula krameri*) depredations to guava fruits: The study on extent of damage by parakeets to guava fruits was undertaken during 2018-19 in the Horticulture farm, AAU campus, Anand. For the study 20 trees were selected from orchard and tagged. Observation recorded for seven months Viz., March and April and June to August, and again in November and December. Depredations on fruits were estimated through direct field observations, applying the probability sampling method. Observations were recorded during morning (7:30 am to 9:30 am) and yet again in the evening (5:00 pm to 7:00 pm) were watchfully recorded. Inflicted fruits were numbered, weighed due to parakeet depredations. Average 41.47 numbers of birds were recorded in guava orchard during morning while it was recorded average 34.28 numbers of birds during evening. The fruit damage was recorded 0.88 % and 0.47 % in morning and evening period, respectively. Overall 11.13 % yield loss due to bird damage in guava field located in campus.

BM 2. Community structures of birds and their diversity in relation to crop stages in different agro-ecological zones of the region

2.1: Monitoring avian diversity in different agro-climatic zones: The study was undertaken in Different habitats of Anand Taluka of central Gujarat region. Study was conducted during summer 2017-18 in four habitats (i) crop land (cereal and vegetables), (ii) wetlands (farm pond, and adjoining area of river) (ii) fallow land (uncultivable land) and (iv) Fruit crop. Transect route with effective 500 m long strip with 50 m width were established. Two transects were laid in each habitat in summer. The Observation recorded during morning hours (7:00 to 11:00 A.M.) twice in each season by using binocular Relative abundance, species richness were recorded. Total 52 species were recorded from four different habitats viz., crop land, wet land, fallow land and horticultural crops. From the crop land, the highest number of species diversity (32) was observed followed by wet land (30), fallow land (26) and Plantation crops (21). However number of birds were recorded highest in wetland ecosystem (833) followed by crop land (456), fallow land (140) and Plantation crop (116) (Table 6)

Table 6. Relative abundance of bird population in different habitat of Agriculture landscape in summer

Sr.No	Bird species	Relative abundance (%)			
		Crop land	Wetland	Fallow land	Plantation crop
1	Ashy prinia	1.1	0	3.65	0
2	Asian koel	0.66	0.36	2.92	0.88
3	Bank myna	0	0	18.2	0
4	Baya weaver	2.21	0	0	1.77
5	Black drongo	1.55	0.72	3.65	4.42
6	Black Ibis	0.22	4.1	0	3.54
7	Black kite	0.44	0	0.73	0
8	Black-winged stilt	0	3.86	0	0
9	Blue tailed bee eater	0	0	20.4	0
10	Brahmany Myna	0.66	0	1.46	0
11	Bronze- winged Jacana	0	0.48	0	0
12	Cattle egret	0.44	0.24	3.65	6.19
13	Comb duck	0	0.96	0	0
14	Common moorhen	0	3.86	0	0
15	Common myna	1.32	0	2.19	1.77
16	Eurasian collared dove	0.44	0	0	0
17	Eurasian golden oriole	0.22	0.36	0.73	0
18	Eurasian spoonbil	0	4.94	0	0
19	Glossy Ibis	0	10.8	0	0
20	Great cormoranat	0	8.43	0	0
21	Greater coucal	0	0	0.73	0
22	Greater flamingo	0	13.6	0	0
23	Green bee eater	1.55	1.69	2.19	6.19
24	Grey francolin	1.1	0	2.92	7.96
25	House crow	0	0.48	0	0
26	Indian robin	1.1	0	3.65	0.88
27	Indian roller	0.66	0	2.19	1.77
28	Jungle babbler	8.39	0.6	7.3	23.9
29	Jungle crow	0.44	0.24	2.19	6.19
30	Large egret	0	0.48	0	0
31	Large gray babbler	0.88	0	0	0
32	laughing dove	0.66	0	0	0

Sr.No	Bird species	Relative abundance (%)			
		Crop land	Wetland	Fallow land	Plantation crop
33	Lesser whistling-duck	0	0.24	0	0
34	Little cormorant	0	7.23	0	0
35	Oriental magpie robin	0.66	0	0	0
36	Painted stork	0	1.93	0	0
37	Pheasant-tailed Jacana	0	0.72	0	0
38	Pied Jacobin cuckoo	0	0.24	0	0
39	Purple moor hen	0	19.5	0	0
40	Purple sun bird	0.88	0	2.19	0
41	Red collared dove	0.44	0	0	0
42	Red vented bulbul	1.55	0	3.65	10.6
43	Red watted lapwing	6.4	9.64	2.92	4.42
44	Rock Pigeon	1.1	0.12	1.46	2.65
45	Rose-Ringed Parakeet	2.43	0	1.46	5.31
46	Sarus crane	0	0.24	0	0
47	Spotted dove	1.55	0	3.65	5.31
48	Tailor bird	0.44	0	3.65	1.77
49	White ibis	0.44	1.93	0	0
50	White thorated kingfisher	0.88	0.36	1.46	1.77
51	White breasted water hen	0	0	0	0.88
52	Wire tailed swallow	58.5	0.6	0	1.77
53	Yello watted lapwing	0.66	0.96	0.73	0
Total No. of birds		456	833	109	114

2.2: Assessment of bird population in different habitats of agricultural ecosystem: The experiment was laid in 2018-19 to detect the change in avian community in Bhal area (chickpea growing region) of Gujarat during year 2018-19. Transect route will be established with effective 500 m long strip and 50 m width. Birds species and their number was recorded. The data were analysis and presented as Occurrence and relative abundance of birds to describe the community structure. Observations were made with aid of binocular. Total 2360 birds of 39 species were observed. The most occurred species were Ashy-crowned sparrow lark, Black drongo, Brahminy starling, Cattle egret, Common myna, Crested lark, Green bee-eater, Jungle babbler, Red-vented bulbul, Sarus crane and Yellow wagtail. Relative abundance of Crested lark was highest and followed by Rosy starling, Wire-tailed swallow and Yellow wagtail (Table 7).

Table 7. Bird community structure in Chickpea agro ecosystem

Bird species	Frequency Occurrence	Occurrence (%)	Total birds Occurrence	Relative abundance (%)
Ashy-crowned sparrow lark	5	100	18	0.76
Bank myna	4	80	37	1.57
Bay-backed shrike	4	80	12	0.51
Black drongo	5	100	31	1.31
Black ibis	3	60	7	0.30
Black-heded ibis	4	80	17	0.72
Black-winged stilt	1	20	35	1.48
Brahminy starling	5	100	29	1.23
Cattel egret	5	100	69	2.92
Common myna	5	100	28	1.19

Bird species	Frequency Occurrence	Occurrence (%)	Total birds Occurrence	Relative abundance (%)
Crested lark	5	100	990	41.95
Great spotted egle	2	40	2	0.08
Green bee eater	5	100	30	1.27
Grey francolin	4	80	23	0.97
House sparrow	3	60	15	0.64
Indian robin	4	80	17	0.72
Indian roller	4	80	15	0.64
Intermediate egret	4	80	31	1.31
Jungle babbler	5	100	43	1.82
Jungle crow	4	80	10	0.42
Open bill stork	1	20	1	0.04
Oriental magpie robim	4	80	26	1.10
Pailid harrier	3	60	3	0.13
Plan prinia	4	80	32	1.36
Pond heron	1	20	1	0.04
Purple sun bird	4	80	17	0.72
Red-vented bulbul	5	100	49	2.08
Red-wattled lapwing	2	40	6	0.25
Rose-ringed parakeet	3	60	39	1.65
Rosy starling	4	80	188	7.97
Sarus crane	5	100	17	0.72
Spotted dove	4	80	19	0.81
White wagtail	3	60	51	2.16
White-spotted Fantail	4	80	31	1.31
White-throated kingfisher	2	40	2	0.08
Wire-tailed swallow	4	80	184	7.80
Woolly-necked stork	4	80	6	0.25
Yellow wagtail	5	100	181	7.67
Yellow-watted lapwing	4	80	48	2.03
Grand Total	147		2360	100.00

BM 3. To Identify, Develop and Evaluate Eco-Friendly Bird Management Techniques

3.1: Effectiveness of egg solution to deter birds visiting crop fields: The demonstration on effectiveness of egg solution to deter birds visiting crop fields were conducted at Regional Research Station, Anand during November-December 2017. Total 1000 sq. m. area of bajra crop was protected by spraying rotten egg solution (1 egg/l water) ribbon and adjoining 1000 sq. m. area of bajra crop sprayed with water. The bird visiting treatment plot was recorded and presented here. Total 723 birds has visited unprotected bajra field while 137 birds have visited bajra treated by egg solution. The mean number of birds visited egg solution treated bajra field (4.89 birds/10 minutes) was significantly low compare to it was observed in unprotected (bajra) field (25.82 birds/10 minutes) (t 6.21, df 54, P<0.05). The egg solution has effectively deterred the bird to visit the crop filed.

3.2: Effectiveness of reflective ribbon to deter birds visiting crop fields: The demonstration on effectiveness of reflective ribbon to deter birds visiting crop fields were conducted at AICRP weed control from during September-November 2017. Total 5550 sq. m. area of maize crop was

protected by installing reflective ribbon and adjoining 5000 sq. m. area of bajra crop kept unprotected. The bird visiting treatment plot was recorded and summarized it in Table. Total 1138 birds has visited unprotected bajra field while 239 birds have visited maize field protected by reflective ribbon. The mean number of birds visited to protected (Maize) field (1.41 birds/ 10 minute) was significantly low compare to it was observed in unprotected (bajra) field (8.49 birds/ 10 minutes). The reflective ribbon has effectively deterred the bird to visit the crop filed.

BM 4: exploitation of beneficial birds for suppressing insect pests

4.1: Impact of mustard crop as intercrop for management of *H. armigera* through birds in chickpea: Chick pea and chick pea + mustard (5:1) were grown separately in a plot size each of 50 m X 25 m area. For netted control net with 1” mesh size were installed with the help of bamboo and galvanized wire. Size of netted control was 5m length X 5m Breadth X 6ft height. Fifteen bird species were recorded in both chick pea and chickpea+ mustard (5:1) plots. Higher number of birds (418) were observed in Chick pea + mustard plot as compare to chickpea alone (179). Impact of beneficial birds are depicted in Table 8.

Table 8. Population of *H. armigera* in Chick pea habitat manipulated plots

Particular	Open				Netted			
	Chick pea		Chick pea + mustard		Chick pea		Chick pea + mustard	
	Eggs	Larva	Eggs	Larva	Eggs	Larva	Eggs	Larva
20.01.17	0.53	2.93	0.33	3.07	0.27	0.80	0.27	1.20
27.01.17	0.33	2.67	0.47	2.87	0.27	0.93	0.27	1.20
03.02.17	0.47	2.93	0.33	2.00	0.13	1.27	0.13	1.53
10.02.17	0.27	2.53	0.13	2.07	0.13	1.47	0.07	1.73
17.02.17	0.00	3.40	0.00	2.27	0.00	1.53	0.00	1.40
28.02.17	0.00	1.60	0.00	1.20	0.00	0.80	0.00	0.67
07.03.17	0.00	2.20	0.00	1.20	0.00	0.93	0.00	0.93
Overall	0.23	2.61	0.18	2.10	0.11	1.10	0.11	1.24

4.2: Establishment of set-aside field for conservation of insectivorous birds: The growing of certain crops on set-aside land to benefit declining farmland bird populations and for biodiversity in general termed as “Set-aside” program (Robinson and Lind, 1999). The relationship between set-aside effect on the basis of data from field studies of birds in cropland and set-aside fields is—and population changes following establishment of these fields.

The agricultural land was acquired to establish the set-aside plot for conservation of insectivorous birds in July 2017. During initial observations on land, it was recorded that plot having low soil fertility, lacking organic matter and highly polluted with weed seeds. This was measure hurdle in establishing the set-aside plot. The decision was made to first improve the soil fertility and eliminate unwanted weed species, before populating the flora supporting insectivorous birds. The sunhemp in monsoon and cow pea in winter was sown as green manuring crop to improve soil fertility and add organic matter. The birds recorded in sunhemp crop were almost negligible.

4.3: Evaluation of nest box design (Entrance hole size) for various cavity nesting birds: The objective of the study was to Evaluation of nest box design for various cavity nesters. The wooden nest boxes having 3.5, 4.5 cm circumference and 6.0 cm height were tested. Experiment was set up at Dharmaj vidi. after obtaining the necessary permission for setting up nest boxes in vidi area. Total 75 Wooden nest boxes having 3.5 and 4.5 cm entrance hole were installed at 6.0 cm height

on tree during January 2018. Out of 75 nests installed, the nesting activity of parakeet was recorded in 5 nest boxes. The parakeets were found visiting the nest boxes.

4.4: Study on waders (Red-wattled Lapwing & Yellow-wattled Lapwing) breeding in farmland: The recent interest in the distribution of breeding waders in worldwide has reflected increasing concern over the effects of intensive farming on waders. In addition to monitoring changes in breeding wader populations and suitable habitats, much needs to be learnt of the habitat requirements of individual species. Detailed breeding-biology studies of local wader populations are therefore of value. The study was carried out at Anand Agricultural University campus in year 2017. Nests were located by searching for incubating birds from roadside watch points and were subsequently watched as often as possible. Nests were visited approximately every two days to determine the number of eggs hatching successfully. Eggs that failed to hatch (and were no longer being incubated) were collected and opened for examination. Success or failure was based on the following criteria: a nest was successful if young were present in the nest or within 10-15 yards of the nest. A nest was judged to have failed if it was found empty only part-way through the incubation period. In determining the time of failure of a nest, it was assumed that a nest was in use if a Lapwing was sitting on the nest, and that a nest had failed if no bird was sitting on it during that, and subsequent, days. Salient findings are as follows;

(a) Nest site : Out of 77 nest recoded from the study area, 4 nests were found in fallow land (playground, college compound, Observatory compound) and remaining 73 nest were located in agricultural area (2 in standing crop, and 71 in harvested or ploughed agricultural field). In agricultural fields, lapwing nest was distributed mainly in ploughed field. Nesting area selected by lapwings is vulnerable to disturbance in form of farm operations in agricultural area. We recoded disturbance in form of preparatory tillage (harrowing, leveling, ploughing) sowing new crop and irrigation.

(b) Nest success: Total 88 nests were found in year 2017, 74 nests of Red-wattled lapwing and 3 nests of Yellow-wattled lapwing. The eventual outcome of all 77 of these nests was known or estimated by gathering evidence presence of egg sell, young ones, eggs, parents etc. Total 77 nests recorded, in 1 nest, eggs were abounded, one or more eggs were damaged/broken eggs recorded in 22 nest. Out of 77 nests, at 51 nests at least one egg hatched.

(c) Clutch size: Out of total 77 nests, te clutch size observed were one at 4 nests, three at 1 nests and four at 72 nests. The clutch size recorded below four eggs mainly because nest and eggs were destroyed before completion of clutch.

(d) Hatching success: Out of 88 nests, at 51 nests at least one egg hatched and in 11 nest at least one egg not hatched was recorded. On 39 nests we observed eggs were lost due to various factor i.e. Farm operation. Overall hatching success observed were 53.74 %, remaining 46.26 % eggs were lost due to various reasons. Majority of eggs were lost due to predation and disturbance during farm operation. Farm operation directly or indirectly encouraged other factors of egg loss i.e. predation, abandon, embryo disturbance resulted in hatching failure

4.5: Role of insectivorous birds in suppression of fruit borer, *Helicoverpa armigera* (Hubner) in tomato: Study was conducted during winter season 2018-19 in MVRS farm, AAU, Anand. Observations of insectivorous birds recorded from the two treatment (Open, Perch area) during morning (After sun rise), noon (13.00-14.00) and evening (Before sun set) by using binocular. Observations of larval populations per ten plants were recorded from the three treatment (Open, Netted and Perch area) during morning (After sun rise). Number of healthy, damaged fruits and weight of fruits per ten plants were recorded. The suppression of fruit borer by insectivorous birds

in tomato field, MVRS farm, AAU, Anand were studied and total 100 observations were recorded for visit of birds on tomato field. Average 4.47 mean number of birds was recorded in open plot while 4.90 birds in perch plot during morning. The population of *H. armigera* larvae recorded in the study is presented in Table 9. Difference in bird visitation during total period in both treatment was found statistically highly significant ($P>0.01$).

Table 9: Population of *H. armigera* larvae recorded in experimental plot.

No. of observations	Mean number of larvae			Per cent reduction in larval population	
	Open	Netted	Perch	Open	Perch
1	37.75	75.75	31.50	50.17	58.42
2	36.75	78.00	27.25	52.88	65.06
3	33.50	78.25	26.75	57.19	65.81
4	31.75	78.75	25.00	59.68	68.25
5	34.00	80.25	26.50	57.63	66.98
Total	173.75	391.00	137.00	277.55	324.53

4.6: Establishment of set-aside field for conservation of insectivorous birds: The objective of the experiment was for Conservation of birds useful in pest management. The flora and fauna in set-aside was monitoring at 15 day interval during the year 2018. Minimum 10 quadrates (1x1 m) were sampled and recorded the plant species and their number. Minimum 10 plants of each species were thoroughly scanned for invertebrates and species and their number. Bird species and its number were recorded at weekly interval. The cereal and pulse crop was grown to enhance the food availability to birds.

(i)Flora: During summer, total 16 plant species were recorded in set-aside field. The most occurred species were *Chenopodium album*, *Vigna unguiculata* *Chenopodium murale* *Digera arvensis* *Trianthema portulacastrum* and *Boerhavia diffusa*. But *Chenopodium album* was dominant species in the present plant community. During Monsoon season, abundance of carpet weed, *Trianthema monogyna* was maximum in cropped as well as non-cropped areas.(Table 10, 11 & 12).

Table 10: Baseline survey of plant community in the set-aside field (Summer 2018).

Common name	Botanical name	Frequency occurrence	Occurrence (%)	Total plant	Relative abundance (%)
Lambs quarter	<i>Chenopodium album</i>	15	100.00	1003	68.56
Nettle leaf	<i>Chenopodium murale</i>	12	80.00	155	10.59
Cowpea	<i>Vigna unguiculata</i>	15	100.00	54	3.69
Carpet weed	<i>Trianthema portulacastrum</i>	10	66.67	47	3.21
Mexican poppy	<i>Argemone maxicana</i>	7	46.67	45	3.08
Creeping spiderling	<i>Boerhavia diffusa</i>	10	66.67	42	2.87
Wild finger	<i>Dectyloctenium aegyptium</i>	7	46.67	33	2.26
Pig weed	<i>Digera arvensis</i>	12	80.00	23	1.57
purple nutsedge	<i>Cyperus rotundus</i>	5	33.33	20	1.37
Commelina	<i>Commelina diffusa</i>	1	6.67	13	0.89
Carrot grass	<i>Parthenium hysterophorus</i>	5	33.33	10	0.68

Common name	Botanical name	Frequency occurrence	Occurrence (%)	Total plant	Relative abundance (%)
Datura	<i>Datura stramonium</i>	1	6.67	8	0.55
Eleusine indica	<i>Eleusine indica</i>	1	6.67	5	0.34
Spiny amaranthus	<i>Amaranthus spinosus</i>	1	6.67	3	0.21
Castor	<i>Ricinus communis</i>	1	6.67	1	0.07
Purslane	<i>Portulaca oleracia</i>	1	6.67	1	0.07

Table 11. Abundance of different plant species in Cropped and Non-cropped plot (Monsoon 2018)

Common Name	Botanical name	Cropped	Non-cropped
Barnyard millet	<i>Echinochloa esculenta</i>	21.88	0.00
Bermuda grass	<i>Cynodon dactylon</i>	0.02	0.00
Carpet weed	<i>Trianthema monogyna</i>	39.14	79.81
Carrot grass	<i>Parthenium hysteroporus</i>	0.07	0.12
Cowpea	<i>Vigna unguiculata</i>	0.72	0.00
Creeping spiderling	<i>Boerhavia diffusa</i>	0.84	0.36
Cress	<i>Lepidium sativum</i>	0.51	0.00
Datura	<i>Datura stramonium</i>	0.01	0.00
Gripe weed	<i>Phyllanthus niruri</i>	0.04	0.96
Indian bean plot	<i>Dolichos lablab</i>	0.22	0.00
Kodo millet	<i>Paspalum Scrobiculatum</i>	10.71	0.00
Lambs quarter	<i>Chenopodium album</i>	0.02	0.36
Mexican poppy	<i>Argemone maxicana</i>	0.07	0.00
Pig weed	<i>Digera arvensis</i>	1.02	2.28
Purple nut sedge	<i>Cyperus rotundus</i>	1.95	14.30
Purslane	<i>Potuleca oleracia</i>	0.05	1.56
Ragi	<i>Elusine coracana</i>	14.27	0.00
Sorghum	<i>Sorghum bicolor</i>	8.28	0.00
Sunhemp	<i>Crotalaria juncia</i>	0.01	0.00
Wild finger	<i>Dactyloctenium aegyptium</i>	0.19	0.24

Table 12. Abundance (%) of plant species in cropped and non-cropped area

Common Name	Cropped								Non-cropped
	Ashwa-gandha	Banti	Cowpea	Cress	Indian bean	Kodo millet	Ragi/bavato	Sorghum	Weed
Barnyard millet	0.00	95.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Bermuda grass	0.00	0.03	0.00	0.00	0.20	0.00	0.00	0.00	0.00
Carpet weed	88.53	2.56	81.54	83.04	88.99	29.91	23.46	37.73	79.81
Carrot grass	0.10	0.00	0.00	0.00	0.30	0.00	0.00	0.27	0.12

Cowpea	0.00	0.00	10.3 5	0.00	0.00	0.00	0.00	0.00	0.00
Creeping spiderling	0.97	0.00	1.17	1.12	1.80	0.99	1.08	0.85	0.36
Cress	0.00	0.00	0.00	8.48	0.00	0.00	0.00	0.00	0.00
Datura	0.00	0.00	0.00	0.00	0.10	0.00	0.00	0.00	0.00
Gripe weed	0.29	0.00	0.11	0.12	0.00	0.00	0.00	0.00	0.96
Indian bean plot	0.00	0.00	0.00	0.00	2.90	0.00	0.00	0.00	0.00
Kodo millet	0.00	0.00	0.00	0.00	0.00	67.88	0.00	0.00	0.00
Lambs quarter	0.00	0.00	0.00	0.37	0.00	0.00	0.00	0.00	0.36
Mexican poppy	0.00	0.06	0.11	0.00	0.00	0.09	0.12	0.05	0.00
Pig weed	2.14	0.36	2.77	1.62	1.70	0.94	0.54	0.75	2.28
Purple nut sedge	7.09	1.53	3.20	4.86	2.70	0.19	0.92	0.96	14.30
Purslane	0.29	0.03	0.21	0.12	0.00	0.00	0.00	0.00	1.56
Ragi	0.00	0.00	0.00	0.00	0.00	0.00	73.88	0.00	0.00
Sorghum	0.00	0.00	0.00	0.00	0.00	0.00	0.00	59.39	0.00
Sunhemp	0.00	0.00	0.11	0.00	0.00	0.00	0.00	0.00	0.00
Wild finger	0.58	0.00	0.43	0.25	1.30	0.00	0.00	0.00	0.24

Total 20 plants species were identified and reported in cropped and non-cropped plot. Cropped highest abundance % was found in *Trianthema monogyna* (39.14) and followed by *Echinochloa esculenta* (21.88), Non-cropped highest abundance % was found in *Trianthema monogyna* (79.81) and followed by *Cyperus rotundus* (14.30). It was found that the Carpet weed, *Trianthema monogyna* plat species was highest abundance was found during Monsoon 2018 (Table 11).

The bird was monitored in set-aside at weekly interval. The abundance of birds in set-aside filed was found fluctuating over the period (Fig. 1). Highest Abundance of birds was found in 13th April 2018 and followed by 26th October 2018. The bird response to disturbance made to habitat through agricultural operation i.e. irrigation, ploughing, weeding.

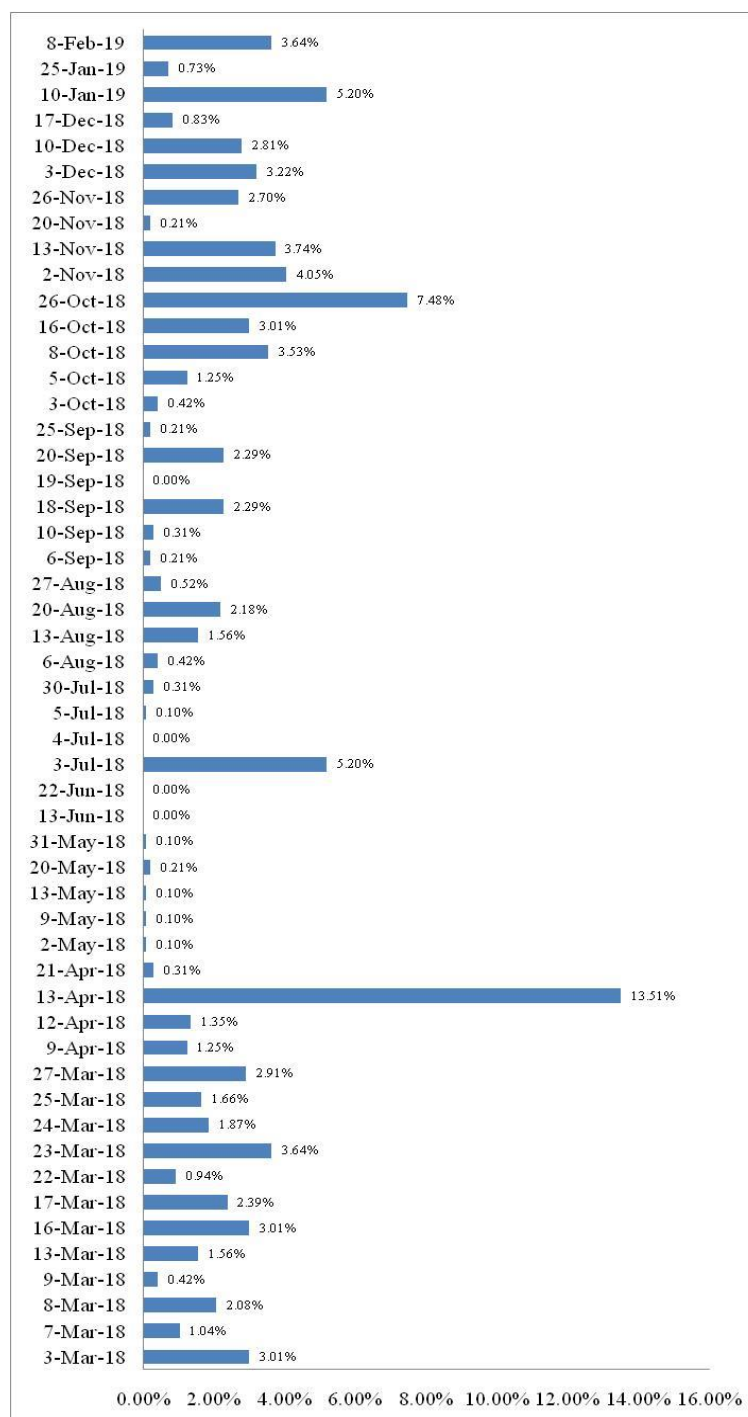


Fig1. Abundance of birds in set-aside field during year 2018-19

4.7: Study on waders (Red-wattled Lapwing & Yellow-wattled Lapwing) breeding in farmland: The study was carried out at Anand Agricultural University campus in year 2018. Nests were located by searching for incubating birds from roadside watch points and were subsequently watched as often as possible. Nests were visited every two days to determine the number of eggs hatching successfully. Eggs that failed to hatch (and were no longer being incubated) were opened collected for examination. Success or failure was based on the following criteria: a nest was successful if young were present in the nest or within 10-15 yards of the nest. A nest was judged to have failed if it was found empty only part-way through the incubation period. In determining the time of failure of a nest, it was assumed that a nest was in use if a Lapwing was sitting on the nest,

and that a nest had failed if no bird was sitting on it during that, and subsequent, days. All nests thought to have failed were visited to check that this was so. In precocial birds, it is difficult to determine. Results on nest sites and nesting success are as follows;

(i) Nest site: Of the Total 72 nests recorded 5 nests were found in wasteland and remaining 67 nests in agricultural (3 nests in standing crop and 64 nests in harvested or ploughed agricultural field). The lapwing nest was distributed mainly in ploughed cropped field. Nesting area selected by lapwings is vulnerable to disturbance in form of farm operations in agricultural area. We recorded disturbance in form of preparatory tillage (harrowing, leveling, ploughing) sowing new crop and irrigation. The one or more time modification of nesting habitat was noted at 22 nests through ploughing or other agricultural operation.

(ii) Nest success: Of the 72 nests, 70 nests of Red-wattled lapwing and 1 nests of each Yellow-wattled lapwing and Grey francolin were recorded. The eventual outcome of all 72 of these nests was that 24 nests were destructed before completion of incubation period while 38 nests survived till completion of incubation period and chick/s were recorded there.

4.8: Evaluation of nest box design (Entrance hole size) for various cavity nesting birds

The experiment was set up at Surjba Park, Dharmaj after obtaining necessary permission from Dharmaj Village Panchayat. Total 78 wooden nest boxes were installed on different tree species during February 2018. The detail on nest location and installation is presented in Table 13. Out of 78 nest box 40 nest were occupied by Common myna, 2 nest were occupied by Brahminy starling, 2 nest were occupied by Oriental magpie-robin, 1 nest was occupied by House sparrow and 8 nest occupied by Squirrel. During survey 22 nest boxes not having any bird activity it may be due to nest box threat posed by Squirrel and other predatory birds. Out of total 78 nests installed almost 71 % nest were occupied in the first year of installation (Fig.2)

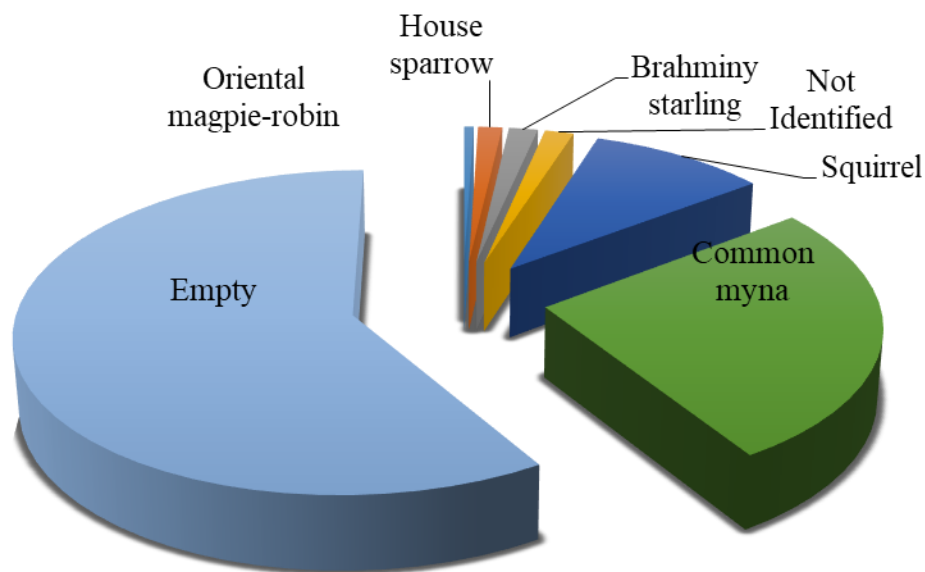


Fig.2. Nest occupancy by birds

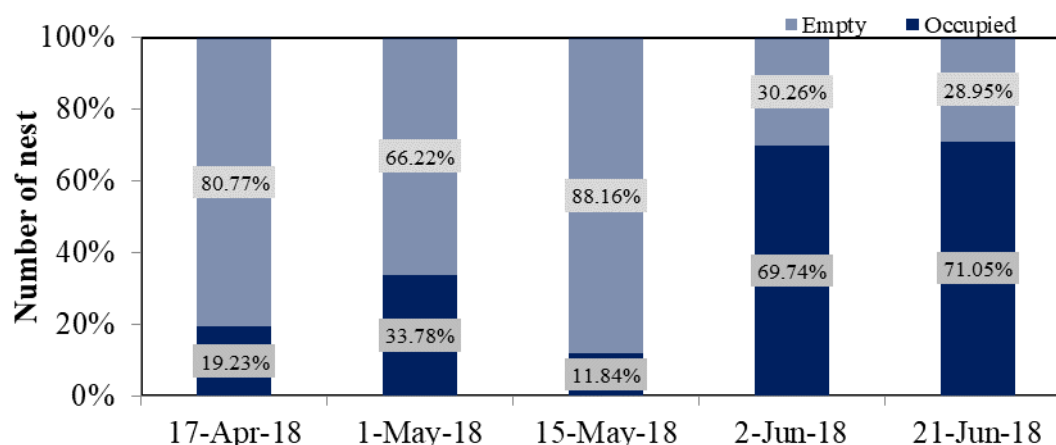


Fig.3: Nest occupancy with progress of breeding season

BM 5. Evaluation of Fruiting / Flowering Trees to Attract Insectivorous / Omnivorous / Depredatory Birds to The Agricultural Land Scape.

5.1: Ecological significance of wild fleshy fruit trees for conservation and management of depredatory and predatory birds: Indian sandalwood, *Santalum album*

Treatments: T1= at stage of flowering , T2= at stage of non-flowering (control)

Methods: Study was conducted in Anand campus of Anand Agricultural University, Anand. Heavy bearing flowering trees of Indian sandalwood, *Santalum album* were identified from study the area and selected for further observation on avifauna during month of November 2017. Total 6 trees were selected for observation Observation was made to find set of birds species that visit a *Santalum album* tree. Birds visiting tree is recorded by instantaneous sampling method at interval of 10 minute for period of 1 hour. The total number birds was analyzed and compared by using appropriate statistical tool. Observations revealed a total of 5 bird species visiting the Sandlwood tree with low frequency and numbers during year 2017. The birds foraged on sandalwood tree were found low during both the year 2016 and 2017. Overall, mean number of observed on tree was negligible. The experiment is concluded with remarks that the bird community was not supported by sandalwood tree in present study area (Table 13).

Table 13. Bird community foraging on Indian sandalwood, *Santalum album* during year 2017

Species	Observations on Birds visiting Sandal tree		
	Frequency	Mean/10 minute	Abundance
Asian Koel, <i>Eudynamys scolopaceus</i>	34	1.32	52.33%
Red-vented Bulbul, <i>Pycnonotus cafer</i>	10	2.20	25.58%
Jungle Babbler, <i>Turdoides striatus</i>	4	4.25	19.77%
Common Myna, <i>Acridotheres tristis</i>	1	1.00	1.16%
White-browed Fantail, <i>Rhipidura aureola</i>	1	1.00	1.16%
Overall	87	0.99	100.00%

5.2: Ecological significance of wild fleshy fruit trees for conservation and management of depredatory and predatory birds

Study was conducted in and around Anand campus of Anand Agricultural University, Anand during year 2018. Heavy bearing flowering and fruiting trees species were identified from study the area and selected for further observation on avifauna. Birds visiting tree is recorded by point count method at weekly interval during the day period. Total 29 species of birds and 775 number

birds were recorded on flesh fruit tree in year 2018. Results presented in Table 14 revealed that Rosy Starling (29.68 %) was dominant bird species and it followed by Jungle Babbler (13.81%), Common Myna (12.90%) and Red-vented Bulbul (11.10%).

Table 14 : Abundance of birds species visiting fleshy fruit trees (N=22)

Sr. No.	Birds species	Residential Status	Total birds	Relative Abundance (%)
1	Asian Koel	RB	24	3.10
2	Common Myna	RB	100	12.90
3	Brahminy Starling	RB	03	0.39
4	Rosy Starling	M	230	29.68
5	Bank Myna	RB	05	0.65
6	Coppersmith Barbet	RB	08	1.03
7	Greater Coucal	RB	05	0.65
8	Rose-ringed Parakeet	RB	28	3.61
9	Spotted Owlet	RB	02	0.26
10	Black Ibis	RB	08	1.03
11	Rock Pigeon	RB	03	0.39
12	Laughing Dove	RB	05	0.65
13	Spotted Dove	RB	01	0.13
14	Red Collared Dove	RB	04	0.52
15	Yellow-footed Green Pigeon	RB	38	4.90
16	Rufous Treepie	RB	02	0.26
17	House Crow	RB	01	0.13
18	Jungle Crow	RB	27	3.48
19	Eurasian Golden Oriole	M	07	0.90
20	White-spotted Fantail	RB	13	1.68
21	Black Drongo	RB	04	0.52
22	Oriental Magpie-Robin	RB	22	2.84
23	Indian Robin	RB	05	0.65
24	Red-vented Bulbul	RB	86	11.10
25	Jungle Babbler	RB	107	13.81
26	Common Tailorbird	RB	09	1.16
27	Purple Sunbird	RB	22	2.84
28	Knob-billed Duck	RB	05	0.65
29	Yellow-crowned Woodpecker	RB	01	0.13
Total	29 bird species		775	100

BM 6. Farmer's Participatory Research on Bird Management

6.1: Farmer's participatory research on bird management

- Demonstration of bird management techniques in Bajra crop at Gopalpura village, Anand. Due to self-explanatory results five farmers has adopted this technology in their field.
- Earthen nests, bird feeders and reflective ribbons were distributed to 65 tribal farmers at KVK, Vyara as a part of demonstration under tribal sub plan
- Distribution of sparrow nest boxes throughout year. On occasion of world sparrow day 200 earthen nest boxes were distributed in school at Chikhodra.

II. LOCATION SPECIFIC PROGRAMMES

BM 7. Biodiversity in Agricultural Landscape with Relevance to Conservation

7.1: Identification of breeding colonies of Painted stork in Gujarat: The map of past records of breeding colonies of Painted Stork was prepared before the initiation of survey. The Painted Stork colonies were surveyed during October-December 2017, the Painted Stork colonies were searched and nest number of painted stork and other species were counted separately on each nesting tree. Salient features of the colony were recorded in the format. Coordinates of the site were recorded using GPS. During the period of study 64 nesting sites were surveyed during October -November 2017. Total 20 colonies of painted storks were identified and it is reported here. Total 3026 nests were recorded, the highest number of nest were recorded in Pil garden (Bhavnagar) (669 nests) followed by Charal (424 nests). It is revealed that distribution pattern of nesting sites are random. About 64 nesting sites of Gujarat state were surveyed. Breeding colonies were recorded in 20 % of previously recorded sites. Colony distribution map is prepared. Most of the colony having successful colonies breeding and raised chicks successfully.

BM 7.2: Identification of breeding colonies of Open-billed stork in Gujarat: The map of past records of breeding colonies of Open-billed Stork was prepared before the initiation of survey. The Open-billed Stork colonies were surveyed during October-December 2017. The total nest number of Open-billed Stork and other species were counted separately on each nesting tree. Salient features of the colony were recorded in the format. Coordinates of the site were recorded using GPS. Total 34 nesting sites from 12 districts of Gujarat are reported and presented in GIS map (Figure). Out of 34 site visited, 17 sites having a active nest and successfully raised the young ones. Total number of nests of Open-billed Stork recorded was 2467 nests. Highest number of nests in colony was recorded at Chalthana (1000 nest) followed by Godhavi (260) and Bharuch (200) sites. It is revealed that distribution pattern of nesting sites was random.

7.3: Monitoring of bird population in wetlands of Gujarat: 2015-17: Waterfowl census was carried on selected wetlands of study area during January-February month of the 2018. The birds were counted by block counting method using Spotting scope (20X80) and binoculars (10X50). Total 58 wetlands were visited to documents the avian biodiversity during January-February 2018. Waterfowl census was carried out on 58 important wetlands of Gujarat state in January -February 2018. Total number of birds recoded from 58 sites was 418568 birds of more than 104 different bird species (Table). The birds numbers was recorded highest at Tarakpur (180000) followed by Nava talav (70000), Malan Bandhara (35014) and Bherai tank (23415). Tarakpur was found important site supporting 50 % of total birds recoded from 58 sites here.

7.4: Monitoring of breeding performance and population status of Sarus Crane: The number of adults and juveniles encountered during the field surveys were recorded during January 2017 for breeding performance and May-June 2017 for population monitoring. The Sarus Crane pairs with juveniles or flocks observed anywhere during the field survey were recorded as it helps to determine distribution and population status. Total 20 sightings of sarus were recorded from Gujarat state during May-June 2017. Total 548 Sarus Cranes were counted from the state. Highest number of Cranes was recorded at Gobarapura talav (150 cranes) of Limbasi tahsil followed by Kanewal (1231) Out of total 548 cranes sighted were 492 adults and 56 juveniles.

A survey was conducted to determine distribution of the territorial breeding pairs of the Sarus Crane in Anand-Kheda district during January 2017. Total 148 cranes were recorded in which only 11 birds were juveniles. The Adult: juvenile ratio was 1.0: 0.081 (Table). Out of 19 pairs seen, 8 pairs were without any juvenile suggesting breeding failure; 9 pairs were with one juvenile whereas 2 pair had two juveniles with them.

7.5: Documentation of Wetland Biodiversity in selected agro-ecological regions of Gujarat:

Survey for Odonates was done in Saurashtra, Kachchh and north Gujarat during monsoon and post-monsoon season. Free flying adults were collected from various types of wetlands. The specimens were preserved dry or wet and brought to the laboratory for identification. Identification was done using standard literature and further confirmation of identification was done by ZSI scientist. Diversity of odonates of Gujarat was studied through general survey and collections done in 33 districts of entire state with reference to biogeographical zones. A total of 68 species belonging to two suborders and 47 genera under ten families were recorded from Gujarat. Twenty three species of Zygoptera (damselflies) and 45 species of Anisoptera (dragonflies) were recorded. In this study, Zygoptera were represented by six families and Anisoptera were represented by four families. Thirty two species are being recorded for the first time from Gujarat state includes two Western Ghats endemic species, *Burmagomphus laidlawi* and *Onychogomphus acinaces* and one Threatened species in IUCN Red list (*Indothemis carnatica*). Thirteen species reported by earlier workers were not encountered during present study. Hence, now total checklist of Odonata of Gujarat has reached to 81 species. Fifteen protected areas of Gujarat were surveyed and maximum species (58) were recorded from Purna Wildlife Sanctuary of Dang district followed by Vansda National Park (48 species). Four biogeographical zones of Gujarat state (Arid, Semi arid, Western Ghat and Coastal area) were surveyed and maximum odonata species (64 species) were recorded from Western Ghat-extension of Gujarat.

