Annual Report 2023-24

NETWORK COORDINATING UNIT

All India Network Project on Vertebrate Pest Management

ICAR - Central Arid Zone Research Institute

Jodhpur 342 003

PROGRESS REPORT

2023-24

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Network Coordinator

All India Network Project on Vertebrate Pest Management

ICAR- Central Arid Zone Research Institute

Jodhpur 342 003

Phone: +91-291-2786689

Email: ainpvpmcazri@icar.gov.in

Website: http://www.cazri.res.in/rodent1/about-ainpvpm.php

Edited by

Vipin Chaudhary

Compiled by

Surjeet Singh Bharath

Contributors

Dr Vipin Chaudhary, ICAR-CAZRI, Jodhpur

Dr V Ravinder Reddy, PJTSAU, Hyderabad

Dr Neena Singla, PAU, Ludhiana

Dr Tejdeep Kaur, PUA, Ludhiana

Dr R K Thumar, AAU, Anand

Dr Mohan Ishwar Naik, UAS, Bangalore

Dr Mani Chellappan, KAU, Trissur

Dr N Sriniwasa Rao, APRRI Maruteru, ANGRAU

Dr Ratul K Borah, AAU, Jorhat

Dr Prabal Saikia, ZRS- N. Lakhimpur, AAU

Dr Mohd. Abas Shah, ICAR-CITH, Srinagar

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COORDINATOR'S REPORT

All India Network Project on Vertebrate Pest Management (VPM) has ten centres functional at seven state Agricultural Universities including the Coordinating Unit at CAZRI, Jodhpur. The centres are working on 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 centres during last Review Meeting in 2023. 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.

Salient achievements of the period, includes, habitat analysis of major vertebrate pests to record their pestilence in the different agroclimatic zones of the country falls in the domain of different centres of the Project. In this backdrop survey to monitor the activity of rodent pest in the western districts, viz. Nagaur, Bikaner, Barmer, Sikar and Jaisalmer of Rajasthan were made and in all across the district's 09 rodent pest species were trapped. The relative abundance of different rodent species across the habitats ranged between 4.35-43.48 per cent in Nagaur district, 5.71-25.71 per cent in Bikaner district, 5.26-26.32 percent in Jaisalmer, district, 5.71-34.29 percent in Barmer district and 6.25-25.00 percent in Sikar district. In the Godavari Zone of Andhra Pradesh *Bandicota bengalensis* was predominant in rice fields and banana plantations, while *Rattus rattus* and *Funambulus palmarum* were more commonly found in coconut and cocoa plantations. In poultry, *B. bengalensis* was observed outside the premises, and *R. rattus* inside the premises. *B. bengalensis* in paddy fields could breed 3.89 times during the *Kharif* season, and 2.26 times during the *Rabi* season. The composition of rodent species in Nalgonda, Vikarabad, and Nagarkurnool districts of Telangana revealed higher population of *Bandicota bengalensis* followed by *Funambulus palmarum*. In Mysore and Tumkur Districts of Karnataka, *Bandicota bengalensis*, *Mus booduga* and *Tatera indica* were predominant in cereal and pulses cropping system (Ragi- field bean & Paddy - Cowpea) and the population was peak in harvesting stages of the crop. While the *Funambulus palmarum* and *Hystrix indica* were predominant in horticultural crops. The rodent diversity in villages of different districts of Punjab revealed that in Kharar block, district Mohali, the most predominant rodent species was *Bandicota bengalensis* in paddy/basmati, bajra, and sugarcane crops, while in block Derabassi, district Mohali, *Millardia meltada* was the most predominant rodent species in wheat crop. In crop fields, orchards, and refuge areas of districts Moga, Faridkot and Ludhiana, rodent species trapped were *B. bengalensis*, *Mus* spp. and *Tatera indica*. The population of *T. indica* was more in dry grassland areas near crop fields. *Rattus rattus* was trapped from crop fields near commensal areas at all the locations. The analysis of long-term (1999 to 2024) data on rodent abundance and diversity in district Ludhiana revealed the presence of four rodent species i.e. *Bandicota bengalensis*, *Mus* spp, *Tatera indica* and *Millardia meltada*. The *B. bengalensis* was predominant species in all districts except Sangrur, Barnala, Mansa, Moga, Ferozepur, Faridkot and Mohali where, *T. indica* was predominant. Incidence of rats in rice fields across Kerala revealed significant variations in Live Burrow Count (LBC) and rat population density. The highest LBC was recorded at RRS Mancompu (12.47 per cent), followed by Thekke-900 (9.37 percent), while the lowest was at Madakkathara (3.33 per cent) and Kuttippuram (3.78 per cent). Rat population density was highest in Alappuzha, with Moncompu recording 30 rats/ha, followed by Champakulam (25 rats/ha) and Thekkeakkara (23 rats/ha). In contrast, Thrissur and Thiruvananthapuram showed lower densities, such as Vellanikkara (6 rats/ha) and Palode (5 rats/ha). Moderate densities were observed in Palakkad and Kannur. In Lakshadweep, trap success rates

varied across islands, with Kiltan achieving the highest rate (10.48 percent), followed by Kavaratti (9.18 per cent), while Agatti recorded the lowest (3.16 percent). These findings highlight the regional differences in rat populations and pest control effectiveness. In Upper Brahmaputra Valley Zone of Assam *Bandicota bengalensis* was the predominant rodent species in urban godowns, kitchen garden, paddy fields and crop fields, *Dremomys lokriah macmillani* in homestead gardens and orchards, and *Rattus rattus* and *Mus musculus* in household and rural stores. Besides, *B. indica* have been recorded from orchards and crop fields' near to human habitats and homestead gardens and *Mus booduga* from crop fields mainly paddy, homestead garden and forests. ICAR-CITH, Srinagar recorded Voles, field mouse, rats and shrews from apple orchards.