7.6: Monitoring of Flamingos breeding ground in Rann of Kachchh: Breeding ground of flamingos was monitored during south-west monsoon through satellite images –MODIS, particularly to determine date of beginning of inundation, spread of water and period of inundation. Movement of flamingos towards breeding ground was monitored either by personal survey of known area or through the network of volunteers. Once, concrete information was received about settling of flamingos in Rann area, a trip was made in October 2017 to confirm nesting. During November to January/February, wetlands of Gujarat were monitored to record presence of brown juveniles. Presence of brown juveniles is indication of successful breeding of flamingos in Rann. Through our studies, it was established that both the species of flamingos breed *en mass* in Great Rann, north of Kuda. A small population also breeds in the Little Rann of Kachchh. Based on the values of precipitation during monsoon and pattern and duration of inundation of Rann (based on Remote sensed images), possibilities of successful nesting can be predicted and that has to be substantiated by ground truthing.

Rann of Kachchh was inundated during south-west monsoon of 2017, particularly during late September. As the water depth (deep blue colour in this image) was high at Kuda-Bela, flamingo city and area north to Nada bet, nesting of flamingo was anticipated at all three sites.

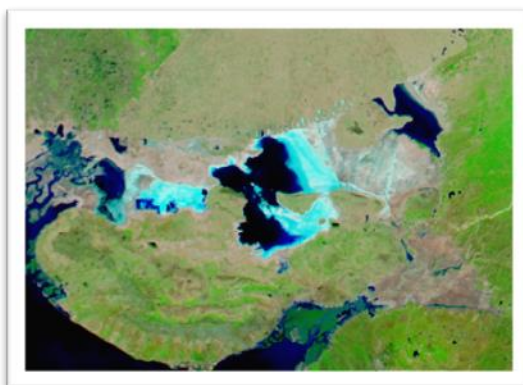


Plate 1 : MODIS image showing Rann of kachchh inundated with water

The first report of successful breeding of both the species of flamingos came from Kuda in Great Rann of Kachchh where more than 80,000 young ones were videographed by Harshendra Kumar Singh (IFS), 6 Nov 2017 of Dehradun. The report of successful breeding came from central part of Little Rann of Kachchh and the Northern side of Nada bet. It was concluded that MODIS image of NASA was be used to monitor extent of inundation and the period of inundation of the breeding ground of flamingos on Rann of Kachchh. If the area remains inundated for ≤ 90 days there are cent percent chances of successful breeding of both the species of flamingos.

7.8: Identification of breeding colonies of Painted stork in Gujarat: Total 64 nesting sites were surveyed during October-November 2018. Total 12 colonies of painted storks were identified and it is reported here. Total 833 nests were recorded, the highest number of nest were recorded in Nana kalodara (254 nests) followed by Khadodhi (166 nests). The nesting colony and number of nest recoded was very low compare previous year. The birds were arrived to breeding place but not attempted to breed and after few days leaved the place.

HV 1: Bio-ecology and Management of higher vertebrates in different crop

HV 1.1: Management of wild boar in agricultural crops: The study was conducted at farmer fields of village: Jahangipura, Anand. The selected field was not having physical barrier. In treatment, planted of 3 to 4 rows of castor crop as border crop with close spacing (high density with row to row 45 cm and plant to plant 30 cm) around the maize crop. Wild boar infestation was recorded from sowing to harvesting of each stage of maize crop. Field was visually inspected by ten randomly quadrate. Each quadrate was 5x5 m² area and approximate percent of area damage was estimated. In the quadrates, both damaged and undamaged stalks were counted.

Ten quadrates each of 5x5 m² were laid randomly in maize crop to access the damage of wild boar. Numbers of plants damaged by wild boar were encountered in each quadrate during different stages of maize crop. There was on an average 62 percent damage was observed in grain filling stage. Wild boars begin to consume maize plants when kernels are in milky stage. Stems were knocked down with the body or snout. The kernels are eaten from the cobs, and if the cobs are sweet and soft, they are sometimes also consumed. Wild boars trample the maize stems into the ground. So, it can be concluded that growing of castor lines around maize crop is not effective to avoid the damage by wild boar.

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	48.60	36.19	1.76	0.23	0.00	0.98	39.15
2018-19	29.90	19.29	4.81	0.09	0	4.95	29.14

UNIVERSITY OF AGRICULTURAL SCIENCES, GKVK, BANGALORE-560 065

PART: I General Information

1.	Name of the Center	University of Agricultural Sciences, GKVK, Bangalore-560 065
2.	Sanction No.	No.5\4-78.pp dated 23.05.1980
3.	Date of Start	January 1978 under DST.No.HCS/DST\255\76
4.	Date of Termination	Network Project of continued nature
5.	Report period	1-4-2017 to 31-3-2019
6.	Scientist In charge of the center	Dr. Mohan I. Naik, Professor and Scheme Head

7. Staff Position (sanctioned)

S N	Name of the Post	No of Posts	Name of Incumbent	Date of Joining	Date of leaving
1	Sr Zoologist	1	Dr. Mohan I. Naik,	01.10.2013	Contd
2	Tech. Asstt	1	Mr Basavadarshan AV (On Contract)	2.03.2017	-
3	Lab. Attender	1	Mr NarayanaShetty, JD	10.04.2008	Contd

PART II: Work Allotted (Technical Programme)

1. Multi location Programmes

R.M. 1: Surveillance of rodents in Predominant cropping systems.

R.M. 2: Monitoring of rodent abundance and damage in selected agro-climatic zones.

R.M. 3: Evaluation of botanicals against rodent pests for Antifeedant / Deterrent / Attractant / Sterilant effects.

R.M. 4: Development / Refinement of rodent pest management modules in Predominant crops / cropping system.

R.M. 5: Studies on Bio ecology on *Bandicota indica*.

R.M. 6: Social engineering Activity on Rodent pest management as participatory adaptive research programme.

2. Location Specific Programmes

1. Rodent management in Organic farming ecosystem.

2. Bio ecology and management of higher vertebrates in different crops - Wild Boar,

3. Mitigation of Human- Animal conflict in agricultural ecosystem a social and ecological perspective.

PART III: Work Done

I. R.M. 1: Surveillance of rodents in Predominant cropping systems.

1. Paddy - vegetables (Hilly zone) and Ragi - field bean (Eastern dry zone): Paddy being a predominant crop during *khari*f in Hilly zone of Karnataka followed by vegetables during summer. The peak rodent activity (58 LBC/ha) was noticed during harvesting stage with 6.86% damage in paddy. The predominant species recorded were *Bandicota bengalensis* (*Bb*) > *Millardia meltada* (*Mme*) > *Mus booduga* (*Mb*). The pregnancy period was throughout the year (50.00 to 66.66%) with F: M ratio of 1:1. In **vegetables** also *Bb* was predominant followed *Mme*, *Mb* and *Ti*. The per cent density was 54 LBC/ha with 6.52% damage. In **ragi** the rodent density varied from 47 to 58 LBC/ha in earhead formation and harvesting stage with an incidence of 4.35 to 5.82 per cent, respectively. Whereas in field bean the peak density of at early stage with 62 LBC/ha with an incidence of 6.36% on sowing seeds and continued till harvest (62LBC/ha and 6.26% incidence). In both the crops *Bb* was predominant following *Mme* and *Mus platythrix* (*Mp*). The M: F ratio was 1:1. The pregnancy % was 25 to 57.14 per cent (Table 1)

3. Paddy – pulse (Southern dry zone) 2018-2019

In paddy, *M booduga* was predominant species initially later stages it was replaced by *B. bengalensis*. The next species was *M. platythrix*. The density reached its peak of 62 LBC during harvesting with 7.23% incidence. However, there was sudden drop in the rodent density and it was 25 LBC/ha with 2.2% incidence on sown seeds of pulses again reached peak 50 LBC/ha with 6.3% incidence at harvesting stage. The rodent activity was recorded throughout the year with pregnancy of 42.86% to 60.00 with F: M ratio of 1:1 and pulse crop the *Tatera indica* was also active (Table 1).

Table 1: Surveillance of rodent in predominant cropping system

Year & Zone	Cropping system	Stage of crop	Month	Rodent density LBC/ha	Incidence (%)	Species composition	Pregnancy (%)
2017-18 (Hilly Zone)	Paddy (Kharif)	Harvesting	Nov / Dec	68	6.8	<i>Bb</i> > <i>Mb</i> > <i>Mme</i>	50-66
	Cabbage (summer)	Head formation	March	54	6.5	<i>Bb</i> > <i>Mb</i> > <i>Ti</i>	42-32
2017-18 (Eastern dry Zone)	Ragi (kharif)	Harvesting	Oct /Nov	58	5.8	<i>Mb</i> > <i>Bb</i> > <i>Mme</i>	28-60
	Field beans (summer)	Harvesting	Jan/Feb	56	6.2	<i>Mb</i> > <i>Mme</i> > <i>Bb</i> > <i>Ti</i>	25-57
2018-19 (Southern Dry Zone)	Paddy (Kharif)	Harvesting	Nov/Dec	62	7.2	<i>Bb</i> > <i>Mme</i> = <i>Mb</i>	42-60
	Field bean (Winter)	Harvesting	Jan	51	6.3	<i>Bb</i> > <i>Mme</i> > <i>Mb</i>	37-66

Bb=*Bandicota bengalensis* *Mme*=*Millardia meltada*, *Mp*= *Mus platythrix*, *Ti*=*Tatera indica*

RM 2: Monitoring of rodent abundance and damage in Western Ghats(hills), Eastern dry zone and Coastal zone

In **Western Ghats (hills)**, the peak incidence on paddy at harvesting stages was 7.31% with 77 LBC/ha. The dominant species were *Mb* followed by *Bb* and *Mme*. In coconut the incidence was 5.32% while the rodents recorded were *Funambulus palmarum*, *Rattus rattus* and *B.*

bengalensis (Table 2). In pineapple at fruit formation stage the incidence was 6.32% with 47 LBC/ha. The predominant species recorded were *M. meltada*, *B.bengalensis* and *T. indica*, whereas in sweet potato the LBC was highest (79 LBC/ha) with high incidence of 8.62% and the dominant species recorded were *B.bengalensis*>*M. booduga*>*M. meltada*. During 2018-19 on sweet potato and pineapple the damage was 10.8 and 5.6 %, respectively. At **eastern dry zone** on ragi the peak density was 61 LBC/ha with 7.31 per cent incidence. In jowar it was 48 LBC/ha with 5.1% incidence. In field bean, cabbage and cucumber the peak rodent activity of 25, 44, 53 LBC/ha with incidence of 1.67, 3.64 and 3.92% was recorded, respectively. In most of the crop the species composition was *B. bengalensis*=*M.booduga*>*M.meltada* and *M.platythrix*. In **coastal zone** on coconut the rodent incidence (RI) was 17.2 and the dominant species was *F. palmarum* and *R. rattus*. In paddy and pulses the peak incidence were 6.72 and 5.82%, respectively with *M. booduga* being a dominant species (Table 2).

Table 2: Monitoring of rodent abundance in Western Ghats, Eastern dry zone/Coastal/Southern Dry Zone.

Crop	Rodent density LBC/ha	Incidence (%)	Species composition
Paddy	37-77	3.3-7.3	<i>Mb</i> > <i>Bb</i> > <i>Mp</i>
Coconut	16-32	2.6-6.3	<i>Fp</i> > <i>Rr</i> > <i>Bb</i>
Pineapple	39-47	3.2-3.7	<i>Bb</i> > <i>Mb</i> > <i>Mme</i>
Sweet potato	36-79	2.3-8.6	<i>Bb</i> > <i>Mp</i>
Ragi	37-48	3.8-5.1	<i>Bb</i> > <i>Mp</i> > <i>Mme</i>
Cucumber	35	3.9	<i>Bb</i> > <i>Mp</i>
Tapioca	49	5.6	<i>Mme</i> > <i>Mp</i> > <i>Bb</i> > <i>Bi</i>
Arecanut	19	0.6	<i>Fp</i> > <i>Rr</i>
Pulses	59-61	5.4-5.8	<i>Bb</i> > <i>Mme</i> > <i>Ti</i>

Bb=*Bandicota bengalensis*; *Mme*=*Millardia meltada*; *Mp*= *Mus platythrix*; *Ti*=*Tatera indica*
Mb= *Mus booduga*; *Fp* = *Funambulus palmarum*

RM. 3: Evaluation of botanicals (papaya seeds-as antifertility agent against *R. rattus*)

The *Rattus rattus* were provided with 0.75g, 1.25g and 1.75g of papaya seeds during the trial period with 25g normal bait for 7, 15, and 30 days continuously in the laboratory. The results (Table) indicated that there was a reduction in the weight of a ovary and uterus, enhancement in the diestrus stage of oestrus cycle (Table), reduction serum cholesterol, serum glucose (Table) reduction in the serum hormonal profiles (estuarial and progesterone) when fed with 1.25g for 30 days. Besides these treatments also affected the mating success rate and there was a reduction in the number of successful female delivered pups and survival rate of pups (Table 3-6).

Table 3: Effect of papaya seed powder on organ weight and serum constituents in *R. rattus* female

Treatment	Organ weight		Serum biochemical constituents		
	Ovary(mg)	Uterus mg)	Glucose (mg/dL)	Cholesterol (mg/dL)	Protein (mg/dL)
0.75 seed + 25g bait-7	24.16±0.55 ^a	75.78±2.6 ^a	103.01±1.89 ^a	73.71±7.20 ^a	4±0.57
0.75 seed + 25g bait-15	23.30±0.82 ^a	75.10±2.81 ^a	102.19±2.15 ^a	69.34±6.06 ^a	3.84±0.49
0.75 seed + 25g bait-30	23.81±1.09 ^a	77.2±2.04 ^a	103.32±2.11 ^a	72.50±4.42 ^a	3.93±0.55
1.25g + 25g bait-7	23.48±0.68 ^a	76.38±2.51 ^a	102.22±2.07 ^a	74.63±6.92 ^a	4.18±0.63

1.25g + 25g bait-15	23.81±1.03 ^a	74.42±2.21 ^a	101.72±3 ^a	73.73±6.10 ^a	3.99±0.57
1.25g + 25g bait-30	15.09±0.67 ^c	56.38±1.34 ^b	56.49±2.63 ^b	50.07±3.07 ^b	3.73±0.40
1.75g + 25g bait-7	23.75±0.65 ^a	76.82±2.24 ^a	104.15±1.32 ^a	71.54±8.15 ^a	3.85±0.47
1.75g + 25g bait-15	16.44±0.80 ^b	55.93±2.58 ^b	58.41±1.63 ^b	46.68±6.62 ^b	4.09±0.39
1.75g + 25g bait-30	15.41±1.10 ^b	54.62±2.81 ^b	55.88±2.49 ^b	49.31±4.54 ^b	3.91±0.36
25g bait (C)	23.95±0.70 ^a	75.98±3.08 ^a	102.04±2.15 ^a	73.49±8.18 ^a	4.01±0.56
CD at 5%	1.055	3.314	2.54	7.34	NS
S.Em. ±	0.371	1.103	0.89	2.58	0.21
CV	4.267	3.867	2.46	9.66	13.19

Values are mean ± SD from 6 animals. Statistical analysis was done by one way ANOVA followed by Duncan multiple range tests. $P < 0.05$ as compared to control.

Table 4: Effect of papaya seed powder on different stages of estrus cycle of *R. rattus* female

Treatment	Estrus cycle (hrs)	Stages of estrus cycle			
		Proestrus (hrs)	Estrus (hrs)	Metaestrus (hrs)	Diestrus (hrs)
0.75 seed + 25g bait-7	99.07±1.35 ^c	12.33±0.63 ^c	26.47±1.89 ^a	6.27±0.23	54.00±2.09 ^d
0.75 seed + 25g bait-15	100.37±0.84 ^{bc}	12.58±0.63 ^{bc}	25.97±1.97 ^a	6.23±0.36	55.58±1.29 ^{cd}
0.75 seed + 25g bait-30	101.12±0.87 ^{bc}	12.58±0.62 ^{bc}	26.37±1.95 ^a	6.28±0.38	55.88±1.27 ^c
1.25g + 25g bait-7	101.35±0.69 ^{bc}	12.80±0.70 ^{bc}	26.02±1.39 ^a	6.47±0.27	56.07±0.84 ^c
1.25g + 25g bait-15	101.60±0.73 ^{bc}	13.00±0.80 ^{ab}	25.85±1.48 ^a	6.60±0.43	56.15±1.54 ^c
1.25g + 25g bait-30	99.58±0.40 ^{bc}	13.85±0.69 ^a	6.80±0.72 ^b	6.62±0.17	72.32±0.81 ^b
1.75g + 25g bait-7	101.07±0.96 ^b	12.73±0.57 ^{bc}	26.07±1.31 ^a	6.37±0.52	55.90±1.50 ^c
1.75g + 25g bait-15	105.55±1.17 ^a	13.05±0.78 ^{bc}	7.05±1.03 ^b	6.32±0.48	79.13±2.54 ^a
1.75g + 25g bait-30	107.77±1.02 ^a	13.42±0.69 ^{ab}	7.05±1.03 ^b	6.45±0.23	80.04±1.35 ^a
25g bait (C)	99.85±0.93 ^{bc}	12.65±0.71 ^{bc}	25.2±0.73 ^a	6.65±0.53	55.35±1.47 ^{cd}
CD at 5%	2.75	0.906	1.650	NS	1.800
S.Em.±	0.97	0.31	0.58	0.06	0.63
CV	2.33	6.031	7.014	5.775	2.498

Values are mean ± SD from 6 animals. Statistical analysis was done by one way ANOVA followed by by Duncan multiple range tests. $P < 0.05$ as compared to control.

Table 5: Effect of papaya seed powder on serum hormonal (pituitary) profiles in *R. rattus* female

Treatment	Serum hormonal (pituitary) profiles		Serum hormonal (Ovary) profiles	
	LH (μ Lu /ml)	FSH (μ Lu /ml)	Estradiol (pg/dL)	Progesterone (pg/dL)
0.75 seed + 25g bait-7	0.47±0.02 ^{ab}	0.85±0.03 ^a	103.25±1.97 ^a	21.82±1.5 ^a
0.75 seed + 25g bait-15	0.46±0.03 ^b	0.83±0.05 ^a	101.89±1.19 ^a	20.70±0.25 ^b
0.75 seed + 25g bait-30	0.48±0.03 ^{ab}	0.85±0.05 ^a	102.15±1.4 ^a	20.58±0.3 ^b
1.25g + 25g bait-7	0.46±0.04 ^b	0.82±0.06 ^a	102.84±2.32 ^a	20.47±0.21 ^b
1.25g + 25g bait-15	0.50±0.02 ^a	0.84±0.04 ^a	103.09±2.53 ^a	21.08±0.44 ^b
1.25g + 25g bait-30	0.17±0.01 ^c	0.45±0.05 ^b	89.94±1.86 ^b	7.93±0.45 ^c
1.75g + 25g bait-7	0.49±0.03 ^{ab}	0.84±0.04 ^a	103.35±1.91 ^a	20.54±0.34 ^b

1.75g + 25g bait-15	0.19±0.01 ^c	0.41±0.03 ^b	90.23±1.03 ^b	7.79±0.34 ^c
1.75g + 25g bait-30	0.20±0.02 ^c	0.46±0.03 ^b	90.80±1.21 ^b	7.82±0.29 ^c
25g bait (C)	0.48±0.04 ^{ab}	0.87±0.03 ^a	102.69±1.22 ^a	20.49±0.18 ^b
CD(0.05)	0.03	0.05	2.016	0.718
S.Em±	0.012	0.018	0.709	0.252
CV	6.71	5.96	1.756	3.65

Values are mean ± SD from 6 animals. Statistical analysis was done by one way ANOVA followed by Duncan multiple range tests, Dunnett's 't' test. $P < 0.05$ as compared to control

Table 6: Effect of papaya seed powder on mating success and delivery by female black rat

Treatment	Number of females with successful mating (%)	Number of females delivered (% females)	Number of pups delivered (gestation period)	Percentage of pups alive after 40 days
0.75 seed + 25g bait-7	3/6 (50%)	2/3 (66.66%)	6(23), 4(22)	40.00
0.75 seed + 25g bait-15	2/6 (33.33%)	1/2 (50.00%)	5(24),	40.00
0.75 seed + 25g bait-30	4/6 (66.66%)	2/4 (50.00%)	7(22), 6(23)	38.46
1.25g + 25g bait-7	4/6 (66.66%)	3/4 (75.00%)	5(21), 6(24), 4(23)	40.00
1.25g + 25g bait-15	2/6 (33.33%)	1/2 (50.00%)	4(24)	50.00
1.25g + 25g bait-30	2/6 (33.33%)	1/4 (25.00%)	3(22)	33.33
1.75g + 25g bait-7	4/6 (66.66%)	1/2 (50.00%)	6(23)	50.00
1.75g + 25g bait-15	3/6 (50.00%)	1/3 (33.3%)	5(22)	40.00
1.75g + 25g bait-30	2/6 (33.33%)	1/2 (50.00%)	4(24)	25.00
25g bait (C)	5/6 (83.33%)	3/5 (60.00%)	6(24), 7(21), 7(23)	52.38

R.M. 5: Studies on Bio ecology on *Bandicota indica*.

i. Trapping efficacy of attractants: The dry fish, jackfruit, chapati mixed with egg yolk, coconut and vada (control) were used as baits as attractants while trapping *B. indica*. Among the bait attractants jack fruit was the best with trapping efficacy of 0.38 and 0.24 rats/trap/night followed by dry fish (0.29 & 0.21), chapati with egg yolk (0.19 & 0.15), coconut (0.14 & 0.12) and vada (0.14 and 0.12) control during 2017-18 during 2018-19, respectively (**Table 7A**).

Table 7 A. Trapping efficacy of attractants against *Bandicota indica*

Attractants	2017-18				2018-19			
	Male	Female	Total	Trap Index	Male	Female	Total	Trap Index
Dry fish	3	3	6	0.29	4	3	7	0.21
Jack fruit	5	3	8	0.38	6	2	8	0.24
Chapatti smeared with egg yolk	2	2	4	0.19	4	1	5	0.15
coconut	1	1	2	0.10	2	2	4	0.12
Potato	-	-	-	-	1	1	2	0.06
Bread	-	-	-	-	2	1	3	0.09
Control (Vada)	1	2	3	0.14	2	2	4	0.12
Total 3 traps 7 days	12	11	23	-	21	11	33	

Trap Index: Rat trapped/day/trap

ii. Additives to enhance the palatability/ consumption: The Jack fruit as an additive enhanced the bait consumption by 10.88 %t followed by fishmeal (7.88%) and egg yolk (5.6%) irrespective of dosages (1, 1.5, and 2.0%) and sex (Table 7B).

Table 7 B. Increase in bait intake with of attractants additives in *Bandicota indica*

Treatment	Rodent Index (RI)		% increase in Bait intake due to additive 2%
	2017-18	2018-19	
Dry fish	0.29 (6)	0.21 (7)	10.88
Jackfruit	0.18 (8)	0.24 (8)	7.80
Chapati (yolk)	0.19 (4)	0.15 (5)	5.6
Vada (control)	0.14 (3)	0.12 (4)	-

Figure in parenthesis indicates actual numbers trapped by three traps for 3 weeks.

iii. Studies on cell types and duration of estrus cycle in *Bandicota Indica*: The mean duration of oestrus cycle was 4.48 in *B. indica* whereas the duration of proestrus, estrus, metestrus and diestrus duration was 13, 32, 6.8 and 55.8 hours with nucleated epithelial cells, nucleated keratinized epithelial cells, keratinized epithelial cells with neutrophils and combination of nucleated epithelial cells, respectively (Table 8).

Table 8: Studies of oestrus cycle of *B. indica*

Stages of oestrus	Duration (hrs)
Proestrus	13
Estrus	32
Meta estrus	3.8
Diestrus	55.8
Total	4.48 days

RM 7 Development of RPM modules in Predominant crops

1. Ground nut: Following treatments were given to ground nut crops in various combinations integrating, mechanical (traps) and chemical (zinc phosphide and bromadiolone) baiting at different growth stages of the crop in order to develop an integrated rodent management module for ground nut.

- T1: Setting 54 Snap traps per ha at germination stage
- T2: Zn3P2 (2%) baiting at germination stage
- T3: Bromadiolone CB (0.25%) at germination stage
- T4: Al2 (Po3)2 application at germination stage
- T5: Setting 54 Snap traps per ha at peg formation stage
- T6: Bromadiolone CB (0.25%) at peg formation stage
- T7: Zn3P2 (2%) baiting at peg formation stage
- T8: Al2 (Po3)2 application in burrows at peg formation stage
- T9: T1+T7 (54 Snap traps per ha at germination stage +2% Zn3P2 baiting at peg or mation stage)
- T10: T3 + T7 (Bromadiolone CB (0.25%) at germination
- T11: T2 + T8 (2% Zn3P2 baiting at germination stage + Al2 (Po3)2 application in peg formation stage)
- T12: T2 + T6 (2% Zn3P2 baiting at germination stage + Bromadiolone (0.25%) CB at peg formation stage)

- T13: Control

The results are depicted in Table 9. Significant reductions of live burrow counts were recorded in T11 [(2% Zn_3P_2) baiting at germination stage and $Al_2(P_2O_5)_3$ application in peg formation stage] with 82 % reduction in LBC which is on par with T9 (54 Snap traps/ha at germination stage and 2% Zn_3P_2 baiting at peg formation stage) with 80 % reduction. The highest yield of 1381.00 kg/ha was also recorded in T11 (2% Zn_3P_2 baiting at germination stage and $Al_2(P_2O_5)_3$ application in peg formation stage) followed by T9 with 1363.65 kg/ha. However, the C: B ratio was highest (1:38.82) in T7 (Zn_3P_2 (2%) baiting at peg formation stage) with yield of 1281.09 kg/ha followed by T8 [$Al_2(P_2O_5)_3$ application in burrows at peg formation stage)] (Table 10).

Table 9: Evaluation of Different Modules in groundnut field for Rodent Management.

Treatments	GERMINATION STAGE			PEG FORMATION STAGE			HARVESTING STAGE	REDUCTION IN POPULATION %
	Live Burrow Count/ha			Live Burrow Count/ha			Live Burrow Count/ha	
	A day before treatment	7 days after treatment	14 days after treatment	A day before treatment	7 days after treatment	14 days after treatment		
T ₁	26.67±1.89	8.33±2.89	10.00±2.00	23.33±3.64	28.33±2.89	33.33±3.77	56.67±3.64	31
T ₂	26.67±2.89	6.67±2.89	8.33±2.78	18.33±3.64	20.00±2.00	28.33±2.64	53.33±3.64	35
T ₃	27.33±1.89	8.33±2.89	11.67±2.23	25.00±2.00	28.33±2.89	33.33±2.64	58.33±5.58	29
T ₄	27.00±2.00	5.00±2.00	6.67±2.89	13.33±2.89	15.00±2.00	20.00±2.00	43.33±5.77	47
T ₅	26.67±2.89	38.33±2.89	43.33±2.89	53.33±2.89	8.33±2.89	10.00±2.00	28.33±2.64	65
T ₆	27.00±2.00	33.33±1.77	38.33±3.29	53.33±2.89	11.67±2.89	18.33±7.64	33.33±2.89	59
T ₇	27.33±1.89	38.33±2.89	43.33±2.89	53.00±1.89	8.33±2.89	13.33±2.89	25.00±2.00	69
T ₈	26.67±1.89	33.33±2.89	38.33±3.24	53.33±2.89	5.00±0.00	6.67±2.89	18.33±2.64	78
T ₉	26.67±2.89	8.33±1.77	10.00±2.00	23.33±2.64	6.67±2.89	8.33±2.89	16.67±2.89	80
T ₁₀	27.00±2.00	8.33±1.67	13.33±2.89	28.33±2.64	6.67±2.89	8.33±2.89	18.33±2.89	78
T ₁₁	26.67±2.89	6.67±2.89	10.00±2.00	20.00±2.00	5.00±0.00	6.67±2.89	15.00±2.00	82
T ₁₂	27.33±2.89	6.67±1.27	10.00±2.00	25.00±2.00	8.33±2.89 ^c	11.67±2.89	18.33±2.89	78
T ₁₃	27.33±2.89	38.33±1.58	43.33±2.89	53.33±2.89	58.33±2.89	61.67±3.77	81.67±5.77	0
SEM	0.98	0.43	0.58	0.54	1.3	0.93	2.19	
F test	NS	*	*	*	*	*	*	
CD	2.91	1.39	1.56	2.13	3.54	1.69	4.10	

Note: Significance at P= 0.05 level: NS-Non significant

Table 10. Efficacy of treatments on yield of groundnut during Kharif 2017

Treatments	Yield (Kg/ha)	Cost: Benefit Ratio
T1	1076.36j	1:4.37
T2	1111.81i	1:20.6
T3	1024.00k	1:10.19
T4	1190.01h	1:22.82
T5	1252.27f	1:9.23
T6	1229.63g	1:30.59
T7	1281.09e	1:38.82
T8	1306.11d	1:32.67
T9	1363.65b	1:10.17
T10	1321.71cd	1:5.17
T11	1381.00a	1:21.88
T12	1335.19c	1:21.40
T13 (Control)	920.80	-
SEM	6.04	-
CD	17.62	-
F Test	*	-

2. Areca nut: Irrespective of baits, the placement of bait plays an important role in reducing rodent population only three treatments where the baits placed at the crown region (on

inflorescence) were found effective i.e. poison baiting with Bromadiolone. The predominant species found in areca plantation were *F. palmarum*, *B. bengalensis* and *R. rattus*. (Table 11).

3. Coffee: Among the six treatments, the application of Difenacoum was effective with reduction of 79.27 % LBC followed by bromadiolone cake application with 74.63 per cent reduction and bromadiolone baiting with 72.60 per cent reduction. The rodents captured includes *B. bengalensis*, *R. rattus*, *T. indica* and *M. melstada*. (Table 10).

4. Pepper: An experiment was taken up at Mudgire, Chikkamagalur (district) with 6 treatments and 4 replications. Snap trap @54/ha was found effective with 95.85 % incidence reduction followed by Bromodiolone baiting and Zn_3P_2 baiting. (Table 11).

Table 11: Rodent management in different crops

Crops	Treatments	% reduction after 1 st application	% reduction after 2 nd application
Pepper	$Zn_3P_2 \rightarrow$ Bromodiolone Bait	74.00	94.6
	Bromodiolone $\rightarrow$ Zn_3P_2 Bait	79.20	90.7
	Snap traps (54/ha)	82.00	95.8
	Control	6.40	54.9
		Coffee	Areca nut
Coffee / Areca nut	Snap trap	71.88	-
	Bromodiolone cake	74.63	92.3
	Bromodiolone bait	72.60	92.3
	Zn_3P_2 bait	67.65	88.5
	Control	7.69	9.3
	Ground application		30-33%

RM 9 Social engineering activity on RPM as participatory adaptive research programme.

Three villages (Sakayyana doddi of Ramanagara Tq & Dist., Edagur of Gubbi Tq, Tumkur Dist. and Hanumapura of Magadi Tq Ramanagara Dist) have been selected for social engineering studies on rodents. In first village (Sakayyana doddi) extension activities on RPM were taken up and the inputs were supplied. But not in second village (Edagur) only extension activities on RPM were taken up. Whereas the third village (Hanumapura) neither extension activities nor inputs have been supplied and treated as control (Table 12).

The observations indicate in Sakayyana doddi the reduction of rodent density was 65.34 and 81.70 % and rodent incidence was 65.63 and 76.22 % after 21 DAT and during harvest, respectively. Whereas in Edagur the reduction in rodent density was 65.34 and 81.70 % and incidence was 25.20% and 42.09 % after 21 DAT and during harvest, respectively. In control village the rodent density increased by 3.47 % after 21 days and 14.88 % at harvesting stage while rodent incidence increased to 4.47 % at 3 weeks after treatment and 8.76 % incidence at harvest.

When the data was subjected to KAP analysis there was innovators in first village and it requires media and publicity whereas second villagers are adopters, they require training Programme

Similarly, during 2018-19 three villages viz., Kachamachenahalli, Veerammanahalli and Sadenahalli of Gowribidanur Tq., Chikkaballapura (Dist.) were adopted to implement RPM campaign on large scale. The treatments were similar and the results were also similar to 2017-18.

Table 12: Social Engineering activity on RPM as adaptive research

Year	Village	LBC/ha		Incidence %		KAP
		21 DAS	at Harvest	21 DAT	at harvest	
2017-18	Sakayanadoddi	14.2 (65.3%)	7.5 (81.7%)	1.33 (65.6%)	0.92 (76.2%)	Media & publicity
	Edagur	22.1 (36.5%)	15.4 (55.8%)	2.8 (25.2%)	2.2 (42.1%)	Training programme
	Hanumapura	43.4 (34) ↑	49.0 (14.8) ↑	4.2 (4.5) ↑	4.4 (8.8) ↑	Demonstration & interaction
2018-19	Kachamachenahalli	14.0 (55.2%)	6.4 (79.4%)	1.33 (66.1%)	1.08 (72.5%)	Media & publicity
	Veerammanahalli	21.29 (38.4%)	19.8 (42.5%)	2.6 (25.3%)	2.8 (30.9%)	Training programme
	Sadenahalli	42.2 (15.49) ↑	52.3 (39.7) ↑	4.3 (10.8) ↑	6.5 (12.5) ↑	Demonstration & interaction

LOCATION SPECIFIC PROGRAMMES

1. Management of rodents in organic farming system

a. Rodent Incidence: The rodent index of 45.12 in organic crops than in the 39.62 inorganic crops. The species composition revealed the dominance of *B. bengalensis* followed by *M. meltada*, *M. booduga*, *T.indica* and *F. palmarum* (Table 13).

Table 13: Surveillance of rodents in organic farming system

Year	Organic		Inorganic	
	LBC/ha	Trapping index	LBC/ha	Trapping index
2017-18	45.12	25.80	39.62	23.69
2018-19	38.56	23.30	34.94	21.71
Species composition	<i>Bb>Mme>Mb>Ti>Fp</i>		<i>Bb>Mme>Mb>Ti>Fp</i>	

Out of 27 potent botanicals tested 7 were effective against the rodent pests. viz., *Strychnos nux-vomica*, *Myristica fragrans*, *Baliospermum montanum*, *Datura stramonium*, *Gliricidia sepium*, *Ricinus communis* and *Azadirachta indica*. The toxicological study of *Strychnos nux-vomica* against different rodent species was evaluated by no choice method. With bark powder mortality observed 8, 9 and 15.5 days in *R. rattus*, *M. platythrix* and *B. bengalensis* with mortality of 60, 60 and 40%, respectively. In bark extract the mortality of 66.6, 50, and 50 % was recorded in *M. meltada*, *M. booduga* and *B. bengalensis* with mean days to mortality of 9, 8.5 and 13.3, respectively. With *Gliricidia sepium* the mean mortality of 10.6, 9 and 17.5 days in *M. meltada*, *M. booduga* and *B. bengalensis* with mortality of 50, 66.6 and 66.6 % was recorded (Table 14).

Table 14: Toxicity of *Strychnos nux-vomica* bark extract/powder, *Gliricidia sepium* powder on rodents.

Plant	Species	Dose	Day to mortality	Mortality %	Bait intake (g/day)	Reduction in body weight
<i>Strychnos nux</i>	<i>M. meltada</i> (No-choice)	20g bait +1g bark powder	9.00	66.66	11.4	5.2
	<i>M.booduga</i> (No-choice)	20g bait +1g bark powder	8.50	50.00	3.05	4.8
	<i>B.</i>	20g bait +1g	13.33	50.00	13.70	10.1

	<i>bengalensis</i> (No-choice)	bark extract				
	<i>B. bengalensis</i> (No-choice)	20g bait +1g bark powder	17.50	66.60	13.4	8.4
	<i>B. bengalensis</i> (bi choice)	20g bait and (20g+1g)	22.00	16.70	Tr-18 UT-9.5	1.8
<i>Glyricidia sepium</i>	<i>M. meltada</i> (No-choice)	20g bait +1g bark powder	10.60	50.00	8.56	4.5
	<i>M. booduga</i> (No-choice)	20g bait +1g bark powder	9.00	66.66	3.2	4.1

The mean of two years study revealed a peak reduction of rodent index of 38.7 in burrow fumigation with chilli powder followed Chilli garlic extract (35.5), castor oil (19.1), and neem oil (14.5). In bromadiolone baiting 61.13% reduction in rodent index was recorded (Table 15).

Table 15: Effect of organic product on rodent density in OFS

Treatment			
	Rodent Index 2017-18	Rodent Index 2018-19	Mean
Chilli- Garlic extract	17.8 (36.2%)	18.9 (34.87%)	35.5
Panchagavya	38.3 (2.84%)	39.3 (23.04%)	12.94
Dashapani	36.6 (36.1%)	37.7 (22.7%)	29.4
Neem oil	27.5(14.75%)	28.6 (14.2%)	14.5
Castor oil	21.6 (19.5%)	22.7 (18.7%)	19.1
Fumigation (Chilli dust)	17.2 (39.4%)	18.3 (38.0%)	38.7
Bromodiolone (0.005%)	12.39(61.1%)	13.3 (69.0%)	65.1

Values in parenthesis indicate the % incidence

In the evaluation of botanicals for antifeedant properties 1% *Strychnos nux-vomica* bark extract and Asafoetida were moderately effective against *Mus booduga* in laboratory conditions and during the study it was also noted that male was sensitive than the females in sensing the smell (Table 16).

Table 16: Antifeedant index *M. booduga*

Concentration (%)	Anti-feedent Index (AFI)	
	Asafoitida	<i>Strychnos nus vomica</i>
0.2	12.2	20.1
0.5	14.1	21.1
1.0	18.9	26.2

HIGHER VERTEBRATES

1. Wild boar Management: Wild boar is a carnivore animal and has highly adapted to increasing agricultural landscape by raiding the crops. The average incidence on various crops varied from 1.47 (Field bean) to 33.82 (Banana) per cent in Mallapura village. 2.40 (Field bean) to 35.98 per cent (Banana) in Arjunanahalli village and 2.34 (field bean) in Alanatha village. Ragi, pigeon pea, groundnut, banana, cowpea, maize, sesamum, castor and mulberry were attacked by wild boar at all stages of the crop with average of No. of raids per fortnight of 6.8, 5.4, 6.9, 7.9, 2.1, 05.8, 06.3, 04.9, and 05.8 2.0, respectively in 2017-18 and 7.6,6.1,7.7,58.6,2.8,6.6,7.1,5.6 and 6.5,during 2018-19. Further observations during 2019-19 revealed that sweet potato and potato experienced 6.6 and 7.5 raids per fortnight. During 2018-19 the incidence by wild boar was maximum in

banana (36.10%) followed by groundnut (33.65%), ragi (29.99%), Pigeon pea (28.13%), potato (21.64%), sweet potato (20.13%), cowpea (18.79%) and maize (18.85%). However, least incidence was noticed in castor (1.33%), field bean (3.57%) and mulberry (7.24%). The average raids per fortnight varies from 2.26 to 8.63 raid, in different crops (**Table 17**). Solar based ecofriendly Harmony Q3 bio acoustic device developed by Grus Eco sciences Bangalore which rippled wild boar was evaluated against wild boar.

Table 17: Wild boar incidence on various crops (3+3 villages)

Crops	2017-18		2018-19	
	% incidence	Av. No. of raids / fortnight	% incidence	Av.No. of raids / fortnight
Ragi	24.4	6.8	29.9	7.6
Pigeon pea	26.6	5.4	28.1	6.1
Groundnut	32.1	6.9	33.6	7.7
Banana	51.7	7.9	36.1	8.6
Field beans	2.1	2.1	3.6	2.8
Cowpea	17.3	5.8	18.8	6.6
Maize	17.7	6.3	18.7	7.1
Sesamum	15.5	4.9	15.9	5.6
Mulberry	6.1	5.8	7.2	6.5
Sweet potato	-	-	20.1	6.6
Potato	-	-	21.6	7.5

Among the various practices fencing with barbed and circular blade and solar wires and effect lasted for entire crop period whereas, with planting the hedges around the crop and erection of used sarees around the crop the effective ness was on par with the above fences though, there were some raids by the wild boar and lasted till third fortnight. Ground nut being the chief crop in the study area different management modules were evaluated. The highest yield of 989 kg/ha was recorded with fencing of barbed wire fence followed by circular blade wire fence (965 kg/ha), placement of HDEP nylon net in the border (910 kg/ha, and erection of used sarees around the crop (890 kg/ha) (Table 18).

Table 18: Evaluation of different treatment against wild boar (Groundnut)

Treatments	2017-18			2018-19	
	No raids/ fortnight	No. of raids/crop period	Yield (Kg/ha)	No. raids/fortnight	Yield over control
Egg yolk (1egg/20 l)	4.5	27	805	-	-
Jute rope (castor oil)	3.17	19	815	-	-
Circular blade wire	0.0	0	965	-	-
Barbed wire fence	0.0	0	989	0	57.21
Used saree	1.7	10	890	2.0	31.70
HDPE Net	0.8	5	910	1.5	50.00
Solar fence	0.50	3	-	10.4	31.8
Coconut rope Kerosene)	3.33	20	-	3.2	11.37
Hedges	2.17	13	-	8.2	-
Control	6.4	38	798	-	-

Crops such as castor, field bean, and safflower were non-preferred by the wild boars planting them at the border could mask the presence of crops visually or olfactory. The Efficacy of the boarder crops was evaluated in sorghum, groundnut, and maize the results indicated that yield of 1956 kg/ha was recorded when bajra was planted as a boarder crop around the sorghum than the control 1825kg/ha with the success per cent of 7.12 over the control. When safflower was taken as

border crop around ground nut the yield increase was from 12.5 to 14.7%. Likewise growing castor as border crop around maize resulted into 10.3% increased yield due to protection from wild boars (Table 19).