Total 14 species of birds were recorded from Vadodara district with the relative abundance ranging from 24.72 per cent (cattle egret) to 0.22 per cent (comb duck). The dominant species recorded in bird community of Vadodara district were cattle egret (24.72 percent), painted stork (13.48 percent), lesser whistling duck (13.48 percent) and black ibis (11.24 percent). In Assam a total of 2717 birds were observed from the survey of 14 districts. Barpeta district recorded highest Shannon index of 3.28 with 37 bird species followed by Lakhimpur with 2.8 Diversity index for 26 species. New Record of Indian Peafowl from Assam agro-ecosystem in Narayanguri in Baksa district near Manas National Park, Swamp francolin in Baksa, Biswanath & Golaghat and Bengal Florican & Blue – breasted Quail in Baksa district of the state. A total of 150 species were recorded from Nalgonda, Vikarabad, and Nagarkurnool districts of Telangana with Peafowls being the most abundant across most crops. Among the crops, bird species were high in Sorghum (45sp) followed by Sunflower (38 sp), Bajra (37 sp) and Maize (30sp). In Mysore and Tumkur Districts of Karnataka, Indian peafowl, rock pigeon, munias and Parakeets were predominant in ragi, maize, sunflower, bajra and sorghum crops. Peafowl in rice and vegetable fields across Kerala and Tamil Nadu showed significant variations in population density. Idukki had the highest density at 5.34 peafowl per block, followed by Palakkad (4.67) and Wayanad (4.06), while Ernakulam (1.73) and Kollam (2.03) had the lowest. Fixed plot surveys revealed peak densities in Thrissur (up to 8.33 peafowl per km²) and Palakkad (up to 8.00 per km²), with lower densities in Kasargod (1.39 per km²). Peafowl were most abundant in fields growing cowpea, watermelon, and okra, while rice and cucurbit fields supported fewer birds.

The nilgai population and its distribution in the four blocks *i.e.* Dabhoi, Vadodara, Vaghodiya and Savli of Vadodara district revealed their maximum presence as female (62 percent) group. About 73 per cent of animals were distributed in fallow land, river belt areas and forest area while remained 27 per cent animals was observed in various crops field. The density of Nilgai was highest in Sumerpur tehsil of Pali district (16.7 individuals per sq. Km) followed by Mundwa tehsil of Nagaur district where density of nilgai was 10.85 individuals per sq. Km in the arid region of Rajasthan. In district Ludhiana in vehicle transect were conducted in 30 habitat clutches (68 villages and 11 forests) of 12 blocks for population assessment of blue bull in the area. The maximum density of blue bull was found in clusters of block Ludhiana-2, and the minimum in block Samrala cluster. The absence of harem groups (male in the female group) in summer & monsoon indicates non-breeding seasons (May-Aug), while their availability in Pre winter, winter, and spring and autumn indicates breeding seasons (Sep-April). There was a total of 849 blue bull sightings in 386 transects during the study period. Female biased sex ratio in adults and sub-adults indicated a high rate of population growth with the birth rate of 01 calf/female. Coordinates of identified habitat villages and forests of blue bull were recorded and mapped.

Wild boar population assessed on the basis of footprint and scat analysis across Nalgonda, Vikarabad, and Nagarkurnool districts in Telangana was in the range of 205 to 2,598 individuals, with high

concentrations in forest fringe areas and crop fields, leading to significant agricultural damage. In Mysore and Uttara Kannada Districts of Karnataka the wild boar mean group size was ranged from 5-16. Wild boar activity in banana and tuber crops across Kerala and Tamil Nadu revealed significant variations in population density. Idukki had the highest average density of wild boars at 12.98 per block, followed by Pathanamthitta (9.12) and Kottayam (8.87), while Ernakulam (2.90) had the lowest. The fixed plot survey showed Idukki's Adimali (15.97 pigs/km²) and Pannimattom (13.19 pigs/km²) had the highest densities, while Ernakulam and Kasargod had lower densities, such as Nileshwar at 2.00 pigs/km². Other areas, like Kumarakom (10.67 pigs/km²) in Kottayam and Balaramapuram (7.64 pigs/km²) in Thiruvananthapuram, showed moderate to high densities, indicating varying impacts on agriculture based on local habitat conditions.

The population density of 195 individuals were recorded with a group size of 8-40 monkey from different locations of Sivasagar and Charaideo districts of Assam. Rhesus macaques were the dominant macaque species in crop fields in Godavari zone (Andhra Predesh). The survey identified 13 macaque troops with a total population of 612 animals, averaging 51 animals per troop. The male-to-female ratio was 1:3.3, with infants being the largest demography, averaging 25.3 per troop, followed by females at 20.5 and males at 6.16. The sex ratio of monkeys in all the study areas in Telangana showed 1:1.89 for male to female and 1:2.1 for female and juvenile. In Mysore and Uttara Kannada Districts of Karnataka the mean group of monkey size ranged from 5 to 18.

In Telangana the problem of black buck was more in crop fields as revealed from their maximum presence in crops (46%) followed by open lands (36 percent) thorny scrub (14 percent) and rocky out crops (7 percent).

Rodent damage to paddy crop across the different locations in Kerala showed varying impacts. Thrissur, Vettikkal had 4.73 per cent damage (196 kg/plot), while Madakkathara had the lowest at 3.49 percent (144 kg/plot). In Alappuzha, RRS Mancompu the highest damage (13.07 percent, 540 kg/plot) was recorded. Malappuram districts showed moderate damage, with Kuttippuram at 5.7 per cent (242 kg/plot). In Lakshadweep, Kavaratti had the highest coconut nut damage (24.57 per cent), while Agatti had the lowest (13.71 percent). The yield loss caused by rodents in different crops under UBVZ of Assam revealed a yield loss in the range of 0.96-2.64q/ha in *sali* rice and 0.68-2.44 q/ha in *boro* rice. Similarly, in vegetable crops the yield loss in the range of 0.61-0.89q/ha was recorded in pea, 0.41-1.86q/ha in potato, and 0.79-2.91q/ha in pumpkin. Rodent damage in rice and wheat was ranged between 0.29 to 1.40 percent in villages of districts SAS Nagar, Bathinda, Malerkotla and Patiala in Punjab. At Srinagar severe damage due to voles was observed in clonal rootstock M9, where the damage was mainly in the root system or the trunk up to 1 foot from ground level. The damage to apple plants was found in the range of 2-8 percent (n = 16) in the surveyed orchards.

Cane damage by parakeet in Sugarcane crop in Lakhimpur (Assam) was most in Borak variety (16.26 per cent) against 7.92 per cent in Kolong. The extent of bird damage in the study locations of Telangana recorded high damage in maize during sprouting stage (25 percent), while in bajra it was 15-20 percent in milky stage followed by Sunflower (10-30 percent). Peafowl damage in rice and vegetable fields across Kerala and Tamil Nadu revealed significant yield losses in various crops. The highest damage was observed in Idukki, where cowpea in Chalassery suffered 19.3 per cent damage, followed by cowpea in Aralam, Kannur (18.8 per cent) and amaranthus in Chovoor, Kottayam (17.2 percent). Rice crop in Perumpalam, Alappuzha had 15.6 percent damage, while Wayanad showed the lowest damage, with cowpea at Kunnampetta experiencing only 4.3 percent damage. In Coimbatore, bottle gourd in

Meenakshipuram faced the most severe impact, with 9.01 percent damage and a yield loss of 600.61 kg/ha, cowpea in Anaimalai had the least damage at 4.8 percent. Overall, cowpea, bottle gourd, and okra were most affected by peafowl damage.

Blue bull damage in Punjab was found throughout the crop growth period with maximum damage at the fruiting stage of crops. Animals caused maximum damage to maize followed by oat, wheat, moong, mustard, cotton, and paddy indicating maize as the preferred crop. In Haryana, monetary loss due to blue bull was more to cotton followed by wheat and mustard crops. In Punjab, monetary loss due to blue bull was maximum for maize followed by wheat and moong crops. Damage to poplar cop was maximum from nursery to 2-year-old plants and at later stages, poplar fields were preferred for resting.

Wild boar damage in rice crop was 12 per cent (0.00 to 20.00 per cent) and in maize crop it was 11.76 per cent (0.10 to 13.00 per cent) in Vadodara district of Gujarat. The damage in banana field was more due to trampling activity. The wild pig damage to Paddy, Maize, vegetables, Chilli, Colocacia was recorded from the fields located nearer to Kaziranga Natural Park and Pobitora Wildlife sanctuary in Assam. The wild boar damage was high in groundnut (40-45 percent) followed by Rice (20-35 percent), Sorghum (25-28 percent), and Cotton (10-22 per cent) in Telangana. Wild boar damage was severe in ragi, banana, paddy, groundnut and cowpea crop in In Mysore and Uttara Kannada Districts of Karnataka. Wild pigs damage in cassava crop was assessed across the districts in Kerala and highest damage was recorded in Idukki, with Adimali experiencing 10.1 per cent damage, resulting in a yield loss of 1,870.27 kg/ha, followed by Thodupuzha (8.9 per cent) and Agandipuram (8.9 per cent) in Malappuram. In contrast, the lowest damage was in Pathanamthitta (2.4 per cent) and Kasargod (2.9–3.5 percent). In Coimbatore, wild pig damage varied by crop, with bottle gourd in Meenakshi Puram sufferd the most (9.01% damage, 600.61 kg/ha), followed by Pollachi's okra (7.2 percent, 133.3 kg/ha). Other areas, including Madhukkarari (cucumber), Kottur (bitter gourd), and Kinathukadavu (cucurbits), experienced moderate losses, while Anaimalai had the least damage, with cowpea showing only 4.8% damage with yield loss of 60 kg/ha.

Macaques damage was recorded in the crops such as maize, banana, coconut, cashew, and oil palm in Godavari zone. In oil palm, 35.5 percent of trees were infested, with 2.6 percent nut damage. Maize fields experienced a yield loss of 1.78 quintals per acre, and banana suffered 14.2 percent fruit damage. The assessment of damage caused by monkeys in the study areas (Nalgonda, Vikarabad, and Nagarkurnool) of Telangana recorded higher damage in Guava (33.3 percent) followed by Cotton (24.6 percent), and Rice (14.8 percent). In paddy, the yield loss caused by Rhesus macaque in Jorhat, Assam was in the range of 1.11-3.46 q/ha, in potato it was 1.11-3.46 q/ha, in vegetables like cabbage and cauliflower, the yield loss was in the range of 1.11-2.97 q/ha and in fruits, they caused an average yield loss of 1.11-4.86 q/ha.

The extent of Blackbuck damage was predominantly high in maize during sprouting stage (28.4 percent) followed by vegetative state (21.1 percent). In case of cotton, blackbuck caused damage more during flowering stage (32.9 percent) where as in groundnut the extent of damage was noticed in all the stages and ranged between 9.6 percent (sprouting stage) to 31.9 percent (maturity stage) in Telangana.

Laboratory evaluation of Kalmegh panchang at 1, 2, 3 percent concentration in bait was very effective, as the consumption of treated bait in all the concentration in choice test was nil. In the village of Goteru (Andhra Pradesh) during *Kharif* 2023, installation of Trap Barrier System (TBS) provided full protection to the paddy crop against rodent pest. The TBS offered 100 percent protection in rice nurseries and 74-92 percent protection against tiller damage in the main field. Reduction of height of TBS to 1.75 ft and a

low-cost multi-catch mesh trap found effective and economical. In storage, bromadiolone (0.005 percent) liquid bait, (mixed with a solvent (DMF), preservative (SB), and jaggery) achieved 87.5 percent control success. In comparison, bromadiolone RB recorded a control success rate of 50 percent, and bromadiolone CB achieved 37.5 percent success. Baits containing *Gliricidia* leaf and bark powders, used alone or with dehulled maize cob powder, resulted in 20-60 percent rodent mortality over 20 days, while bromadiolone (0.005 percent) achieved 100 percent mortality within 8.14 days. Botanicals, namely Neem, Gliricidia, Vitex, Garlic, Chilli and Pepper extracts was found effective as repellent (88.33-78.85 %) against rodents at 8 and 10 per cent and the effect was up to 12-13 days. In organic/natural cropping system the combination of cultural practices, trapping and application of botanicals recorded the reduction in rodent population by 71.26 per cent. Application of Brodifacoum 0.005 percent BB at 15 days before transplanting and grain maturity in rice significantly reduced the rodent population by 83.12 per cent. In sugarcane two application of Brodifacoum 0.005 percent BB in the month of August and September at 15 days interval after the first treatment significantly reduced the rodent population by 80.68 per cent. The Trap Barrier System (TBS) in the deep-water rice fields of Thekke-900 and Ezhukkad, Kerala, was very effective in control rat infestations. A total of 335 rats were captured, with significant fluctuations in weekly captures. Fields protected by TBS yielded 5.43 t/ha in Thekke-900 and 5.53 t/ha in Ezhukkad, compared to 3.25 t/ha and 3.39 t/ha, respectively in unprotected fields. The spray of castor based botanical rodenticides (ecodon) on bunds during tillering stage of rice at Jorhat in the evening hours reduced the rodent population to 59.03 and 54.4 per cent after Ist week of treatment, 51.83 and 41.6 percent after 2nd weeks of treatment and 30.7 and 29.4 percent after 3rd week of treatment in terms of LBC and TI, respectively. In *boro* rice, the treatment T3 **(**zinc phosphide baiting at PI stage+ bromodiolone baiting at milky stage) recorded the highest reduction in rodent damage (65.31 percent) followed by treatment T4 (bromadiolone baiting at PI stage + trapping). Evaluation of ready-to-use brodifacoum bait (0.005 percent) against *Bandicoot bengalensis* and *Rattus rattus*, in no-choice and choice trials, revealed 100 percent mortality of male and female of *R. rattus* and *B. bengalensis* in no-choice tests within 3-6 and 2-3 days, respectively. Whereas, in choice test 33.33-66.67 percent mortality in male and female of *R. rattus* within 3-9 days and 50-83.33 percent in male and female of *B. bengalensis* within 5-8 days was achieved. LFP_{50} was determined to be 1.81 and 1.82 days in male and female *R. rattus* and 2.10 and 2.33 days in male and female *B. bengalensis*, respectively. Quinestrol, based nanoparticles (QNP) was prepared using the emulsion-evaporation method and evaluated with blank PLGA nanoparticles (PNP). The impact of these nanoparticles on the level of reproductive hormones in female rats (*Bandicota bengalensis*) measured using ELISA and compared with the effect of bulk quinestrol (QB). The amount of quinestrol loaded in QNP was 10 times less than that in QB and was effective for 75 days, demonstrated prolonged efficacy in altering reproductive hormones compared to QB, which remained effective for 45 days. The PLGA based nanoparticles thus represented a promising approach for sustained delivery of quinestrol to effectively control fertility in rodents.