Table 19: Evaluation of Boarder crops to manage wild boars

Crops	2017-18		2018-19	
	No. of raids fortnight	% success over control	No. of raids fortnight	% success over control
Sorghum + Bajra (6 rows)	4.2	7.12	-	-
Groundnut + safflower (4 rows)	2.4	14.70	6.8	12.5
Groundnut nut + field beans (6 rows)	5.6	7.39	4.9	17.5
Groundnut + Soybean (6 rows)	4.4	9.31	-	-
Maize + castor (4 rows)	4.4	10.30	-	-
Control	7.0	-	-	-

II. Mitigation of Human Animal conflict: The survey on crop damage revealed that Elephant, wild boar, peacock, rodents, hare, sloth bear, Monkey were the critical vertebrate pests that depredated the crops and caused the nuisance with high intent of interest towards conflict. The crop raiding activity was nocturnal in most of the cases whereas monkey and elephant showed diurnal activity, it was also noted that wild boar, monkey, peacock, and rodents were observed throughout the crop cycle or occurred during the maturity of the crop and at the time of harvest. The damaged crops were ragi, sweet potato, pulses, oil seeds, vegetables, banana, and Jackfruit. The mode of damage was by trampling, digging and direct feeding of the crops (Table 20). The fresh and dried fodder of Eupatorium and lantana bushes provided the immediate and temporary habitat to expand and facilitate the growth of the pest population. Among the bird pest's parrots and peacock were the critical pests the occurrence of peacock was more in ragi and vegetables whereas, parrots depredated most of the fruit orchids. In the survey it was found that cheetah/leopard, Jackal/Fox and mongoose were the predominant predators mostly predate on cow, buffaloes, sheep and poultry birds (Table 21).

The economic losses to farmers due to the conflict was assessed according to farmer perspective the maximum damage was recorded in Banana (15.47-52.65 %) followed by groundnut (15.64-48.76%), vegetables (8.21-36.78%), ragi (15.23-36.78%), sweet potato (9.25-27.34%), Red gram (7.45-23.32%), papaya (2.76-12.67%), cowpea (2.3-10.56%), field bean (1.2-4.58%) and horse gram (0.9-5.37%).

With interest to mitigating the level of conflict the survey on prevalent management measures practiced by local farmers plays a vital role in developing modules for management. Hence, the survey was taken up and revealed Fencing (Power, barbed wire fence), burning of crackers, the lighting of serial sets, sounding through drums, artificial fires, F M radio and use of the local dogs were the management practices practiced by the farmers in the survey area. The approach towards the management measure depended on the economic status and facilities available by the government, among them approach towards the solar power fencing (13.7%) was one of the instances to note (Table 22). Rest of the farmers depended on barbed wire fence (19.6%) and lighting of serial sets in the crop border (22.1%) and erection of used sarees around the crop (26.7 %).

R M 10: ITK's for higher vertebrates.

In recent decade, a greater emphasis is given towards the conservation of ecosystem by reducing the application of chemical products. With the above mandate, the survey was conducted throughout the state for collecting the prevalent safe and ecofriendly methods for the management of vertebrate pests and some of them have been evaluated both in the laboratory and field (**Table 22**).

Table 20. Crop raiding by major vertebrate pests

Sl.No	Animal	Crops damaged	Month/ Stage of Occurrence	Activity	Mode of Damage
01	Elephant	Ragi, paddy, banana, tamarind, jack fruit, papaya.	December to May	Diurnal	Trampling and feeding
02	Wild boar	Sweet potato, Ragi, ground nut, jowar, Pulses.	Throughout the crop period	Nocturnal	Wallowing
03	Peacock	Ragi, vegetables		Diurnal	Feeding
04	Rodents	Ragi, ground nut, pulses.	Pre and post-harvest	Nocturnal	Cutting, Feeding and Hoarding
05	Black napped Hare	Vegetables, sweet potato, Pulses.	Harvesting	Diurnal	Cutting and feeding
06	Sloth bear	Jack fruit, sweet potato.	January to July	Nocturnal	Feeding
07	Monkey	Jack fruit, Coconut, Banana, papaya	Fruiting	Diurnal	Feeding, Cutting, trampling
08	Parrot	Papaya, Guava, Mango, Corn	Fruits	Diurnal	Eating the berries of the fruit

Table 21: Livestock Predation by wild animals in study area.

Predator	Number of cases reported /month	Predated animals	Place of predation	Time of predation	Comments	Most reported beats
Cheetah/leopard	22	Cow, buffalo Goat, Sheep, Poultry birds.	Grazing fields, Home sheds.	Diurnal	Secondary attraction by dogs due to poultry wastes	Savanadurga, Hanumandurga, Siddadevabetta, Madanayakana durga, Bhantarakuppe, Kaleri kavalu, Chiluru
Jackal/fox	4	Goat, Sheep, Poultry birds		Evening	Predates during the grazing period in the vicinity of forests	
Mongoose	27	Poultry birds	Sheds, Fields	Evening, early morning	Predation during the foraging at domestic areas.	All the beats

Table 22: Mitigation measures practiced by farmers in study area (ITK'S).

Sl.No	Management measures practiced	Control measures practiced for crops	Targeted species	Percentage of Adoption
1	Fencing (Barbed wire fencing and Solar power fencing)	Ragi, jowar, sweet potato	Wild boar, Elephant	19.6 (mainly by Economy and marginal farmers)
2	Burning of Crackers	Ragi, banana, papaya, pulses, groundnut	Wild boar, peacock, Elephant, Sloth bear, Monkey	17.5
3	Lighting serial sets	Sweet potato, groundnut	Wild boar	22.1
4	Sounding through drums	Ragi, sweet potato, pulses etc....	Elephant, wild boar, parrot, Monkey	9.2
5	F.M Radio	Ragi, banana, pulses, groundnut	Wild boar	5.8
6	Use of Local dog	Ragi, banana, pulses, groundnut	Wild boar, Monkey	7.6
7	Erection of used sarees around crop	Ragi, banana, pulses, groundnut	Wild boar	26.7
8	Artificial fires	Ragi, banana, pulses, groundnut	Wild boar, Elephant, Sloth bear	1.7
9	Cultivating un preferred crops	Groundnut	Wild boar, Elephant, Monkey	2.4
10	Use pf human hairs and urines	Ragi, Maize, Pulses, Groundnut	Wild boar	-
11	Burning of rubber tyres/ dung of local pigs	Ragi, Maize, Pulses, Groundnut	Wild boar / porcupine	-
12	Use of rotten egg	Ragi, Maize, Pulses, Groundnut	Porcupine/ wildboar	-
13	Use of chilli/pepper powder	Ragi, Maize, Pulses, Groundnut	Rodents	-
14	Castor seeds/ Glyricidia bark	Ragi, Maize, Pulses, Groundnut	Rodents	-

Fencing (Barbed wire fencing and Solar power fencing) was adopted by comically rich farmers, other practices by marginal and poor farmers.

TRIBAL SUB PLAN (TSP)

Sl. No.	Date	Places	No. of families	No. of participant for training
1.	28-11-2017	Sakayanadoddi (Ramanagara)	40 (Iruligas)	85
2.	25-5-2018	Jenukalpalya (Magadi Tq.)	40 (Iruligas)	65

3.	10-11-2018	Budipadaga (Chamarajanagara Tq)	76 (Soligas)	100
4.	27-4-2019	Goremadudoddi, Banuvadi (Chamarajanagara Tq)	97 (Soligas)	125
5.	7-6-2019	Muneshwaracolony, Sreenivasacolony, (Chamarajanagara Tq)	67 (Soligas)	100

EXTENSION ACTIVITIES

1. Training programme on Vertebrate Pest Management (RPM) conducted (2017-19)

Period	No. of programme	No. of Beneficiaries
2017-18	7	505
2018-19	9	819

2. Training programme as resource person

Period	No. of programme	No. of Beneficiaries
2017-18	3	60+30+30
2018-19	3	35+30+35

3. Radio and TV Programme

Period	No. of Programme
2017-18	3
2018-19	1

4. Field visit

Period	No. of field visit
2017-18	27
2018-19	16

5. Demonstration of activities of RM/VPM

Period	NO. of Demonstrations	No. of farmers
2017-18	12	792
2018-19	11	614

PUBLICATIONS

- Naik, M.I., Basavadarshan, A.V., and Hugar, S. V., 2017, Food consumption by different species of rodents (Muridae: Rodentia) under laboratory conditions. *J. Soil. Biol. Ecol.*, **37**:255-262.
- Naik, M.I., Adarsh, K.K. and Hugar, S. V., 2017, Burrow ecology of rodents in and around groundnut field. *J. Soil. Biol. Ecol.*, **37**:263-280.
- Naik, M.I. and Basavadarshan, A.V. 2018, Efficacy of castor (*Ricinus communis* L.) as boarder crop for management of Wild boar (*Sus scrofa* L.) in Ragi (*Eleusine coracana* Gaertn.) and Pigeon pea (*Cajanus cajan* L.), *National conference on Biodiversity: Management issues and conservation strategies*. 21 and 22, Dec., 2018, Ankola, Uttara Kannada. p.57.
- Naik, M.I., Ramachandra Mohan, M. and Basavadarshan, A.V., 2018, Incidence and population ecology of rodent pests in organically cultivated Ragi (*Eleusine coracana* Gaertn.) and Ground nut (*Arachis hypogaea* L.), *National conference on Biodiversity: Management issues and conservation strategies*. 21 and 22, Dec., 2018, Ankola, Uttara Kannada. p.58.

- Naik, M.I. Basavadarshan, A. V and Boraiah, B., 2019, Evaluation of plant based eco-friendly rodenticides, *XIV Agricultural science congress*. 20 to 23, February. 2019, Pusa, New Delhi. p.279.
- Naik, M.I. Basavadarshan, A. V and Boraiah, B., 2019, Burrow structure of greater Bandicoot, *Bandicota Indica* (Bechstein), *XIV Agricultural science congress*. 20 to 23, February. 2019, Pusa, New Delhi. p.280.

Popular articles:

- Mohan I. Naik and Basavadarshan A. V., 2018, Vertebrate pest management (PÀ±ÉÃgÀÄPÀ ¥ÁætÂ 'ÃqÉUÀ¼À ¢ªÀðºÀuÉ). *Krishi vignana*, 42(4):18-21.

EXTENSION MATERIALS PREPARED

1. Extension Technologies for the management of rodent pests in cropping systems of Karnataka (in English).
2. Human Animal Conflict in Agricultural Ecosystem.
3. Extension Technologies for the management of rodent pests in cropping systems of Karnataka (in Kannada).
4. Management of rodents - Rats and mice in houses and fields (pamphlets in Kannada).
5. Incidence of rodents in households and their management (pamphlets in Kannada).

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in Lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	39.60	32.45	2.69	0.14	0.00	2.00	37.28
2018-19	45.25	23.94	10.00	0.95	5.00	8.00	47.89

KERALA AGRICULTURAL UNIVERSITY, THRISSUR

1. Part I: General Information

1. Name of the centre	AINPVPM College of Horticulture, KAU, Thrissur
2. Sanction no.	DARE (GOI) Letter No. 15-1/2014-IA-III dated 17 th September, 2014 and ICAR Letter F. No.1-17/2014-PIM (Pt.) dated 19 th September, 2014 and F. No.4-1/2014-PP dated 26 th September, 2014.
3. Date of start	March 2014
4. Date of Termination	Network Project of continued nature
5. Report period	2017-19
6. PI/ Scientist In-charge	Dr. MANI CHELLAPPAN

7. Staff Position

S. No.	Name of post	No. of posts sanctioned	Name of incumbent	Date of Joining	Date of Leaving
1	Ornithologist	1	Dr. Mani Chellappan	2015	Continuing
2.	Jr. Ornithologist	1	Ms. Sreeja, P Ms. Vidya, C. V. Dr. Ranjith, M. T.	2015 22-8-2017 18-6-2019	18-8-2016 17-6-2019 Continuing
3.	Technical Assistant	1	Miss. Henna, M. K Mr. Renjithkumar	2017 10-7-2019	6-7-2019 Continuing

A. RODENT CONTROL

I. Multi location Programmes

RM 1: Surveillance of pest rodents in predominant cropping systems.

i. Deep water rice: Two different deep water rice cultivations are being followed in Kerala viz., Kole and Pokkali. Majority of the kole lands in Kerala are spread over Thrissur and Malappuram districts. These are low-lying areas located 0.5 to 1 m below the mean sea level. 'Puncha' is the main season (Dec./Jan. to April/May) in kole cultivation. Only one crop is raised in the kole areas. Pokkali is another unique system of deep water rice which combines rice cultivation as well as prawn culture in the same field. The rice variety is effectively resistant to flood and salinity. The rice plant grows to a height to 1.5 m. The preparation of Pokkali system of rice cultivation starts in the month of May. Initial work starts with raising bunds followed by making mounds of 1 m² base and 50 cm height. The mounds are allowed to dry by preventing the entry of water into the fields. With the south west monsoons down pouring, salts and toxic elements are washed off from the mounds and drained off. On these mounds, sprouted Pokkali seeds are sown. The seeds are sprouted by tightly packing them in baskets of coconut leaves with an inside lining of banana or teak leaves and soaking in fresh water for 12 to 15 hours. After a month period, the mounds are leveled off. The seedlings on the mounds are spread uniformly in the field. The seedlings grow quickly and get established in the field and withstand floods that follow. The crop will be ready for harvest within 4 months and harvesting is mainly done using boats.

ii. Rodent monitoring in Pokkali and other low land rice (Kole lands): Approximately one acre plots of rice fields were selected and replicated 10 times. Each plot was monitored for the rodent damage viz., removed seeds, cut tillers at each stage of the crop, etc. Rat damage in rice field started immediately after sowing and the sprouted seeds were taken away by the rodents from the field. Live burrow count was done and traps (Sherman trap, snap trap, live trap, Moncombu trap and Thanjavur kitty) were used to monitor the rodent population in the identified fields depending upon the water level. Among the traps, Thanjavur kitty performed well when the water level was low (42% trapping success). Moncombu trap was better in the inundated rice fields (56% trapping success). Sherman trap, snap trap and live trap worked well on the rice field bunds (35, 25 and 19%, respectively). As the LBC was below 50 per cent, anticoagulant baits were used which resulted in reduced rodent damage to the crop. Major rodents caught during the study were *Mus booduga*, *Rattus norvegicus* and *Bandicota bengalensis*. Rodent damage was low in the early stage of the crop and the damage started increasing as the crop in the maximum tillering and reproductive stages. The damage was relatively more between 30 and 90 days of the 140 days old rice crops during both the years of study (Table1).

Table 1. Rodent damage to rice crop

S. No	Days after sowing of rice crop	Mean Rodent damage (No. of plants damaged/acre)	
		2017-18	2018-19
1	1- 30	1.32	1.78
2	31- 60	6.67	4.01
3	61- 90	3.43	4.92
4	91- 140	0.27	1.91
	Mean	2.923	3.155
	SD	NS	NS

RM 2: Monitoring of rodent abundance and damage in selected agro-climatic zones of the region (Central Plains of Kerala)

(i) Surveys in the Central Plain region of Kerala revealed occurrence of over a dozen rodent species infesting field crops, vegetable, fruit, tuber and plantation crops. Both the species of bandicoots along with field mouse and Norway rats were the major species in rice fields. Coconut and cacao, the two major plantation crops harbored roof rats and squirrels (giant and three striped) in various proportions. Porcupines were observed in fields of cucurbit & Tomato, fodder grasses and cashew plantations. Two species of squirrels viz., Malabar giant squirrel (in cashew, mango and coconut orchards) and three striped squirrels (in Mango and cacao orchards) were also encountered in this region. The Asiatic long tailed tree mouse and brown spiny mouse were noticed in cucurbit and tomato fields. The rodent species abundance in different crops during the two yearlong study are detailed in Table 2.

Table 2. Rodent species abundance in different crops in Central plain region of Kerala

S. No	Crop/Rodent species	Relative abundance (%)	
		2017-18	2018-19
1	Rice		
	Larger bandicoot rat	18	15
	Lesser bandicoot rat	17	19
	House rat	6	3
	Norway rat	46	51

	Kerala rat	1	3
	Field mouse	12	9
2	Coconut		
	Roof rat	55	44
	Larger bandicoot rat	26	32
	Giant Malabar squirrel	19	24
3	Cassava		
	Larger bandicoot rat	45	47
	Lesser bandicoot rat	55	53
4	Cacao		
	Roof rat	46	49
	Three stripped squirrel	47	42
	Giant Malabar squirrel	7	9
5	Mango		
	Three stripped squirrel	89	87
	Giant Malabar squirrel	11	13
6	Banana		
	Lesser bandicoot rat	100	100
7	Cucurbits and tomato		
	Porcupine	85	84
	Brown spiny mouse	3	4
	Asiatic long tailed tree mouse	12	12
8	Cowpea		
	House rat	67	72
	Larger bandicoot rat	33	28
9	Fodder grass		
	Porcupine	100	100
10	Cashew		
	Porcupine	95	92
	Malabar giant squirrel	5	8

(ii) Assessment of rodent damage: Rodent damage rice crop in all the stages of growth, however significant damage started from active tillering onwards as the feeding switched over from vegetative tissue to the more nutritive panicles. The distribution of damage was highly variable like isolated damage patches of severe to evenly distributed damages. Boarder rows sustained little or no damage as a protective instinct. The damage patch distance varied from the size of the field. In addition to damage to the tillers, rodents also cut and heaped the rice plants on bunds by the lesser bandicoot rat (*Bandicota bengalensis*)

Rodent damage assessment in rice was done by selecting fields at random in Palakkad and Thrissur districts. In the selected fields, plots (approx.1 acre) were selected at random. Observations on damage by rats were taken using diagonal transect starting with the first hill. Both damaged and undamaged tillers were counted. The process was repeated by selecting the next positions of the diagonal transect until 25 samples at equal distances were taken. Finally the damage index (P) was calculated as

$$P = (A * 100) / (A + B)$$

Where A = Total no. of damaged tillers in the 25 hill sample
B = Total no. of healthy tillers in 25 hill sample

Table 3. Rodent damage in irrigated rice

Month	Place	LBC (%)	Rice variety	Mean tiller damage (%)
Aug 2018	Vettical	10.0	Jyothi	8.52
Aug 2018	Madakkthara	38.0	Jyothi	6.31
Sep 2018	Punnamparambu	39.0	Uma	11.02
Jan 2019	Madakkthara	1.0	Jyothi	1.00
Feb 2019	Kuzhalmannam - A	5.0	Jyothi	9.89
Feb 2019	Kuzhalmannam - B	4.0	Jyothi	7.50
Feb 2019	Kuzhalmannam - C	3.0	Jyothi	5.59
Feb 2019	Kuzhalmannam - D	2.0	Jyothi	3.68
Feb 2019	Mundoor - A	3.0	Sreyas	1.13
Feb 2019	Mundoor - B	Nil	Sreyas	0.00

Among the rice varieties, Uma suffered the maximum damage by the rodent attack followed by Jyothi. Rice variety Sreyas had the least (1.13%) damage (Table 3).

(iii) Rodent management in rice fields: Rodent damage was more during in the milky stage of rice. To manage the rice field rodents, coconut leaf petiole was placed as owl perches @ 20 per acre to attract the barn owls. Motor engine oil @ 2 per cent was mixed with water while irrigating the field to repel the rats. Following other rat management techniques were used in rice fields at different situations

- Field sanitation around the cropped field especially the field bunds
- Closing rat burrows on bunds before sowing which reduced the seed picking by rodents from the nursery and direct sown rice crop
- Burrow smoking with pepper or chilli powder which scarred and repelled off the resident rodents from the hide outs
- Flooding of burrows to kill juveniles
- Growing of plants viz., *Echites malabaricus* (Palvally - *Ichnocarpus frutescens*), *Plumbago rosea* and *Vetiveria zizanioides* on the bunds repel the rats to some extent
- Mixing the rice seeds with 50 kg powdered neem cake at the time of sowing reduced the rodent damage
- Spraying kerosene emulsion or motor oil emulsion (@ 2%) on the bunds reduced the rodent damage in the field
- Use of metalized reflective ribbon to scare the rodents
- Anticoagulant cakes found better than the acute poison like zinc phosphide. The visceral mass of apple snail (*Pila globosa*) found to be good bait for the rice field rodents. Other baits used were, peanut butter, coconut gratings and tapioca roots
- Mixing egg white (2ml) with zinc phosphide (2g) in an empty molluscan shell was found to be readily accepted by the rodents
- Use of Nymphae seeds for baiting had found acceptance to rats in the rice field

RM 3: Social Engineering Activity on Rodent Pest Management as Participatory Adaptive Research in adopted villages

Under this study, three villages were selected viz., Madakkathara, Kuzhalmannam and Mundoor in Thrissur and Palakkad districts. Trap Barrier System was demonstrated in these villages. Initially, sensitization on rodent problems and related health risks for the rice field workers and the general public was given in a series of field classes. Inputs (barrier sheet, trap, etc) plus technical support were given to one set of plots, only technical support for the second set of

plots and nothing was given for the control plots. Plots of 4m x 5m (half cent area) were laid out for the rodent management. Yellow sheets (of approximately 200 micron thick HDPE) were used for the TBS programme. As the strong gust of wind was expected in the selected areas, the sheets were secured with poles and ropes. Part of the sheet was buried 30 beneath the mud. A multi-catch trap (designed and fabricated by the AINPVPM, Thrissur) was used for trapping. In the selected area, the LBC ranged between 1.8 and 9.17. When compared to the control and plots which received only technical support, the TBS had significantly low rat damage (6.68%) as compared to 10.98% in control. (Table 4). The rats caught in the traps got identified by the ZSI and it was *Bandicota bengalensis*.

Table 4 . Effect of TBS on rat damage to rice crop

Plot No	Mean rat damage (%)		
	Control plots	Plots with only technical support	Plots with TBS
A Plot	14.8	13.5	9.9
B Plot	10.2	12.4	7.5
C Plot	10.7	9.8	5.6
D Plot	8.2	7.9	3.7
Mean	10.98	10.90	6.68
SD	2.646*	2.6*	3.09*

II. Location specific studies

a. Rodent management in plantation crops

(i) Coconut: A typical rodent damage to tender coconut consisted of a small hole of about 5 cm near the perianth region. After gnawing the husk, the rodents consumed the inner contents and the damaged nut fell within 2-6 days. Rodents often preferred young and tender coconuts. The damage particularly was more in coconut where it was inter- cropped with nutmeg or cocoa. In the recent past the incidence of Giant Malabar squirrel on coconut had increased as it damaged both the tender and matured nuts. In the coconut nursery, the sprouting nuts were damaged by the larger bandicoot rat, *B. indica* and porcupines, *Hystrix indica*.

Rodent damage assessment was done in coconut by selecting plots with approximately 100-150 palms. Observations were recorded for fresh rodent damaged nuts fallen. Ten palms with rodent damage were selected for continuous observations. The damage by the rodents was calculated as,

$$\text{Rodent infested trees (RI)} = \frac{\text{No of trees with fallen nuts}}{\text{Total no of trees}} \times 100$$

$$\text{Damage (\%)} = \frac{\text{No of damaged coconuts in selected plot}}{\text{Average yield per tree} \times \text{No of trees in selected plot}} \times 100.$$

The data on extent of damage to coconut ranged from 1.32 to 6.56% in different months (Table 5)

Table 5. Month wise rodent damage to nut in the observation area

Month	Mean nut damage (%)	Month	Mean nut damage (%)
Jan, 2018	6.56	Sep, 2018	5.34
Feb, 2018	5.93	Oct, 2018	4.58
Mar, 2018	4.64	Nov, 2018	4.36
Apr, 2018	1.92	Dec, 2018	2.83
May, 2018	1.32	Jan, 2018	2.11
Jun, 2018	2.70	Feb, 2018	3.6

July, 2018	2.4	Mar, 2018	1.78
Aug, 2018	3.52		

Cloth pouches containing 25g Borep was taken and tied up in coconut bunches at two sides repelled rodents to some extent.

Table 6. Effect of BoRep and neem oil (2%) on rodents on coconut

Coconut plots	Mean coconuts damaged / palms (%)	
	Effect of BoRep	Effect of neem oil
Location 1	33.3	100.0
Location 2	66.7	0.0
Location 3	62.5	33.3
Location 4	33.3	100.0
Location 5	80.0	100.0

When compared to neem oil, Borep treatment had better repelling action against rodents as evident from the mean nut damage per palm (Table 6).

(ii) Cocoa: Rodent damage was rampant on cocoa pods. Both rats and squirrels damaged the pod. Month-wise damage was recorded in cocoa plantations. The damage was more on pods when harvesting of matured pods got delayed and the damage was throughout the year. Rodent damage on cocoa pods was calculated by recording as follows

a= no of fruits freshly attacked

b = no of fruits attacked 1-2 week ago

Damage (%) = (a+b) / total no of fruits *100

Rodent damage to cocoa pods was observed throughout the year (Table 7) ranging between 5.95 % (October) to 14 % (Feb-March).

Table 7. Month-wise rodent damage on cocoa pods

Period	Mean cocoa pod damage (%)	Period	Mean cocoa pod damage (%)
Jan	10.7	July	8.57
Feb	14.1	Aug	10.95
Mar	14.4	Sep	7.00
Apr	9.86	Oct	5.95
May	8.00	Nov	6.66
Jun	7.74	Dec	9.67

Rodent management practices in cocoa plantations

- Harvesting of matured pods was recommended to reduce the incidence of rodents in homesteads
- Use of Sherman and snap traps on tree trunks
- Cutting down border trees with the cocoa plants
- Zinc phosphide bait with peanut butter was readily accepted by rats in cocoa plantation

b. Molecular characterization of rodents

(i) Sample collection: The animals were collected from different agricultural fields in various locations of Thrissur, Kerala, India. Sherman trap was used to collect *Rattus rattus*, *Rattus ranjinae* and *Rattus wroughtoni* and steel trap was used to collect *Rattus norvegicus*. A small

piece of tail (0.4-0.5 cm) was removed, labelled and immediately stored in 90% ethyl alcohol at -20°C.

(ii) DNA isolation and PCR: Total genomic DNA isolated from the preserved sample using DNA extraction kit (QIAGEN DNeasy blood and tissue kit, Germany) according to the manufactures instructions. Agarose gel electrophoresis was carried out in electrophoresis unit (GeNei™ MIDI SUBSYSTEM) to check the quality of isolated DNA. By using Nanodrop (JENWAY Genova Nano, ver. 1.55.3), the absolute quantity and quality of DNA was measured. Good quality of genomic DNA (50ng/μl) was used for barcoding. DNA was barcoded by sequencing of a short fragment of mitochondrial cytochrome oxidase subunit (COI). For the amplification of COI gene, following forward and reverse primers were used; C1-J-2183F-CAACATTTATTTTGATTTTGG and C1-N-2568R- GCWACWACRTAATAKGTATCATG. PCR reaction was carried out in 20 μl reaction volume, containing 50ng/ μl of template DNA, 10μl PCR master mix (TAKARA Emerald), 0.6 μl of forward and reverse primer and nuclease free water

The PCR conditions were, Lid temperature 98°C, initial denaturation 94°C for 4 min, 35 cycles each of denaturation 94°C for 45 sec, primer annealing for 1 min and primer extension 72°C for 45 sec, followed by 10 min extension at 72°C and storage at 4°C in Verity Thermal Cycler (Applied biosystems). Amplification products were resolved electrophoretically on 2 % agarose gels run at 60 V for 1.5 h with a 100 bp DNA ladder (Genei, Bangalore) in 1X TAE, visualized by staining with ethidium bromide and photographed under ultraviolet light by a gel documentation and analysis system (BioRad Gel DOC-It™ imaging system).The mitochondrial cytochrome oxidase I (COI) region of all samples got amplified using PCR and sequenced using ABI3730XL DNA Analyser.

(iii) Data analysis: The sequence generated from this study was analyzed for sequence homology using the nucleotide BLAST at NCBI, submitted to BankIt, GenBank. Further the specimen details and sequences were submitted to BOLD database and a unique barcode was generated for each species. The sequences generated from this study were compared and aligned using the CLUSTALW program. A phylogenetic tree was constructed using clustal 2.1 and similarity between these four *Rattus* species were analysed.

Total genomic DNA from four *Rattus* species (*R. ranjinae*, *R. rattus*, *R. norvegicus*, *R. wroughtoni*) were isolated using QIAGEN DNeasy blood and tissue kit. The mitochondrial cytochrome oxidase I (COI) region of all samples were successfully amplified using PCR. There were no insertions, deletions or stop codons in the sequences from all the samples. The blast searches showed 93 per cent identity for *R. rattus* and 94 per cent for *R. norvegicus*. The phylogenetic tree showed that there is highest similarity obtained between *R. rattus* and *R. ranjinae* (95 per cent). *R. rattus* and *R. wroughtoni* showed 92.78 per cent similarity and *R. ranjinae* and *R. wroughtoni* showed 88.05 per cent similarity. Least similarity obtained between *R. norvegicus* and *R. wroughtoni*. The present study help us to identify the species at molecular level.

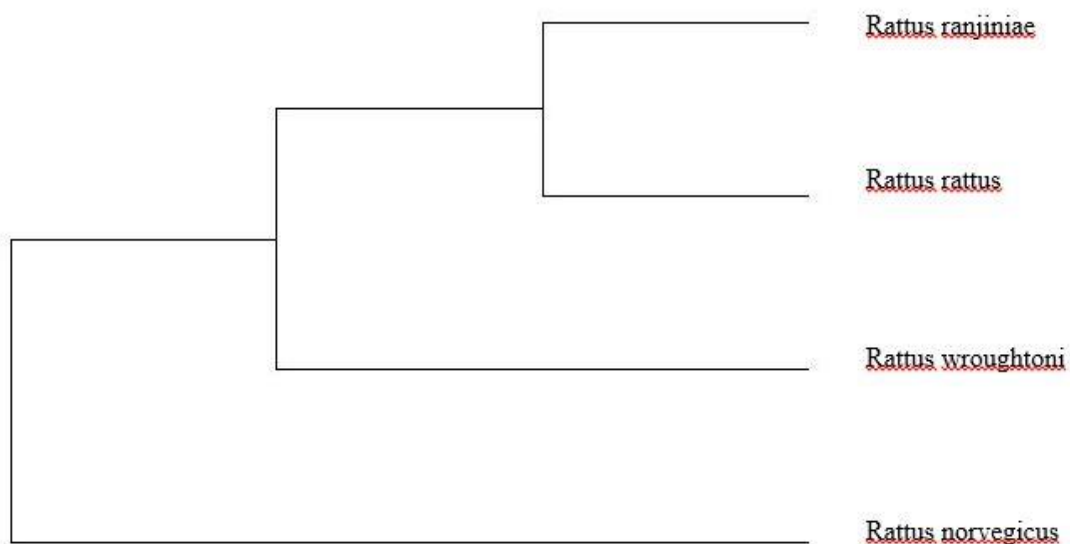


Fig. 1. Phylogenetic tree of *Rattus* species

Though the *Rattus ranjiniae* resembled the larger bandicoot, *Bandicota indica*, it showed 95 per cent similarity to the *R. rattus* genome. It had 92 per cent similarity with *R. r. wroughtoni* and 85 percent similarity with *R. norvegicus*.

Table 8. Molecular characterization (barcode) of *Rattus* sp.

S. No	Name of species	NCBI Accession umber	BOLD Process ID
1	<i>Rattus rattus</i>	MH624135	BRR001-17
2	<i>Rattus rattus wroughtoni</i>	MH727647	RAWRO001-19
3	<i>Rattus ranjiniae</i>	MH624133	BRRA001-17
4	<i>Rattus norvegicus</i>	MH624134	RANO001-19

Fig. 2. Illustrative barcode of *Rattus rattus* (NCBI - MH624135; BOLD-BRR001-17)

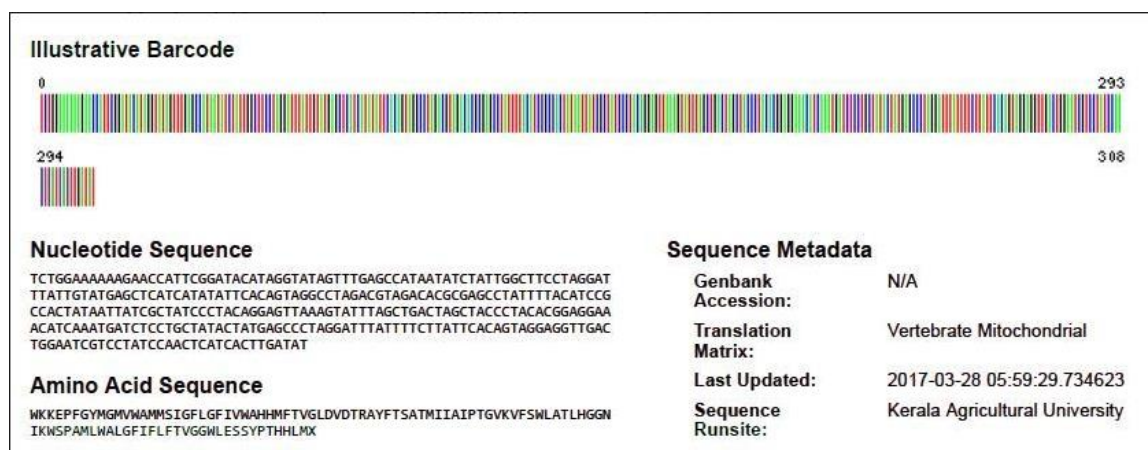


Fig. 3. Illustrative barcode of *R. r. wroughtoni* (NCBI- MH727647; BOLD- RAWRO001-19)

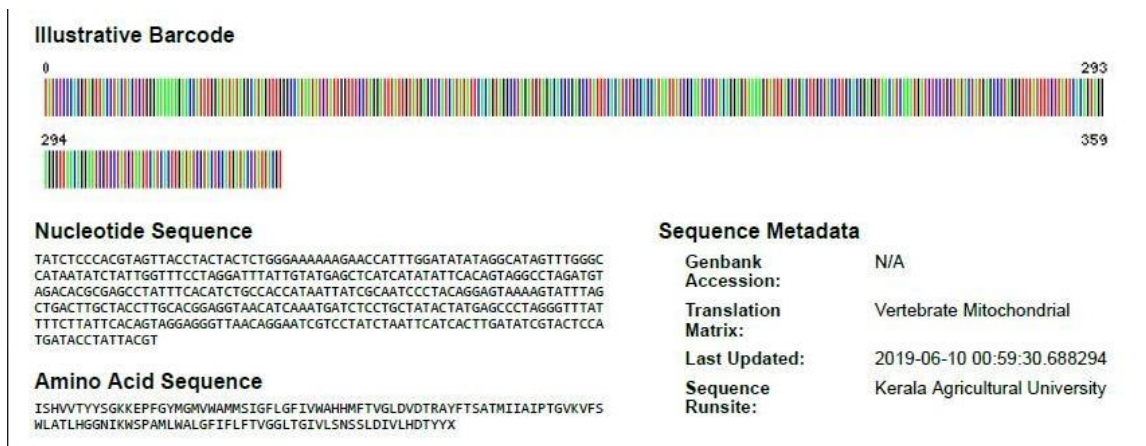


Fig. 4. Illustrative barcode of *R. ranjiniae* (NCBI- MH624133; BOLD- BRRA001-17)

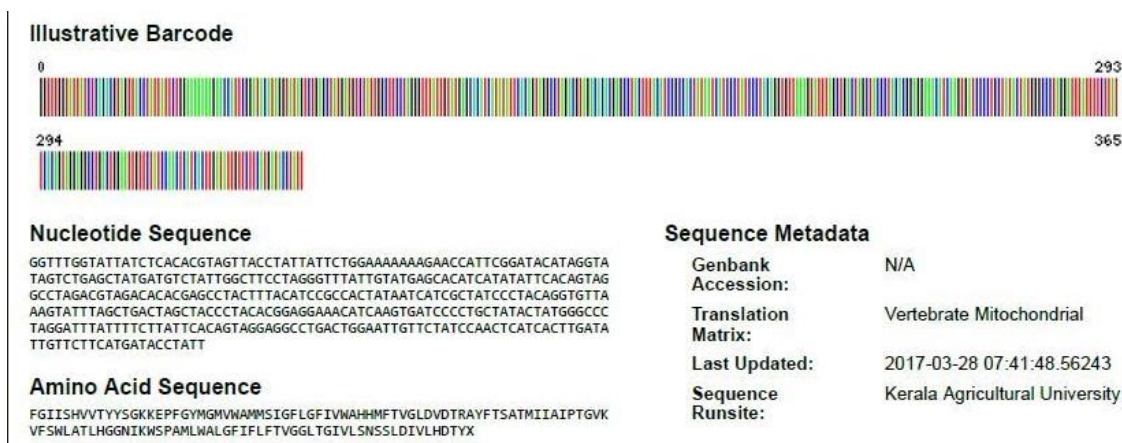
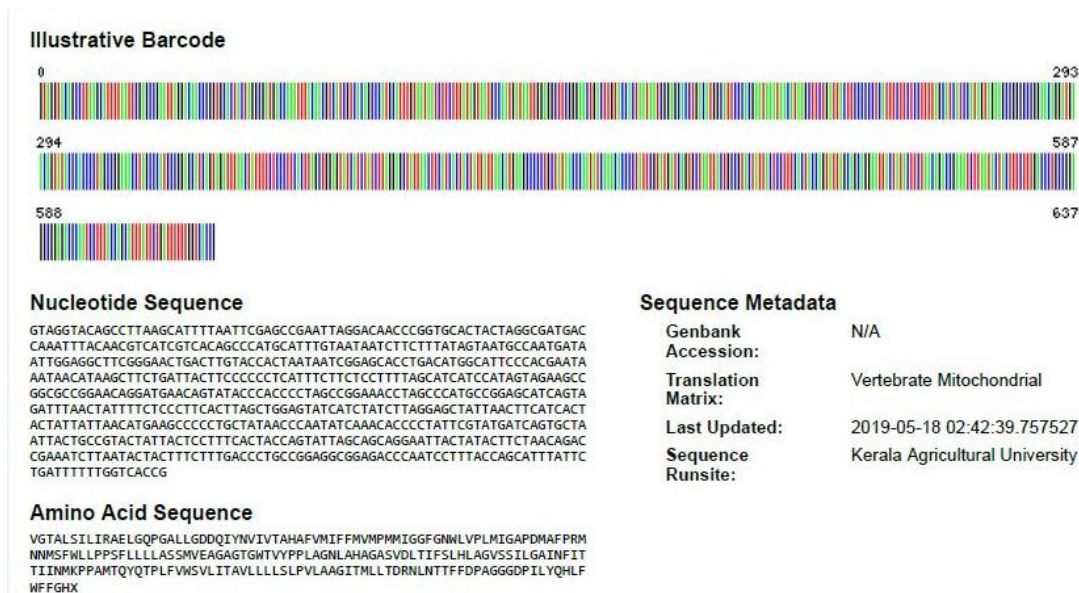


Fig. 5. Illustrative barcode of *R. norvegicus* (NCBI- MH624134; BOLD- RANO001-19)



Specimen identification

Only one sample was sent for identification from ZSI during the period under report

S No	Sample I D	Date of sample collection	Place of collection	Result received on	Remarks/ identification
1	AINPAO-VPM/Estt.1(R)/2017-2018	15-1-2019	Kuzhalmannam	27-2-2019	<i>Bandicota bengalensis</i>

(B) AGRIL ORNITHOLOGY

I. Multi location Programmes

BM 1. Surveillance of depredatory birds in predominant cropping systems.

(i) Avian diversity in rice-rice system: Line transect count method was adopted to carry out the bird survey. A transect line covering the study area was selected with a strip width of 100-200m on both sides. Seventy two species of birds were recorded in the irrigated rice system of Kerala in 2017-18 periods which belonged to 27 families. Cattle egret was the most dominant bird (RA 9.32%) during followed by pond heron (RA 6.40%). Depredatory birds viz., blue rock pigeon (RA 5.41%), baya weaver (RA 3.54%) and spotted munia (RA 2.28%) visited the crop field at the time of sowing, grain filling, maturity and harvest stages of the crop and were among the top ten birds during the period under report. Shannon diversity index for the rice field birds was 2.81 and Berger Parker index of dominance was only 0.08. However the species richness of birds in 2018-19 was less (69) with less density under each species (Table 9). In the irrigated rice crop in the observation area, baya weaver (RA 14.64%) was the most dominant bird during the period under report followed by cattle egret (RA 13.56.56%), blue rock pigeon (RA 4.46%) and common myna (RA 3.35%)

Table 9. Diversity indices of rice field avian fauna

Parameters	2017-18	2018-19
Species richness	72.00	69.00
Shannon index	2.81	2.72

Shannon's diversity index showed that except during the south-west monsoon period (diversity index ranged between 1.67 and 3.77) it was more than 2.00 and the maximum diversity occurred in November to January during the period under report. Cattle egret was the most dominant beneficial bird and the weaver as the key depredatory bird. In both the years, baya weaver was the most dominant depredatory bird in the rice ecosystem. Other depredatory bird viz., blue rock pigeon population was rather low, but caused significant crop damages at various stages. In all the years, the population fluctuation of the birds followed similar trend, the beneficial birds outnumbered the depredatory birds. The cattle egret population was more in the non-rainy season and lower during the monsoon period from June to September. Mean density of dominant birds of rice fields in relation to weather parameters were worked out which showed that rainy season was not favorable for the beneficial birds and the population was negatively correlated with the annual mean rain fall in the State. The reverse was true with depredatory birds viz., baya weaver where the population was positively correlated. All other weather parameters were not significantly correlated with the bird population.

(ii) Observation of roosting sites of birds: Purple moorhen roost was observed from Enamavu (10.5006,76.10681), Chalakkudy (10.289715,76.312584), Puzhakkal (10.555510,76.184316) and Irinjalakkuda (10.3846011,76.183806) kole fields from the month of November onwards. The

roost of cormorants, Asian openbill stork, lesser whistling duck was also observed during the study period.

The roosts may grouped as; Small roost – less than 100 birds; medium roost – 100 to 500 birds; large roost – more than 500 birds (Table 10).

BM 2. Community structure of birds and their diversity in relation to crop stages - Central plains

A 4 km transect line with strip width of 200m to both sides was fixed. The survey was conducted periodically and the observations were noted on sighting the birds. The birds count, roosting sites and the feeding behaviour has been recorded. The birds were observed and images were captured with the help of binoculars and DSLR camera. Using the field guide Birds of the Indian subcontinent by Grimmet the species were identified. The community structure and bird species diversity were measured as two phases in the growing period of paddy, during vegetative stage and reproductive and harvesting stage.

The relative abundance and bird species diversity were calculated,

Bird species	2017-2019 x 100	
	Roosting Site	Type of Roost
Baya weaver	Coconut palm Palmyra palm Rice field reeds	Small to Medium
Cattle egret	Coconut palms in the fringes of paddy field	Small
Common myna	Ficus , peepul and rain tree	Medium
Cormorant	Gulmohar and rain tree	Medium
House crow	Flame of forest, neem, peepul, tamarind, rain tree, gulmohar	Medium to large
House sparrow	Forest tree Pongamia	Small
Lesser whistling teal	Natural and man made ponds	Small Medium
Pond heron	Flame of forest, glyricidia tree	Small
Purple moorhen	Uncultivated paddy fields and fringes of pokhali rice fields, kole lands	Small to medium
Rose ringed parakeet	Peepul, palms and other forest trees	Small
Streaked weaver	Reeds on rice field bunds	Large
Asian open bill stork	Gulmohar and rain tree	Medium

Relative abundance (RA) = Total no. of individuals of species A

Table 10. Roosting sites and type of roosts

Total no. of individuals of all species

Bird Species Diversity were calculated using Shannon -Weiner equation

$$H' = - \sum (p_i \times \ln p_i)$$

H' = Shannon -Weiner diversity index.

P_i = proportion of total sample represented by species i.

Shannon -Weiner index is a measure of both species' evenness and abundance. It showed the community composition.

Depredatory birds: Main depredatory birds recorded were baya and streaked weavers, lesser whistling teal, rose ringed and plum headed parakeets, small green barbet, purple moorhen, blue rock pigeon, peafowl, red vented and red whiskered bulbuls, cormorants, greb, *etc.* Five locations were selected to assess the depredatory bird damage to crops/ aquaculture around the roosting sites. The crop damage varied depending upon the extent of isolation of the cropped area and the crop stage. Rice crop suffered to depredation in nursery, vegetative, grain filling and the maturation stages and the depredatory birds raided the crop at these specific stages. Wherever the crop was sown direct, the population of the granivorous birds was more immediately after sowing taking away the sprouted seeds. In vegetative stage, the depredation by the purple moorhen was reported from the kole lands and Pokhali field. Trampling of the crop happened by the heron groups when they land on the plants. Purple moorhen in rice area had caused considerable damage to the vegetative stage of rice crop. In the grain filling stage of the weaver (baya weaver in the general rice fields and streaked weaver in the kole and Pokhali lands) cause considerable damage to the crop. In the maturity stage of the rice crop, parakeets (rose ringed, blossom headed and the blue winged parakeets) inflict considerable damage in rice. The extra depredation by the parakeets had primarily caused the damage. Trailing cow pea (as vegetable and seed crops) was heavily damaged by parakeets. Maturing banana was damaged by barbets and parakeets. Okra crop when grown for seed purpose was depredated heavily by parakeets and barbets. Brinjal fruits were depredated by small green barbet cow pea pods damaged by purple moorhen in the low land rice fallow. Blue rock pigeon was the most destructive in rice fields in direct sown crop, rice nursery and in the maturity stage if the crop got lodged (Table11).

Table 11. Depredatory bird damage to crops

Crop	Stage	Mean damage in observation area (%)		
		Depredatory bird	2017 -18	2018 -19
Rice	Nursery bed and direct sown crop	Baya weaver	4.60	3.50
		Blue rock pigeon	6.50	2.00
		Common teal	3.25	2.50
	Vegetative stage	Purple moorhen	34.7 5	18.5 0
	Filling stage	Streaked weaver	5.00	1.25
		Baya weaver	4.50	6.00
	Maturity stage	Munia	2.50	1.75
		Plum headed and rose ringed parakeets	3.25	4.25
	Lodged rice	Teal	1.00	2.00
	Cow pea	Rose ringed parakeet	9.50	10.5 0
		Plum headed parakeet	2.75	4.50
		Pea fowl	4.50	3.25

		Purple moorhen	0.00	0.00
Banana	Fruiting stage	Rose ringed parakeet	9.50	7.50
		Small green barbet	5.50	4.50
		Crow	3.25	2.50
		Koel	2.75	3.50
		Tree pie	2.25	3.75
		Common myna	1.25	0.25
Okra	Maturity stage	Rose ringed parakeet	7.50	12.75
		Small green barbet	2.00	1.00
Mango	Fruiting stage	Small green barbet	0.00	0.25
		Koel	1.50	2.00
		Rose ringed parakeet	4.50	1.75
		Crow	3.00	2.75
		Common myna	1.00	0.25
Papaya	Fruiting stage	Small green barbet	6.00	5.00
		Koel	2.50	4.50
		Flame back wood pecker	2.25	0.25
		House crow	2.50	4.00
Jack	Fruit	Myna	0.50	1.75
		Koel	1.50	0.25
		Barbet	0.50	1.25
		House crow	2.50	2.25
Bitter gourd	Matured fruit	Barbet	2.50	2.00
Snake gourd	Matured fruit	Barbet	1.50	2.50
Brinjal	Maturing fruit	Small green barbet	6.00	9.00
Chillies	Matured fruit	Peafowl	2.00	4.50
Guava	Maturing fruit	Small green barbet	3.00	4.25
		Rose ringed parakeet	1.25	3.75

Community structure of birds was analysed in paddy fields during rabi season. Monitoring of birds was started during the time of land preparation up to the harvesting of the crop. During this growing period 54 species of birds belonging to 26 families were observed in the observation area. The most prominent of the species was egrets (RA 34.63 %) followed by glossy ibis (RA18.60%), cormorant (RA 10.61%), painted stork (RA 7.12%). The greatest number of species was observed during the month of October (37 species). During the month of November and December bird species count as well as individual count was comparatively less since the crop was at vegetative and flowering stage. After grain formation and maturity, the number of birds count increased. Even though painted stork (migratory bird) was the fourth most species with high relative abundance, its occurrence was recorded only in October prior to sowing. In case of glossy

ibis, it had been recorded only before sowing and after harvesting, not in other stage of the crop (Table 12).

Table 12. Shannon – Weiner diversity index of rice field birds

Month	October	November	December	January	February
Diversity indices	2.113	3.055	2.550	2.215	1.740

High value of Shannon - Weiner index represent diverse and equally distributed community. Even though the bird count was less in the month of November, the species diversity indices was more in November (3.055) followed by December (2.550). The winter migration of birds might be the reason for the more bird diversity indices value during November and December.

BM 3. To identify, develop and evaluate eco-friendly bird management techniques

a) Evaluation of different botanicals as feeding deterrents in the captivity and fields (rice and vegetables): Botanicals viz., *Andrographis paniculata*, *Cassia auriculata* and *Lantana camara* leaves (10% aqueous leaf extract) and seeds of *Annona squamosa* (10% aqueous seed extract) were screened for feeding deterrent properties against depredatory birds like blue rock pigeon. *A. paniculata* leaf extract was on par with the methyl anthranilite (0.2%), ecodon (1.0%), copper oxychloride (0.1%) and whole egg (1.0%) in reducing the feeding of parakeet. *Annona squamosa* (10% aqueous seed extract) was the next best in reducing the food intake by the bird.

Passerine bird feeding was significantly reduced by methyl anthranilite (0.2%), ecodon (1.0%), copper oxychloride (0.1%) and strontium chloride (0.1). Whole egg had no such significant effect as that of pigeon. Among the aqueous extracts, leaf of *Lantana camara* (10 % aqueous leaf extract) had significantly reduced the feeding in munias.

Table 12. Screening of non-lethal chemicals as feeding deterrents against depredatory birds in captivity

S. No	Plant extract / repellent	Concentration (%)	Per cent feeding (out of 50 g of treated grains)			
			Blue rock pigeon		Munia	
			T	C	T	C
1	Methylantranilite	0.20	3.00 ^a	29.00 ^b	0.50 ^a	8.50 ^{bc}
2	Ecodon	1.00	4.00 ^a	30.30 ^{bc}	2.50 ^b	9.50 ^{bc}
3	Strontium chloride	0.10	0.75 ^a	28.05 ^a	0.50 ^a	8.50 ^{bc}
4	Copper oxychloride	0.10	0.50 ^a	27.50 ^b	0.00 ^a	9.00 ^c
5	Whole egg	1.00	4.50 ^a	29.00 ^a	1.75 ^{ab}	8.75 ^{bc}
6	Cinnamaldehyde	0.20	3.25	30.00	0.75	8.25
7	Sucrose	1.00	0.75	29.50	0.50	9.25

DMRT ($p=0.05$); values following same alphabet are not significantly different; T – Treatment; C- Untreated control

b. Evaluation of chemical/ non chemicals as deterrent s in the fields: Methylantranilate, strontium chloride, copper oxy chloride, sucrose, clay slurry and albumin based repellents were tested against granivorous birds in rice fields and compared with untreated control.

Table 13. Effect of non-lethal repellents against granivorous birds

Treatments	Area of seed bed (sq.m.)	Mean area damaged (sq. m)	Area damaged (%)
T1- Biobird repellent @ 2%	15	2.87	19.13 ^b
T2- Strontium chloride @0.2%	15	5.33	35.53 ^c
T3- Copper oxychloride 0.2%	15	2.65	17.67 ^b
T4- Albumin mix @2%	15	4.90	32.67 ^c
T5- Sucrose @1%	15	5.25	35.00 ^c
T6- Clay slurry	15	1.00	6.67 ^a
T7- Control	15	8.50	56.67 ^d

Among the treatments, clay slurry performed well as the stickiness of the clay annoyed the depredatory birds and reduced feeding resulted. Among the repellents, both bio bird repellent and CoC were equally effective. When compared to control, all the treatments were significantly effective (Table13).

c. Field evaluation of different management methods in various crops in farmers' fields.

Depredatory bird damage varied with the crop, stage of the crop and the location of the field. Available bird management techniques were employed in the field to protect different crops from the depredatory birds. Complete covering of the economically important parts resulted in low depredation; sometimes it was near total in protecting against the bird depredation. The metallic reflective ribbon offered protection for two to three weeks depending upon the stage of the crop, season and the location with a condition that the ribbons would be recalled after the vulnerable stage passed off. (Table 14).

Table 14. Effectiveness of depredatory bird management techniques

Crop	BPM Technique	Depredatory bird	Effectiveness (%)
Rice	Methyl anthranilate based feeding repellent	Weaver birds and munia	32.0 ± 6.0
Rice	Metallized reflective ribbon	Rose ringed and plum headed parakeets	57.0 ± 14.0
Cow pea	Reflective ribbon	Parakeets and pea fowl	84.0 ± 12.0
Pulse	Reflective ribbon in maturing crop	Parakeets and peafowl	65.0 ± 7.0
	Teak leaf protection	Parakeet and spotted dove	95.0 ± 5.0
	Nylon rope and metalized reflective ribbon fencing	Peafowl	92.0 ± 5.0
Plantain	Bunch cover with polythene sheet	Barbets, parakeets, koel, babblers, crow, myna, bulbuls	99.0 ± 1.0
Plantain	Banana leaf trash cover	Barbets, parakeets, koel, babblers, crow, myna, bulbuls	92.0 ± 5.0

BM 4. Exploitation of beneficial birds for the suppressing of insect pests - *Amaranthus*

An amaranthus field of 40m x 8m was divided into 20 sub-plots. Each sub-plot measured 5m in length and 8m in width. Six treatments, each having 4 replications (R1, R2, R3, and R4) were randomly aligned in these sub-plots. Ten amaranthus plants were tagged to take observations in each sub-plots. The six treatments were bird exclusion net, malathion, flubendiamide, *Bacillus thuringiensis*, Bt + perch and untreated control, respectively. Observations were made at an interval of 3, 5, 7 and 21 days. Chemicals were sprayed two times, where the second one was done after the completion of first set of observations. In each observation the number of folded leaves and the number of larva, pupa and adults (*Psara basalis*) emerged from each folds were recorded. **Treatments:** T1 – Bird exclusion net; T2- Malathion (2ml/L); T3- Flubendiamide (0.1 ml/L); T4- Bt (20ml/1L); T5- Bt + bird perch and T6- Untreated control

Table 15. Role of insectivorous birds in the management of amaranthus leaf folder, *Psara basalis*

Replication	Treatment					
	T1	T2	T3	T4	T5	T6
R1	21	4	2	19	5	11
R2	9	1	4	5	7	7
R3	23	4	0	19	6	16
R4	4	5	0	9	3	2
Mean	14.25 ^a	3.50 ^{bc}	1.50 ^c	13.00 ^a	5.25 ^{bc}	9.00 ^{ab}

When the insectivorous birds were excluded as in T1 (Table 15), the number of larvae were more whereas the insecticide treated plots had significantly less number of insects. Combination of bird perch and Bt treatment had significantly low number of insects.

BM 5. Evaluation of fruiting / flowering trees to attract insectivorous / omnivorous birds to the agricultural landscape

During the time of flowering and fruiting, nectarivorous and frugivorous birds got attracted towards many trees. Some insectivorous birds also got attracted to feed on the caterpillars on trees. Evaluation of trees attracting depredatory birds was carried out in different agricultural landscape including paddy fields of kole wetland and other landscapes.

- Indian ash tree - *Lannea coromandalica*: Birds like Asian koel, parakeets, orioles feed fruits of this tree. During flowering insects like beetles and other pollinators were recorded on the flowers
- Spinous Kino Tree - *Bridelia retusa*
- Bombax - *Bombax ceiba* Mynas and starlings were seen feeding on fruits of and nectar of bombax flower. When compared to other members of this family, rosy starling roost had often seen at the time of flowering
- Copper pod – *Peltophorum pterocarpum*: white eye, drongo, myna, robin, oriole and chloropsis found feeding on caterpillar; vernal hanging parrot observed to feed on nectar of copper pod flower

BM 6. Farmers' participatory research on bird management

a. Reflective ribbon – nylon rope fence against peafowl depredation: Field experiment was conducted in farmers' vegetable field to evaluate the effectiveness of reflective ribbon and two rows of nylon rope tied around the field with the support of poles at five meter intervals. Nylon rope was tied at a height of 30 cm between the ropes and at the top a single row of reflective ribbon twisted once at one meter interval. The entire setup got repeated as a grid (1 cent) fashion in

the field Due to the physical obstruction and visual scarring effect, no damage was recorded in the protected field; however, up to 75 per cent damage could be observed in the un protected fields (Table 16).

Table 16. Effect of reflective ribbon and nylon rope fencing against peafowl in vegetables plots

Year	Crop	Area (m ²)	Protected field		Un protected field		Damage (%) over protected field
			No of seeds germinated	No of seedlings damaged by peafowl	No of seeds germinated	No of seedlings damaged by peafowl	
2017-18	Cowpea var.Bhagyalakshmi	1000	3500	0	3575	2430	67.97
2018-19	Cowpea var.Bhagyalakshmi	1000	3650	0	3412	2560	75.03

II. Location specific programmes

a) Bio-ecology of purple moorhen and its management in kole lands: The purple moorhen (*Porpyrio porphyrio*), also known as Grey headed swamp hen, a swamp bird present in marshy reed beds and flooded rice fields. Purple moorhen was reported in large numbers from kole fields. The availability of food and undisturbed roosting and breeding sites enhanced its population in kole fields.

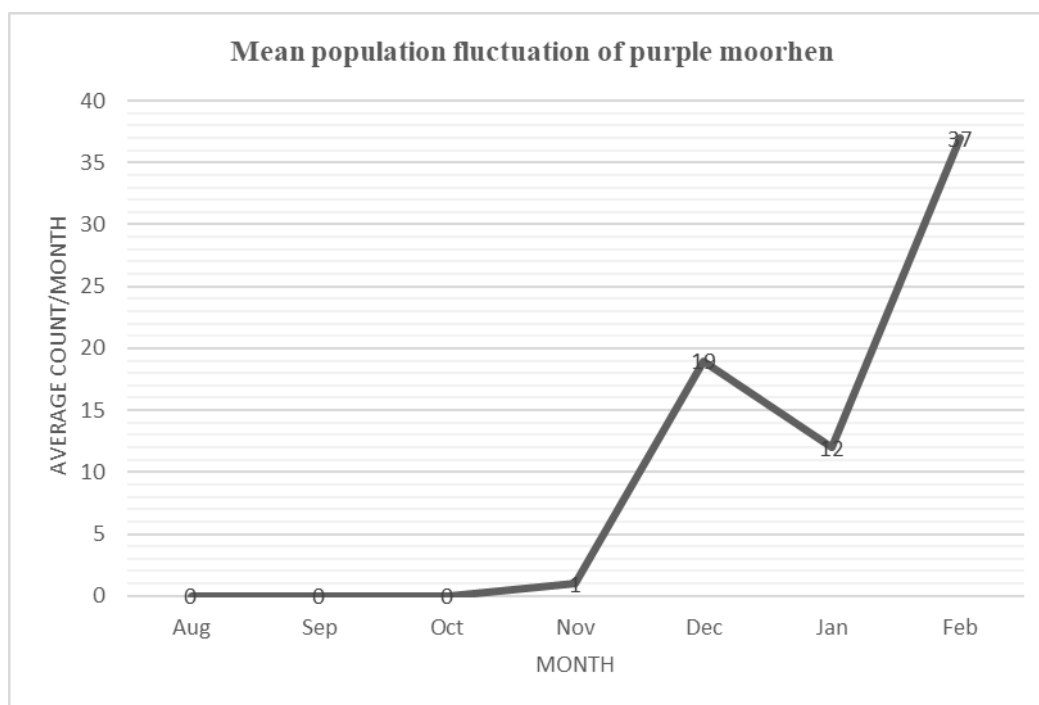
It roosted on the bushy areas or marshy regions, where human interference was less. Purple moorhens had seen in abundance in the regions with invasive growth of water hyacinth. In kole wetlands it roosted on the brackish water invaded with water hyacinth and came to feed on crops cultivated where the human activity was less.

The study area covered kole fields of Thrissur district, with detailed work carried out in Enamavu (10.5006, 76.10681), Chalakkudy (10.289715, 76.312584), Puzhakkal (10.555510, 76.184316) and Irinjalakkuda (10.3846011, 76.183806) kole fields. The kole wetlands were low lying tracts located 0.5m to 1m below Mean Sea Level (MSL) and remained submerged for about 6 months in a year. The study area was a Ramsar site, lying between 10° 20' and 10° 40' N latitudes and 75° 58' and 76° 11' E longitudes and also part of Kecheri and Karuvannur river systems.

To study the behavioural pattern of purple moorhen continuous sampling method was adopted. All the activities of birds were observed and recorded at regular interval. The activities observed included roosting, feeding, walking, preening, fighting, etc.

Even though it was a resident species, it had been reported in large numbers from the month of November and onwards.

Fig 7. Pattern of occurrence of purple moorhen from Enamavu kole fields



During the monsoon season purple moorhen sighting was not reported from the kole fields. From November onwards it had been recorded and its number shot-up during February. Nestlings were observed from December onwards. Purple swamphen observed to be an omnivore. It fed on the soft shoots, grains, frogs and molluscs. They had seen foraging on water hyacinth stolen for most of the time. It fed on tender shoots of paddy and cause severe damage during the vegetative stage of rice.

Management of purple moorhen in the field: Physical deterrent strategies were effective. Among the different treatments, roosting site clearance was the most effective followed by LED flash lights and netting. As the bird damage occurred even during after dusk period, reflective ribbon was not that effective. However, the birds became habituated to the condition.

Table 17. Effect of management methods on purple moorhen damage in rice

S. No	Treatment	Purple moorhen density	Mean purple moorhen damage (%)
1.	Net	18	14 ^d
2.	LED light flashes	10	3 ^e
3.	Reflective ribbon	22	25 ^c

4.	Roosting site clearance	7	<1 ^e
5.	Bio bird repellent	31	38 ^b
6.	Bursting crackers	97	44 ^a
7.	Control plot	200	47 ^a

b. Studies on metagenomics of bird fecal matter for identification of useful virus and bacteria to suppress insect pests of crops: Fecal pellets of purple moorhen were collected from two situations viz., intensive pesticide used area (kole lands) and relatively pesticide free area. Collected specimens were preserved in 90% ethyl alcohol at -20° C. DNA isolation from the fecal pellet got standardized. Next generation sequencing technology had been carried out to analyse the microbial community within the species by isolation and polymerized chain reaction using 16S rDNA primer (16S rDNA f-GAGTTTGATCCTGGCTCAG and 16S rDNA r-ACGGCTACCTTGTACGACTT). Sample was sequenced at SciGenom Labs Private Limited, Cochin (IlluminaMiSeq). The data generated by the study were being analyzed.

(C) HIGHER VERTEBRATES

HV 1: Bio ecology and management of higher vertebrates in different crops.

- Status and distribution of the species in the region of study: wild boar was one of the major threat to agriculture and human life in Kerala during the period under report. It caused more damage and next to the damage caused by elephants. Multiplying fast, the omnivorous animal was steadily spreading from forest fringes to inhabited areas, opening new fronts in the conflict with humans.
- Population details, habit, habitat, food and feeding habits: As a nocturnal feeder, the wild pig mostly raided plantains during summer period and chewing up the pseudostem, damaged fallen coconuts and tubers including tapioca, colocasia and elephant yam. It also dug up turmeric and ginger plants and trampled paddy rice fields to feed
- Extent of crop damage at different crop growth stages

Table 18. Wild pig damage in crops in Kerala

S. No	Crop	Crop stage	Mean wild pig damage (%)
1.	Rice	Nursery and maturity stage	4.00
2.	Plantain	Before flowering	20.00
3.	Tapioca	Tuber formation	38.00
4.	Colacassia	Tuber formation	3.00
5.	Yam	Tuber formation	7.00
6.	Snake gourd	Seedling and early vegetative stage	19.00
7.	Amaranthus	Vegetative stage	53.00
8.	Coconut	Nursery and fallen coconut	62.00
9.	Ginger	Rhizome formation	12.00
10.	Turmeric	Rhizome formation	3.50

d) Identification of traditional practices

- Guarding
- Cut, short hair (collected from barber shop) application in paths traversed by wild pig
- Sound from metallic parts
- Use of domestic dogs
- Stone wall around the cropped area

- f. Bar soap mixture spray
- g. Reed line
- h. Cracker line for periodic bursting of cracker
- i. Saree and other cloth typing around and in the fields
- j. Kerosene spray around the field
- k. Plastic cover typing in the field
- l. Metal sheet barrier fence

e) Development of management technologies and Testing of proven technologies: Wild boar posed a serious threat to crops like banana, vegetables, rice, tuber crops, etc. in Kerala. Field experiments were conducted to evaluate the effectiveness of different methods to prevent wild boar entry into amaranthus crop field and protect the crop from its attack. Nylon net was tied around amaranthus field at a height of 120 cm feet with the support of poles and also spread over the ground surface about 90 cm and fixed firmly to the ground. A plastic rope was tied around the net at a height of about 20 cm from the ground level to secure firmly to the poles in an inclination. Olfactory repellent with strong smell was taken in muslin cloth and tied on poles at a distance of 1m around the field at a height of 10 cm from the ground level. Among treatments, modified nylon net fencing around the field and use of olfactory repellent were found to be superior in deterring wild boar. These methods were effective in preventing the damage. (Table 19).

Table 19 .Effect of management measures against wild pig

S. No	Treatment	Amaranthus crop field				Mean damage (%)	
		Location A		Location B		Location A	Location B
		Total area (m ²)	Mean damaged area (m ²)	Total area (m ²)	Mean damaged area (m ²)		
1	Nylon net	500	30	500	62	6.00	12.40
2	Olfactory repellent spray @ 50ml/L of water	500	55	500	65	11.00	13.00
3	Control	500	300	500	275	60.00	55.00

TRIBAL SUB PLAN ACTIVITIES

1. Thalikkallu Tribal Colony: Thalikkallu tribal colony is situated in Alathur thaluk of Palakkad District of Kerala, The main tribes belongs to this area is Kadar. Kadars are one among the primitive tribes of Kerala who are exclusively living in forest areas. They are forest dwellers, they have long served as specialized collectors of honey, medicinal plants and resin for trade with merchants. A pilot study was conducted in a sample of one Kadar settlement. The Scientist and staffs camped near by the tribal settlement and conducted a meeting of 63 tribal families and enquired the details of major crops cultivated in the area and problems faced during the cultivation and harvesting. Pepper, areca nut coffee etc are the major cultivated crops in this area. They showed us the wilting and yellowing of the pepper plants and also reported that the wild animal intrusion in the cropped area (Wild boar, Deer etc). Also they enquired about apiculture. As per their needs, the following training programmes were given to the tribal community.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management
- Training on Apiculture

Field visits have been conducted for crop damage assesment and plant and soil samples were collected for further analysis. The laboratory analysis showed that the yellowing and wilting in black pepper was due to fungus and we recommended the application of bio control agents viz., *Pseudomonas* and *Trichoderma* and for minimizing the wild boar incidence, we suggested the application of borep . During the second visit, we supplied the inputs(*Pseudomonas*, *Trichoderma*) for disease management & borep for managing the wild boar incidence.

2. Periyakudy Tribal Colony: Periyakudy tribal colony is located in Marayoor Grama Panchayath, Devikulam Block of Idukki District of Kerala, The main tribes belongs to this area is Muthuvan. Muthuvan lives in hamlet called “*kudi*”. The kudi’s are headed by “*kani*” which is vernacular means superior or protector; these tribes have been cultivating vegetables in the forest areas through organic methods, using cow dung, farm waste and green manure instead of chemical pesticides and fertilizers. The team met the Agriculture officer, Panchayath President, SC Promoter and other officials to collected valuable information about the tribes. The teams called for a meeting of 100 tribal families and imparted training on the following subjects.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management

Conducted field visits for crop damage assesment and noticed the incidence of rodents and wild animals intrusion in cropped area. We recommended the technologies developed by our centre to manage wild animal intrusions and incidence of rodents and also supplied the inputs to control plant diseases (*pseudomonas*, *Trichoderma*)and to manage wild animal intrusion (borep) in cropped area.

Kammaran Kudi Tribal Colony: Kammaran Kudi tribal colony is situated in Marayoor Panchayath, Devikulam Block of Idukki District of Kerala, The main tribes belongs to this area is Muthuvan. The team approached the Agriculture officer, Panchayath President, SC Promoter and other officials to collect valuable information about the tribes. The teams called for a meeting of 47 tribal families and training was given in the following aspects.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management

Conducted field visits for crop damage assesment and noticed the incidence of wild animals in the cropped area. We recommended the technologies developed by our centre to manage wild animal intrusions in cropped area and also supplied the inputs to manage the wild animal intrusion in cropped area(Borep, Reflective ribbon, Hand sprayers, Nylon net and Flickering light).

3. Iruttalakudy Tribal Colony: Iruttalakudy tribal colony is situated in Marayoor Panchayath, Devikulam Block of Idukki District of Kerala, The main tribes belongs to this area is Muthuvan. The team visited the Agriculture officer, Panchayath President, SC Promoter and other officials to collect valuable information about the tribes. The teams called for a meeting of 58 tribal families and imparted training on the following subjects.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management

Field visits were conducted for crop damage assesment and noticed the incidence of wild animals in the cropped area. We recommended the technologies developed by our centre to manage wild

animal intrusions in cropped area and also supplied the inputs to manage the wild animal intrusion in cropped area(Borep, Reflective ribbon, Hand sprayers, Nylon net and Flickering light).

4. Puthukudy Tribal Colony: Puthukudi tribal colony is situated in Marayoor Panchayath, Devikulam Block of Idukki District of Kerala. The team approached the Agriculture officer, Panchayath President, SC Promoter and other officials and collected valuable information about the tribes. The teams called for a meeting of 25 tribal families and trainings were given on the following areas.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management

Also conducted field visits for crop damage assesment and noticed the incidence of wild animals in the cropped area. We recommended the technologies developed by our centre to manage wild animal intrusions in cropped area and also supplied the inputs to manage the wild animal intrusion in cropped area(Borep, Reflective ribbon, Hand sprayers, Nylon net and Flickering light).

5. Velakkalkudi Tribal Colony: Velakkalkudi tribal colony is located in Marayoor Grama Panchayath, Devikulam Block of Idukki District of Kerala. The main tribes belongs to this area is Muthuvan. The team met the Agriculture officer, Panchayath President, SC Promoter and other officials and collected valuable information about the tribes. The teams called for a meeting of 41 tribal families and imparted training on the following aspects based on the needs.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management

Also conducted field visits for crop damage assesment and noticed the incidence of wild animals in the cropped area. We recommended the technologies developed by our centre to manage wild animal intrusions in cropped area and also supplied the inputs to manage the wild animal intrusion in cropped area(Borep, Reflective ribbon, Nylon net) and Trichoderma for managing the plant deiseases.

6. Kuruva Tribal Colony: Kuruva tribal colony is situated in Dasanakkara and Pakkam Village of Wayanad Districts of Kerala, The main tribes belongs to this area is Kurumar. The Kurumas are a tribal community who are believed to have descended from the Vedas, the ancient rulers of this region. This community mainly dealt with forest products and they were further divided into three subsets on the basis of their occupation: i.e., Mullu Kuruma (who collect bamboo), Then Kuruma (who collect honey), and Urali or Bettu Kuruma (who are wood cutters, fishermen, and artisans). Among these, the Mullu Kurumas consider themselves as superior over other groups. These tribes have been cultivating vegetables and rice in the forest areas through organic methods, using cow dung, farm waste and green manure instead of chemical pesticides and fertilizer. The teams called for a meeting of 70 tribal families and imparted training on the following aspects based on their needs.

- Training on depredatory bird and rodent management in the agricultural fields
- Demonstrated the technologies developed by our centre related to depredatory bird and rodent management

Field visits for crop damage assesment were also conducted and noticed the incidence of wild animals in the cropped area. We recommended the technologies developed by our centre to

manage wild animal intrusions in cropped area and also supplied the inputs to manage the wild animal intrusion in cropped area(Borep, Nylon net, Hand sprayer) and Psuedomans , Trichoderma for managing the plant deiseases.

EXTENSION ACTIVITIES

- a. Regular field visit and briefing the importance of birds in the agriculture to the farmers
- b. Periodical farmer interactions with respect to the rodents and wild animal management in different crops
- c. Department of Agriculture Officers meeting in which the importance of management of rodents, wild animals and birds in agriculture was discussed
- d. Informal classes for the visiting Vocational Higher Secondary School and College students
- e. Briefing of rodents, wild animals and avian influence in agriculture in the Agro-clinics organized by the B. Sc (Ag) students for the benefit of the farmers
- f. Participating in exhibitions and displaying various management methods available to manage rodents, wild animals and birds
- g. All India Radio Programme – Rodent management (Malayalam)

OVERALL IMPACT OF THE PROJECT

The Centre had created good impact in the management of rodents, birds and wild animals at vulnerable stage of the crop. The Centre had distributed nesting boxes for the cavity nesters from the conservation point of view. Due to the increased awareness and environment conscious public approach the Centre for advice in the ecological management of problem birds and conservation of beneficial birds. Various public health departments and NGOs had approached the Centre for the management of rodents in the wake of flood in Kerala.

TEACHING

Following B. Sc, M. Sc and Ph. D courses were taught by Project Scientists in the University.

- Ento 3204. Non insect pest (1+1)
- Ento 3011. Experiential learning (0 +10)
- Ento 509. Principles of Integrated Pest Management (2 + 1)
- Wild 1201. Invertebrate biodiversity and forest entomology (2 + 1)
- Ento 517. Vertebrate pest management (1+ 1)
- Ento 611. Molechular techniques in entomological research (1+1)

LINCKAGES WITH INSTITUTION

AINP on Vertebrate Pest Management Centre had linkages with the following institutions

1. Department of Agriculture, Kerala
2. College of Forestry, KAU
3. Kerala Forest Research Institute, Peechi
4. AICRP on Pesticide Residue, Vellayani
5. Kerala Veterinary and Animal Sciences University
6. Forest Department, Kerala
7. SACON, Coimbatore
8. Tamil Nadu Agricultural University, Coimbatore
9. KVIC
10. CBTRI, Pune
11. Kerala Veterinary and Animal Sciences University, Wayanad

12. Kerala University of Health Sciences, Thrissur
13. KVKs, Kerala
14. Department of Agriculture and Farmers's Welfare, Lakshadweep islands

FUTURE THRUSTS

1. Metagenomic analysis of gut endosymbionts of rodents and birds in different agro ecosystem
2. Rodent management in poly houses and protected cultivation
3. Management of giant Malabar squirrel in plantations
4. Management of sambar deer

PUBLICATION

- Mani Chellappan, Ambady Pallikadan, Sujala C. Subrahmanyam, Henna M. Kaderkutty, and Ranjith M. Thodikayil, 2017. Metagenomic analysis of cattle egret (*Bubulcus ibis* L.) specific gut microbiota. *Genome*. 60, 920
- Sreeja, P and Mani Chellappan, 2017. Management of Indian peafowl, *Pavo cristatus* (L) on rice in Kerala. *Ann. Pl. Prot. Sci.* 25(2): 304-307
- Mani Chellappan and C. V. Vidya. 2017. Integrated management of depredatory birds in cropped fields (Malayalam)
- Mani Chellappan and C. V. Vidya. 2017. Borep – for the management of wild boar problem in cropped fields (Malayalam)
- Mani Chellappan and Henna, M. K 2019. Molecular characterization of four *Rattus* species using mitochondrial cytochrome oxidase I (mtCOI) region. Presented in the International Gene School – Empowering Agricultural Research through Meta Genomics, Kasertsart University, Bangkok, Thailand
- Mani Chellappan, 2019. Rodent management– Malayalam video documentary
- Mani Chellappan and Ranjith, M. T. 2019. Purple moorhen management – leaflet in Malayalam
- Harish, E. R., Mani Chellappan, Makesh Kumar, T., Deepu Mathew, Ranjith, M. T. and Girija, D. 2019. Next generation sequencing reveals endosymbionts variability in cassava whitefly, *Bemisia tabaci* across the agro-ecological zones of Kerala, India. *Genome* <https://doi.org/10.1139/gen-2018-0050>

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	29.38	18.98	4.18	0.20	0.00	0.00	23.36
2018-19	46.85	21.23	15	0.6	5	5	46.83

ACHARYA N.G. RANGA AGRICULTURAL UNIVERSITY

A. P. Rice Research Institute & R.A.R.S, Maruteru – 534 122

PART: 1 General Information

1. Name of the centre	Regional Agricultural Research Station, Maruteru- 534 122 Acharya N G Ranga Agricultural University
2. Sanction No	F.No. CS.8/2/2017-IA-III dtd. 11.01.2018& CS/8-13/2018-PP dtd.17.01.2018
3. Date of Start	23-09-1985
4. Date of termination	Network Project of continued nature
5. Report period	2017-18& 2018-19
6. Scientist In-charge	Dr. Namala Srinivasa Rao Senior Scientist (Ento)&PI

7. Staff Position

S. No.	Name of the post	No. of Posts	Name of Incumbent
1	Senior Scientist	01	Dr. Namala Srinivasa Rao
2	Scientist	01	Smt. B. Anusha
3	Technical Assistant	01	CH. Devanandam

PART: II Work Allotted (Technical Programme)

I. Multi- location programs

RM1. Surveillance of pest rodents in predominant cropping systems (Rice-Rice-Pulse)

RM2. Monitoring of rodent abundance and damage in selected agro-climatic zones of the region (High Altitude/ Southern Zone)

RM3. Evaluation of botanicals against rodent pests for anti-feedant/ deterrent/ attractant/ sterilant effects

RM4. Evaluation of chemical compounds for toxic and anti-fertility properties for data generation on Indian rodents.

RM5. Development/Refinement of rodent management modules in predominant crops/ cropping systems and under storage conditions.

RM6. Bio-ecology of major rodent species (Habit, habitat, food, feeding/ burrowing behavior, population dynamics, reproduction and breeding biology etc) - *Mus booduga*

RM7. Social engineering activity on rodent pest management as participatory adoptive research in adopted villages

II. Location specific Programs

a. Refinement and validation of CTBS in irrigated rice for management of *B. bengalensis*

b. Burrow dynamics of *B. bengalensis* in various field crops

c. Studies on tolerance of bromadiolone against *B. bengalensis*

d. DNA bar-coding of major pest rodent species of Andhra Pradesh

III. Higher vertebrates

HV1. Bio ecology and management of higher vertebrates in different crops

PART: III Work done (Programme- wise)

RM 1. Surveillance of pest rodents in predominant cropping systems (Rice-Rice-Pulse)

Surveillance was carried for rodent pests in rice-rice-pulse cropping system for 2 consecutive years in research station farm as well as in farmer's fields in the district. Surveillance data of research station revealed that rodent incidence was very low during both the years when compared to previous seasons/ years. During 2017-18, a peak LBC of 24.2/ ha was noticed during the month of January (*rabi* season), which declined later gradually. Whereas in 2018-19, the population in terms of LBC was relatively low and incidence peaks were noticed during the months of July and October with 15 and 13.3 LBC/ ha, respectively, which was reduced gradually with progress of the season. In general, rodent infestation was found low during both the years (Fig.1).

Corresponding to the rodent incidence, the damage to the crop was also found below the ETL (<4% tiller damage) during both the years. Though the rodent infestation hover around medium, the mean tiller damage was found very low with 2.9 and 0.98 percent in 2017-18 and 2018-19, respectively. Though the mean per cent tiller damage value found below ETL, few peaks were recorded during the year 2017-18 during the months of August and September (Fig.1)

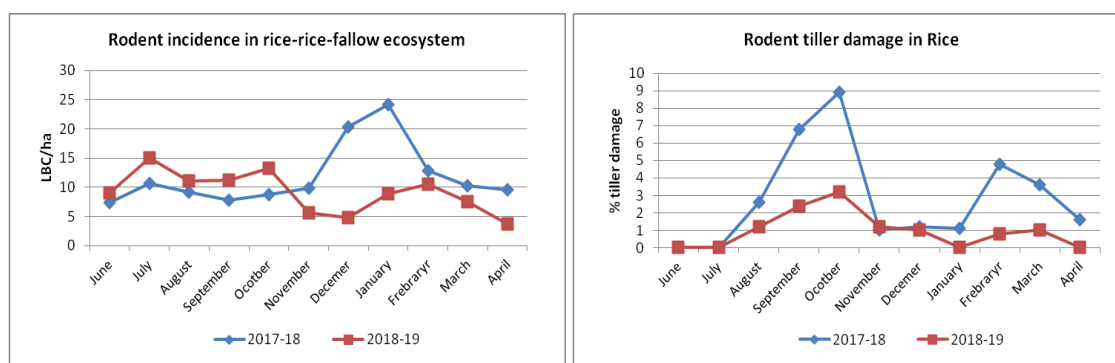


Fig.1. Rodent incidence and tiller damage in rice during 2017-18 and 2018-19

The breeding females of *B. bengalensis* were low in the season. Population growth estimate computed from breeding parameters (**Table 1**) indicated that the *B. bengalensis* infesting

paddy could breed @ 2.62 and 2.58 times per season with the seasonal productivity of 1.28 and 1.32 young ones per female in *kharif* and *rabi* 2017-18, respectively (**Table 2**). Whereas in 2018-19 the reproductive rates were recorded higher as 5.62 and 4.58 in *kharif* and *rabi* with an annual productivity of 20.2 young ones per female (**Fig. 2 & 3**).

During 2017-18 the lowest reproductive rates of *B. bengalensis* were recorded as seen in its previous years. The reproductive rates were also low in 2018-19 when compared general trend in this region. The lowest reproductive rates are mainly due to the deficit rainfall recorded during the study period than the normal. Which shows the impact of rainfall on the multiplication of lesser bandicoots, a wet rodent predominant in irrigated rice ecosystem.