Butter paper bag and non-woven bags with (4.82, 6.71) shown maximum protection in guava against parakeets. Maximum average number of healthy fruit 7978.71 kg/ha was recorded in treatment of butter paper bagging which was at par with the nonwoven bagging (7667.08 kg/ha). Cent per cent protection in pomegranate was received from paper bag and nylon net bagging against rose–ringed parakeet (*Psittacula krameri*) depredation at Anand. Integration of bio acoustic, Eco gun and wrapping of maize cobs in outer three rows reduced the cob damage in maize crop due to parakeet to 13.56 percent against 44.47 per cent damage in untreated control. Depredation of birds at Telangana in Maize at sowing stage was reduced to 87.5 percent by application of whole egg solution @ 2%, while in sunflower spray of salt

solution @ 25 gm/lit at milky stage recorded reduced damage of 25.9 percent and similarly in sorghum spray of Egg + Hing @ 25ml/lit recorded reduced damage percentage of 15.67. In bajra crop the treatments of salt solution @25gm/lit recorded reduced damage percentage 18.9. In the management of parakeets in sunflower and maize crop the least ear head cob damage was recorded when the crop fields were protected with Nylon net (0 %), followed by bioacoustics device (3.26 percent), placement of reflective tape in grid format (4x4 ft) (3.47 percent) and wrapping of maize cobs with adjacent leaves (5.31 percent). An electronic sensor-based scarecrow developed by PAU center was effective to detect the birds and immediately turn on the lights and sound to ward off them.

Management of blue bull by physical barriers (such as barbed wire fencing, chain-linked fencing, electric fencing, and nylon net), mechanical and visual deterrents (such as bioacoustics devices, LED bulbs, and reflective ribbons) and repellents (such as phenyl, neelbo, and repellent based formulation i.e., RBF) was attempted in different crops in Punjab. Physical barriers, such as, chain-linked fencing, electric fencing, and nylon net, each at a height of ≥ 7 feet, had given promising results by providing complete protection for ≥ 2 years. Bio-acoustic devices and reflective ribbons successfully reduced animal visits or percent damage for a short period of time, while, chemical repellents, RBF significantly reduced the percent crop damage, was cost-effective and remained operative for 21-69 days.

Kheti rakshak and repellents application prevented the entry of wild boar in paddy crop or nearby field area up to 15 days at Vadodara (Gujarat). Application of RBF repellent pouches @ 10 feet at Sowing and pod formation stage of groundnut crop separately enhanced the yield by 20.51 per cent by deterring the wild boar. Laser-Based Animal Repeller to deter wild pigs, by using a laser beam to trigger distress and predator sounds when interrupted developed by KAU, Thrissur evaluated with other wild pig management methods, including solar-based electric fencing, shade net fencing, bio-acoustic devices, and olfactory repellents. The laser repeller demonstrated moderate effectiveness, with 4.19 percent plant damage and a yield of 239.11 kg/plot, outperforming the control plot (16.27 percent damage, 156.91 kg/plot) and olfactory repellents. The sprayable olfactory repellent, BoRep, to deter wild boars and rodents, wherein a stable, water-miscible nano-formulation, is the target is under developmental stage.

A maximum avoidable loss of 76.13 per cent can be achieved in Papaya by protecting crop from Monkey with HDPE net. Nylon netting around maize fields provided 45-64 percent protection by macaque visits to the fields. Additionally, low-cost solar fencing offered 78.3-94.0 percent protection against macaques and increased the yield by 15-31 percent compared to non-solar fenced fields at Maruteru (Andhra Pradesh). The cost of solar fencing was Rs. 25,000 for 6 acres of field. Use of nylon net, solar fencing and neelbo repellent was found to be effective in managing the monkey menace in the crop fields throughout the crop period in Rural District of Bengaluru.

In the management of deer in groundnut and ragi crop at Pavagada (Karnataka) placement of nylon net, solar based led deterrent light was found to be effective in reducing the crop raids.