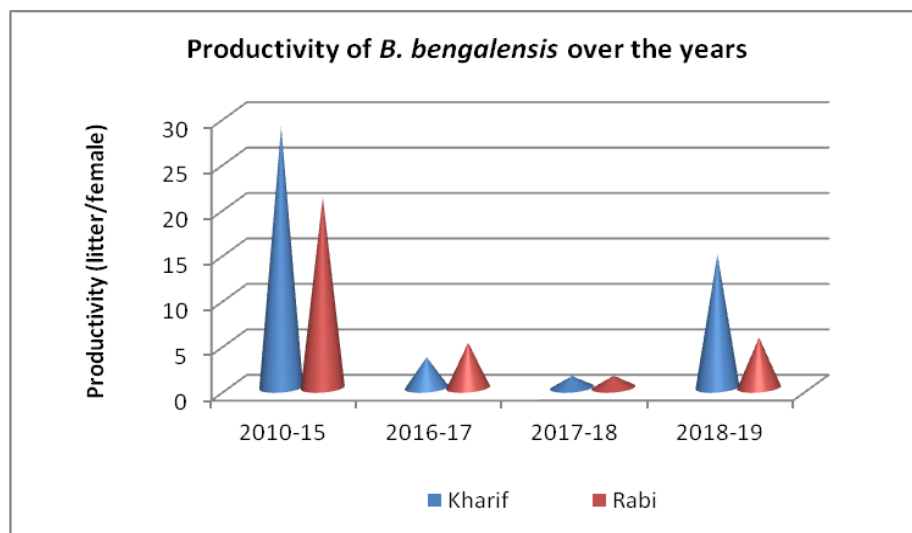


Fig.2. Productivity of *B. bengalensis* during 2017-18 and 2018-19

Table 1. Breeding parameters of *B. bengalensis* in rice fields in Godavari delta during 2017-18 and 2018-19

Month	Sample Size	No. of Males	No. of Females	Sex ratio (M : F)	No. of pregnant females	Percent Pregnancy	Total litter
June, 2017	29	18	11	1:0.61	6	54.5	3
July, 2017	59	36	23	1:0.64	16	69.6	11
August, 2017	25	13	12	1:0.92	7	58.3	5
September, 2017	26	17	9	1:0.53	7	77.8	0
October, 2017	58	30	28	1:0.93	20	71.4	10
November, 2017	62	30	32	1:1.07	17	53.1	7
December, 2017	85	43	42	1:0.98	20	47.6	26
January, 2018	110	46	44	1:0.96	23	52.3	56
February, 2018	56	28	28	1:1.00	14	50.0	32
March, 2018	57	31	26	1:0.84	8	30.8	12
April, 2018	48	26	22	1:0.85	8	30.8	14
Mean	55.9	28.9	25.2	1:0.8	13.3	54.2	16.0
June, 2018	24	13	12	1:0.9	0	0	0
July, 2018	41	22	19	1:0.9	0	0.0	0
August, 2018	23	9	14	1:1.6	0	0.0	0
September, 2018	24	9	15	1:1.7	0	0.0	0
October, 2018	24	10	14	1:1.4	9	64.3	75

November, 2018	68	24	44	1:1.8	22	50.0	233
December, 2018	27	12	15	1:1.3	0	0.0	45
January, 2019	33	16	17	1:1.1	0	0.0	0
February, 2019	16	9	7	1:0.8	0	0.0	0
March, 2019	25	7	18	1:2.6	1	5.6	36
April, 2019	14	4	10	1:2.5	3	30.0	0
<i>Mean</i>	<i>29.0</i>	<i>12.3</i>	<i>16.8</i>	<i>1:1.5</i>	<i>3.2</i>	<i>13.6</i>	<i>35.6</i>

Table 2. Population growth estimates of *B. bengalensis* at Maruteru

S. No	Population growth parameter	Values			
		<i>Kharif 2017</i>	<i>Rabi 2017-18</i>	<i>Kharif 2018</i>	<i>Rabi 2018-19</i>
1	Reproductive rate F*	2.62	2.58	5.62	4.58
2	Average litter / female	0.49	0.51	2.61	1.21
3	Productivity per season (F x Avg. litter/ female)	1.28	1.32	14.66	5.54
	Productivity per year	2.60		20.2	

Note: *F= P(t/v), P- prevalence of pregnancy (Avg. % pregnant/ season), t- time period of samples in days, v-time of gestation



Fig.3. Mother lesser bandicoot with litters

RM 2. Monitoring of rodent abundance and damage in selected agro-climatic zones of the region (High Altitude and Tribal Zone)

Rodent species composition was investigated in High Altitude and Tribal Zone of Andhra Pradesh. The information revealed that there was low incidence of rodent pests with respect to LBC/ha and also damage incidence. The rodent species, *Rattus rattus* was found to be predominant species in HAT Zone (90.25%) followed by *B. bengalensis* (6.66%). The trapped *R. rattus* were weighed, sexed and their morph metric parameters were recorded. The mean weight of the male and female were 185.35 and 121.04 respectively. The tail length and body length of the males were

18.98 and 14.00 respectively, whereas in females it was 17.14 and 13.86 respectively. The mean sex ratio of Male: Female was observed as 1: 0.61 from the sampled population. (Fig 4)

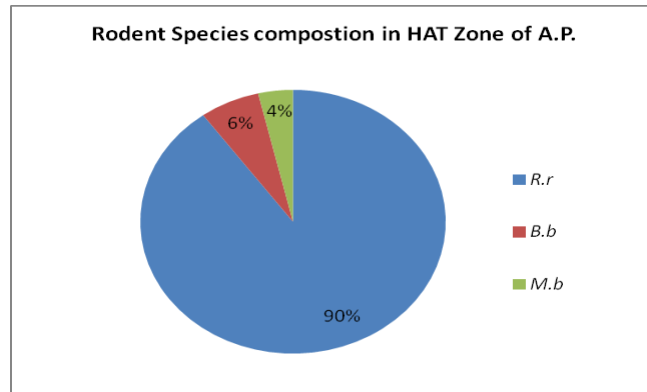


Fig.4. Rodent species composition in High Altitude Zone of Andhra Pradesh

Similar observations were made during the 2nd year of study i.e. 2018-19. The rodent species, *Rattus rattus* constitute 87.96% of the trapped population followed by *B. bengalensis* with 5.9% share. The males weighed more over the females as seen in the previous year with a mean body weight of 172.2 and 137.6 respectively. The tail length and body length of the males were 18.5 and 13.8 respectively, whereas in females it was 17.2 and 14.2, respectively. The mean sex ratio of Male: Female is 1: 0.92. The species composition in the study regions are detailed in **Table 3**. The morphological parameters of the predominant species (*R. rattus*) is briefed in **Table 4**.

Table 3. Species composition of rodents in High Altitude and Tribal Zone of A.P.

S. N	Name of the area	Total rodents trapped	Species rodents trapped			Percentage of species composition		
			<i>R.r</i>	<i>B.b</i>	<i>M.b</i>	<i>R.r</i>	<i>B.b</i>	<i>M.b</i>
2017-18								
1.	RARS, Chinthapalli	58	53	3	2	91.3	5.17	3.44
2.	HRS, Chinthapalli	34	31	3	0	91.1	8.82	0
3.	Asaraada	41	38	2	1	92.6	4.87	2.43
4.	Kokkirapalli	30	26	2	2	86.6	6.66	6.66
5.	Rinthada	32	28	3	1	87.5	9.37	3.12
Total		195	176	13	6	90.25	6.66	3.07
2018-19								
1.	Paderu	60	50	5	5	83.3	8.3	8.3
2.	Hukumpet	35	31	3	1	88.5	8.6	2.9
3.	Guda	39	37	2	0	94.8	5.2	0.0
4.	Araku	32	28	2	2	87.5	6.3	6.3
5.	Killoguda	28	24	3	1	85.7	1.1	3.5
Total		194	170	15	9	87.96	5.90	4.2

Table 4. Morphological Parameters of *Rattus rattus* under storage conditions in HAT zone

S. N o	Location	No. of animal s	Males				Females				M : F
			No. of male s	Mean wt (g)	Tail lengt h (Cm)	Body lengt h (Cm)	No. of female s	Mean wt (g)	Tail lengt h (Cm)	Body lengt h (Cm)	
2017-18											
1.	RARS,CHP	53	31	187.75	20.1	16.5	22	100.51	16.6	13.0	1 : 0.70
2.	HRS, CHP	31	19	210.07	17.6	12.3	12	110.34	18.2	14.1	1 : 0.63
3.	Asaraada	38	23	200.12	19.4	14.8	15	150.74	18.3	14.7	1 : 0.65
4.	Kokkirapalli	26	18	157.52	17.5	12.2	8	125.36	17.4	15.2	1: 0.44
5.	Rinthada	28	17	171.28	20.3	14.2	11	118.29	15.2	12.3	1 : 0.64
Total		176	108	926.74	94.9	70.00	68	605.24	85.7	69.3	-
Mean		35.2	21.6	185.35	18.98	14.00	13.6	121.04	17.14	13.86	1 : 0.61
2018-19											
1.	Paderu	50	28	173.8	18.3	14.4	22	108.5	14.3	12.0	1: 0.78
2.	Hukumpet	31	15	190.1	20.5	11.5	16	130.6	15.8	15.3	1 : 0.93
3.	Guda	37	17	180.1	19.8	14.8	20	180.2	18.6	14.5	1: 1.17
4.	Araku	28	13	140.1	17.4	13.2	15	140.3	20.7	17.2	1 : 1.15
5.	Killoguda	24	15	183.2	16.8	15.3	9	128.3	16.8	12.4	1 : 0.60
Total		170	88	867.4	92.8	69.2	82	688.0	86.2	71.4	-
Mean		34.0	17.6	172.2	18.5	13.8	16.4	137.6	17.2	14.2	1: 0.92

RM 3. Evaluation of botanicals against rodent pests for anti-feedant/deterrant/attract/sterilant effects.

Baits mixed with various botanical seed powders inhibited the consumption in the test animals. The consumption decreased in all test bait concentrations over the control treatment, where plain bait is given. Among the treatments Datura and Ganneru has showed potent toxicity against the animal. Datura 10% and Ganneru 10% recorded 26.5 and 27.5 mean bait consumption by the test animal. Both the botanicals recorded 100 per cent mortality with a mean mortality time of 17 and 10 days, respectively. Other two, castor and *Jatropha* recorded low food intake with 75% mortality in the test animal with high mean mortality times. In all the botanical treatments the test animals lose their body weight over the control (Fig. 5 & Table 5).

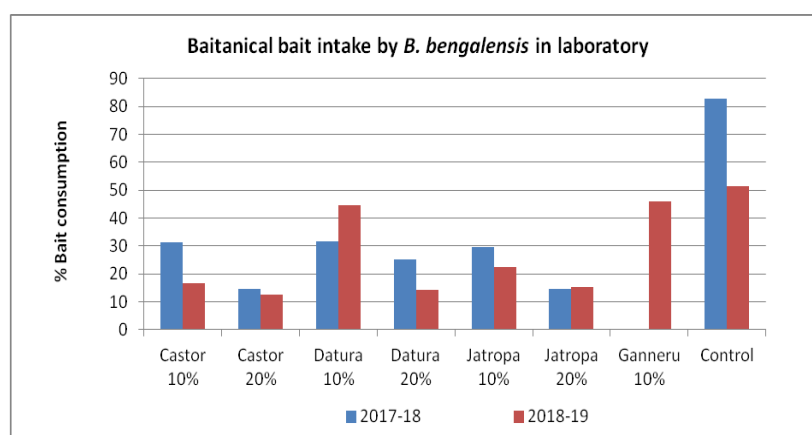


Fig. 5. Efficacy of botanical baits against *B. bengalensis*

Table 5. Effect of Botanical baits on Lesser bandicoot, *B. bengalensis*

Botanical	Bait given(g)	Total Consumed (g)	Mean Consumed	% consumption	%mortality	Mean time mortality
Datura 10%	240.0	107.0	26.5 $\pm$ 13	44.58	100.0	17.0
Castor 10%	240.0	40.0	10.0 $\pm$ 6.0	16.66	75.0	23.0
Ganneru 10%	240.0	110.0	27.5 $\pm$ 6.45	45.83	100.0	10.0
Jatropa	240.0	54.0	13.5 $\pm$ 3.20	22.50	75.0	18.0
Control	240.0	123.0	30.7 $\pm$ 12.6	51.25	25.0	--

RM4. Evaluation of chemical compounds for toxic and anti-fertility properties for data generation on Indian rodents

-Not conducted – due to non-availability of new chemical compounds

RM 5. Development/refinement of rodent management modules in predominant crops/cropping systems and under storage conditions

During the year 2017-18, among all the modules evaluated for efficacy against rodent pests, the **modules M5 and M2** (M5-Sustained application of ALP) (M2-rodent management operations of cultural practices, ZNP-Bromadiolone-ALP) has recorded mean per cent control success of 72.12 and 67.82 in reduction of LBC and 70.89 and 64.65 % control success in reducing the tiller damage, respectively (Table 6 a&b and Fig).

Table 6a. Efficacy of rodent management modules against *B. bengalensis* in rice

Module	Kharif 2017-18							
	% reduction in live burrows				% reduction in tiller damage			
	Tillering	PI	Harvest	Pooled	Tillering	PI stage	Harvest	Pooled

	stage	stage	stage		stage		stage	
M1	56.12	48.24	64.38	56.25	58.26	32.42	66.32	52.33
M2	68.32	56.28	78.86	67.82	68.24	46.28	79.42	64.65
M3	58.56	48.65	72.42	59.88	62.14	38.26	76.62	59.01
M4	62.36	58.62	62.75	61.24	66.34	48.16	64.38	59.63
M5	69.32	68.33	78.86	72.17	72.38	58.14	82.14	70.89
M6	42.28	32.33	36.73	37.11	50.42	24.62	38.46	37.83
Control	-	-	-	-	-	-	-	-

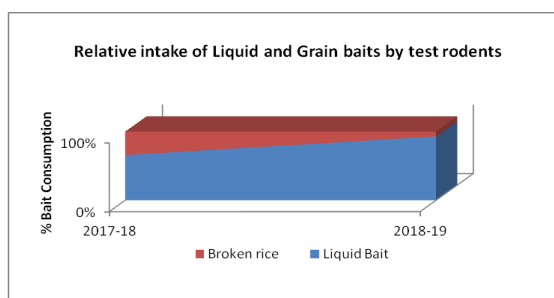
During the year 2018-19 also similar results were obtained, where Module 5 has recorded highest per cent control success 74.0 % in reducing the liver burrows with 66.3 % control success in reducing the tiller damage. The next best treatment found was Module-2 where all practices are integrated with a control success of 67.8% in live burrow reduction and 62.2% tiller damage reduction over the control treatment (**Table 5b and Fig.6**).

Table 6b. Efficacy of rodent management modules in reducing Live burrows 2018-19

Module	Kharif 2018-19							
	% reduction in live burrows				% reduction in tiller damage			
	Tillerin g	PI stag e	Harves t stage	Poole d	Tillerin g	PI stag e	Harves t stage	Poole d
M1	54.3	50.2	58.24	54.2	58.26	34.26	62.14	51.6
M2	66.4	58.3	78.8	67.8	68.22	46.28	72.12	62.2
M3	59.4	49.3	74.3	61.0	62.14	38.26	76.62	59.0
M4	64.3	59.3	64.5	62.7	62.14	48.16	66.24	58.8
M5	72.4	70.2	79.4	74.0	66.34	64.24	68.24	66.3
M6	44.0	32.8	34.8	37.2	50.42	26.24	36.24	37.6
Control	-	-	-	-	-	-	-	-
CV	20.67	9.3	8.1	14.3	16.24	12.3	9.6	12.3
CD	11.4	7.9	9.2	8.9	8.4	10.2	8.2	9.4
F-test (0.05%)	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.	Sig.

Under storage, intake of poison baits by the test animals is a great challenge as they move in food surplus environs. Hence, liquid baits are evaluated for improving the poison bait intake there by reduction in the pest rodent populations.

Fig.6. Relative intake of liquid and grain baits by rodents



During the present season i.e. 2017-18, liquid baits were tested for effective control of the pest rodents in storage godowns. The intake of liquid bait was almost double or even more than the solid bait intake. The total bait consumed was 25.0g in liquid bait, where as it was only 13.0 g in solid bait during the year 2017-18. Similar trend of bait consumption was noticed during the second year also (**Table 7 and Fig.7**).

Table 7. Consumption rate of liquid baits by R. rattus in storage

Bait additives	Bait placed (ml/ g)	No. of bait points	Total bait consumed	% bait consumption
2017-18				
Liquid bait (5% jaggery)	30	10	25.0	83.33
Broken rice based bait	30	10	13.0	43.33
2018-19				
Liquid bait (5% jaggery)	30	10	18.4	61.33
Broken rice based bait	30	10	0.13	00.46

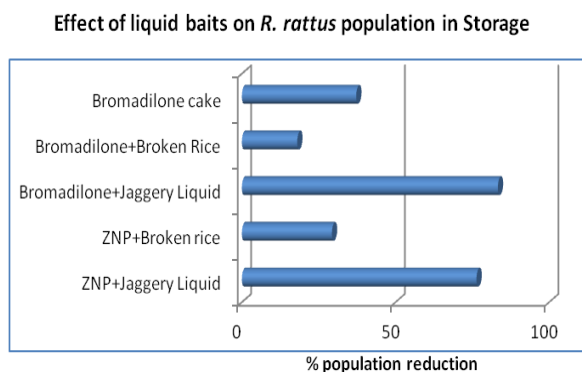


Fig.7. Effect of liquid baits on *R. rattus* population in storage

Table 8. Effect of liquid poison baits on population reduction of *R. rattus* in storage

Treatment	Bait placed (ml/g)	Bait points	Activity/ Tracking Index (%)		% reduction in Population
			Before (BTC)	After (ATC)	
207-18					
Liquid bait+2%ZNP	50	4	45	10	77.7
Broken rice bait +2% ZNP	50	4	35	25	28.6
Control	50	4	40	45	-
2018-19					
Liquid bait-0.005% bromadiolone	50	5	60.0	10.0	83.33
Broken rice bait +Bromadiolone	50	5	55.5	45.5	18.01
0.005% bromadiolone cakes	5	5	64.5	40.5	37.20
Control	50	5	50.5	56.5	-

During 2017-18, the efficacy of ZNP in reducing the rodent population in godown was tested using liquid baits. Before imposing the treatments the tracking index was noticed in the godowns by laying tracking tile near the baiting points. The pre-treatment index ranged 35-45, and then the baits were offered to the animals by placing them in metallic permanent bait stations. The tracking index was also noticed 3 days after the treatment and the control success was arrived using relevant formula. When ZNP 2% is offered through 5% jaggery solution the control success was 75-77% where as it was 28- 30% only, when offered through broken rice based bait (**Table 8**).

Whereas in the year 2018-19, bromadiolone was used in the place of ZNP in the same way the experiments conducted in the previous year. The increased intake of liquid baits has resulted in

higher per cent kill (83.33%) of test animals as against the 18.01 to 37.20 % kill in the broken rice or cake based bromadiolone 0.005% baiting. The liquid baits recorded highest per cent kill of the test animals. Overall the success of rodent control in food surplus environs like storage godowns was more with rodenticides when they offered through the liquid baits (Fig.8)

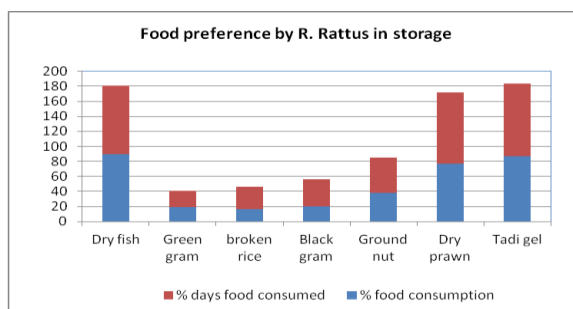


Fig.8. Food preference by R. rattus in storage

Under storage conditions, multi-choice bait experiments were also conducted in addition to liquid bait studies to find out the highly preferential bait by the storage rodents. Among the baits offered in multi choice condition, the intake was more in dry fish, dry prawn and tadi gel, which are on par with each other. Dry fish and dry prawn are the non-vegetarian baits most preferred by the rattus species present in the godown. Among the baits the broken rice was the most less preferred. During the entire test period of 12 days, the baits dry fish, dry prawn and tadi gel were touched almost every day by the target species. Green gram and broken rice were least preferred in terms of days of preference in multi-choice tests (Fig 9 and Table 9).



Fig. 9. Experimental setup for multi-choice tests

Table 9. Intake of different baits under Multi choice conditions in Storage

Treatment	Total food consumed (g)	Daily food consumption (g)	% food consumption	Days food touches	% days food consumed
Dry fish	89.3 ^a	7.4 ^a	74.4 ^a	11.0 ^a	91.7 ^a
Green gram	19.0 ^c	1.6 ^c	15.8 ^c	2.7 ^c	22.2 ^c
broken rice	16.0 ^c	1.3 ^c	13.3 ^c	3.7 ^{bc}	30.6 ^{bc}
Black gram	20.3 ^c	1.7 ^c	16.9 ^c	4.3 ^{bc}	36.1 ^{bc}
Ground nut	38.0 ^b	3.2 ^b	31.7 ^b	5.7 ^b	47.2 ^b
Dry prawn	77.0 ^a	6.4 ^a	64.2 ^a	11.3 ^a	94.4 ^a
Tadi gel	86.7 ^a	7.2 ^a	72.2 ^a	11.7 ^a	97.2 ^a
CV	18.68	18.91	18.71	17.78	17.78
CD	16.45	1.39	13.72	2.27	18.95
F-test	Sig	Sig	Sig	Sig	Sig

RM 6. Bio-ecology of major rodent species (habit, habitat, food, feeding/burrow behavior, population dynamics, reproduction & breeding biology etc.)- *Mus booduga*

Rodent trapping is practiced for catching the field mouse using locally available bamboo butta traps. Among the trap catches the bandicoots continued 87% and *M. booduga* were only 12.2%. Upto Kharif 2018, *Bandicota bengalensis* catches were more compared to *Mus booduga*. But in rabi, *M. booduga* catches were relatively higher, however the overall catches for *B.bengalensis* was more (Fig 10).

The trapped species were weighed, sexed and observations were taken on different morphological parameters like Tail length, body length, Ear size, foot size etc. The mean weight of the male and female were 7.4 and 7.1 respectively. The tail length and body length of the males were 2.86 and 3.72 respectively, whereas in females it was 2.7 and 3.52 respectively (Table 10a &b)

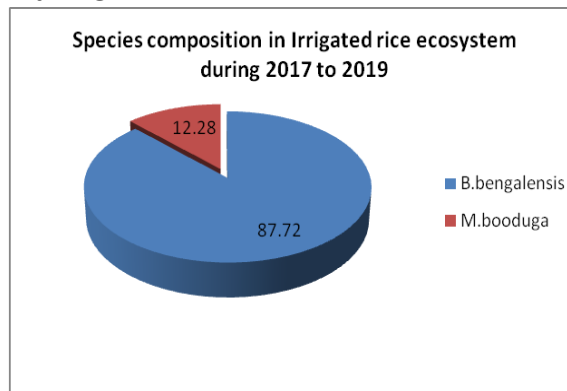


Fig 10. Rodent species composition during 2017-19.

Table 10a. Morphological parameters of *Mus booduga* males under field conditions 2017-18

Month	No. of animals	Male	Mean wt (g)	Male Ear size (Cm)		Tail length (Cm)	H.B. Size (Cm)	Foot size (Cm)	
				Left	Right			Front	Hind
July, 2017	3	1	11.5	0.9	0.7	4.7	5.85	0.5	1.85
Aug, 2017	4	2	13	0.85	0.7	4.9	6.6	1.25	1.8
Sep, 2017	3	2	12.5	0.75	0.85	4.7	6.15	1.25	2.1
Oct, 2017	-	-	-	-	-	-	-	-	-
Nov, 2017	-	-	-	-	-	-	-	-	-
Total	10	5	37	2.5	2.25	14.3	18.6	3	5.75
Mean	2	1	7.4	0.5	0.45	2.86	3.72	0.6	1.15

Table 10b. Morphological parameters of *Mus booduga* females under field conditions 2017-18

Month	No. of animals	Female	Mean wt (g)	Male Ear size (Cm)		Tail length (Cm)	H.B. Size (Cm)	Foot size (Cm)	
				Left	Right			Front	Hind
July, 2017	3	2	11	0.65	0.8	4.3	6.2	0.63	1.2
Aug 2017	4	2	12	0.7	0.8	4.45	5.4	1	1.35
Sep, 2017	3	1	12.5	0.65	0.8	4.75	6	1.1	1.3
Oct, 2017	-	-	-	-	-	-	-	-	-
Nov 2017	-	-	-	-	-	-	-	-	-
Total	10	5	35.5	2	2.4	13.5	17.6	2.73	3.85
Mean	2	1	7.1	0.4	0.48	2.7	3.52	0.55	0.77

During the 2nd year of study (2018-19) also similar trend was noticed in trap catches and the trapped species were weighed, sexed and observations were taken on different morphological parameters like Tail length, body length, Ear size, foot size etc. The mean weight of the male and female were 11.93 and 10.83, respectively. In the traps erected in the field, bandicoots were more trapped rather than *M booduga* in other moths expect during February (Table 10c &D).

Table 10c. Morphological parameters of *Mus booduga* males under field conditions

Month	No. of animals	Male	Mean wt (g)	Male Ear size (Cm)		Tail length (Cm)	H.B. Size (Cm)	Foot size (Cm)	
				Left	Right			Front	Hind
July, 2018	2	1	11.4	0.92	0.71	4.9	5.95	0.5	1.85
Aug, 2018	1	1	12.8	0.82	0.68	5.1	6.62	1.25	1.8
Sep, 2018	0	-	--	-	-	4.8	-	1.25	2.1
Oct, 2018	0					-	-	-	-
Nov, 2018	0					-	-	-	-
Dec, 18	0								
Jan, 19	0								
Feb, 19	18	10	11.6	0.84	0.72	4.9	6.05	1.20	2.1
Total	21	12	35.8						
Mean	2.63	1.5	11.93						

Table 10d. Morphological parameters of *Mus booduga* females under field conditions

Month	No. of animals	Fe-male	Mean wt (g)	female Ear size (Cm)		Tail length (Cm)	H.B. Size (Cm)	Foot size (Cm)	
				Left	Right			Front	Hind
July, 2018	2	1	10.5	0.64	0.78	4.31	6.0	0.62	1.22
Aug, 2018	1	0	11.8	0.72	0.70	4.25	5.5	1.1	1.25
Sep, 2018	-	-	-	-	-	-	-	-	-
Oct, 2018	-	-	-	-	-	-	-	-	-
Nov, 2018	-	-	-	-	-	-	-	-	-
Dec, 18	-	-	-	-	-	-	-	-	-
Jan, 19	-	-	-	-	-	-	-	-	-
Feb, 19	18	1	12.0	0.82	0.72	4.86	6.12	1.23	2.03
Total	21	1	32.8						
Mean	2.63	0.12	10.93						

RM 7. Social engineering activity on rodent pest management as participatory adoptive research in adopted villages

During 2017-18, Mass Rodent control campaign on community basis was organized in the village Kommuchikkala in rice fields during Tillering stage of the crop. The per cent rodent control success of 83.43% in terms of live burrows and 73.48% in terms of tiller damage was achieved respectively. At Kommuchikkala village knowledge was provided and campaign was also organized on community basis with complete technical support from the project. In the another village Alamuru where only knowledge was provided per cent rodent control success of 62.45% was achieved in respect of LBC/ha and 66.15% in terms of tiller damage. KAP analysis was also done during 2017-18 indicated that farmers need demonstrations & interactions as one of the motivational media (Table 11a &b).

Table 11a. KAP analysis in the project area (2017-18)

<i>b. Particulars</i>	Kommuchikkala	Alamuru	b) Poduru
Score – K	77.1	60.8	56.5
Score – A	82.9	75.4	71.6
Score – P	72.7	68.3	61.8
Motivational media	Demonstrations & interactions	Demonstrations & interactions	Demonstrations & interactions
Techniques adopted	Knowledge & campaign organized on community basis	Only knowledge provided	Control

Table 11b. Social Engineering on Rodent Control through Participatory Adoptive Research (PAR) in Rice (2017-18)

Name of the village	Kommuchikkala	Alamuru	c) Poduru
Area in hectares	120	90	80
Treated area in hectares	120	90	80
Mean no. of live burrows / ha			
a) Pre treatment	49.5	54.6	58.3
b) Post treatment	8.2	20.5	51.8
Per cent Rodent control success	83.43	62.45	
Percent tiller damage/ha			
a) Pre treatment	28.1	33.3	22.9
b) Post treatment	7.45	11.27	20.4
Per cent Rodent control success	73.48	66.15	

During 2018-19, Mass Rodent control campaign on community basis was organized in the village Kommuchikkala in paddy fields during Tillering stage of the crop. The per cent rodent control success of 80.22% in terms of live burrows and 69.35% in terms of tiller damage was achieved respectively. At Kommuchikkala village knowledge was provided and campaign was also organized on community basis with complete technical support from the project. In the another village Alamuru where only knowledge was provided per cent rodent control success of 46.24% was achieved in respect of LBC/ha and 24.18% in terms of tiller damage. KAP analysis was also done during 2018-19 indicated that farmers need demonstrations & interactions as one of the motivational media (Table 12 a&b).

Table 12a. KAP analysis in the project area (2018-19)

<i>a. Particulars</i>	Kommuchikkala	Alamuru	d) N Rameswaram
Score – K	77.1	60.8	56.5
Score – A	82.9	75.4	71.6
Score – P	72.7	68.3	61.8
Motivational media	Demonstrations & interactions	Demonstrations & interactions	Demonstrations & interactions
Techniques adopted	Knowledge & campaign organized on community basis	Only knowledge provided	Control

Table 12b. Social Engineering on Rodent Control through Participatory Adoptive Research (PAR) in paddy (2018-19)

Name of the village	Kommuchikkala	Alamuru	e)N. Rameswaram
Area in hectares	120	110	100
Treated area in hectares	120	110	100
Mean no. of live burrows / ha			
a) Pre treatment	21.54	19.46	22.46
b) Post treatment	4.26	10.42	20.14
Per cent Rodent control success	80.22	46.24	-
Percent tiller damage/ha			
a) Pre treatment	14.52	21.42	22.9
b) Post treatment	4.45	16.24	22.4
Per cent Rodent control success	69.35	24.18	-

Location specific programs:

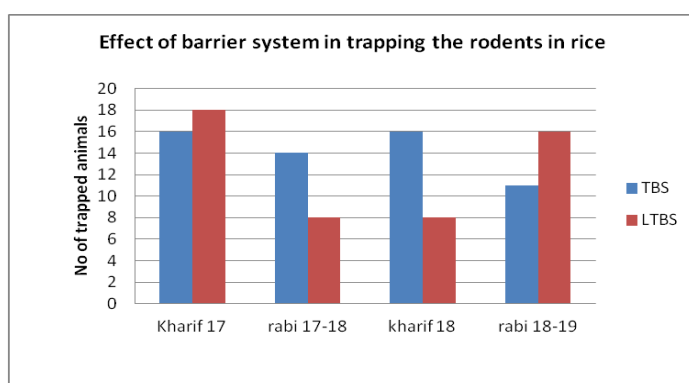
RM 8. Refinement and validation of CTBS in irrigated rice for management of *B. bengalensis*

In order to reduce the input costs for erecting trap barrier system, Linear Trap Barrier System (LTBS) was evaluated in comparison to the TBS, where the barrier is erected only one side- migratory direction of the animal.



Fig 11. Trap barrier system erected in rice nurseries

The trap catches were depicted in the **Fig. 12** and that show that the LTBS is also proved equally effective in trapping the animals. The trap catches were 16 in LTBS as against 18 in TBS

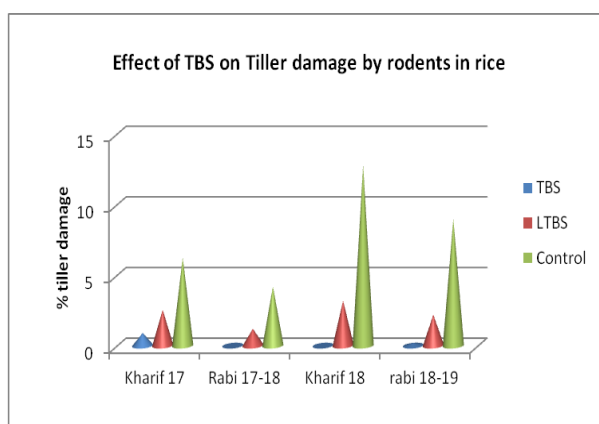


during kharif 2017. In the rabi 2017-18, the trap catches were very low both in TBS and LTBS due the low level incidence in the field itself. The trap catches were 16 in TBS and 8 in LTBS during *kharif* 2018 and 11 in TBS and 16 in LTBS during *rabi* 2018-19. Over all, the entire trap catches were very low during both the years due to low incidence of *B. bengalensis* due to un-favorable

conditions exists in this area.

Fig 12. Effect of trap barrier system in trapping rodents from rice fields

During the year 2017-18, the tiller damage was found as 0.9% in TBS and it was 2.5 % in LTBS as against 6.24% in control plots in kharif season. Whereas in rabi season the tiller damage was found nil in TBS fields as against 0.8 in LTBS and 4.6 per cent in control fields. The tiller damage was below the ETL even in control plots due to low incidence of the pest in the year (Table 13 a&b, Fig 13).



During the year 2018-19, TBS has offered cent per cent protection against *B. bengalensis* except meager tiller damage of 0.2% at one location may be due to poor maintenance of the barrier. LTBS is also offered significantly superior protection with only tiller damage of 3.2 and 2.2 per cent in kharif and rabi, respectively as against 12.8 and 9.0 % tiller damage in control plots.

Fig 13. Effect of TBS on tiller damage by rodents in rice

Table 13a. Tiller damage protection by TBS and LTBS in irrigated rice against *B. bengalensis* during the year 2017-18

Season	% tiller damage					
Kharif 2017	TBS			LTBS		
	Before P.I	After P.I	Total	Before P.I	After P.I	Total
Location 1	-	-	-	1.4	1.2	2.6
Location 2	0.6	0.0	0.6	1.4	0.8	2.2
Location 3	0.8	0.4	1.2	1.2	0.8	2.0
Location 4				2.4	1.0	3.4
	0.9			2.55		
Control	6.24					
Rabi 2017-18						
Location 1	0.0	0.0	0.0			
Location 2	0.0	0.0	0.0			
Location 3	0.0	0.0	0.0	1.2	0.0	1.2
Location 4				0.8	0.6	1.2
	0.0			1.2		
Control	4.20					

Table 13b. Tiller damage protection by TBS and LTBS in irrigated rice against *B. bengalensis* during the year 2018-19

Treatment	% Tiller damage due to <i>B. bengalensis</i>	
	Kharif 2018	Rabi 2018-19

	Nursery	Main field	Total	Nursery	Main field	Total
TBS	0.0	0.0	0.0	0.0	0.2	0.2
LTBS	1.4	1.8	3.2	0.8	1.4	2.2
Control	4.6	8.2	12.8	2.8	6.2	9.0

RM 9. Burrow dynamics of *Bandicota bengalensis* in various field crops

Studies on burrow dynamics of *B. bengalensis* revealed that there was a multi ramous branching in each burrow and depth of the burrow is comparatively more during *rabi* with 15.98 ± 1.34 cm in vegetative stage and 12.17 ± 0.46 cm in reproductive stage of the crop than *Kharif* with 8.6 ± 1.94 cm in vegetative stage and 10.18 ± 2.89 cm in reproductive stage of the crop. Opposite to the entry hole, secret exit hole exists which enables the animal to escape emergencies (Table 14).

Table 14. Burrow dynamics of *B. bengalensis* in clay loamy soils

Crop Stage	Length (Cm)	Width (Cm)	Depth (Cm)	No. of branches		Length of the branches	
				Left(Cm)	Right(Cm)	Left(Cm)	Right(Cm)
Kharif 2017							
Veg.stage	143.7	8.4	8.6	2.2	1.8	22.8	25.01
Rep.stage	80.3	8.88	10.18	2.5	2.2	22.12	20.81
Rabi 2017-18							
Veg.stage	192.4	11.87	15.98	3.7	3.1	20.1	19.53
Rep.stage	179.7	10.95	12.17	4.1	3.4	18.34	16.09
Rabi 2018							
Veg.stage	128.7	21.54	15.08	1.9	1.8	14.76	15.96
Rep.stage	120.3	21.92	12.84	3.1	2.1	11.96	13.89
Rabi 2018-19							
Veg.stage	140	22.36	15.12	2.5	2.2	13.06	15.7
Rep.stage	91.6	20.24	18.68	2.9	2.9	11.87	13.36

During the 2nd year also, similar trend was noticed in the burrow character of *B. bengalensis* in rice ecosystem. The burrows are with multi ramous branching, in each burrow and depth of the burrow is comparatively more during *rabi* with 15.1 cm in vegetative stage and 18.7 cm in reproductive stage of the crop. It was 15.1 and 12.8 in kharif. Opposite to the entry hole, secret exit hole exists which enables the animal to escape emergencies.

RM 10. Studies on tolerance of bromadiolone against *B. bengalensis*

All the test animals were died in all the test concentrations. The mean time mortality was low at higher concentration compared to the lower concentration. During 2017-18, due to low incidence of *B. bengalensis*, only 6 animals were used for treatment. All the test animals were died all the test doses, but with varied mean mortality times. Mean mortality time decreased with increased concentration of the bromadiolone, it was 12.8 days at $\frac{1}{2}$ the recommended dose, 6.92 day at recommended dose and 4.86 days at double the recommended dose (**Fig 14 & Table 15**). During 2018-19 also only 9 animals were used at each test concentration due to poor availability of animals from the low level of field incidence. All the test animals were died all the test doses, but with varied mean mortality times. Mean mortality time decreased with increased concentration of the bromadiolone, it was 10.24 days at $\frac{1}{2}$ the recommended dose, 7.88 day at recommended dose and 6.92 days at double the recommended dose (**Table 16**)

Table 15. Toxicity of Bromadiolone on Field collected *B. bengalensis* at Maruteru

Treatment	No. of animals treated	No. of animals dead	% mortality	Mean mortality time
Bromadiolone (0.0025%)	06	06	100.0	12.8+2.8
Bromadiolone (0.005%)	06	06	100.0	6.92 +2.6
Bromadiolone (0.01%)	06	06	100.0	4.86 + 1.2
Control (Plain bait)	06	01	16.66	-

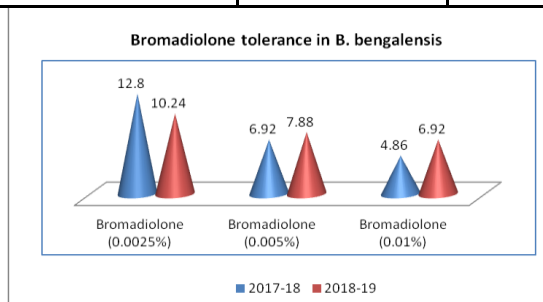


Fig 14. Bromadiolone

bengalensis

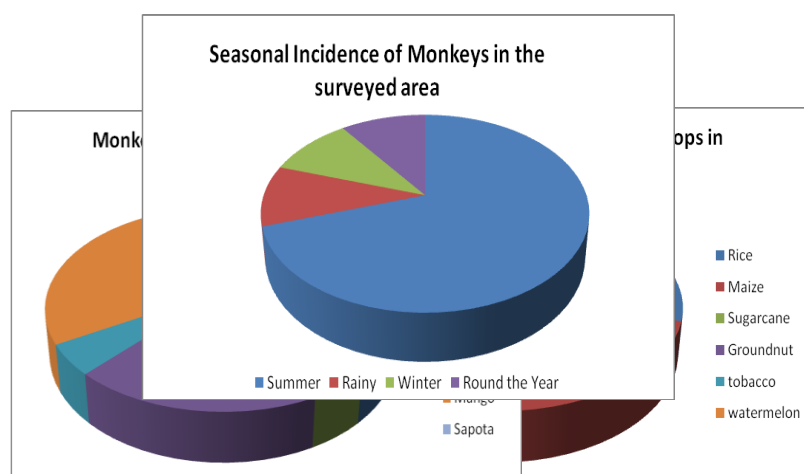
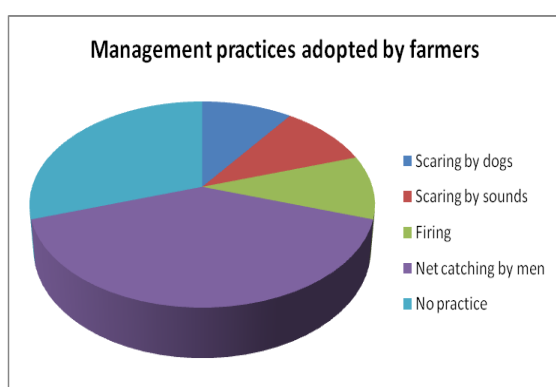
tolerance in *B.*

Table 16. Toxicity of Bromadiolone on Filed collected *B. bengalensis* at Maruteru

Treatment	No. of animals treated	Mean bait consumption	% mortality	Mean mortality time
Bromadiolone (0.0025%)	09	29.2 + 9.1	100.0	10.24+2.4
Bromadiolone (0.005%)	09	31.4 + 9.6	100.0	7.88 +2.2
Bromadiolone (0.01%)	09	21.2 + 11.5	100.0	6.92 + 1.8
Control (Plain bait)	09	16.4 +10.4	-	-

HV1: Bio-ecology and management of higher vertebrates in different crops (wild boar)

Base line was collected on the incidence of wild boar and monkey in upland mandals of Godavari Zone. Wild boar is not a major pest except in 2-3 mandals. In recent year monkey menace has been increased and maximum damage was found in coconut, cashew, rice and maize crop. Farmers mostly scaring the monkeys by making sounds, using dogs, and air guns etc. The monkey problem is mostly noticed during summer season



PUBLICATIONS

I. Research / Technical Publications:

- Srinivasa Rao, N., Sakthivel, P and K. Praveen Kumar. 2017. Effective bait and trap for controlling rodents in poultry sheds. *Indian Journal of Poultry Science*. 52(3): 307-311.
- Srinivasa Rao, N and B. Anusha. 2018. Rodent pest scenario and impact of rainfall on incidence and multiplication of *Bandicota bengalensis* in irrigated rice ecosystem of Godavari delta of Andhra Pradesh. *Rodent News letter* 42(1-4): 4-7
- Srinivasa Rao N and B. Anusha. 2018. Trap barrier system: an effective technique for protecting the rice nurseries against *Bandicota bengalensis* in rodent endemic areas. *Rodent News letter* 42(1-4): 10-12
- Anusha B and Srinivas M. 2018. Biology of spotless ladybird beetle, *Cycloneda sanguinea* (Limbifer) on two spotted spider mite, *Tetranychus urticae* (Koch). *Indian Journal of Entomology* 80(3): 997-999
- B Anusha, M. Srinivas and N Srinivasa Rao. 2018. Survey on rodent species composition in High altitude and tribal zone (HAT) zone of Andhra Pradesh. *Journal of Entomology and Zoology studies* 6(6): 600-602
- Srinivasa Rao N, Praveen Kumar K and Sakthivel P. 2019. Efficacy of botanical repellents against wild boar in field crops. *Green farming* 10(3): 368-371
- Srinivasa Rao N, Anusha B., Narsimha Rao Ch. V and Tripathi R.S. 2019. Evaluation of Flocoumafen and Difenacoum against lesser bandicoot rat, *Bandicota bengalensis* (Gray) in rice, *Journal of Entomology and Zoology studies* 7(3): 907-910.
- Srinivasa Rao N. Integrated Rodent Pest Management in Rice, *Vyavasayam Magazine* September, 2018: 23-25 p.
- Srinivasa Rao N., Tripathi, R. S, Satyanarayana PV and B. Anusha. Integrated rodent pest management in rice, *Technical Bulletin* 1, 2018, 32p.
- Srinivasa Rao N. Vivida Pradhana Pantallo Elukala Samagra Yajamanyam, *Vyavasya Panchagam*: 2019, 432-435 p.
- Srinivasa Rao N. Pantallo Adavi Pandula Samasya- Yajamanayam, *Vyavasya Panchagam*: 2019, 436-444 p.
- Srinivasa Rao N., Anusha B., Pawankumar Reddy PSK., Prasad Reddy., SSV., Satyanarayan a PV and P. Muniratnam. Raitannalaara Elukalato Jagratta suma! *Rythu Nestam Magazine*, April, 2019: 58-60p.
- Srinivasa Rao N, Anusha, B and SSV Prasad Reddy. Era Tera to Varilo Elukala Bandh. *Rythu Nestam Magazine*, July, 2019: 53-54p.

Srinivasa Rao N and B Anusha. 2018. Era tera paddathi dwara Varilo Elukala nivarana Technical Brochure. 4 p.

Srinivasa Rao N and B Anusha. 2018. Pantapolallo saamoohika Elukala nivarana. Technical brochure 4p.

II. National & International Seminars/Workshops/training programmes attended.

S. No	Name of the Faculty	Place	Duration		Purpose	Source of Finance
			From	To		
1.	Dr. N. Srinivasa Rao Sr Scientist (Ento) & B. Anusha Scientist (Ento)	KAU, Thrissur	09.11.2017	11.11.2017	2 nd All India Group meeting on Vertebrate pest Management	ICAR
2.	Dr. N. Srinivasa Rao Srr Scientist (Ento) & B. Anusha Scientist (Ento)	RARS, Maruteru	30.06.2017		ANGRAU Research Management System	ANGRAU
3.	Dr. N. Srinivasa Rao Sr. Scientist (Ento.)	LARS, Tirupati	14.05.2018	16.05.2018	State Level Technical Programme of Entomology	ANGRAU
4.	Dr. N. Srinivasa Rao Senior Scientist (Ento)	NIPHM, Hyd	17-09-18	01-10-18	Phytosanitary treatments- ALP and MBR fumigation	NIPHM, Hyderabad
5.	Dr. N. Srinivasa Rao Senior Scientist (Ento)	NIPHM, Hyd	05-10-18	06-10-18	Rodent Pest Management workshop	NIPHM, Hyderabad
6.	Dr. N. Srinivasa Rao Senior Scientist (Ento)	Lam, Guntur	11-12-18	11-12-18	e-procurement procedures	ANGRAU
7.	Dr. N. Srinivasa Rao Senior Scientist (Ento)	NIPHM, Hyd	04-02-19	04-02-19	Brain storming session on design and finalization of online course on House hold pest management	NIPHM, Hyderabad
8.	Dr. N. Srinivasa Rao Senior Scientist (Ento)	NIPHM, Hyd	14-03-19	15-03-19	Plant Health Management in coconut: Opportunities and challenges	CDB, Kochi & NIPHM, Hyderabad
9.	Dr. N. Srinivasa Rao Senior Scientist (Ento)	Lam, Guntur	14-05-19	16-05-19	State level technical program of Entomology	ANGRAU

III. Radio/T.V.Programmes : 10 Nos

S. No.	Name of the Faculty	Title of the Programme	TV/ Radio	Date
1	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Rodent pest management in cocoa intercropped with coconut	ETv-Annadata & Cadbury Corp.	10.07.2017
2	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated rodent pest management in kharif rice	ETv-Annadata	13.09.2017
3	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated rodent pest management in kharif rice	ETv-Annadata	03.10.2017
4	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated rodent pest management in Cocoa	ETv-Annadata	16.11.2017
5	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated rodent pest management in rice for rabi	ETv-Annadata	20.12.2017
6	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated rodent pest management in rice for rabi season	ETv-Annadata	15.02.2018
7	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated Rodent Pest Management in Rice, IRPM in Coconut and IRPM in Sugarcane	ETv-Annadata	16-07-2018
8	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Marutunna Vaatavarana paristitullo perugutunna Elukala bedada	AIR, Vijayawada	25-07-2018
9	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated Rodent Pest Management in Rice	DD- Saptagiri	26.07.2018
10	Dr. N. Srinivasa Rao Sr Scientist (Entomology)	Integrated rodent pest management and TBS in rice	10-TV	27-10-2018

IV. Guest lecturers delivered:

S. No	Name of the Faculty	Topic	Date	Venue	Remarks
1.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Integrated Rodent pest management in rice	11.07.2017	RARS, Lam	APSSDC
2.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Zoonotic Diseases awareness creation, emergency preparedness & role of PCOs.	02.08.2017	NIPHM, Hyderabad	NIPHM
3.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Ethology of rodents and their management	03.08.2017	NIPHM, Hyderabad	NIPHM
4.	B. Anusha Scientist (Ento.)	Rodent pest management in paddy	06.09.2017	RARS, Maruteru	Guest speaker
5.	B. Anusha Scientist (Ento.)	Integrated rodent pest management in paddy	04.11.2017	RARS, Maruteru	Guest speaker
6.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Rodent pest management in cocoa	02.01.2018	Iyanavalli Lanka	YSRHU-DCCBD

7.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Rodent pest management in cocoa	02.02.2018	HRS, Ambajipet	YSRHU-DCCBD
8.	B. Anusha Scientist (Ento.)	Rodent pest management in paddy	24.02.2018	KVK, Undi	Guest speaker
9.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Integrated rodent management in organic cultivation	17.08.2018	KVK, Undi	ASCI
10.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Zoonotic diseases and control measures	24.09.2018	NIPHM, Hyd	NIPHM
11.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Recent advances in rodent pest management in rice	05.10.2018	NIPHM, Hyderabad	NIPHM
12.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Integrated Pest and disease management in rice	16.11.2018	Koyyagudem	Apollo Tyres
13.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Rodent behavior, Rodent pest management in urban environment	19.11.2018 20.11.2018	BMC, Mumbai	PMPWAM & BMC
14.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Rodent pest management in cocoa and coconut	21.12.2018	HRS, Ambajipet	Cashew-DCCBD
15.	Dr. N. Srinivasa Rao Sr Scientist (Ento)	Skill orientation to Integrated rodent pest management practices	29.03.2019	RARS, Maruteru	ASCI

V. Field Diagnostic visits made:

S. No.	Date	Places visited	Diagnostic/production oriented survey	Project Scientists participated
1.	29.06.2017	Alamuru, R.C.puram, Karapa, Kakinada & Anaparthi	Kharif campaign	Dr. N. S Rao and other Scientists
2.	29.06.2017	Rajahmundry, Korukonda & Rampachodavaram div.	Kharif campaign	B. Anusha and others
3.	27.07.2017	Gujjanavolu, Kovvur	Field diagnostic visit in paddy	Dr. N. S Rao and other Scientists
4.	01.08.2017	Sankavaram, Kattipudi and Tuni	Field diagnostic visit in paddy and other crops	Dr. N. S Rao and other Scientists
5.	24.08.2017	Kothapeta, Setanagaram Rajanagaram	Field diagnostic visit in paddy and other crops	Dr. N. S Rao and other Scientists
6.	20.09.2017	Central delta of East Godavari	Diagnostic field visit	B. Anusha, and others
7.	25.09.2017	Maddigedda Reservoir Project at Addateegala	Crop planning for ensuing Rabi season	B. Anusha, Dr. M. Srinivas, Dr. M. Nanda Kishore, Dr. A. Sireesha

8.	26.09.2017	T.P.gudem, Bhimavaram Akiveedu	Field diagnostic visit in paddy	Dr. N. S Rao and other Scientists
9.	13.10.2017	Ungutur, Bhimadolu Dendulur	Impact of Heavy rains on crops- survey	Dr. N. S Rao and other Scientists
10.	17.10.2017	Central delta of East Godavari	Diagnostic field visit	B. Anusha and others
11.	24.10.2017 27.10.2017	High Altitude and Tribal zone	Rodent survey	B. Anusha and field staff
12.	15.11.2017	Sarabhavaram, Prattipadu	Seed Complaint visit	Dr. N. S Rao and other Scientists
13.	17.11.2017	Denduluru, Eluru	Pest and Disease incidence survey	Dr. N. S Rao and other Scientists
14.	18.11.2017	Central delta of East Godavari	Special Diagnostic survey for pest and disease incidence	B. Anusha, Dr. S. Krishnam Raju, Dr. M. Srinivas.
15.	24-26, Nov 2017	ARS, Vijayarai	Inaguration of maize research centre at ARS, Vijayarai	Dr. N. S Rao and other Scientists
16.	05.12.2017	KVK, Undi	Soil Health Day- KVK, Undi	Dr. N. S Rao and other Scientists
17.	06.01.2018 08.01.2018	Tallapudi	Janamabhoomi maa vooru	Dr. N. S Rao and other Scientists
18.	01.02.2018	Kommuchikkala village	Rodent control campaign	Dr. N. Srinivasa Rao and B. Anusha
19.	23.02.2018	Maruteru, Tanuku, T.P.Gudem villages	Pest and Disease diagnostic survey	Dr. N. S Rao and other Scientists
20.	05-07-2018	T.P. Gudem, Tanuku, Palakollu and Bhimavaram	Rodent Survey	Dr. N. S Rao
21.	18-08-2018	Kovvur division	Heavy rains and FAW survey	Dr. N. S Rao and other scientists team
22.	28-08-2018	Tanuku, Undrajavaram, Duvva, T.P. Gudem, Nallajerla, Yernagudem	crop damage due to heavy rains	Dr. N. S Rao and other scientists team
23.	05-09-2018	A. Vemavaram, Palakollu, Nidadavolu and Duvva	Crop damage due to heavy rains	Director of Research, ADR, PS (Rice) and N Srinivasa Rao
24.	06-09-2018	Matsyapuri	Field visit to IFS systems	ADR, Coordinator, KVK, undi and Srinivasa Rao
25.	23-10-2018	Kovvur sub division	Field diagnostic visit	Dr. N. S Rao and other scientists team
26.	21-12-2018	Amalapuram, Mummidivaram, Rajole and central delta mandals	Rodent Survey	Dr. N. S Rao and field staff
27.	9-4-2019	V R Gudem,	Survey on incidence of Higher vertebrates	Dr. N. S Rao and field staff

		Nalljerala, D. Tiurmala and JR Gudem.	(Monkey, wildboar)	
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Trainings to farmers/field visits

S.N	Name of the Scientist	Date	Name of the Training Programme	Place	No of days	No of participants
1.	Dr. N. Srinivasa Rao Sr. Scientist (Ento)	28.06.2018	Eruvaka Poornima	Alampuram, T.P. Gudem	1	250
2	Dr. N. Srinivasa Rao Sr. Scientist (Ento)	06.09.2018	Community Rodent control campaigns	Matsyapuri	1	200
3.	Dr. N. Srinivasa Rao Sr. Scientist (Ento)	10.09.2018	Community Rodent control campaigns	Duvva, TP Gudem	1	200
4.	Dr. N. Srinivasa Rao Sr. Scientist (Ento)	23.04.2019	Integrated rodent pest management practices	RARS, Maruteru-	1	50

VI. On-farm trials (OFT)

S.No	Season	Particulars	No. of locations	Details
1	Kharif 2018	On farm trials on Trap barrier system against lesser bandicoots in rice	01	Eletipadu
2	Khairf 2019	On farm trials on Linear Trap barrier system against lesser bandicoots in rice	10	East Godavari-5 West Godavari-5

VII. TSP activities

TSP- 2018-19 AINP on VPM- ANGRAU, Maruteru Centre

SN	Budget allocated	Expenditure	Output*	Details of output and unit	Target (No)	Achievements (No)	% ach to Target
1	6.0	6.0	Output 1	Distribution of inputs	200	397	> 100%
			Output 2	Trainings	06	06	100%
				Booklets/ brochures	01+02	01+02	100%

Physical Output Targets/ achievements

S.No	Description	Unit	Annual 2018-19 Target	Annual 2018-19 Achievement
1	Distribution of rodent management inputs like multi-catch traps, glue traps	Multi-catch trap-1	400	400 1900

	and poison bait for effective rodent management in rural storage godowns, residences and baiting in crop fields	Glue traps-1 Poison bait cakes weighing 100g each	1900 750 bait cakes	75 bait cakes
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Physical Outcome Targets/ achievements

S.No	Description	Unit	Annual 2018-19 Target	Annual 2018-19 Achievement
1	Training programs for improving the skills in rodent management like setting up of a trap, preparation and safe application of poison bait etc.	Capacity building program-1	06	06
2	Publication of booklets and brochures for knowledge/ technology dissemination 1) Booklet on rodent pest management in rice 2) Brochures on a) Community rodent control in crops b) Trap barrier system for rodent control in rice	Booklet- 1 (1000 copies) Brochures- 2 (1000 copies)	01 02	01 02

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	22.90	24.35	0.49	0.10	0.00	0.00	24.94
2018-19	43.5	24.63	10.51	0.33	0	5.94	41.41

ASSAM AGRICULTURAL UNIVERSITY, JORHAT

PART I: General Information

1. Name of the Center	: Assam Agricultural University, Jorhat
2. Sanction No.	: Demand No. 3 – DARE, 01.10.2001
3. Date of Start	: 23.03.2001
4. Date of Termination	: Network Project of continued nature
5. Report Period	: 2017-18 & 2018-19
6. Scientist In charge	: Dr. R K Borah

7. Staff Position

Sl No.	Name of Post	No. of Posts	Name of incumbent
1	Scientist	01	Dr R K Borah
2	Technical Assistant	01	Mr D Gogoi
3	Field Assistant	01	Mr. S J Bhuyan

Part II: Work Allotted (Technical Programme)

I. Multilocation Programmes

RM 1: Surveillance of rodent pests in predominant cropping systems (rice-pulses)

RM 2: Monitoring of rodent abundance and damage (once in each crop season) in selected agro-climatic zones of the region (Hill Zone)

RM 3: Evaluation of botanicals against rodent pests for antifeedant /deterrent/ attractant/ sterilitant effects

RM 4: Development/ Refinement of rodent pest management modules in predominant crops/cropping systems

RM 5: Bio-ecology of major rodent species (Habit, habitat, food, feeding/burrowing behaviour, population dynamics, reproduction & Breeding Biology etc. (*B. bengalensis*))

RM 6: Social Engineering activity on Rodent Pest Management as participatory adaptive research in adopted villages

II. Location specific programmes

RM 7. Collection, cataloguing and evaluation of local traps

RM 8: Bio-ecology and management of *Dremomys lokriah* in plantation crop

RM 9: Bio-ecology and management of higher vertebrates (monkeys) in different crops

III. Higher vertebrates

RM9. Bio-ecology and management of higher vertebrates (monkeys) in different crops

Part III. Work Done (Programme wise)

RM 1: Surveillance of rodent pests in predominant cropping systems (Rice-pulses)

1.1. Rodent incidence in rice-pea cropping system: Surveillance of rodent pests in rice –pea cropping system was carried out at UBVZ of Assam. The data presented in **Table 1** revealed that live burrow count (LBC), trap index (TI) and rodent damage recorded at different crop growth stages of rice increased with the advancement of the crop growth. Maximum LBC/ha (46.11), trap

index (6.61) and damage (7.67%) was recorded at harvesting stage of the rice. The lowest LBC/ha (12.26), trap index (2.06) and tiller damage (1.81 %) was recorded at vegetative stage. Losses recorded due to *B bengalensis* (**Table 1**) at tillering stage was 1.81 % which increased to 7.67 % at harvesting stage and 7.11 % at ripening stage. Incidence of rodents in pea was recorded between Novembers to February (**Table 2**). The highest incidence was recorded at maturity stage (32.67 LBC/ha) followed by pod formation stage (28.89). In early growth of pea, the LBC/ha was low (4.41). The trap index revealed that highest trapping was recorded at maturity stage (4.91%), followed by pod formation stage. The data on rodent damage at different growth stages of pea revealed significant differences among them. The highest damage was recorded at maturity stage (4.13%) followed by harvesting stage. Comparatively low rodent infestation was recorded in pea grown after rice.

Table 1. Incidence of rodents in rice-pea cropping system (Pooled of 2 years)

Crop stage	Rice (<i>Kharif</i>)		
	LBC/ha	TI	Damage (%)
Vegetative	12.26±1.71	2.06±0.43	1.81±0.73
Panicle initiation	20.41±1.01	2.71±1.11	1.46±1.61
Maturity	32.11±1.41	4.81±0.87	4.62±1.01
Ripening	41.67±1.06	5.65±1.15	7.11±1.16
Harvesting	46.11±1.28	6.16±1.01	7.67±0.46
SE(±)	2.32	0.86	1.21
CD (P=0.05)	4.71	1.71	2.51

Table 2. Incidence of rodents in rice-pea cropping system (Pooled of 2 years)

Crop stage	Pea (<i>rabi</i>)		
	LBC/ha	TI	Damage (%)
Vegetative	4.41±1.61	1.06±0.42	1.86±0.41
Flowering	8.86±0.36	2.14±1.16	1.11±0.71
Pod formation	28.89±0.76	4.81±1.31	3.89±1.01
Maturity	32.67±1.01	4.91±1.11	4.13±0.92
Harvesting	26.64±1.01	4.06±1.02	3.91±1.11
SE(±)	1.57	1.11	0.89
CD (P=0.05)	3.16	2.31	1.71

1.2 Rodent incidence rice-blackgram cropping system: The data presented in **Table 3** reveal that live burrow count (LBC), trap index (TI) and rodent damage recorded at different crop growth stages of rice increased with the advancement of the crop growth. Maximum LBC/ha (46.17), and tiller damage (7.61%) was recorded at harvesting stage of the rice, followed by ripening stage with mean LBC/ha of 41.44, and cut tillers of 7.04 %. The lowest LBC/ha (18.11) and cut tillers (2.26%) was recorded at tillering stage of the crop. From the tillering stage, rodent activity started in the field. The panicle initiation stage of *sal* rice was the critical stage of taking any rodent control measures to prevent from economic losses. Losses due to field rat, *B bengalensis* were recorded in terms of per cent cut tillers at different crop growth stages. It was revealed (Table 3) that the rodent damage also gradually increased with the advancement of crop growth. The tillers damage was 2.26 % at tillering stage which was increased to 7.61% at harvesting stage. The highest incidence in black gram in terms of live burrow count (LBC/ha) was recorded at pod formation stage (32.00) followed by maturity stage (26.46). The data on rodent damage at different growth stages of black gram revealed significant differences among them. The highest damage was

recorded at pod formation (4.67%) followed maturity stage (4.21%). Comparatively low rodent infestation was recorded in blackgram at early growth stages.

Table 3. Incidence of rodent pests in rice-black gram cropping system (2017-18)

Crop stage	Rodent density (LBC/ha)	Rodent damage (%)
RICE		
Tillering	18.11	2.26
Panicle initiation	22.66	4.21
Maturity	36.17	6.61
Ripening	41.44	7.04
Harvesting	46.17	7.61
SE(±)	1.61	1.01
CD (P=0.05)	3.36	2.16
BLACK GRAM		
Vegetative	14.61	2.66
Pod formation	32.01	4.67
Maturity	26.46	4.21
SE(±)	1.67	1.11
CD (P=0.05)	3.31	2.36

1.3 Rodent incidence rice-green gram cropping system: The incidence of rodents was recorded the highest at the maturity stage of rice (44.60 LBC/ha) followed by Flowering stage (26.66 LBC/ha). At vegetative stage, the LBC/ha was only 12.60. The trap index (6.66%) was recorded at the maturity stage of rice whereas in the flowering stage, the trap index was 5.62%. With the advancement of crop growth, the damage was increasing and the highest tiller damage was recorded at the maturity stage of *kharif* rice (6.88%). In green gram, the highest incidence in terms of LBC /ha was recorded at the pod formation stage (29.11 LBC/ha) followed by flowering stage (24.60 LBC/ha). Similarly, trap index as well as damage was also recorded the highest at the pod formation stage followed by flowering stage (**Table 4**).

Table 4. Incidence of rodents in rice-green gram cropping system (2018-19)

Crop	Crop stage	LBC/ha	TI	Damage (%)
Rice	Vegetative	12.60	4.41	3.20
	Flowering	26.66	5.62	5.80
	Maturity	44.60	6.66	6.88
SE(±)		1.81	1.21	1.16
CD (P=0.05)		3.76	2.58	2.31
Green gram	Vegetative	16.66	1.11	2.21
	Flowering	24.60	3.86	5.82
	Pod formation	29.11	4.01	6.11
SE(±)		1.36	1.21	1.11
CD (P=0.05)		2.74	2.56	2.37

1.4 Species composition and abundance of field rodents in rice-vegetable cropping system in different soil types: The study was carried out at farmer's field of three villages viz., Bekajan, near foot hills of Nagaland, Neulgaon, the river bank of the Brahmaputra and Allengmora, a typical rice-vegetable growing area of Upper Brahmaputra Valley Zone of Assam. Study on rodent species composition in rice-vegetable cropping system revealed the presence of 4 (four) species of which *B. bengalensis* was found to be the most predominant followed by *B. indica*, *M. booduga* and *R. sikkimensis*. viz., *B. bengalensis*, *B. indica*, *Mus booduga*, *Rattus sikkimensis*.

At Neulgaon *B. bengalensis* and *M. booduga* were the most abundant species. Likewise four rodent species viz., *B. bengalensis*, *M. booduga*, *R. sikkimensis* and *Dremomys lokriah macmillani* were recorded from the rice-vegetable cropping system of Allengmora. 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.

Out of these five field rodents recorded viz., *B. bengalensis*, *B. indica*, *M. booduga*, *R. sikkimensis* and *D. lokriah macmillani* 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 ± 0.41 and 0.25 ± 0.44) during 2015-16 and 2016-17, respectively. The present investigation revealed the occurrence of all the five rodent species in *kharif* rice of rice-vegetable cropping system in both the years.

Species composition of field rodents in *kharif* rice at Bekajan, near Nagaland foot hills revealed the per cent abundance of *B. bengalensis* (67.69%), *B. indica* (21.53%) and *M. booduga* (7.69%) as the predominant species followed by *R. sikkimensis* (3.07%) during 2018-19. While at Neulgaon, near the river bank of the Brahmaputra, *B. bengalensis* was the predominant with (95% abundance followed by *M. booduga* (5%). On the other hand, *B. bengalensis* (65.45%), *M. booduga* (20%), *D. lokriah macmillani* (9.09%) and *R. sikkimensis* (5.45%) were recorded from the rice field of Allengmora during 2018-19.

RM 2: Monitoring of rodent abundance and damage (once in each crop season) in selected agro-climatic zones of the region (Hill Zone)

Monitoring of rodent incidence and damage has been carried out in crop fields, vegetables and stores in Hills zone of Assam. The lesser bandicoot rat, *Bandicota bengalensis* has been recorded as the most predominant rodent species in all major cropping system at Hills Zone of Assam while *D. lokriah macmillani* caused maximum damage to coconut, arecanut, pumello and fruits crops like jack fruit, pineapples, guava etc. The rodent pests infesting crop fields in Hills zone of Assam reveals the predominance of *B. bengalensis*.

The highest rodent damage was recorded in potato (14.6%) followed by sugarcane (14.2%), pumpkin (14.0%), pine apple (12.46%). Similarly, the highest LBC/ha was recorded in sugarcane (42.60) followed by rice (38.67), pine apple (36.76), potato (36.62), pea (32.67). The recorded rodent species were *Bandicota bengalensis*, *B. indica*, *Rattus sikkimensis*, *Rattus rattus*, *Mus musculus* and *Dremomys lokriah*.

RM 3: Evaluation of botanicals against rodent pests for anitifeedant /deterrent/ attractant/sterilant effects

3.1 Repellent effect of botanicals against *R. rattus*; The repellent effect of botanicals viz. *P. hydropiper*, *C. chinense*, *R. communis*, *A. indica* leaf, *A. indica* seed kernel and *J. curcus* were evaluated against *R. rattus* no choice feeding trial (Table 5). The data revealed that bait consumption by the rats from treated site was highest in *P. hydropiper* (2.86 g/100 g bw in male and 2.81g/100 g bw in female) and lowest with *A. indica* seed kernel (1.06 g/100 g bw in male and 1.11g/100 g bw in female). In the present investigation, the repellenency index (RI) was recorded higher with *A. indica* seed kernel (67.61% in male and 66.04% in female) followed by *R. communis* (61.11% in male and 60.46% in female) and *C. chinense* (55.51% in male and 54.61% in female).

3.2 Repellent effect of botanicals against *B. bengalensis*: The repellent effect of botanicals viz. *P. hydropiper*, *C. chinense*, *R. communis*, *A. indica* leaf, *A. indica* seed kernel and *J. curcus* was assessed based on the consumption of plain bait from both treated and untreated sites by both sexes of *B. bengalensis* (Table 6). The consumption of bait by *B. bengalensis* from untreated site was the highest in *R. communis* (4.82g/100g bw in male and 4.80g/100 g bw in female) closely followed by *A. indica* seed kernel (4.78 g/100g bw in male and 4.80g/100g bw in female) whereas minimum consumption of bait was recorded with *A. indica* leaf (3.27g/100g bw in male and 3.20g/100 g bw in female).

3.3 Antifeedant effect of botanicals against *R. rattus*: The effect of botanicals viz. *Carica papaya*, *Solanum khasianum*, *Ananas comosus*, *Moringa oleifera*, *Azadirachta indica* was assessed based on the consumption of plain as well as botanicals treated baits by both the sexes of *B. bengalensis* under choice feeding trial (Table 7). The highest consumption was recorded with *A. comosus* (2.87g/100g bw in male and 2.81 g/100g bw in female), followed by *C. papaya* (2.02g/100g bw in male and 2.28g/100g bw in female) and *A. indica* (1.82g/100 g bw in male and 1.96g/100g bw in female). The *M. oleifera* showed higher antifeedant index in both the sexes i.e. (67.11% in male and 66.26% in female) followed by *S. khasianum* (56.26% in male and 57.12% in female). All the botanicals reduced feeding rates when compared with control. This shows having fairly good antifeedant properties of botanicals especially *M. oleifera* followed by *S. khasianum*.

3.4 Antifeedant effect of botanicals against *B. bengalensis*: During no-choice test (Table 8) the lowest consumption of treated bait was recorded with *S. khasianum* followed by *M. oleifera*. The highest consumption of treated bait was recorded with *C. papaya* followed by *A. comosus* and *A. indica*. This indicates that good antifeedant effect on test animals towards *S. khasianum*, and *M. oleifera* in comparison to *C. papaya*, *A. comosus* and *A. indicia*. In post treatment period the consumption of plain bait was lower with *S. khasianum* followed by *M. oleifera* in case of both male and female rodent in both choice and no-choice feeding test. The *S. khasianum* showed the highest antifeedant index i.e 63.97% in male and 65.18% in female, followed by *M. oleifera* (60.91 % in male and 61.33% in female)

Table 5. Repellent effect of botanicals against *R rattus* under laboratory condition

Treatments (botanicals)	Sex	Mean daily food consumption (g/ 100 g bw) Mean $\pm$ SE			Post treatment	Repellency index (%)
		Pre treatment	During treatment	't' value		
<i>Polygonum hydropiper</i>	M	7.66 $\pm$ 0.30	2.86 $\pm$ 0.09 ^{NS}	0.64	4.41 $\pm$ 0.19	50.11
	F	7.70 $\pm$ 0.28	2.81 $\pm$ 0.07 ^{NS}		4.32 $\pm$ 0.22	51.66
<i>Capsicum chinense</i>	M	8.06 $\pm$ 0.35	2.11 $\pm$ 0.14 ^{NS}	0.76	3.24 $\pm$ 0.19	55.51
	F	7.80 $\pm$ 0.37	2.18 $\pm$ 0.17 ^{NS}		3.17 $\pm$ 0.09	54.61
<i>Ricinus communis</i>	M	7.56 $\pm$ 0.41	1.91 $\pm$ 0.16 ^{NS}	0.65	4.43 $\pm$ 0.21	61.11
	F	7.93 $\pm$ 0.21	1.89 $\pm$ 0.11 ^{NS}		4.51 $\pm$ 0.29	60.46
<i>Azadirachta indica</i>	M	7.90 $\pm$ 0.29	2.01 $\pm$ 0.11 ^{NS}	0.40	4.53 $\pm$ 0.22	58.26
	F	7.66 $\pm$ 0.32	1.96 $\pm$ 0.14 ^{NS}		4.31 $\pm$ 0.27	59.61
<i>Azadirachta indica</i> seed kernel	M	8.00 $\pm$ 0.33	1.06 $\pm$ 0.10 ^{NS}	0.83	3.78 $\pm$ 0.18	67.61
	F	8.03 $\pm$ 0.40	1.11 $\pm$ 0.06 ^{NS}		3.80 $\pm$ 0.16	66.04
<i>Jatropha curcas</i>	M	7.76 $\pm$ 0.25	2.81 $\pm$ 0.05 ^{NS}	0.52	5.02 $\pm$ 0.17	51.41
	F	7.73 $\pm$ 0.43	2.76 $\pm$ 0.08 ^{NS}		5.25 $\pm$ 0.21	48.66
Control	M	7.86 $\pm$ 0.27	6.56 $\pm$ 0.13		9.49 $\pm$ 0.26	-
	F	7.96 $\pm$ 0.34	6.11 $\pm$ 0.14		9.78 $\pm$ 0.32	-
SEd ($\pm$)	M	0.43	0.21		0.23	
	F	0.47	0.15		0.33	
C D (P=0.05)	M	NS	0.44		0.49	
	F	NS	0.32		0.69	

NS-non significant M-male F-female bw-body weight

Table 6. Repellent effect of botanicals against *B.bengalensis* under laboratory condition

Treatments (botanicals)	Sex	Mean daily bait consumption (g/ 100g bw) Mean± SE				Repellency index (%)	
		Pre treatment	During treatment		Post treatment		
		Plain bait	Untreated	Treated			‘t’ value
<i>Polygonum hydropiper</i>	M	8.46±0.33	3.48±0.11	2.70±0.04 ^{NS}	1.87	4.32±0.11	12.62
	F	7.70±0.26	3.39±0.09	2.68±0.09 ^{NS}		4.68±0.13	11.69
<i>Capsicum chinense</i>	M	8.32±0.31	3.89±0.12	1.22±0.16**	3.28	3.89±0.15	49.92
	F	7.80±0.35	3.90±0.08	1.20±0.06**		4.03±0.09	49.06
<i>Ricinus communis</i>	M	7.90±0.40	4.82±0.17	1.59±0.08**	3.17	5.08±0.12	31.12
	F	8.07±0.19	4.80±0.06	1.64±0.09**		5.15±0.24	31.14
<i>Azadirechta indica</i>	M	8.27±0.24	3.27±0.15	2.50±0.13 ^{NS}	1.21	4.86±0.20	13.34
	F	8.18±0.30	3.20±0.16	2.45±0.12 ^{NS}		4.57±0.09	13.27
<i>Azadirechta indica</i> seed kernel	M	8.42±0.31	4.78±0.05	0.97±0.09**	3.53	4.89±0.17	66.26
	F	7.98±0.42	4.80±0.13	1.02±0.17**		5.03±0.19	65.06
<i>Jatropha curcus</i>	M	7.96±0.22	3.90±0.13	2.40±0.10 ^{NS}	3.17	5.15±0.07	23.80
	F	8.19±0.11	3.70±0.14	2.32±0.09 ^{NS}		5.12±0.08	22.29
Control	M	8.08±0.27	8.20±0.06	8.14±0.13	-	9.17.53±0.18	-
	F	8.11±0.33	8.29±0.09	8.26±0.18	-	9.34± 0.17	-
SEd (±)	M	0.43	0.16	0.20		0.18	
	F	0.47	0.18	0.19		0.19	
C D (P=0.05)	M	NS	0.33	0.42		0.38	
	F	NS	0.38	0.39		0.39	

NS-non significant M-male F-female bw-body weight

Table 7. Antifeedant effect of botanicals against *R rattus*

Treatment	Sex	Mean daily bait consumption (g/ 100g bw) Mean ±SE					Antifeedant Index (%)
		Pre treatment	During treatment		‘t’ value	Post treatment	
			Untreated	Treated			
<i>Carica papaya</i>	M	8.06 ± 0.61	3.66±0.06	2.02 ± 0.17 ^{NS}	2.02	4.16 ± 0.66	42.61
	F	7.78± 1.51	3.58±0.13	2.28± 0.06 ^{NS}	2.13	4.93 ± 0.30	43.11
<i>Solanum khasianum</i>	M	7.51 ± 1.03	4.56±0.17	1.31 ±0.12 ^{**}	4.45	2.76 ± 0.26	56.26
	F	8.71 ± 0.89	4.78±0.19	1.36± 0.14 ^{**}	4.37	2.81 ± 0.69	57.12
<i>Ananas Comosus</i>	M	8.41 ± 0.95	3.72±0.50	2.87 ± 0.17 ^{NS}	1.74	4.03 ± 0.57	38.67
	F	8.47 ± 1.38	3.56±0.11	2.81 ± 0.08 ^{NS}	1.53	4.26 ± 0.37	36.67
<i>Moringa oleifera</i>	M	8.56 ±1.43	4.86±0.23	1.11 ± 0.13 ^{**}	4.53	2.20 ± 0.66	67.11
	F	7.71± 1.22	4.56±0.32	1.06± 0.11 ^{**}	4.66	2.08± 0.38	66.26
<i>Azadirachta indica</i>	M	7.82 ±1.05	3.47±0.15	1.82 ± 0.06 ^{NS}	2.29	4.81 ± 0.45	52.56
	F	8.51 ± 0.12	3.26±0.13	1.96 ± 0.12 ^{NS}	2.17	4.40 ± 0.62	51.71
Control	M	8.67 ± 0.79	7.78±0.56	5.11±0.46	-	7.41± 0.32	-
	F	8.08± 1.47	7.84±0.59	5.06±0.35	-	7.83±0.55	-
SEd (±)	M	0.69	0.58	0.32		0.34	
	F	0.82	0.34	0.37		0.30	
CD (P = 0.05)	M	NS	0.97	0.77		0.75	
	F	NS	0.73	0.86		0.67	

NS-non significant M-male F-female bw-body weight

Table 8. Antifeedant effect of botanicals against *B. bengalensis* (no choice test)

Treatment	Sex	Mean daily bait consumption (g/ 100g bw) Mean $\pm$ SE				Antifeedant Index (%)
		Pre treatment	During Treatment	't' value	Post treatment	
<i>Carica papaya</i>	M	8.17 $\pm$ 1.45	4.58 $\pm$ 0.99 ^{NS}	0.52	4.26 $\pm$ 0.51	37.81
	F	8.70 $\pm$ 1.75	5.03 $\pm$ 0.05 ^{NS}		4.63 $\pm$ 0.11	39.86
<i>Solanum khasianum</i>	M	7.62 $\pm$ 2.69	1.62 $\pm$ 0.24 ^{NS}	0.81	2.86 $\pm$ 0.65	63.97
	F	7.41 $\pm$ 0.43	1.52 $\pm$ 0.16 ^{NS}		2.53 $\pm$ 0.65	65.18
<i>Ananas comosus</i>	M	8.66 $\pm$ 1.05	4.46 $\pm$ 0.46 ^{NS}	0.46	4.20 $\pm$ 0.26	32.01
	F	8.51 $\pm$ 0.57	4.73 $\pm$ 0.46 ^{NS}		4.11 $\pm$ 0.21	45.09
<i>Moringa oleifera</i>	M	7.83 $\pm$ 2.70	1.12 $\pm$ 0.57 ^{NS}	0.30	2.06 $\pm$ 0.35	60.91
	F	7.80 $\pm$ 0.90	1.02 $\pm$ 0.30 ^{NS}		2.74 $\pm$ 0.64	61.33
<i>Azadirachta indica</i>	M	8.56 $\pm$ 1.05	3.72 $\pm$ 0.32 ^{NS}	0.77	2.61 $\pm$ 0.11	39.41
	F	8.31 $\pm$ 0.90	3.71 $\pm$ 0.11 ^{NS}		2.56 $\pm$ 0.11	50.66
Control	M	8.01 $\pm$ 1.09	7.71 $\pm$ 0.31	-	7.23 $\pm$ 0.37	-
	F	8.98 $\pm$ 2.16	7.51 $\pm$ 0.98	-	7.91 $\pm$ 1.31	-
SEd ($\pm$)	M	1.25	0.37		0.32	
	F	0.88	0.33		0.41	
CD(P = 0.05)	M	NS	0.81		0.70	
	F	NS	0.73		0.90	

** **bw**- body weight; **NS**- non significant

RM 4: Bio-ecology of major rodent species (Habit, habitat, food, feeding/burrowing behaviour, population dynamics, reproduction & Breeding Biology etc. (*B. bengalensis*))

4.1. Distribution of burrows in *kharif* rice during 2017-18: The data on distribution of live burrow of field rodents in *kharif* rice revealed the presence of three species viz. *B. bengalensis*, *B. indica* and *M. booduga*. In the vegetative and tillering stage, only burrows of *B. bengalensis* have been noticed whereas, there was no *B. indica* and *M. booduga* in the vegetative and tillering stage. All the three species were recorded from panicle initiation stage of rice. All total (61.06) nos. of rodents burrows have been recorded at the milky stage of rice of which numbers of *B. bengalensis* (40.11), *M. booduga* (8.48) and *B. indica* (12.47). Throughout the growth stages. *B. bengalensis* was the predominant species in *kharif* rice (**Table 9**). Out of the total burrows, 68.42% burrow of *B. bengalensis* and 13.39% burrows of *M. booduga* and 18.18% burrows of *B. indica* were recorded throughout the different growth stages of *kharif* rice in rice-vegetable cropping system.

Table 9. Distribution of rodent burrows in *kharif* rice during 2017-18

Months	Crop stage	LBC/ha			Total
		<i>B. bengalensis</i>	<i>M. booduga</i>	<i>B. indica</i>	
July	Vegetative	8.61	0.00	0.00	8.61
August	Tillering	21.11	0.00	0.00	21.11
September	Flowering	36.66	8.16	12.66	57.48
October	Milky	40.11	8.48	12.47	61.06
November	Harvesting	26.66	6.11	8.16	40.93
December	Post-Harvest	10.41	6.06	4.44	20.91

4.2. Distribution of burrows in *rabi* vegetables during 2018-19: In *rabi* vegetables, during sowing, no rodent species were found present (**Table 10**). From seedling stages, they started come to the field. All the three species were recorded from the vegetative stage. All total (29.38) numbers of rodent burrows have been recorded at the vegetative stage; 39.18 numbers at maturity and 26.98 numbers at harvest. Out of the total burrows, 74.74 % burrows of *B. bengalensis*; 12.12 % burrows of *M. booduga* and 13.11% burrows of *B. indica* were recorded throughout the different growth stages of *rabi* vegetables in rice-vegetables cropping system.

4.3. Monthly reproductive pattern of *B. bengalensis* (2017-18): The data indicated two periods for female reproductive activity during March –May and July-October in rice-vegetables cropping system. Reproductive activity was not observed during November to February. The highest (61.53%) prevalence of pregnancy was recorded in the month of September and the lowest (8.33%) in the month of July. The mean numbers of embryo per female was recorded highest (8.07 ± 0.61) in April and the lowest (3.52 ± 0.71) in the month of July. Throughout the period, out of total adult females only 25.23% were visibly pregnant with an average of 18.31% prevalence of pregnancy. The mean embryo per female throughout the period in rice-vegetables cropping system was recorded as 6.18 ranging from 3-8 nos/female.

Table10. Distribution of rodent burrows in *rabi* vegetables during 2018-19

Months	Crop stage	LBC/ha			Total
		<i>B. bengalensis</i>	<i>M. booduga</i>	<i>B. indica</i>	
December	Sowing	0.00	0.00	0.00	0.00
January	Seedling	4.41	0.00	0.00	4.41
February	vegetative	21.06	4.21	4.11	29.38
March	Maturity	28.11	4.61	6.46	39.18
April	harvesting	20.71	4.11	2.16	26.98

Table11. Reproductive pattern of *B bengalensis* in rice-vegetables cropping system (2017-18)

Months	No. observed	No. visibly pregnant	Prevalence of pregnancy	Embryo /female (Mean±SE)
July	12	1	8.33	3.52±0.71
August	17	5	29.41	5.15±0.67
September	13	8	61.53	7.11±0.47
October	12	5	41.66	6.51±0.24
November	7	0	0.00	-
December	6	0	0.00	-
January	5	0	0.00	-
February	3	1	0.00	-
March	5	4	20.11	4.41±0.71
April	14	3	28.57	8.07±0.61
May	10	0	30.33	6.67±0.57
June	3		0.00	-

RM 5: Development/ Refinement of rodent pest management modules in predominant crops/cropping systems

Rice: Following treatments were imposed in kharif and boro rice for evaluation of various rodent management modules;

- T1: Cultural practices + spraying of ecodon (1:20) on bunds at MT& PI stage
- T2: Cultural practices + regular trapping with local bamboo traps @50 traps/ha starting from one month after transplanting
- T3: Cultural practices+ spraying of ecodon (1:20) on bunds at MT stage+ zinc phosphide baiting at PI stage+ bamboo traps (50 traps/ha) at maturity stage.
- T4: Cultural practices+ spraying of ecodon (1:20) on bunds at MT stage+ bromadiolone baiting at PI stage + bamboo traps (50 traps/ha) at maturity stage.
- T5: Control

5.1. Effect of integration of different treatments on rodent incidence in *kharif* rice:

During *kharif* 2017-18, the treatment (T3: Cultural practices+ spraying of ecodon (1:20) on bunds at MT stage+ Zinc phosphide baiting at PI stage+ bamboo traps (50 traps/ha) at maturity stage) recorded the highest reduction in rodent population *i.e* 66.98% LBC and 58.29 % trap index(TI) followed by treatment (T4: Cultural practices+ spraying of ecodon (1:20) on bunds at MT stage+ Bromadiolone baiting at PI stage + bamboo traps (50 traps/ha) at maturity stage) (**Table 12**).

Table 12. Effect of integration of different treatments on rodent incidence in *kharif* rice.