A field demonstration of *Kheti Rakshak* (Model: KR-18) was organized in paddy field at Paddy Research station, Dabhoi, Vadodara district. Two exhibitions were organized at Vadodara block (Vadodara district) and Petlad block (Anand District) on vertebrate pest management. Training and demonstration on Vertebrate Pest Management were organized for farmers of villages of Jaisalmer, Chandan and Mohangarh of district Jaisalmer, Inana and Amarpura of district Nagaur, Meghsar and Chandsar of district Bikaner, Kawas and Bidasar of district Barmar and Gokulpura and Chanpura of district Sikar. Under Tribal Sub Plan of AINP on VPM Two field training on “Rodent Pest Management” was conducted in the villages of Chandela and Girwar, District Sirohi in Panchyat Bhawan on 23th & 24th

August, 2023, respectively. Proven technologies were demonstrated in 6.0 ha of area at North Lakhimpur, the solar fencing ***(AGRI- SOLAR***), was very effective in preventing the Monkey. Similarly, ECO-Gun and wrapping of maize cobs in outer 3 rows significantly reduced the cob damage by parakeets. Fencing by HDPE net of 5 cm mesh and 1.5 mm thickness up to 8 feet in height found very effective in preventing monkey's entry in to the crop fields to the extent of 80-100 per cent and also very cost effective. Mass rodent control campaigns were organized in the adopted village of Chinnamallam during *Kharif* 2023 and *Rabi* 2023-24, targeting paddy fields during the tillering stage. The success rate for rodent control was 77.65 percent in terms of live burrows and 73.3 percent in terms of tiller damage during *Kharif*, and 79.76 percent for live burrows and 77.97 percent for tiller damage during *Rabi*. Demonstrated Agri-solar in eleven locations in Telangana to control monkey damage in different crops and received cent per cent protection with positive feedback. Agri-solar technology was implemented in ten locations in Telangana to manage wild boar populations and reduce crop damage. Across all the locations, crops protected with Agri-solar technology reported no damage, while control fields experienced a damage ranging from 20 to 45 percent. The incremental cost-benefit ratios ranged from 1:0.98 to 1:6.97 depending up on the crop and were highest in groundnut.

Participatory adaptive research on vertebrate pest management (VPM) was taken up in three villages *viz.*, Mothirakanni, Chelakkara, and Kambolachira (Kerala) with local farmers to address wild boar and rodent issues. The research included various management techniques such as Kumbham traps, BoRep olfactory repellent, and physical barriers like shade nets and electric fencing. Results show that BoRep reduced wild boar incidence by 42-45 percent, and electric fencing was the most effective in protecting cassava, with a 45.6 percent yield increase. A KAP survey on vertebrate pest management (VPM) showed that while most farmers (58 percent) had good knowledge of pest damage symptoms, fewer understood the causes (32 percent) and management techniques (37.6 percent). The most adopted practice was repellent use (48 percent), followed by net fencing (14.4 per cent) and coloured saree fencing (12.4 percent). Fewer farmers used solar-electric fencing (6 percent) or bio-acoustic devices (1.6 percent). The results highlight a need for more education on pest causes and broader adoption of effective management strategies.

A total of 261 moorhens were found (11.86 moorhens on average per wetland) in wetlands of Padra, Savli, Karjan, and Dabhoi block of Vadodara district. The population was more in marshy land (70 per cent) and less in ponds (30 per cent). A very little damage was observed in paddy crop in the initial stage after transplanting.

Damage caused by five striped squirrel, *Funambulus pennantii* was recorded in orchards and crop fields. The highest relative percentage damage was recorded to peach (33 percent) followed by loquat (26 per cent), raspberry (24 per cent), ber (22 per cent), kakri (18 per cent), sponge gourd (15 percent), tomato (13 percent) and brinjal (9 percent). Installation of an aluminium cone guard on the trunk and reflective ribbon on the canopy of plum trees resulted in 90 percent protection of fruits from squirrels and parrots. The use of different methods such as reflective ribbon, reflective ribbon + nylon net, and reflective ribbon + nylon net + reflective CDs was found to achieve 40-70 percent control success. The mean damage to pomegranate flowers and fruits across the month was 9.97±3.98 and 13.20±3.16 percent, respectively, whereas; mean yield loss to dates was 80.47 gm per bunch per plant due to *F. pennantii*. Among various treatments applied, control success with treatments, Netting+Trapping+Bagging, Netting+Trapping+Bagging+Burrow Baiting and Netting around the border were at par in pomegranate and date palm.

Southern palm squirrels, *Funambulus palmarum* spent 40.73 percent of their time (16.29 minutes) on feeding followed by exploring (22.9 percent), moving (15.03 percent), chasing (2.78 percent), resting (8.95 percent), freezing (1.35 percent), grooming (1.13 percent), and other activities (2.65 percent). Among the various repellent tested, T4 (Sulphur) and T3 (Garlic and dry chili mixture) was most effective, with 96.46 and 95.56 percent control success, respectively. The highest squirrel population density and crop damage was recorded in pomegranate plantations and protection with nylon fish nets of 1-inch mesh size and installing of the metal funnel trap reduced the squirrel population in pomegranate plantations.

The assessment of integration of different treatments on the incidence of squirrel (*Dremomys lokriah*) in coconut revealed that among various treatment combinations, treatment T4 (squirrel guard at the height of 8 ft at 45-degree angle from the ground + trapping) was the best, as the squirrel infestation as well as the nut damage in this treatment was reduced to 62.36 & 53.23 percent, respectively.

Porcupine damage to crops in Kerala, particularly cassava, coconut, brinjal, and papaya, has become a significant concern for farmers, especially in hilly and forest-adjacent areas. Highest damage due to porcupine was recorded in coconut (8.50 ± 4.04) and cassava (8.00 ± 3.26). Management of porcupine through various methods (BoRep, Rogor, natural repellents, and different fencing options) in farmers' fields at Madakkathara revealed that the iron sheet fencing (T5) was the most effective, showing the lowest plant damage (0.50 ± 0.57) and yield loss (49.89 kg/ha), followed by Rogor application and BoRep. The control plot, with no protection, experienced the highest damage and yield loss (309.11 kg/ha).

Metagenomic analysis of gut microbiomes in agriculturally important birds identified Proteobacteria, Firmicutes, and Bacteroidetes as dominant bacterial phyla in the little egret, with species like *Pseudomonas spp*. and *Escherichia spp*. aiding in antibiotic resistance control, digestion, and vitamin production. In peafowl, *Prevotella* spp. helped digest plant material, while *Bacillus* spp. provided antifungal and immune-modulating benefits. These findings highlight the functional roles of gut microbes in supporting organism health and potential agricultural benefits.

Genomic DNA was extracted from non-invasive faecal samples using the QIAamp Fast DNA Stool Mini Kit (Qiagen, Germany) following the manufacturer's protocol. The study reported the first documented invasion of *Rattus tanezumi* in north-western India, identified through mtDNA COI and CytB barcoding. The findings indicated that *R. tanezumi* has expanded its range into new areas of northern and northwestern India, where it has likely been misidentified as *R. rattus* due to its morphological similarities. Phylogenetic analysis of the Punjab isolates revealed that these sequences clustered tightly with a known *R. tanezumi* isolate from China.