Treatment	Pre treatment		Post treatment		Reduction (%)	
	LBC/ha	TI	LBC/ha	TI	LBC/ha	TI
T1	26.11	3.99	16.16	2.86	38.11	28.32
T2	23.87	3.86	15.11	2.67	36.68	30.82
T3	26.67	3.98	8.81	1.66	66.98	58.29
T4	24.01	3.81	8.96	1.76	62.68	53.80
T5	25.56	3.31	42.01	6.76		

5.2. Effect of integration of different treatments on rodent incidence in *boro* rice: In *boro* rice, the treatment (**T3**: Cultural practices+ spraying of ecodon (1:20) on bunds at MT stage+ zinc phosphide baiting at PI stage+ bamboo traps (50 traps/ha) at maturity stage) recorded the highest reduction in rodent incidence *i.e*. 55.21 % LBC and 44.81% TI followed by treatment(**T4**:

Cultural practices+ spraying of ecodon (1:20) on bunds at MT stage+ bromadiolone baiting at PI stage + bamboo traps (50 traps/ha) at maturity stage.). (**Table 13**).

Table 13 . Effect of integration of different treatments on rodent incidence in *boro rice*

Treatment	Pre treatment		Post treatment		Reduction (%)	
	LBC/ha	TI	LBC/ha	TI	LBC/ha	TI
T1	17.12	3.12	12.11	2.22	29.26	28.84
T2	16.79	3.78	10.67	2.41	36.51	22.50
T3	15.91	3.66	7.12	2.02	55.21	44.81
T4	16.79	3.26	8.66	1.96	49.41	39.87
T5	16.41	3.11	33.34	5.87		

5.3 IRPM module against field rodents in rice-vegetables cropping system: The treatments of various modules evaluated are

- **M1:** Cultural practices + spraying of ecodon(1:20) on bunds at tillering stage+ zinc phosphide baiting at PI stage+ trapping(bamboo traps) at maturity stage +Smoking with egg tray plate at harvest + vegetative stage of vegetables
- **M2:** Cultural practices+ spraying of castor oil (1:20) on bunds at tillering stage + bromadiolone baiting at PI stage+ trapping (bamboo traps) at maturity stage + smoking with dry chilli at harvest+ vegetative stage of vegetables
- **M3:** Cultural practices + Spraying of ecodon(1:20) on bunds at tillering and PI stage +trapping with bamboo traps at maturity stage & ripening stage +smoking with egg tray plate+ vegetative stage of vegetables
- **M4:** Control

All the test modules evaluated in rice- vegetable cropping systems were significantly superior over control in reducing rodent population. The module **M1:** (Cultural practices + spraying of ecodon(1:20) on bunds at tillering stage+ zinc phosphide baiting at PI stage+ trapping(bamboo traps) at maturity stage +Smoking with egg tray plate at harvest) was found to be the best module having per cent control success of 67.11% and 53.01 % in rice and vegetables, respectively (Table 14 and 15).

Table 14. Effect of different modules on rodent incidence (LBC/ha) in rice-vegetables cropping system

Modules	LBC/ha					
	Rice			vegetables		
	Pre treatment	Post Treatment	% control success	Pre treatment	Post Treatment	% control success
M1	26.61	8.78	67.11	18.46	8.67	53.01
M2	24.89	9.66	61.18	16.66	9.01	45.91
M3	24.60	11.26	54.23	17.41	10.11	41.92
M4	26.96	41.81	-	28.67	34.61	-
M5						

Table15. Effect of different modules on rodent incidence (% damage) in rice-vegetables cropping system

Modules	Damage (%)					
	Rice			vegetables		
	Pre treatment	Post Treatment	% control success	Pre treatment	Post Treatment	% control success
M1	4.41	2.06	53.28	3.66	1.87	48.91
M2	4.91	2.86	41.75	4.01	2.46	38.65
M3	4.01	2.47	38.41	3.99	2.61	34.58
M4	4.26	7.01		3.86	6.11	-

RM6.Social engineering activity on rodent pest management as participatory adaptive research in adopted villages

The site for social engineering activity was at Bohikhuwa under Mori Dhansiri Gaon Panchayat, Revenue circle-Bokakhat under Bokakhat Sub division. The major cropping system of the adopted villages was rice-rice. Two villages namely ‘Bohikhuwa 1’ and ‘Na Ali Bohikhuwa’ and No 2 Bohikhuwa’ were selected as adopted, partially adopted and control villages respectively. In adopted village (Bohikhuwa 1) training on rodent management and method demonstrations were provided and necessary inputs were supplied. However in partially adopted village only training (no input) was provided. In the beginning of the *sali* season, initial rodent population and damage index from the villages were recorded. Then in the village ‘Bohikhuwa 1’ rodent control measures along with training on rodent pest management were provided. All the villagers participated in the training programme. In the control village, neither any training nor input was provided and only data on rodent infestation were recorded. Prior to initiating the work, survey was also conducted through a well-structured questionnaire to assess farmers’ existing knowledge, attitude and rodent control practices. It was almost similar across the selected villages. Farmers considered rodent as pests responsible for low to medium damage in the field. They purchased rodenticides from the local markets occasionally and apply in their own ways. Most of the farmers knew the importance of clean cultivation, weeding of bunds etc. But they do not have knowledge about pre-baiting, scientific bait preparation and application techniques. Some farmers purchased bromadiolone available in the local markets and apply in their households.

The training on rodent pest management was provided in the beginning of the crop season. The farmers adopted the rodent control measures *i.e* Application of bromadiolone(0.005%) as cake at PI stage + local bamboo traps (*maat chitap*) @ 50 traps/ha. Emphasis has been given in clean cultivation including weeding on bunds and surroundings.. The rodent damage and population was recorded at the beginning of the crop season followed by maximum tillering stage, panicle initiation stage, ripening and harvesting stage of the crop.

KAP Surveys: KAP survey was conducted in all the three villages viz. Adopted village: Bohikhuwa 1, Partially adopted village: Na Ali Bohikhuwa , Control village: No 2 Bohikhuwa. Interventions were: 1) Training, 2) Method demonstration of bait preparation and application and 3) Supply of inputs. The questionnaire consisted of 55 questions under the head - (i) General information, (ii) Knowledge, (iii) Attitude, (iv) Practices

The survey indicated that more than 94 % of the population was pure agriculturists while less than 6% had other livelihood also mainly services and small scale businessman. Four to thirteen per cent farmers reported low damage while 87- 95 per cent farmers reported medium damage due to rodents and none reported high damage due to rodents. The area of damage other than field was

store and household goods .Out of which more damage was reported in crop field (47-80%). None of the farmers in all the three villages had attended any training on rodent pest management. Regarding the number of rodent species available prior to the training 42.8 to 72.3 farmers reported three species. Farmers (16-39%) adopted the mechanical control methods i e use of traps available in the local market whereas 41-61 % farmers depends on cultural methods for control of rodent pests. In the stores, most farmers (87-100%) were dependant on cleanliness and none used metallic bins. After the intervention the number of farmer using rodenticides also increased and more farmers used bromadiolone than prior to interventions. Most farmers used the rodenticides outside the burrows. Various attributes of KAP as responded by the farmers are briefed in Table 16, 17 and 18.

Table 16. KAP analysis report about knowledge (V1: Adopted village: Bohikhuwa 1; V2: Partially adopted village: Na Ali Bohikhuwa and V3: Control village: No 2 Bohikhuwa)

Particulars	V1	V2	V3
Knowledge			
1. Damage intensity	(% respondents)		
a) Low	5.20	10.10	12.52
b) Medium	94.80	89.90	87.48
c) High	0.00	0.00	0.00
2. Area of damage(% respondents)			
a) Store	31.23	12.50	21.05
b) Residence	12.66	8.33	31.58
c) Field	56.11	79.17	47.37
d) Others	0.00	0.00	0.00
3. Rodent species prevalent in village			
1 species	0.00	0.00	0.00
2 species	0.00	0.00	0.00
3 species	42.80	72.30	70.26
4 species	57.20	27.30	29.74
5 species	0.00	0.00	0.00
4. Training attended: No any Farmer attended any training before our interventions			
5. Rodent Management			
a) Adopted	44.12	47.21	66.67
b) Not adopted	55.88	52.79	33.33
6. Management strategy adopted			
a) Mechanical	38.88	26.67	16.67
b) Cultural	48.01	41.11	61.11
c) Biological	0.00	0.00	0.00
d) Chemical	14.00	32.22	22.22

Table 17. KAP analysis report about Attitude

Particulars	% respondents		
	V1	V2	V3
Attitude			
1. Best Management strategy			
Mechanical	24.66	33.33	28.11
Cultural	32.26	26.41	33.33
Biological	0.00	0.00	0.00
Chemical	43.08	40.26	38.56
2, Success obtained			
Yes	31.11	10.26	31.58

No	68.89	89.74	52.63
3.Control create more problem			
Yes	20.11	12.51	44.66
No	79.89	87.49	55.34

Table 18. KAP analysis report about Practices

Particulars	% respondents		
	V1	V2	V3
Practices			
1.Weed Management			
Yes	88.11	70.83	81.11
No	11.89	29.17	18.89
2. Repairing of infested bunds			
Yes	94.12	91.67	89.47
No	5.88	8.33	10.53
3.Management in store			
a)Use of Metallic bins	0.00	0.00	0.00
b)Cleanliness	94.61	86.67	89.61
c) Rodent proofing	5.39	13.33	10.39
4.Washing trap			
Yes	0.00	0.00	0.00
No	100.00	100.00	100.00
5.Kill the predators of rats			
a) Kill	0.00	0.00	0.00
b) Not kill	100.00	100.00	100.00
6.Rodenticide use			
a) Not used	66.71	76.34	62.41
b) Zinc phosphide	12.46	9.55	19.48
c) Bromadiolone	20.83	14.11	18.11
7. Placement of Rodenticide			
a) In burrow	0.00	0.00	0.00
b) Out side	96.67	86.11	91.82
c) Not used	3.33	13.89	8.18

The data indicated that rodent infestation increased gradually from tillering stage and reached a peak during the harvesting stage of the crop. In the adopted plot however rodent infestation decreased from PI stage of the crop. The LBC in the control plot was 9.81 during tillering stage of the crop which increased up to 40.16 at harvesting stage, while in the adopted village LBC was 10.11 in tillering stage and increased up to 18.81 at PI stage and then decreased again to 11.21 at harvesting due to intervention in terms of application of rodenticides + bamboo traps. Similar trends were also observed in case of Trap Index and Cut tillers damage (19). The tiller damage in the adopted village was 3.11% at the maximum tillering stage and 4.12% at PI stage of the crop. The damage decreased from PI stage (4.12%) to 3.11 & 3.01 % at ripening and harvesting stage, respectively due to intervention in the rodent control measures. On the other hand, the damage increased with the advancement of the phenological stages of the crop in the control villages (Table 20). Similar trends were noticed in vegetables crops also. The yield received in the adopted village was 3.16 t/ha as against 2.65 t/ha in the control plot (Table 20)

Table 19: Live burrow count (LBC), Trap Index in different crop stages of *sali* rice at Social Engineering site at Bohikhuwa during 2017-19 (V₁-Adopted Village V₂-Control Village)

Stage of the crop	LBC (No/ha)		Trap Index (%)	
	V1	V2	V1	V2
Tillering	10.11	9.81	3.86	3.91
Max. tillering	14.67	13.60	6.67	5.86
PI stage	18.81	20.60	6.82	6.91
Ripening	10.16	32.67	4.11	7.06
Harvesting	11.21	40.16	3.16	7.12

Table 20. Damage in different crop stages and yield at Social Engineering Site at Bohikhuwa during 2017-19 (V₁-Adopted Village V₂-Control Village)

Stage of the crop	Tillers damage (%)		Yield (Kg/ha)	
	V1	V2	V1	V2
Max. tillering stage	3.11	3.81	-	-
PI stage	4.12	4.41	-	-
Ripening	3.11	6.67	-	-
Harvesting	3.01	6.81	3167	2654

Table 21. Live burrow count Trap index at different crop stages of vegetables at social engineering site (2018-19) (V1-adopted village V2-Partially adopted village V3-Control village)

	V1	V2	V3
Live burrow count /ha			
a)Pre treatment	32.26	30.61	28.86
b) Post treatment	14.14	24.31	40.11
% control success	56.16	20.58	
Trap index (TI)			4.67
a)Pre treatment	4.61	4.12	6.11
b) Post treatment	2.33	2.76	
% control success	49.45	33.01	

Impact Assessment of Farmers Participating Adaptive Research under Social Engineering

A survey was conducted before and after the treatment in rice -vegetable cropping system to know the impact of education and training in the form of per cent adoption of different practices. Data reveals different levels of adoption for different practices (**Table 22**). Before training farmers were not practicing rodent control in the rice field .Only some farmers used anticoagulants rodenticides to kill rodents in their store, house, etc. but after education in the form of training and demonstration, 62.4% farmers started practicing rodent control with zinc phosphide. Before education, farmers were not aware about pre baiting in case of zinc phosphide, but after training, they practiced pre baiting. The farmers were demonstrated about the use of local bamboo traps to control rodents, their placement in the rice field. It has been revealed that 76.6% farmers used bamboo traps after training and demonstration and 61.1% farmers used mechanical traps in the field. Most of the farmers were aware about anticoagulant rodenticides and they frequently used rodenticides against rodents in their houses, store (56.6%) etc.

Table 22. Impact assessment of farmers participating adaptive research under social engineering activities

Sl No	Rodent control practices	% adoption	
		Before	After
1	Doing regular rodent control in field crop	0.00	73.3
2	Doing regular rodent control other than crop field	12.2	80.0
3	Use anticoagulant	14.7	56.6
4	Poison baiting in the crop field	0.0	62.4
5	Poison baiting in the lean period	0.0	0.00
6	Doing prebaiting incase of acute rodenticides	0.0	46.6
7	Use bait station	0.0	88.2
8	Use local bamboo traps	0.0	76.6
9	Use of mechanical traps	0.0	61.1
10	Doing weeding	0.0	86.6
11	Treatment in surrounding area/vacant lands	0.0	14.2
12	Collection of remaining poisons bait	0.0	96.6
13	Washing of traps before reuse	0.0	87.7
14	Collection of dead rodents	0.0	74.1

RM 7. Location specific programme: Collection, cataloguing and evaluation of local traps

7.1. Evaluation of local traps in *Ahu* rice (2017-18): The performance of the traps was evaluated at milky and maturity stage of *Ahu* rice. A pre-treatment record of rodent infestation was also done at vegetative stage to know the infestation level. The trap index recorded (**Table 24**) with *maat chitap* treatment at milky and maturity stage were at par i.e., 6.36 and 7.11, respectively. The placement of *maat chitap* at milky and maturity stage yielded a trap index of 6.04 and 7.20, respectively and the placement of *neul chitika* at milky and maturity stage, the trap index were 3.62 and 3.48 respectively which showed significant variation of *maat chitap* over *neul chitika* in both the stage i.e. milky and maturity stage.

7.2. Evaluation of local traps in *boro* rice (2018-19): The trap index recorded (**Table 24**) with *maat chitap* treatment at milky and maturity stage were (4.36 and 5.11), respectively which showed non-significant variation with the trap index recorded at milky and maturity stage of bandicoot traps. The placement of *maat chitap* at milky and maturity stage, the trap index were (3.94 and 4.20), respectively and the placement of *neul chitika* at milky and maturity stage, the trap index were (2.62 and 2.81) respectively which showed significant variation of *maat chitap* over *neul chitika* in both the stage i.e. milky and maturity stage ($t=3.11$).

Table 24. Comparative evaluation of local traps in *Ahu* rice and *boro* rice

Treatment	Ahu		Boro	
	Milky stage	Maturity stage	Milky stage	Maturity stage
T₁: <i>Maat chitap</i>	6.36±0.61	7.11±0.41	4.36±0.61	5.11±0.41
T₂: Bandicoot trap	6.87±0.27	7.98±0.67	4.87±0.27	5.98±0.67
t(0.05)	3.09 ^{NS}	2.35 ^{NS}	2.09 ^{NS}	2.15 ^{NS}
T₁: <i>Maat chitap</i>	6.04±0.37	7.20±0.35	3.94±0.37	4.20±0.35
T₂: <i>Neul Chitika</i>	3.62±0.12	3.48±0.08	2.62±0.12	2.81±0.08
t (0.05)	2.15	3.21	2.06	3.11

RM 8: Location specific programme: Bio-ecology and management of *Dremomys lokriah* in plantation crops

The seasonal incidence of *Dremomys lokriah* in plantation crops was carried out in different locations viz. Melang-Jagduwar, Dhansiri (Karbi Anglong), Kordoiguri (Borpathar), FRC, AAU, Jorhat, Upor Temara, Bekajan, Borhulla, Bohikhuwa during 2017-19. The monitoring was done at monthly interval observing the damaged nuts fell into the ground and by observing the freshly fallen nut below the tree. One person climbed up to the top portion of the tree and counts all the damaged nut attached to the pedicel to work out extent of damage in coconut. Survey on species compositions as well as damage intensity caused by *D. lokriah* in different crops were carried out in different locations of Assam. The squirrel infestations ranged from (18-31% RI & 4-7% ND) in different surveyed villages during 2017-19. The squirrels seem to avoid traditional fruit trees for their nesting since majority of the nests were recorded on non-fruited trees. The squirrels choose the place of nesting which seemed safer and away from disturbances of animals and human activities. Field observations revealed that squirrels are active throughout the day but more active during morning (5.00 to 9.00am) and evening (4.00 to 6.00 pm). The squirrel's activities recorded throughout the year with a peak activity period from April-September (**Table 25**).

Table 25. Squirrel incidence in different crops

Village/Area (location)	Species recorded	Nesting site	Activity (peak activity)	Infestation (%)	Damage (%)
Melang-Jagduwar	* <i>D. lokriah</i>	*Tree holes *Bamboo bushes	Throughout the year (April-August)	21.67	4.06
Dhansiri (Karbi Anglong)	* <i>D. lokriah</i> and *Flying Squirrel	*Crevices in the buildings *Tree holes *Bamboo bushes	Throughout the year (June-Sept)	18.67	4.11
Kordoiguri-Borpathar	* <i>D. lokriah</i> and *Flying Squirrel	*Tree holes *Bamboo bushes *Abandoned houses	Throughout the year (March-August)	31.16	7.07
FRC, AAU, Jorhat	<i>D. lokriah</i>	*On the tree *Crevices in the buildings	Throughout the year (May-August)	18.71	4.31

The farmers opinions about squirrel problem in different crops was sought which is briefed as under.

- Squirrels activity has been observed throughout the year, during day time only.
- Squirrels infest mainly fruit crops like jack fruit, guava, pomegranate, litchi, pine apple, pomello, mango and mainly coconut and areca nut.
- Squirrels were observed to construct their nests above ground on different tree, bamboo plantation, and abandoned houses, safer from disturbances of animals and human activities.
- In areca nut, squirrels attack tender nuts and in coconut, they make hole in the centre of the nut.
- The observations indicated that *D. lokriah* is a major problem species in coconut and other fruit crops in Assam

Effect of integration of different treatments on squirrel infestation in coconut: A trial was conducted to see the impact of integration of different treatments on the incidence of squirrel in

coconut. Before starting of the trial, all the trees were numbered and the entire squirrel damaged fallen nuts at the base of the tree were removed from the site so as to record the fresh damaged nuts. The bromadiolone wax cakes were placed at the base of the panicle containing tender nuts. The baiting was done for three days. Observations were made for fallen nuts / nuts damaged after one month of the treatment. In all five treatments integrating with cultural, mechanical and chemical methods in different combination were imposed (Table 26). Three treatments had use of chemical (bromadiolone) along with other techniques. Among the 5 treatments, the highest control success in respect of squirrel infestation as well as the nut damage *i.e* 61.11% & 53.96 %,respectively was recorded with **T1** (removal of weeds/bushes/dry leaves /crown cleaning at monthly intervals + Crown baiting with bromadiolone) (0.005%) at monthly intervals + erecting squirrel guard at the height of 8 ft at 45 angle from the ground followed by **T5** (removal of weeds/bushes/dry leaves/crown cleaning at monthly intervals +Crown baiting with bromadiolone (0.005%) at monthly intervals + trunk banding with Aluminum sheet at the height of 8 ft from the ground) yielding 53.59% reduced RI and 47.76% reduction in nut damage Table 26).

Table 26. Effect of integration of different treatments on squirrel infestation in coconut

Treatments	Infestation (%)			Damage (%)		
	Pre treatment	Post Treatment	% Control success	Pre treatment	Post Treatment	% Control success
T1	24.86	9.67	61.11	8.84	4.07	53.96
T2	26.71	14.26	46.61	8.71	5.11	41.33
T3	22.91	13.01	43.21	8.17	5.21	36.23
T4	24.43	15.11	38.14	8.41	5.66	32.69
T5	26.01	12.07	53.59	8.06	4.21	47.76

T1: removal of weeds/bushes/dry leaves/crown cleaning at monthly intervals +Crown baiting with bromadiolone (0.005%) at monthly intervals + erecting squirrel guard at the height of 8 ft from the ground.

T2: removal of weeds/bushes/dry leaves/crown cleaning at monthly intervals +Crown baiting with bromadiolone (0.005%) at monthly intervals + erecting net guard at the height of 8 ft from the ground.

T3: removal of weeds/bushes/dry leaves/crown cleaning at monthly intervals + erecting squirrel guard at the height of 8 ft from the ground.

T4: removal of weeds/bushes/dry leaves/crown cleaning at monthly intervals + erecting net guard at the height of 8 ft at 45 angle from the ground.

T5: removal of weeds/bushes/dry leaves/crown cleaning at monthly intervals +Crown baiting with bromadiolone (0.005%) at monthly intervals + trunk banding with Aluminum sheet at the height of 8 ft from the ground.

III-Higher vertebrates

RM 9: Bio-ecology and management of higher vertebrates (monkeys) in different crops

Survey on monkeys was carried out in 2017-19 at different locations of Jorhat and Golaghat districts, regularly infested by higher vertebrates like monkeys etc. Some major observations are as follows;

Rhesus macaque (*Macaca mulatta*) is one of the most commonly known monkeys in India. The species is distinguished by their brown body, pink face bereft of fur. The head is disk like and the

hairs are erected towards back. Testes hanging, body size large (Male) and in females the red sexual skin, teats or swelling in the anal region. Breeding season: March-July
Habit and habitat: Lives in organized troops of 12-68. Occurs both in forests as well as urban areas. The movements of troops are mainly influenced by the availability of food and during the fruiting season their activities remained confined with 1-1.5 square kilometre. Monkeys are omnivores. They eat meat and plant based foods. Most monkeys eat fruits, nuts, seeds, flowers. Some monkeys also eat meat in the form of birds' egg, small lizards, insects and spiders also. The major preferred food items are given in Table 27.

Table 27: Food preference by monkeys

SN	Food plants	Plant parts used	Damaging time/season	SN	Food plants	Plant parts used	Damaging time/season
1	Jack fruit	fruits	summer	10	Cucumber	Plant, fruit	summer
2	Mango	fruits	summer	11	Pumpkin	Tender fruits	Winter/summer
3	Papaya	fruits	summer	12	Brinjal	Tender fruits	winter
4	Litchi	fruits	summer	13	Ridge gourd	Tender fruits	summer
5	Guava	fruits	summer	14	Pea	Plant, pods	winter
6	Banana	fruits	throughout the year	15	Bamboo	Tender shoots	summer/rainy
7	Cabbage	Tender plants & head	winter	16	Maize	Tender plant	summer
8	cauliflower	Tender plants & head	winter	17	Black gram	Tender plant/pods	winter
9	Tomato	Tender plants, fruits	Winter/summer	18	Green gram	Tender plant/pods	winter

The Survey reports from villagers/farmers are summarized below.

- The villagers residing nearby forest the damage of crop frequently done by monkeys. They have shifted from traditional rice cultivation to tea plantation.
- Farmers use to grow Agar plant (aromatic plant) in their tea garden for shade as well as in their homestead gardens. The people of some localities use to cultivate Bhut jolokia and moder tree which give a high return to the farmers. The crop is safe from monkeys also.
- Villagers come out in group to protect their crops and scare them to distance.
- Crops like bitter guard, papaya, sour guard (kunduli), chilly and mustard are safe from monkey damages.
- The troops size are influenced by the availability of food and occupied habitat. In rural areas, comparatively larger troops are found compared to the urban areas.
- During summer and hot season, foraging activity is mainly at morning and the evening hours.
- In monsoon, they were seen to start their foraging at irregular times and were largely influenced by rains.

Common practices adopted by farmers against monkeys

- Use of anti-birds nets as a physical barrier around the high value crop field. Net was raised up to 2 meters in height and cover area with the help of bamboo post.

- Cultivation of least preferred crops like bhindi, ginger, turmeric, colocasia ,
- Use of fire –crackers; air guns, Noise/bells/ beating drums; Catapults/use of gullets
- Individual or cooperative guarding of the crop fields and Use of Dog squads
- Meroni: Raising of vegetables in open crop field with bamboo boundaries.
- Galvanized tin boundary around the homestead garden
- Bhut jolokia spray so that the monkeys once eat the plants feel severe burning in their tongues.
- Keeping rice ball baits made of boiled rice+ salt +red chilli+ oil. As soon as the monkeys taste the bait(mixture) ,they feel burning and thirst and will avoid the area.
- Tying the dry fishes on branches around the fields and above the crop help in keeping away the monkeys because of irritating smell emanating from the dry fish.
- In some areas, farmers burn elephant dung or other materials that create heavy smokes

TSP ACTIVITIES

Sl No	Name of the Village(s)	Significant outcome and impact
1	Tamulpur, Kumarikata, Simulibari, Kachukatta, Singheemari, Katribari, Borbalichahi, Simlabari, Pahuwajan (Dist: Baksa)	*Field training cum demonstrations were conducted to aware the farmers about the application of rodenticides, bait preparation, bait placement, burrow baiting, bait stations, precautions to be taken at the time of rodenticides application ,how to prepare local bamboo chitika and how to place them to catch rodents etc. * More than 500 local bamboo chitika popularly known as ‘<i>Maat Chitap</i>’ prepared by AAU, Jorhat Centre and mechanical traps were distributed among farmers. *Zinc phosphide and bromadiolone cakes were also distributed to the farmers in the training programme *The pre and post evaluation of impact of training cum demonstrations indicated that there was a reduction of rodent population (46.11-67.21%) in the <i>kharif</i> season. It also revealed that 55.67-66.23 % of farmers had adopted the rodent control measures after training whereas the per cent adoption before training was only 10.19- 12.66%. * All the participants were keenly interested to learn the techniques of local bamboo trap “<i>maat chitap</i>” in the control of rodents in field conditions.
2	Neul Gaon, Gorukhuti, Borchapori, Charighoria (Dist: Jorhat)	*Field training cum demonstration were conducted among the farmers to sensitize them regarding rodent problem in the post flood situations. * The farmers were trained on use of rodenticides and safety measures to be taken. * At the end of the training programme, they were involved to prepare the zinc phosphide bait, different local bait stations and bait placement in the rodent affected field. * Local bamboo chitika ‘<i>Maat Chitap</i>’ were distributed among farmers and asked them to multiply the bamboo chitika supplied by the AAU, Jorhat Centre . *The rodent control success ranged from 43.33-66.67% leading to 37.16-47.21 % reduction in tiller damage. *All participated farmers used local bamboo traps in the field and they multiplied the same for the easy and effective control of field rodents.
3	Bohikhuwa, Ekoraja,	*More than seventy farmers participated in the training cum

	Dhansirimukh Dist: Golaghat	awareness programme *Main focus was rodenticides time and method of applications, use of ITKs in the control of rodent pest, use of bamboo chitika in the control of field rodents etc. *Inputs like zinc phosphide, bromadiolone as well as bamboo chitika were distributed among farmers *Farmers were advised to multiply the rodent chitika “Maat chitap” supplied by the AAU, Jorhat centre. * All the farmers had shown keen interest in the bamboo traps and its utilization against rodent pests. *All participated farmers used local bamboo traps in the field under <i>kharif</i> season and they multiplied the same for the easy and effective control of field rodents.
4	Upor Temara, Potiapara, Kumolia Dist: Golaghat	*Awareness cum method demonstration programme were conducted *More than 100 farmers were participated the training programme *Farmers were demonstrated about the different rodent control measures, bait preparation, placement, preparation of bait stations from locally available materials, use of different ITKs and use of <i>andur chitika</i> in the control of rodent pest *The farmers were divided in to different groups and were learnt to locate and identify the live burrow, how to prepare pre bait and toxic baits, how to keep bait materials in the bait stations etc. *It had been revealed that 67.8% farmers used local <i>andur chitika</i> ‘Maat chitap’ after training and farmers showed enthusiasm in disseminating the technology of the use of bamboo traps to their friends and relatives

EXTENSION ACTIVITIES

Sl.No	Date	Topic	Venue
2017-18			
1	30-06-17	Training on integrated rodent pest management in rice-rice cropping system	Bohikhuwa, Bokakhat
2	18-07-17	Trainings on rodent pest management in rice-oilseed cropping system	Uppor Temara, Badulipar
3	27-07-17	Interactive programme on rodents and their management in kharif rice	Dhanjan
4	18.08.17	Farmers training on rodenticides and their application and different methods etc	Upor Temara
5	31.08.17	Field training on different rodent control measures in rice-pulse cropping system	Bekajan
6	23.11.17	Farmers fair at SRS Buralikson	SRS, Buralikson
7	8. 12.17	Farmers training on integrated rodent pest management	Ekorajan, Bokakhat
8	22.12.17	Field demonstration on different rodent control measures in rice-vegetables cropping system	Upor Temara, Badulipar
9	25.01.17	Method demonstration on rodent pest and their management	Bohikhuwa, Bokakhat
10	22.02.18	Interactive programme on monkey damage in Agricultural Ecosystem	Rangamati, Badulipar

11	06.03.18	Interactive programme on monkey damage in Agricultural Ecosystem	Dhekial,Golaghat
12	28.03.18	Survey, interaction and discussion on monkey menace	Melang,Jorhat
13	4.06.18	Trainings on rodent pest management	Bohikhuwa & Upor Temara
14	25.06.18	Group discussion and interactive programme on rodent infestation in Sali rice	
15	12.7.18	Demonstrations on rodent pest management in Sali rice	Neul Gaon
16	13.8.18	Training on integrated rodent pest management in rice-rice cropping system on	Jaraguri
17	13.8.18	Interaction programme on rodent pest infestation in Sali rice at on	Mallow khat
18	11.10.18	Farmers training on rodent pest management at on	Neul gaon
19	13.10.18	Demonstrations on rodent pest management on coconut plants	Sarangpi gaon
20	10.11.18	Farmers day	Titabor
21	16.11.18	Field demonstration on rodenticides application in poultry farms and their safety measures	Uriamghat
22	16.11.18	Method demonstrations on squirrel attack and their control in plantation crops	Jamuguri
23	25.11.18	Method demonstration on use of baiting techniques and local traps as a part of integrated rodent pest management	Moridhansiri
24	25.11.18	Method demonstration cum field trainings integrated rodent pest management	Upor temara
25	10.12.18	Training cum Method demonstrations on field rodents	Bahphala
26	10.12.18	Training cum Method demonstrations on field rodents	Moidhya Parbotriya
27	22.12.18	Training cum Method demonstrations on field rodents	Kachukata ,Baksa
28	23.12.18	Training cum Method demonstrations on field rodents	Singheemari ,Baksa & Katribari ,Baksa
29	24.12.18	Training cum Method demonstrations on field rodents	Niz Khur Baha,Baksa
30	27.2.19	Method demonstration on use of baiting techniques and local traps as a part of integrated rodent pest management	Dhansirimukh
31	27.2.19	Method demonstration on use of baiting techniques and local traps as a part of integrated rodent pest management	Upor temara
32	12.3.19	Group discussion and interactive programme on rodent infestation in Boro rice	Bohikhuwa
633	12.3.19	Group discussion and interactive programme on rodent infestation in Boro rice	Dhansirimukh
34	15.3.19	Training cum Method demonstrations on field rodents	Upor Temara
35	25.3.19	Training cum Method demonstrations on field rodents	Dharkuchi,Baksa
36	25.3.19	Training cum Method demonstrations on field rodents	Phahuwajara,Baksa
37	26.3.19	Training cum Method demonstrations on field	Borbalichahi ,Baksa

		rodents	
38	26.3.19	Training cum Method demonstrations on field rodents	Simlasbari ,Baksa
39	28.3.19	Field trainings on integrated rodent pest management	Merapani

RESEARCH PUBLICATIONS

- Thangjam, R. Borah, R K and Nath, P D. 2017. *Bemisia tabaci* is a vector of CHLCV in bhut jolokia, *Capsicum chinense*, Jacq.: Molecular evidence. Paper presented at *National Symposium on Molecular Insect Science* (Feb 6-8) 2017: pp-67
- Sanghamitra, S., R K Borah and Dutta, B C. 2017. Evaluation of some botanicals on the feeding behaviour, growth and development against rodent. Poster presented at *National Symposium on Molecular Insect Science* (Feb 6-8) 2017: pp-59
- Borah, R K 2017. Rodent incidence in rice-pea cropping system. *Ann. Pl. Protec. Sci* 25 (1): 215-230.
- Mallick, A and Borah, R K. 2017. Evaluation of local bamboo traps against rodents in rice. *Indian J Ent*, 79(4):522-424
- Thangjam, R, Borah, R K and Saikia, D K. 2017. Pest complex of king chillies, *Capsicum chinense* in Assam, NE India. *The Bioscan*, 12(4):2069-2073.
- Borah, R K 2018. *Jatropha* (*Jatropha curcus*) seed powder as antifeedant against house rat, *Rattus rattus* *Rodent Newsletter*, 40(4):
- Phukan, M. and Borah, R K 2019. Species composition of field rodents in rice-vegetables cropping system at Upper Brahmaputra Valley Zone, Assam. *Journal of Entomology and Zoology Studies*, 7(1): 961-969.
- Thangjam, R, Ramaya, H R, Deka, M K Borah, R K and Singh, H R. 2018. Pollination diversity and foraging behaviour of honey bee, *Apis cerana indica* on Niger. *Indian Journal of Entomology*, 80 (3): 867-869.
- Borah, R K and Sarma, S 2018. Repellency of some indigenous plants from Assam against Lesser bandicoot rat, *Bandicota bengalensis*. *Indian Journal of Entomology*, 80(3):769-772
- Borah, R K. 2019. Incidence of lesser bandicoot, *Bandicota bengalensis* in rice-rice cropping system in UBVZ of Assam. *Annals of Plant Protection Sciences* (March) 2019

Extension Bulletins Published (2018-19)

- **R K Borah** Soisor Potharot samondhito Andur Niyantran Vavastra (In Assamese)
- **R K Borah** Rodents and their managements in Assam (In English)
- **R K Borah** Rodent pest management in the poultry farms in Assam (In English)
- **R K Borah** Squirrel and their management (In English & Assamese)

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	39.95	56.60	0.62	0.27	0.00	0.98	58.47
2018-19	100	68.91	18.83	0.22	0	4.38	92.34

**REGIONAL AGRICULTURAL RESEARCH STATION,
ASSAM AGRICULTURAL UNIVERSITY,
NORTH LAKHIMPUR (ASSAM) - 787032**

PART: I General Information

1. Name of the centre	Assam Agricultural University, RARS, North Lakhimpur
2. Sanction No	Sanction Letter no. (F. No. 10-1/2009-PP Dated 29-01-2009)
3. Date of start	23 November 2009
4. Date of Termination	Network Project of continued nature
5. Report period	2017 to 2019
6. Scientist In-charge	Dr. PRABAL SAIKIA

7. Staff Position

Sr. No.	Name of post	No. of posts	Name of incumbent
1	Principal Investigator	01	Dr. Prabal Saikia

Part II. Work Allotted

BM 1. Surveillance of depredatory birds in predominant cropping systems (Rice-rice)

BM 2. Community structure of birds and their diversity in relation to crop stages in different agro-ecological zones of the region. (Upper Brahmaputra Valley Zone)

BM 3. To identify, develop and evaluate eco-friendly bird management techniques

- Evaluation of chemical/ non chemicals as deterrents in the fields
- Field evaluation of different management methods in various crops in farmers' fields/universities/ university farms/ government farms). Crop: Rice & Mustard

BM 4. Exploitation of beneficial birds for the suppressing of insect pests (*Army worm in Rice*)

BM 5. Evaluation of fruiting/ flowering trees to attract insectivorous / omnivorous / Depredatory birds to the agricultural land scape.

BM 6. Farmer's participatory research on bird management

Location specific programmes

5. AAU, North Lakhimpur

- a) Studies on the role of crop lands in attracting water birds to Majuli- the biggest river island.

(B) HIGHER VERTEBRATES

HV 1: Bio ecology and management of higher vertebrates (Monkey) in different crops.

- a) Status and distribution of the species in the region of study.
- b) Population details, habit, habitat, food and feeding habits.
- c) Extent of crop damage at different crop growth stages
- d) Identification of traditional practices
- e) Development of management technologies and Testing of proven technologies in different crops.

Part III. Work done (Programme-wise)

BM 1. Surveillance of predatory birds in predominant cropping systems (Rice-rice)

Studies were conducted in different districts of Upper Brahmaputra Valley (UBV) and North Bank Plain (NBP) zones of Assam in Rice/Rice cropping system. Ninety bird species belong to 38 families were recorded in the upper and lower Brahmaputra valley zone of Assam. The highest (8) no of species belonged to the family Anatidae followed by Ardeidae (7) and Motacillidae (6) while only one species each was observed under the family Upupidae, Rostratulidae, Rhipiduridae, Rafinesque, Pycnonotidae, Podicipodidae, Ploceidae, Phasianidae, Paridae, Oriolidae, Estrildidae, Dicruridae, Cisticolidae, Capitonidae, Alaudidae. A total of 7181 individuals of birds were recorded in Lakhimpur district followed by 3994 in Sivasagar against. Only 94 individuals of birds were recorded in Kokrajhar district during the survey period. The species richness ranged from 15 to 82 in different districts and recorded highest in Sivasagar district with diversity index of 3.3 (Fig 1)

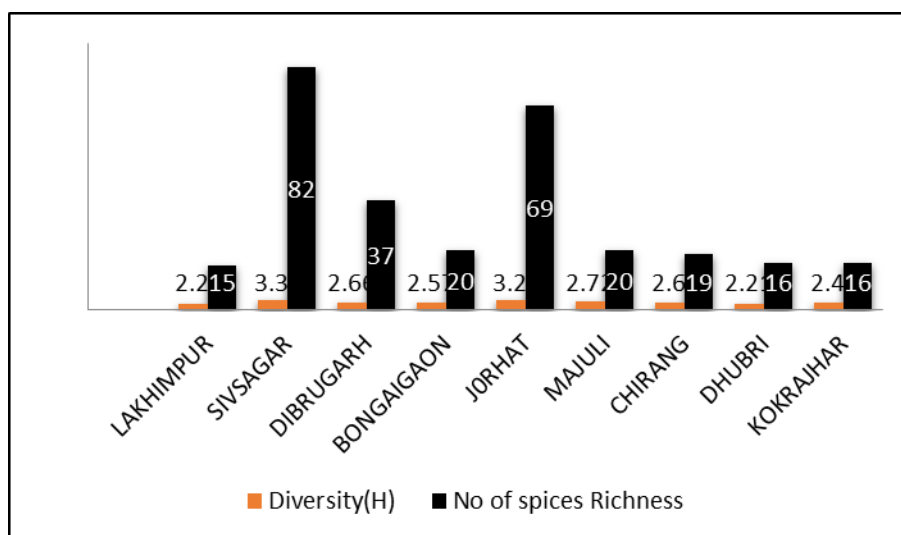


Fig 1: Species Richness and Diversity Index in different districts of Assam

21 species of birds were found to be common in all the 9 districts and recorded a higher mean abundance of Cattle Egret (27.41%) in all the districts followed by spotted dove (7.85%) and Asian pied sterling (7.62%). Highest abundance of Cattle egret (46.02%) was observed in Sivasagar district against Baya weaver (18.14%) in Lakhimpur district and Sand martin (38.83%) in Jorhat district.

Estimation of Bird population in paddy field of a few districts of Assam: Bird population was estimated during the month of June 2018 in the districts of Nagaon, Sonitpur and Lakhimpur by following Path Index (PI) method which is a quick method for sampling estimate. This index is very useful for comparing regions and variations season-wise. The index is fairly reliable as birds have pronounced “edge effect”, which manifest along pathways and roads while slowly motoring or cycling along a fixed rout. $PI = N/M$, where N= total number of birds and M= total number of Kilometers. The study reported highest PI of 4.77 in Nagaon district against 3.66 and 2.53 in Lakhimpur and Sonitpur districts respectively, indicating higher bird population foraging in the paddy field of Nagaon along the pathways during *Kharif* season.

Evaluation of bird roosting sites, habitat suitability index & impact in relation to different cropping systems: Dropping Index (DI) was used to gauge the strength of bird population roosting on a tree or other roosting sites. Dropping boards of 1 sq m were placed at random below the tree canopy and other bird roosts viz., T- Perch, Artificial Nest box etc. The number of

droppings per board have been averaged out and expressed as: $DI = Dr/N$, where Dr = total number of droppings and N = number of boards. Higher DI of 31.6 was observed below the artificial nest boxes installed in the RARS field followed by Puja (23.6), Simul tree (22.6) and T- Perch of 9 feet height (21) installed for owl.

Food, feeding habits of depredatory birds

Seed morphology on feeding preference of birds: The grain with lower L: B ratio was less preferred by birds as reflected by higher germination percentage. Tall varieties with wide plant spread and flag leaf with relatively less projection above the ear head were found to be preferred by weaver and Munia.

BM. 1. B. Density Relative, abundance and Fluctuation of Common predatory birds in paddy eco system at RARS, North Lakhimpur

The Density and relative abundance of Common Myna was found to be highest in *Kharif* rice during the survey period with maximum population foraging in the month of July – August (Table 1 & 2).

Table 1. Density and relative abundance of bird fauna in Assam

Bird species	Density	Relative abundance (%)
Cattle egret	0.44	25.18
Black Drongo	0.07	3.81
Jungle Myna	0.47	26.72
Common Myna	0.48	27.34
Pond Heron	0.31	17.58

Table 2. Trends in foraging activity of common bird fauna in rice ecosystems

Predatory birds	April	May	June	July	August
Cattle egret	28.57	22.57	28.66	29.81	32.42
Black Drongo	3.28	4.28	4.5	5.0	5.36
Jungle Myna	19.85	25.42	30.33	39.36	38.42
Common Myna	21.85	31.14	29.83	39.09	37.57
Pond Heron	5.28	19.71	22.16	24.0	30.85

BM 2. Community structure of birds and their diversity in relation to crop stages in different agro- ecological zones of the region. (Upper Brahmaputra Valley Zone)

Transact line survey was conducted in 14 locations of in Sivasagar district covering Paddy field, homestead garden and wetlands adjacent to paddy fields during 20 November, 2017 to 13 March 2018. Thirty-four species of birds were recorded during the survey period (**Table 3**). Eastern Cattle-Egret was found to be dominant species with 54.96 per cent abundance followed by common Myna (12.18%), weaver birds (8.07%), Jungle Myna(5.42%), Purple swamp hen(4.86%), Yellow footed Green pigeon(4.52%), Barn swallow (2.95%), Rose Ringed Parakeet(1.47%), were found to be most abundant species.

Table 3. Bird species of agricultural field in UBV zone

Sl No	Common Name	Per cent abundance
1	<i>Eastern Cattle – Egret</i>	54.96
2	<i>Common Myna</i>	12.18
3	<i>Jungle Myna</i>	5.42
4	<i>Asian Pied Starling</i>	0.17

7	<i>Indian Pond – Heron</i>	0.26
8	<i>White-breasted water hen</i>	0.22
9	<i>Spotted Dove</i>	0.85
10	<i>Purple Swamp hen</i>	4.86
11	<i>Indian Roller</i>	0.08
12	<i>Stonechat</i>	0.08
13	<i>Rose Ringed Parakeet</i>	1.47
14	<i>Yellow footed Green pigeon</i>	4.52
15	<i>Black Drongo</i>	0.29
16	<i>Magpie Robin</i>	0.20
17	<i>House Sparrow</i>	0.15
18	<i>Eurasian Tree Sparrow</i>	0.19
19	<i>Barn Swallow</i>	2.95
20	<i>Red Wattled Lapwing</i>	0.10
21	<i>Red Junglefowl</i>	0.05
22	<i>Baya weaver</i>	8.07
23	<i>Greater Adjutant Stork</i>	0.09
24	<i>Black headed Ibis</i>	0.06
25	<i>Common Hoopoe</i>	0.03
26	<i>Green Bee eater</i>	0.12
27	<i>Brown Shrike</i>	0.08
28	<i>White throated King fisher</i>	0.12
29	<i>Spot billed Duck</i>	0.94
30	<i>Little Cormorant</i>	0.06
31	<i>Common Coot</i>	0.23
32	<i>Asian Open bill</i>	0.15
33	<i>Lesser Adjutant Stork</i>	0.05
34	<i>White Wagtail</i>	0.12

Predatory and Depredatory bird species abundance: A total of 27 species (77.15 %) beneficial predatory bird species were recorded during the study period against only 8 species identified as depredatory species. Among the total bird population 60.28% (17 spp) were insectivorous; 20.06 % omnivorous (11 spp); 13.64% granivorous (4 spp) and 5.99% (2 spp) were recorded as frugivorous.

BM 3. To identify, develop and evaluate eco-friendly bird management techniques

Field evaluation of different management methods in various crops in farmers' fields/universities/ university farms/ government farms). Crop: Rice & Mustard:

Large scale demonstration of T- Perch to provide artificial roosting sites in Sali (Kharif) paddy in 30 ha of rice field of tribal farmers (Boro tribe) and 20 ha of mustard field among tribal farmers. 500 Nest boxes for cavity nester birds. 2. Distributed 30 kg of Bird scaring Ribbon among Deuri tribe of Assam, 500 Nest boxes for cavity nester birds.

BM 4. Exploitation of beneficial birds for the suppressing of insect pests (*Army worm in Rice*)

Eight species of birds recorded during a transact line and random survey in Lakhimpur district of Assam as major predatory birds of Army worm (Table 4). Among the species Eastern Cattle Egret was found to be more abundant species (42.03%) followed by common Myna (29.53%) and Jungle Myna(12.68) , Asian Pied Starling(7.23%), Jungle Crow(4.21%), House crow (1.79%), Indian Pond Heron(1.40%).

Table 4. Percent abundance of beneficial bird species in Army worm infested rice field.

Sl No	Common Name	Scientific Name	% abundance
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1	Eastern Cattle - Egret	<i>Bubulcus coromandas</i>	42.03
2	Common Myna	<i>Acridotheres tristis</i>	29.53
3	Jungle Myna	<i>Acridotheres fuscus</i>	12.68
4	Asian Pied Starling	<i>Gracupica contra</i>	7.23
5	Jungle Crow	<i>Corvus macrorhynchos</i>	4.21
6	House Crow	<i>Corvus splendens</i>	1.79
7	Indian Pond - Heron	<i>Ardeola grayii</i>	1.40
8	White-breasted water hen	<i>Amauronis phoenicurus</i>	1.09

BM 5. Evaluation of fruiting / flowering trees to attract insectivorous / omnivorous / Depredatory birds to the agricultural land scape.

Fourteen flowering and fruiting plant were identified those attract insectivorous and omnivorous birds. These plants serve the purpose of maintaining beneficial birds in the agro eco-system. 16 species of birds recorded in Mulberry followed by *Bakul (Mimusops elengi)* fruit (10).

BM 6. Farmers' participatory research on bird management

- Impact assessment of Bird Pest Management (BPM) Technologies developed by AINP on VPM, through large scale demonstration showed significant results and adoption was high among farmers in the state of Assam.
- Organized a Zonal level Kisan Mela with participation of farmers and farm scientists from six districts of Northern Assam.
- Large scale demonstration on role of insectivorous birds in suppression of insect pests in cereal and oilseed crops through installation of T shape bird perches made of either bamboo or tree branch @ 50/ha as a component of IPM in Boro paddy, Toria and Rabi Maize in Darrang, Baksa and Udalguri districts of Assam in collaboration with KVKs of respective districts among the tribal farmers under Tribal Sub Plan (TSP) programme had succeeded in controlling insect pests. Adopted by farmers in the districts were assessed.
- **Recorded** six species of Insectivorous birds as dominant species perching on 'T'- Perch installed in paddy field during *Kharif* 2017 in all the 10 districts under 4 agroclimatic zones of Assam during demonstration period. Abundant species: Black Drongo> Pied Starling> Bee eaters>Stonechats> shrikes>King fishers.

Table 5. Predatory birds recorded recorded from demonstration field Kadam, Lakhimpur (Transact 500 m X 50 m)

Treatment	No. of Predatory birds recorded /0.25ha (N = 11) Mean+- SE	t values
T – Perch @ 50/ha	10.50 +- 2.62	3.804*
Farmers practice (ITK)	1.36 +- 0.43	3.155*

“ITK: Use of bamboo perches to encourage predatory birds

IMPACT ASSESSMENT OF TECHNOLOGY ('T' – Perch) THROUGH LARGE SCALE DEMONSTRATION

Field study was conducted through PRA tools (**matrix scoring**) using 20 key informants on four criteria for two alternative practices were obtained in respect of scores out of 10. *The study was conducted in Kadam (Lakhimpur); Gandhiburi (Nagaon).; Bhergaon Serajuli(Sonitpur) Mahaliapara(Darrang) and Maniari Tinali (Kamrup).* FLD were conducted in 10 locations in 10 districts under Technology Showcasing programme in collaboration with KVK (Table 6). **Table 6. Average ranking for technology option through PRA tool (matrix scoring)**

Criteria	‘T’ - Perch	Farmer’s Practice (ITK)**	t values
Efficacy in bird perching	5.87	3.92	4.223*
Resource availability	7.29	4.12	6.802*
Cost effectiveness	7.68	4.43	6.244*
Ease in use	7.70	3.58	8.250*

ITK: Use of bamboo perches to encourage predatory birds

HIGHER VERTEBRATES

HV1: Bio ecology and management of higher vertebrates in different crops.

Monkeys have increasingly become a serious menace in cultivated and human domesticated environments. Both in rural and urban areas, populations of monkeys have increased to proportions such that man and monkey conflict have become intolerable. Most of the agricultural and horticultural cultivable areas have become foraging and feeding areas. An opinion survey was conducted in different agroecosystems of four districts viz. Sivasagar, Dibrugarh and Jorhat (Table 7) during 2018-19. The survey revealed the presence of only Rhesus monkey, *Macaca mulatta* in agro ecosystems. The population of monkey was observed to be high in Sivasagar district (44) with male (9), female (24) and juvenile (11) in a troop. In all the locations female and juveniles outnumbered the males. The habitat of the monkeys was mostly observed to be the nearby forests from the people’s living place. Feeding depends on their food preferences and some crops are non-preferred (Table 7, 8 and 9) by the monkeys. In majority of the places, people do not take up any measures to reduce monkey menace. Some measures that the people have adopted for minimizing the menace are use of slingshot and keeping dogs to guard the place.

Table 7. Opinion Survey of *Macaca mulatta* in Sivasagar, Dibrugarh and Jorhat districts under Upper Brahmaputra Valley Zone of Assam

Sl.No.	Variables	Categories	Site selected for opinion survey		
			Sivasagar	Dibrugarh	Jorhat
1	Population size	Total	44	17	15
		Male	9	4	5
		Female	24	7	7
		Juvenile	11	6	3
2	Type of habitat	Nearby forest	62.5%	50%	57.14 %
		Bamboo groove	25%	-	42.86 %

		Tea garden	-	50%	-
3	Feeding	Most Preferred crop	Papaya	Banana	Papaya
		Non preferred crop	Chilli, turmeric, pineapple, ginger, colocasia, okra, toria, lemon, corriander, spinach, cabbage, ash gourd etc		
4	Perceived measures for minimizing the monkey menace	Keeping dog	31.25%	12%	42.85%
		Use of slingshot	6.25%	-	28.57%
		Use of stick	2%	-	-

Table 8. Non-preferred crops by *Macaca mulatta* as food (based on opinion survey)

Sl.	Crop	Scientific name	Family
1	Chilli	<i>Capsicum annum</i>	solanaceae
2	Black pepper	<i>Piper nigrum</i>	Piperaceae
3	Onion	<i>Allium cepa</i>	Alliaceae
4	Ginger	<i>Zingiber officinale</i>	Zingiberaceae
5	Bitter gourd	<i>Momordica indica</i>	Cucurbitaceae
6	Ash gourd	<i>Benincasa hispida</i>	Cucurbitaceae
7	Collocasia	<i>Colocasia esculenta</i>	Araceae
8	Okra	<i>Abelmoschus esculentus</i>	Malvaceae
9	Toria	<i>Brassica rapa</i>	Brassicaceae
10	Mint	<i>Mentha virides</i>	Lamiaceae
11	Turmeric	<i>Curcuma longa</i>	Zingiberaceae
12	Spinach	<i>Beta vulgaris</i>	bengalensis
13	Coriander	<i>Coriandrum sativum</i>	Apiaceae
14	Cabbage	<i>Brassica oleracea v. capitata</i>	Brassicaceae
15	Wheat	<i>Triticum aestivum</i>	Poaceae
16	Pineapple	<i>Ananas sativus</i>	Bromeliaceae
17	Arecanut	<i>Areca catechu</i>	Palmae
18	Coconut	<i>Cocos nucifera</i>	Palmae
19	Lemon	<i>Citrus limon</i>	Rutaceae

Table 9. Most preferred crops by Rhesus Macaque according to opinion survey

District	Papaya	Banana	Mango	Pumpkin	Paddy	Brinjal	Gourd
Sivasagar	31.50%	38%	18.75%	6.25%	25%	12.50%	6.25%
Dibrugarh	12.50%	50%	30%	2.5%	10.5%	2.5%	-
Jorhat	57.14%	42.85%	14.28%	2.5%	-	2.5%	6.25%

II. Location specific Programmes

Role of crop lands in attracting water birds to the Majuli River Island

Like croplands, the seasonal wetlands are reported to be the areas of water birds' significance, since most water birds use them as foraging grounds. The objectives of the study were (i) To document the abundance and composition of water birds using croplands and (ii) To

evaluate the significance of croplands adjoining the open water habitat in attracting water birds, especially the migratory ones. The Survey was undertaken at sites like, Cakuli, Bhareki and Dakshinpat during 8 & 25 January, 2018.

A total of 141 bird species were recorded at study site that belonged to 14 family of which 57 spp are water birds. Among these species 39 found foraging in crop lands. The Oriental White Ibis (NT) *Threskiornis melanocephalus* is the **first report from Majuli** recorded in crop field. Greater Adjutant Stork *Leptoptilos dubius* (EN) & Lesser Adjutant- Stork *Leptoptilos javanicus* (VU) were also recorded in crop field of Majuli (Table 10 & 11).

Table 10: Water bird composition in wetland & Cropland habitats of Majuli River Island

Bird Family	No. of spp	% abundance
1. Phalacrocoracidae	2	3.51
2. Anhingidae	1	1.75
3. Ardeidae	9	15.78
4. Ciconiidae	3	5.26
5. Anatidae	16	28.07
6. Rallidae	5	8.77
7. Jacanidae	2	3.51
8. Charadriidae	3	5.26
9. Scolopacidae	5	8.77
10. Laridae	2	3.51
11. Apodidae	1	1.75
12. Alcedinidae	4	7.01
13. Hirundinidae	2	3.51
14. Threskiornithidae	2	3.51

Table 11. Avifauna richness in Majuli Island ecosystem

Parameter		Wetland Types		
Total Avi fauna Richness(No)	141	Agricultural land (cultivable+ grazing land)	Marshy land (partially inundated with vegetation)	Open water (water body without vegetation)
Water birds Richness (No)	57	39	27	27
% abundance	40.42	68.42	47.36	47.36

A checklist on birds of Dakshinpat Satra, Majuli – the biggest River Island of the world was prepared. Highest number of species were recorded from the family Anatidae (n=16) followed by Ardeidae (n= 9). During the study period 3 species birds were recorded as Near Threatened (NT), 3 species as Vulnerable (VU) and one Endangered (EN).

EXTENSION ACTIVITIES

- Thirty (30) awareness cum training programs on *Role of Birds in agriculture* was organized in 23 districts of Assam on the occasion of **World Sparrow Day 2019** in collaboration with KVKs of Assam Agricultural University (AAU). Distributed 5000 artificial Bird nest boxes designed by the Centre among the farmers, students and housewives. Such a massive

awareness drive to sensitize common people on the issue of agro biodiversity conservation was organized for the first time in Assam.

- Organized Zonal level *Kisan Mela*, Exhibition and Scientist – Farmers interaction on 14 Nov 2018. The program was attended by 500 farmers, KVK Scientists, Faculty members of College of Agriculture, Biswanath Charali, College of Veterinary Science, Lakhimpur. The Director of Research (Agri) Assam Agricultural University (AAU); Director of Extension Education, AAU, District Magistrate, Lakhimpur were present in the inaugural session as distinguished guests.
- A 3-day workshop on *conservation strategies of common wild birds* was organized in Silapathar Science College. 100 students and teachers of Dhemaji district participated.
- Published a book on bird of agro ecosystem in Assam entitled *Gaonfura Coraibur* in vernacular language with support from ICAR- AINP on VPM in association with AAU and Nature's Beckon, a renowned NGO of N E India.



Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	18.50	17.00	0.20	0.25	0.00	1.00	18.45
2018-19	46	20.55	17.53	0.74	0	5	43.82

COLLEGE OF HORTICULTURE AND FORESTRY, CENTRAL AGRICULTURAL UNIVERSITY, PASGHAT (2017-18)

(Principal Investigator: Dr M M Kumawat)

(a) Rodent Control

Survey was conducted during April, 2017 to March, 2018 in five villages namely *Mirem*, *Ledum*, *Taki lalung*, *Rani* and *Sille* in East Siang district of Arunachal Pradesh. Field survey was also conducted in instructional and research farm, College of Horticulture and Forestry, Pasighat. The trap index (no. of animals/100 traps/night), live burrow count method (No./ha), extent of damage and reproductive status of the species were recorded in wet land rice, *Jhum* rice, maize, potato, tomato, brinjal, cabbage, cauliflower and French bean in the surveyed area. In rice cultivation system, the number of live burrows/ha., trap index and damage in the month of June were less as compared to the harvesting stage of the crop. The number of live burrows ha⁻¹ increased subsequently and reached maximum in October and remained high in November to December. The mean number of live burrows ha⁻¹ in crop season was ranged from 2.5 to 11.67 in the region. The trap index was ranged from 2.00 to 9.33 in the district. The average damage percent in East Siang were ranged from 0.27 to 2.16, respectively. In case of *Jhum* rice which is grown on the onset of *monsoon* the number of rodent population were less but it was gradually increased month by month. Surveillance of rodent was also recorded on maize crop in East Siang district of Arunachal Pradesh. The highest damage (3.04%) in maize was observed in Ledum village followed by Taki Lalung village (2.82). The average damage percent in maize crop in East Siang was 2.15. The highest trap index (10.67) was recorded in Mirem village. Among the horticultural crops, highest damage (2.64 %) was observed in potato crop in all the villages ranged from 1.86 to 3.86%. In cauliflower crop, no any damage was observed in all the villages. The least damage was caused in cabbage (Table 1).

Table 1. Surveillance of pest rodents in vegetable crops.

S.N.	Name of Village	Damage (%)						Trap index	No. of live burrows/ha
		Beans	Potato	Tomato	cabbage	Cucurbits	Brinjal		
1.	<i>Mirem</i>	0.15	2.02	0.57	0.10	0.70	0.00	14.67	1.20
2.	<i>Ledum</i>	0.54	3.25	0.20	0.00	0.60	0.00	12.67	1.50
3.	<i>Taki lalung</i>	0.24	2.22	0.25	0.00	0.23	0.10	8.00	1.70
4.	<i>Rani</i>	0.09	3.86	0.42	0.07	1.75	0.20	5.33	0.25
5.	<i>Sille</i>	0.15	1.86	0.00	0.00	0.90	0.47	4.00	0.40
	Mean	0.23	2.64	0.29	0.03	0.84	0.15	8.93	1.01

For monitoring of rodent abundance and damage in selected agro-climatic zones different places of East Siang, Upper Siang, West Kameng, Lohit and Anjaw districts was selected and observations on trap index, damage per cent and number of rodent species found were collected as given in the Table 2). The percent damage in rice of all the districts was ranged from 0.76 to 3.12 whereas percent damage in maize was observed from 1.73 to 2.23. A total four species were observed in all the districts as mentioned above viz. *Bandicota bengalensis*, *Mus cookiinarum*, *Rattua rattus*, and *Rattus sikkimensis*.

Table-2: Data on rodents trap index and per cent damage in Arunachal Pradesh

S.N.	Crop	Trap index	Damage %	No. of species	Percentage of species
1.	East Siang District				
	Rice	6.30	3.12	4	Bb- 47.6%, Rs- 33.3%, Rr- 9.52%, Mc- 9.5%
	Maize	5.70	1.73	4	Bb- 41.18%, Rs- 35.3%, Rr- 11.8%, Mc- 11.8%
2.	Lohit District				
	Rice	6.75	1.15	3	Bb- 33.3%, Rs- 26.6%, Rr- 40.0%
	Maize	8.87	2.23	3	Bb- 15.4%, Rs- 46.15%, Rr- 38.46%
3.	Upper Siang District				
	Rice	7.87	1.42	3	Bb- 25.0%, Rs- 66.67%, Rr- 8.33%
4.	Anjaw District				
	Rice	10.67	1.26	4	Bb- 22.73%, Rs- 36.36%, Rr- 27.27%, Mc-13.64%
5.	West Kameng District				
	Rice	5.25	0.76	2	Rs- 50.0%, Rr- 50.0%

Bb-Bandicota bengalensis, Mc-Mus cookinagarum, Rr-Rattus rattus, Rs-Rattus sikkimensis

(b) Agril Ornithology

1. Estimation of damage caused by birds in Agricultural Landscape of Northeastern region :

A survey was conducted at different agricultural landscapes of the foothills of East Siang District of Arunachal Pradesh from April 2017 to March, 2018. The survey covers 10 ha of wetland rice, 3 ha of jhum rice, 3 ha of jhum maize, 3 ha of pineapple orchard, 3 ha of ginger and turmeric field, 5 ha of multiple cropping field (like beans, red gram, maize, sugarcane, rapeseed/ mustard, vegetables, palms, fruit plants, etc.) and 3 ha of vegetable field. Jhum rice suffers more bird damage than the wetland rice (Table 3).

Table 3. Birds damage at different locations of East Siang District of Arunachal Pradesh in rice and maize.

Rice		Maize	
Locations	Panicles damage (%)	Locations	Cob damage (%)
Mirem (Jhum)	3.4 (10.63)*	Jhampani (Wetland)	15.3 (23.03)
Ledum (Jhum)	1.2(6.29)	Pasighat (Wetland)	2.2 (8.53)
Sille (Wetland)	0.87 (5.35)	Sille (Wetland)	0.87 (5.35)
Taki lalung (Wetland)	0.56 (4.29)	Taki lalung (Wetland)	0.42 (3.72)
Rani (Wetland)	0.43 (3.76)	Rani (Wetland)	0.33 (3.29)
SEd±	2.13	SEd±	4.21
CD _{0.05}	6.96	CD _{0.05}	11.53

*figures in parenthesis are angular transformed values.

Highest bird damage of 3.4 per cent damaged panicles was recorded at Mirem village area and it was followed by Ledum village area (1.2 per cent damaged panicles). At Sille, Taki lalung and Rani Villages, the bird damage in rice were 0.87, 0.56 and 0.43 per cent damaged panicles, respectively. In maize, maximum bird damage was recorded at Jhampani (15.3 per cent damaged cobs). Wetland maize at Sille, Taki lalung and Rani recorded moderate bird damage with 0.87, 0.42 and 0.33 per cent damaged cobs, respectively. 2.2 per cent bird damage was observed at Pasighat area.

Management of munias in rice crop: A field trial was carried out for control of munias (*Lonchura punctulata* and *Lonchura striata*) damage in rice. The experiment was carried out at two locations i. e. Napid and Bodak areas. Isolated and surrounded by forest trees or bamboo plantation field were selected for the experiment. In each location four replications and six treatments were maintained. The treatments includes- i) Installation of reflective ribbon, ii) Spraying of egg solution@ 1 chicken egg /5 lit. of water at milky stage of rice, iii) Spraying of neem formulation @ 3ml/lit. of water at milky stage of rice, iv) Hanging of polythene bags @ 40 poles/ha, v) Hanging of roasted meat@ 40 poles/ha, vi) Hanging of rotten frogs @ 40 poles/ha and vii) Untreated control.

At both Mirem and Ledum villages, the average number of grains/panicle in the treatments with reflective ribbon (224.3 and 244.02, respectively) and spraying with egg solution (211.1 and 222.3, respectively) were comparable and found to be more effective treatments (Table 4). Spraying of neem (2.9.5 and 218.2 grains/ panicle) and hanging of roasted meat (198.4 and 186.1 grains/panicle) was found superior to hanging of polythene bags and untreated control at Mirem and Ledum villages, respectively. The highest average yield was recorded in reflective ribbon (3.76 tons/ha) and it was closely followed by spraying of egg solution (3.52 tons/ha) and neem oil spray (3.11 tons/ha) at Mirem. The lowest gain yield was recorded in untreated control (2.86 tons/ha). However, at Ledum, highest grain yield was recorded in reflective ribbon (3.86 tons/ha) and it was comparable with spraying of egg solution (3.59 tons/ha) and spraying of neem (3.22 tons/ha). Hanging of polythene bags recorded the grain yield of 3.12 tons/ha, and it was on par with hanging of roasted meat (3.2 tons/ha), hanging of rotten frogs (2.98) and untreated control (2.95 tons/ha).

Table 4. Bio-efficacy of eco-friendly management practices against munias in rice.

Treatment	Mirem		Ledum	
	Average number of grain/panicle	Yield (tons/ha)	Average number of grain/panicle	Yield (tons/ha)
Reflective Ribon	224.3 ^a	3.76 ^a	244.02 ^a	3.86 ^a
Spraying of poultry egg solution @ 1egg/5 lit of water	211.1 ^b	3.52 ^b	222.3 ^b	3.59 ^b
Spraying of neem oil @ 3ml/lit of water	209.5 ^b	3.11 ^b	218.2 ^b	3.22 ^b
Hanging of Polythene bags	190.36 ^d	2.98 ^{b,c,d}	187.2 ^c	3.12 ^c
Hanging of roasted meat	198.4 ^{c,d}	3.02 ^{c,d}	186.1 ^c	3.2 ^c
Hanging of rotten frogs	202.1 ^c	2.87 ^d	186.6 ^c	2.98 ^c
Untreated control	182.3 ^e	2.86 ^d	187.9 ^c	2.95 ^c
SEd±	7.25	0.24	5.98	0.32
CD _{0.05}	21.31	0.61	18.93	0.92

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	0.38	0.00	0.38	0.00	0.00	0.00	0.38

**ODISHA UNIVERSITY OF AGRICULTURE AND TECHNOLOGY, BHUBANESWAR
(2017-18)**

(Principal Investigator: Dr L N Mohapatra)

Data on survey of rodent abundance and damage potential in two villages viz., Achyutpur and Dihakuransha of Jajpur district during *Kharif* season at ripening & harvesting stage of rice crop revealed that maximum burrows density at harvesting stage (34.5/ha) followed by ripening (26.5/ha) (mean of two villages). Similarly mean maximum rodent damage in terms of percent cut tiller was also recorded in harvesting stage (14.2) followed by ripening (6.3). During 2017-18 rodent density (LBC/ha) and damage potential was monitored in different vegetables in selected villages. Results indicated that maximum rodent density (LBC) was recorded in tomato (35.0) followed by potato (26.0), cucumber (18.0) and radish (15.0). In other vegetable like pumpkin, cauliflower and brinjal, LBC was comparatively less (6.0 – 10.0). Rodent damage in vegetables ranged from 1.1 to 10.9 per cent with an overall mean of 6.53 per cent. Maximum damage was observed in tomato (10.9%) followed potato (9.6%) and cucumber (7.9%),

Rodent abundance and damage in various crops in the Mid Central Table Land Agro climatic zone of Odisha at pre harvest stage during 2017-18 revealed maximum rodent population (LBC) in rice (29.2/ha) having damage of 12.8 per cent followed by sweet potato (16.2/ha) with damage of 8.4 per cent (Table1). In other crops like arhar, maize, sugarcane and ground nut rodent population (LBC) varied 5.2 to 10.4 with damage of 2.4 to 6.1 per cent. Studies on species composition of rodent at harvesting stage of rice in various selected villages in this agro climatic zone indicated that among the four species of rodents, *Bandicota bengalensis* was the predominant species (65.33%) followed by other species like *Rattus rattus*(14.23%), *Bandicota indica*(10.73%) and *Mus booduga* (9.51%).

Table 1. Rodent abundance and their damage in various crops at pre- harvesting stage during 2017-18

Crop	Name of the village	Rodent density(LBC/ha)	Damage potential (%)
Rice	Parbatia	29.2	12.8
Sweet potato	Parbatia	16.2	8.4
Sugarcane	Talagarh	8.8	5.2
Groundnut	Ragadiapada	10.4	6.1
Maize	Parbatia	6.6	2.8
Arhar	Saptasaryapada	5.2	2.4

Studies on species composition of rodent at harvesting stage of rice in various selected villages in this agro climatic zone indicated that among the four species of rodents, *Bandicota bengalensis* was the predominant species (65.33%) followed by other species like *Rattus rattus*(14.23%), *Bandicota indica*(10.73%) and *Mus booduga* (9.51%)(Table 2).

During Rabi 2017-18 Talagarh village of Angul district was adopted for farmer's participatory adoptive research in tomato. In this adopted village training on rodent damage and control and technology of rodent control demonstration were carried out for which various inputs were provided. For comparison, village Ragadiapada was taken as control village where no inputs or training was provided. In the adopted village Talagarh the treatment consisting of application of

Zinc phosphide (2%) bait @ 10 gm/ burrow twice at 10 days interval after one day pre baiting commencing peak flowering stage of tomato(0.4ha) were imposed.

Table 2. Species composition of Rodents in rice in Mid Central Table Land at harvesting stage during 2017-18

District	Name of the village	Total No. of rodents trapped	Percentage of rodent species composition			
			<i>B.b</i>	<i>M.b</i>	<i>R.r</i>	<i>Bi</i>
Dhenkanal	Parbatia	15	53.33	6.67	26.67	13.33
	Saptasaryapada	18	66.67	5.55	11.11	16.67
Angul	Talagarh	16	68.75	12.50	12.50	6.25
	Ragadiapada	15	73.33	13.33	6.67	6.67
Mean			65.53	9.51	14.23	10.73

Bb-Bandicota bengalensis, Mb-Mus booduga, Rr-Rattus rattus, Bi-Bandicota indica

Rodent abundance viz., mean no of live burrows/ha and per cent damaged plants was recorded from both treated and untreated village. Tomato yield was recorded from both treated and untreated village. Then the per cent of control success on mean live burrows/ha and per cent plant damaged by rodents were also computed. Results revealed that rodent abundance (LBC) and per cent damaged plants by rodent was minimum in treated tomato plot (6.0 and 3.8%) as compared to untreated plot (26.0 and 10.6%). The treated tomato plot also gave higher yield (12.18t/ha) over the untreated plot (10.76t/ha). The per cent control success on live burrows and plant damage were 76.92 and 64.15, respectively resulting 13.19 per cent increase in yield in treated village.

The off campus one day training programme on awareness on rodent damage in store and field and its control was carried out in all the adopted villages during February and March, 2018 (Table 7). All together 300 farmers were trained at six off campus training programmes held at Dihakuransha, Achyutpur, Talagarh, Ragadiapada, Saptasaryapada and Parbatia on various aspects of rodent damage to different crops viz., rice, sugarcane, coconut, sweet potato, vegetables, groundnut, maize, arhar etc., bait preparation, method of application and other rodent management techniques. The field day/demonstrations were organized in all the six adopted villages during 2017-18 and altogether 110 farmers participated in the programme (Table 3). Various techniques demonstrated to the farmers were identification of live burrow by different rodent species in rice field, placement of rat trap in field and store, bait preparation and methods of placement of bait in rodent burrows in different crops.

ITKs used by the farmers for control of rodents and other higher vertebrates in various adopted villages were documented. Survey results revealed that watering the rodent burrows was a common practice for reducing rodent menace in vegetable field by the farmers of Parbatia and Saptasaryapada village. For control of rodent in rice field the farmers of village Talagarh, Achyutpur, Parbatia were acquainted with placement of Furadan granules in rodent burrow.

Table 3. Field day/ Demonstration organized in adopted villages

Sl No.	Technology	Name of the village	No of participants	Date
1	Identification of live burrow by different rodent species in rice	Parbatia and Achyutpur	20	21.12.17

	field			
2	Technique of rat trap placement in field and store	Parbatia and Achyutpur	20	22.12.17
3	Technique of bait preparation and methods of placement of bait in rodent burrows in tomato	Talagarh	18	18.1.18
4	Technique of bait preparation and methods of placement of bait in rodent burrows in sugarcane	Ragadiapada	16	18.1.18
5	Technique of bait preparation and methods of placement of bait in rodent burrows in cucumber	Saptasaryapada	16	20.1.18
6	Technique of bait preparation and methods of placement of bait in rodent burrows in sweet potato	Parbatia	20	20.1.18

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	12.93	0	8.08	2.70	0	0	10.78

DR. B.S. KONKAN KRISHI VIDYAPEETH, DAPOLI, DISTT RATNAGIRI
(2017-18)
(Principal Investigator: Dr V K Patil)

1. Survey and surveillance of bird community structure in Paddy/Pulses system: A total of 24 species of birds were recorded in various pulses grown after harvest of paddy. *Columba livia* and *Petronia xanthocollis* were the most abundant birds. The Indian Roller *Coracias benghalensis* was the most frequent and moderately abundant bird since it is usually a singly feeding species. No species of bird was observed to be raiding crop extensively. But the abundance of insects on pulse flowers attracted several insectivorous birds. **2. Bird community structure Cashew plantations:** Of the total 50 bird species were recorded in cashew plantations two species viz., Red-whiskered bulbul *Pycnonotus jocosus* and Red-vented bulbul *P. cafer* were the most frequent and abundant. Flowering stage (December, January) witnessed almost double abundance of birds compared with fruiting stage (February to April) and even the species richness was relatively high with more than 30 species occurring in both the months (Fig. 3). The two species of sunbirds Purple sunbird *Cinnyris asiaticus* and Loten's sunbird *C. lotenius*, Green Bee-eater *Merops orientalis*, Cattle egret *Bubulcus ibis* and Eurasian golden Oriole *Oriolus oriolus* were relatively common in flowering stage whereas Spotted dove *Stigmatopelia chinensis* and Jungle babbler *Turdoides striata* were common in fruiting stage. The species that occurred throughout the study period included the two bulbul species, Green Bee-eater, Common Iora, Black Drongo, Magpie Robin. Whereas most of the common birds of cashew ecosystem were insectivorous and thus contributing to the pest control function, no bird species were observed to damage cashew nuts or cashew-apple extensively.

3. Study of prey composition of *Tyto alba* using pellet analysis: As reported in previous year, five roosting/nesting sites of Barn owls monitored and 8 species of rodents (*Bandicota bengalensis*, *Bandicota indica*, *Golunda ellioti*, *Millardia meltada*, *Mus philipsi*, *Mus saxicola*, *Rattus rattus*, and *Tatera indica*) and one species of Insectivore, *Suncus murinus* were recorded in the regurgitated pellets. The food-niche breadth of Barn owls was much wider in semi-natural habitat (9 species) than in urbanized habitat (5 species). The wide array of prey species in semi-natural habitat is encouraging as this would result in control of several rodent pests in agricultural lands. *S. murinus* was the most frequent prey item in both habitats. However, in urban habitats, the biomass contribution was more from *B. bengalensis*. The relationship between number of prey consumed per night and prey species consumed revealed that *B. bengalensis* being a larger rodent, one prey individual usually satisfied the diet of the Barn owl for a night. However, whenever, the Barn owls consumed *M. saxicola* or *S. murinus*, it needed to hunt further for more prey individuals.

3. Efficacy of a bioacoustics instrument developed by Grus Ecosciences (Harmony Q3) was studied against southern gray langurs in mango orchard during peak fruiting season however there was no significant deterring effect on langurs as they quickly got habituated to the sounds.

4. Survey of wild animals causing crop damage: Higher vertebrates like Bonnet Macaque, Langur, Wild boar, Gaur, Sambar were recorded to raid the standing crops. Amongst these Bonnet Macaque *Macaca radiata* was ranked as top crop-raider by majority of the farmers.

Budget Utilization

Year	Allocation	Actual expenditure					Total
		P&A	RC	TA	NRC	TSP	
2017-18	2.35	0.00	2.22	0.10	0.00	0.00	2.33

**ICAR- INDIAN INSTITUTE OF HORTICULTURAL RESEARCH (IIHR), BENGALURU
(2017-18)
(Principal Investigator: Dr A K Chakravarthy)**

On an average six monkey troops were found foraging in and around IIHR, Hesaraghatta, Bengaluru during 2014-15. Due to hostile conditions, the monkeys might have moved and settled at another place. This situation is persisting from January 2017. These observations suggested that the monkeys have the mechanism to limit their population depending on the carrying capacity of the habitat.

Monkeys were observed to feed on locally available food like fruits of *Ficus benghalensis*, jackfruit, tamarind etc. As they associated with human settlements, they also received food from local people and at times stealthily took away food items from the provision stores, hotels and residences. The foraging area of this troop was quite larger and this troop use to rapid orchards, gardens and agricultural fields. In January 2017, the number of this troop increased from 30 to 44 and from January- June 2017, the number of animals raised to 49. The troops Comprised of many adults, infants, and so many males and females.

An aggressive monkey troop in a two acre banana plantation in Mathkur near IIHR (about 2 km) was successfully trapped and translocated to forest areas, around 28 monkeys were successfully trapped without any human or monkey casualties. Thus there after no record of monkey damage in the banana plantation occurred. After one year a small troop of 12 monkeys was found feeding and foraging in the banana cultivated patch. During 2017, the caging of animals was continued, however, the monkeys didn't respond to baits in the cages but they continued to feed and forage in the banana cultivated patch. This experiment clearly indicated that monkeys learn quickly to avoid baits and escape from trapping.

The bioacoustic gadget was effective against monkeys and offered complete protection, to all the vegetable and fruit crops up to up to an area of 6 acres for almost 2 months. The operative time of the gadget gradually reduced so that monkeys did not adapt to the sound emanated by the gadget. Observations are being continued. In grape vineyards at IIHR Bengaluru the acoustic gadget was placed on 14th December 2016 to 15 February 2017 when the harvest were completed. The gadget was operated at about 08.30 am in the morning for 5 min. in addition to gadgets the animals were also chased away physically. Observations recorded from March 2017 to August 2017, when the gadget was withdrawn, the troop of monkeys foraged in the area freely and animals didn't showed any inhibition for foraging in the area. Since the vines are in vegetative phase, the monkeys didn't incur any loss/damage to the vines. But the fact that the animals foraged freely in the absence of acoustic gadget revealed that the acoustic gadget was instrumented in protecting the crop from monkey depredations.

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	

2017-18	1.41	0.00	1.41	0.00	0.00	0.00	1.41
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INDIAN INSTITUTE OF SCIENCE, BENGALURU
(2017-18)
(Principal Investigator: Dr S.G. Ramachandran)

1. Efficacy study of Neelbo on wild monkey menace: The present experiment was undertaken to study the efficacy of Neelbo (Pest Control India Pvt. Ltd.), a stray animal repellent on wild monkey menace. A wild monkey troupe consisting of approximately 30 monkeys which are roaming around Indian Institute of Science campus, Bangalore were selected for this study since these animals are damaging the garden around Central Animal Facility (CAF), Indian Institute of Science. The movement, troupe size, duration of their stay near Central Animal Facility were observed for one month before initiating the treatment. Subsequently, experiment was initiated by mixing 500 ml of Neelbo in 2500 ml of water and 10 small pieces of gunny bags (1.5 ft x 1.0 ft) were dipped in the solution. These gunny bag pieces were spread at different locations around Central Animal Facility and observed the monkey menace. It was observed that monkeys which were freely moving freely (before experiment) stopped coming near to the CAF soon after the initiation of experiment. However, few monkeys came nearer to the gunny bags on Day 8 but could not stay for long. This could be due to heavy rains previous day and the contents of the gunny bags must have got diluted. Red arrow in the graph indicates replenishing (re-soaking) the gunny bag with Neelbo again. Monkeys started entering into the garden area again by day 44 onwards. This study indicates that the Neelbo is effective for 20 to 30 days in controlling the monkey menace.

2. Food preference (fruits) by monkeys: In an earlier experiment to identify the preference for fruits by caged monkeys, Jack fruit was the first choice followed by Guava and Singapore cherry. However, another study, banana was also offered to verify the choice of fruits again. It was found that Jack fruit was the first choice again followed by banana and Guava (Table 1). Similar study was conducted on wild monkeys for their preference for fruits. It was observed that Jack fruit was the first choice again followed by banana and Guava (Table 2). It is therefore concluded that jack fruit is the most preferred fruit by both wild and colony born monkeys.

Table 1. Choice of fruits by monkeys

Type of fruit	Animal # 1	Animal # 2	Animal # 3
Jack fruit (<i>Artocarpus heterophyllus</i>)	1	1	1
Banana (<i>Musa</i> spp.)	2	2	3
Guava (<i>Psidium guajava</i>)	3	3	2
Singapore cherry (<i>Muntingia calabura</i>)	4	4	4
Ashoka fruit (<i>Polyalthia longifolia</i>)	5	5	5
Wood apple (Bael fruit) (<i>Limonia acidissima</i>)	6	6	6
Tamarind fruit (<i>Tamarindus indica</i>)	7	7	7

2. Effect of predator alarm calls in monkeys: A bio-acoustic device (Harmony Q3/Q5; Grus Ecosciences; which has frequency range of 80 Hz to 20,000 Hz preloaded with predator calls and

also distress calls was evaluated. This instrument was customized to send the signals starting from 70 decibels to 110 decibels. It was observed that monkeys got alerted initially for the predator calls and few monkeys started looking at the source of predator calls and few monkeys started moving away from the source and try to hide or cover-up. Adult male positions himself conspicuously while the rest of the group were looking at the source of alarm call. The adult male started shaking the body and tries to vocalize loudly to warn other group members. After few minutes their behaviour turned to normalcy and did not respond to the predator calls subsequently. This may be due to our presence in their vicinity and low threat perception.

Table 3. Choice of fruits in wild monkey

Type of fruit	Animal # 1	Animal # 2	Animal # 3
Jack fruit (<i>Artocarpus heterophyllus</i>)	1	1	1
Banana (<i>Musa</i> spp.)	2	2	2
Guava (<i>Psidium guajava</i>)	3	4	3
Singapore cherry (<i>Muntingia calabura</i>)	4	3	4
Ashoka fruit (<i>Polyalthia longifolia</i>)	5	5	5
Wood apple (Bael fruit) (<i>Limonia acidissima</i>)	6	6	6
Tamarind fruit (<i>Tamarindus indica</i>)	7	7	7

3. Effect of predator's urine: Study was undertaken to determine the efficacy of predator's urine in reducing the monkey menace. Two farmlands were selected near Sagar, Shimoga Dist., Karnataka state. Small pieces of cloth were soaked in lion urine (approximately 2-3 ml/piece) and 40-50 such soaked cloth pieces were placed at a distance of approximately 50 m in areas infested with monkey menace. It was observed that scent of urine successfully kept the troupe away from the plantation for 30 days. Similar kind of experiment was repeated with cloth pieces soaked in tiger urine and it was observed that monkeys did not enter the plantation for 21 days. This approach has resulted in keeping away the menace for 3 to 4 weeks effectively.

Budget Utilization

Year	Allocation	Actual expenditure					Total (Rs. in lakhs)
		P&A	RC	TA	NRC	TSP	
2017-18	0.95	0.00	0.76	0.18	0.00	0.00	0.94