The ready-to-use stable synthetic pheromone (acetophenone) based zinc phosphide bait proved highly effective as rodenticide even after extended storage periods. It could be effectively used for instant relief against rodent pests and to mitigate bait shyness /poison aversion in rats against zinc phosphide.

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MULTILOCATIONAL PROGRAM

1. HABITAT ANALYSIS AND DISTRIBUTION OF MAJOR VERTEBRATE PESTS

India's diverse ecosystems host a range of vertebrate pest species that impact agriculture, forestry, and human settlements. The seriousness and frequency of impact by these pests depend much on the type of habitat they prefer, their adaptability, and geographical distribution. A thorough understanding of the habitats these pests occupy and their distribution patterns is essential for developing targeted and effective management strategies.

Habitat analysis provides insight into environmental conditions that facilitate or inhibit vertebrate pests' populations. Vertebrate pests differ by type of vegetation, climate, availability of food and water, and human activities in establishing, reproducing, and relationships with their surroundings. Species composition and density also differ in different regions, sometimes to the detriment of native ecosystems as well as human interests. For instance, rodents thrive in agricultural fields, cities, and towns with adequate food and cover in which they can cause marked crop losses and extensive damage to stored food products. Birds can exploit open fields, fruit orchards, and grain storage facilities that prove a demanding proposition for farmers and food storage managers.

Distribution patterns of vertebrate pests might be seasonal and geographically variable due to the movements, climate change, and changes in land use. Mapping and analysing the distribution of major vertebrate pests across different habitats provide critical data for predicting infestation risks and implementing timely management measures. Such knowledge enables pest control professionals and ecologists to design localized, ecologically sound, and cost-effective strategies to mitigate the impacts of these species.

In this context, examining the habitat preferences and distribution of vertebrate pests is a foundational step in managing their populations. It allows for a better understanding of the dynamics between pest species and their environments, ultimately helping to protect agricultural productivity, biodiversity, and public health.

Accordingly, the centers are continuously making attempt to assess the habitat preferences and distribution of wild herbivores across different states, focusing on identifying the environmental and anthropogenic factors that influence their presence and density. This assessment provides a foundation for developing region-specific management strategies that consider both ecological and economic impacts, ultimately aiming to reduce the damage caused by these resilient and prolific species.

1.1. RODENTS

1.1.1. Rajasthan (CAZRI, Jodhpur)

A survey was conducted in the arid districts of Rajasthan to assess the impact of land-use changes, driven by increased irrigation facilities through river canalization, and other climatic factors on the native rodent fauna (Fig. 1.1). During the survey year, the Nagaur, Bikaner, Jaisalmer, Barmer, and Sikar districts were studied across three distinct habitats: crop fields, areas near habitation (ruderal), and fallow lands. Live trapping was conducted using Sherman traps, with 30 traps arranged in a trap line in each of the selected habitats, ensuring comprehensive coverage of rodent populations in the region. The primary crops cultivated in the irrigated fields of the surveyed districts included groundnut, guar, bajra, til, and moong during the kharif season, and mustard, cumin, and wheat during the rabi season. In fallow lands, the vegetation primarily consisted of shrubs, bushes, and trees. Trapping in these diverse habitats revealed the presence of nine pest rodent species across the districts. Specifically, in the Nagaur district, 69 individuals representing six species were trapped over 360 trapping nights. The species identified included *Tatera indica*, *Millardia meltada*, *Golunda ellioti*, *Mus booduga*, *Mus musculus* (Murinae), and *Funambulus pennanti* (Sciuridae), highlighting the diversity of rodent fauna in the region (Table 1.1). In Bikaner, 35 individuals were trapped over 360 trapping nights across various habitats, representing seven rodent species. These included *T. indica* and *Meriones hurrianae* (Gerbillinae); *M. meltada*, *Mus booduga*, *R. rattus*, and *Mus musculus* (Murinae); and *F. pennanti* (Sciuridae). Additionally, an insectivore, *Suncus* sp., was also recorded (Table 1.2). In Jaisalmer, 19 individuals were trapped over 360 trapping nights across habitats, with seven species: *T. indica*, *M. hurrianae* (Gerbillinae), *Gerbillus gleadowi*, *Gerbillus nanus*, *R. rattus*, *M. booduga* (Murinae) and *F. pennanti* (Sciuridae) (Table 1.3). In

Barmer 35 individuals were trapped over 360 trapping nights across habitats, with six species: *T. indica, M. hurrianae* (Gerbillinae)*; M. musculus* and *M. booduga* (Murinae), *F. pennanti* (Sciuridae) and *R. rattus* (Table 1.4). In Sikar 16 individuals were trapped over 360 trapping nights across habitats, with six species: *T. indica, G. ellioti, M. booduga, R. rattus, M. musculus* (Murinae) and *F. pennanti* (Sciuridae) (Table 1.5). In Nagaur, Jaisalmer and Sikar districts, *T. indica* was predominant, whereas in Bikaner and Barmer districts, *M. hurrianae* was predominant across habitats. However, among the habitats more individuals were trapped from crop fields, with a corrected trap success of 48.62, 15.11, 7.23, 13.43 and 5.88, respectively, from Nagaur, Bikaner, Jaisalmer, Barmer and Sikar districts (Tables 1.1a, 1.2a, 1.3a, 1.4a & 1.5a).

The Shannon Diversity Index across various habitats indicated greater diversity in the crop fields. In Nagaur district, the index was 1.43, with six species; in Bikaner district, it was 1.72 with seven species; in Jaisalmer district, it was 1.42 with seven species; in Barmer district, it was 1.27 with six species; and in Sikar district, it was 1.14 with six species (Tables 1.1b, 1.2b, 1.3b, 1.4b & 1.5b). The relative abundance of different rodent species across habitats ranged from 4.35percent to 43.48percent in Nagaur district, 5.71 per cent to 25.71percent in Bikaner district, 5.26 percent to 26.32 percent in Jaisalmer district, 0.56 percent to 3.33 percent in Barmer district, and 6.25 percent to 25.00percent in Sikar district (Tables 1.1, 1.2, 1.3, 1.4 & 1.5).

Table 1.1. Species composition and relative abundance of rodent pests in different habitats of Nagaur District

Species	Crop Field	Ruderal	Natural Fallow	Total	RA (percent)	TS
Tatera indica	28	0	2	30	43.48	8.33
Millardia meltada	16	0	0	16	23.19	4.44
Funambulus Pennantii	6	3	0	9	13.04	2.50
Golunda ellioti	7	0	0	7	10.14	1.94
Mus musculus	2	2	0	4	5.8	1.11
Mus booduga	3	0	0	3	4.35	0.83
Total	**62**	**5**	**2**	**69**	**100**	**19.15**
RA (percent)	**89.85**	**7.24**	**2.89**	**-**	**-**	**-**

Table 1.1a. Habitat-wise corrected Trap Success

Observation	Crop field	Ruderal	Fallow	Total
No. of trap nights	180	90	90	360
No. of captures	62	5	2	69
No. of sprung traps	19	10	15	44
Sprung trap (percent)	10.56	11.11	16.66	38.33
Adjusted Trap success (percent)	38.50	6.25	2.66	47.41
Corrected Trap success (percent)	**48.62**	**6.45**	**2.70**	**55.77**

Table 1.1b. Rodent Diversity in different Habitats

Diversity indices	Crop field	Ruderal	Fallow
Number of species	6	2	1
Shannon index (H')	**1.43**	**0.60**	**0.00**
Species richness (d)	1.211	0.612	0.00
Evenness index (J)	0.798	0.865	0.00
Simpson's Index (D)	0.704	0.480	0.00

Table 1.2. Species composition and relative abundance of rodent pests in different habitats of Bikaner District

Species	Crop Field	Ruderal	Natural Fallow	Total	RA (percent)	TS
Tatera indica	5	0	2	7	20.00	1.94
Meriones hurrianae	7	0	2	9	25.71	2.50
Millardia meltada	2	0	0	2	5.71	0.56
Funambulus Pennantii	5	0	0	5	14.29	1.39
Mus booduga	2	0	2	4	11.43	1.11
Rattus rattus	1	2	0	3	8.57	0.83
Mus musculus	1	4	0	5	14.29	1.39
Total	**23**	**6**	**6**	**35**	**100**	**9.72**
RA (percent)	**65.72**	**17.14**	**17.14**	**100**	**-**	**-**

Table 1.2a. Habitat-wise corrected Trap Success

Observations	Crop Field	Ruderal	Fallow	Total
No. of trap nights	180	90	90	360
No. of captures	23	6	6	35
No. of sprung traps	16	10	12	38
Sprung trap (percent)	8.88	11.11	13.33	33.32
Adjusted Trap success (percent)	14.02	7.5	7.69	29.21
Corrected Trap success (percent)	**15.11**	**7.79**	**8.00**	**30.9**

Table 1.2b. Rodent Diversity in different Habitats

Diversity indices	Crop Field	Ruderal	Fallow
Number of species	7	2	3
Shannon index (H')	**1.72**	**0.27**	**1.09**
Species richness (d)	1.913	0.558	1.116
Evenness index (J)	0.833	0.389	0.992
Simpson's Index (D)	0.794	0.444	0.667j

Table 1.3. Species composition and relative abundance of rodent pests in different habitats of Jaisalmer district

Species	Crop Field	Ruderal	Fallow	Total	RA (percent)	TS (percent)
Tatera indica	5	0	0	5	26.32	1.39
Funambulus Pennantii	1	1	0	2	10.53	0.56
Rattus rattus	0	2	0	2	10.53	0.56
Mus booduga	1	0	1	2	10.53	0.56
Gerbillus gleadowi	2	0	1	3	15.79	0.83
Gerbillus nanus	0	1	0	1	5.26	0.28
Meriones hurrianae	3	1	0	4	21.05	1.11
Total	12	5	2	**19**	**100**	**5.29**
RA (percent)	**63.15**	**26.31**	**10.52**	**-**	**-**	**-**

Table 1.3a. Habitat-wise corrected Trap Success

Observation	Crop field	G/R	Fallow	Total
No. of trap nights	180	90	90	360
No. of captures	12	5	2	19
No. of sprung traps	08	06	05	19
Sprung trap (percent)	4.44	6.67	5.56	16.67
Adjusted Trap success (percent)	6.97	5.95	2.35	15.27
Corrected Trap success (percent)	**7.23**	**6.13**	**2.38**	**15.74**

Table 1.3b. Rodent Diversity in different Habitats

Diversity indices	Crop field	G/R	Fallow
Number of species	5	4	2
Shannon index (H')	**1.424**	**1.332**	**0.693**
Species richness (d)	1.609	1.864	1.442
Evenness index (J)	0.884	0.961	0.999
Simpson's Index (D)	0.722	0.720	0.500

Table 1.4. Species composition and relative abundance of rodent pests in different habitats of Barmer district

Species	Crop Field	Ruderal	Fallow	Total	RA (percent)	TS (percent)
Meriones hurrianae	7	5	0	12	34.29	3.33
Rattus rattus	0	0	2	2	5.71	0.56
Mus booduga	2	1	0	3	8.57	0.83
Tatera indica	4	4	0	8	22.86	2.22
Mus musculus	0	0	2	2	5.71	0.56
Funambulus Pennantii	8	0	0	8	22.86	2.22
Total	**21**	**10**	**4**	**35**	**100**	**9.72**
RA (percent)	**60**	**28.57**	**11.43**	**100**	**-**	**-**

Table 1.4a. Habitat-wise corrected trap Success

Observation	Crop field	Ruderal	Fallow	Total
No. of trap nights	180	90	90	360
No. of captures	21	10	4	30
No. of sprung traps	13	10	8	31
Sprung trap (percent)	7.22	11.11	8.88	27.21
Adjusted Trap success (percent)	12.57	12.5	4.87	29.94
Corrected Trap success (percent)	**13.43**	**13.35**	**5.00**	**31.78**

Table 1.4b. Rodent diversity in different habitats

Diversity indices	Crop field	Ruderal	Fallow
Number of species	4	3	2
Shannon index (H')	**1.274**	**0.943**	**0.693**
Species richness (d)	0.985	0.868	0.721
Evenness index (J)	0.918	0.858	0.999
Simpson's Index (D)	0.698	0.580	0.500

Table 1.5. Species composition and relative abundance of rodent pests in different habitats of Sikar district

Species	Crop Field	Ruderal	Fallow	*Total*	*RA (percent)*	TS (percent)
Tatera indica	2	0	2	4	25.00	6.94
Mus booduga	1	0	0	1	6.25	1.74
Rattus rattus	0	3	0	3	18.75	5.21
Golunda ellioti	3	0	0	3	18.75	5.21
Mus musculus	1	0	0	1	6.25	1.74
Funambulus Pennantii	3	0	1	4	25.00	6.94
Total	**10**	**3**	**3**	**16**	**100**	**27.78**
RA (percent)	**62.30**	**18.85**	**18.85**	**100**	**-**	**-**

Table 1.5a. Habitat-wise corrected Trap Success

Observation	Crop field.	Ruderal	Fallow	Total
No. of trap nights	180	90	90	360
No. of captures	10	3	3	16
No. of sprung traps	5	6	10	21
Sprung trap (percent)	2.77	6.66	11.11	20.54
Adjusted Trap success (percent)	5.71	3.57	3.75	13.03
Corrected Trap success (percent)	**5.88**	**3.63**	**3.82**	**13.33**

Table 1.5b. Rodent diversity in different habitats

Diversity indices	Crop field	Ruderal	Fallow
Number of species	5	1	2
Shannon index (H')	**1.141**	**0.00**	**0.637**
Species richness (d)	1.773	0.000	0.901
Evenness index (J)	0.708	0.000	0.918
Simpson's Index (D)	0.760	0.000	0.444

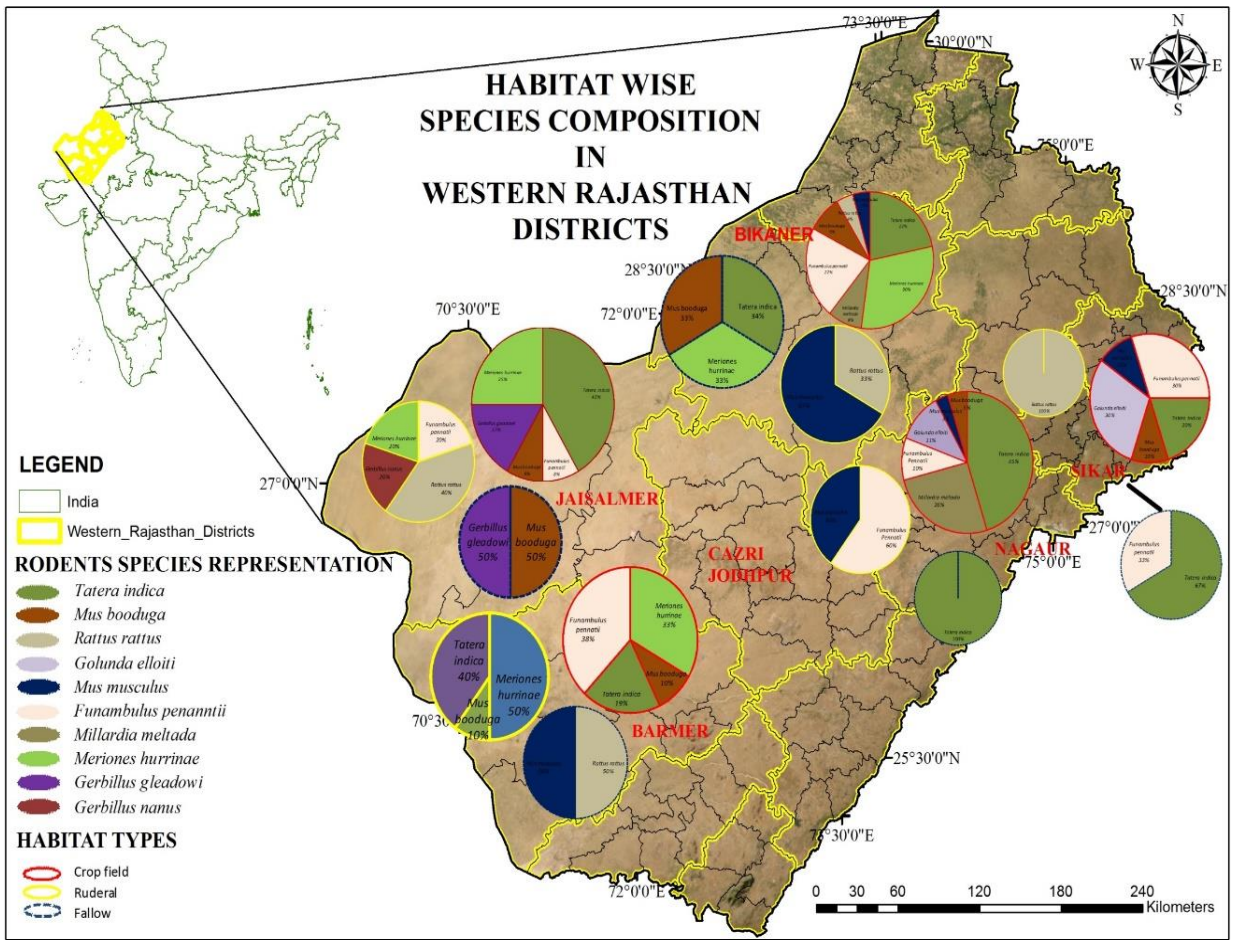


Fig 1.1. Habitat wise species composition in districts of Western Rajasthan

1.1.2. Telangana (PJTSAU, Hyderabad)

During the survey period, assessments were conducted in villages from the Pudur, Pargi, Kotipally, Doma, and Kulkacherla mandals of Vikarabad district; Kangal, Narketpally, Nalgonda, and Nampally mandals of Nalgonda district; and Bijinepally, Tadur, Thimmajipet, Uppunthala, Kalwakurthy, Nagarkurnool, Telkapally, and Amrabad mandals of Nagarkurnool district. The surveys recorded the status and extent of damage to crops such as rice, cotton, red gram, vegetables, groundnut, and coconut (Table 1.6).

Table 1.6. Rodent Survey locations in different districts

District	Mandal	Village	Crops
Vikarabad	Pudur	Kankal, Chinthapalli, Nizampetmedipally, Turkaenkapally	Rice, Cotton, Redgram & Vegetables
	Pargi	Rukmapally, Rangapur, Jafferpally, Busireddypally, Kandlapur, Ravulapalle	
	Kotipally	Kothapally, Lingampally	
	Doma	Khammamnacharam, Bedynikthanda, Peerampally, Dongayenkapally	
	Kulkacherla	Kamuripally, Ippaipally, Rampur, Salveed	

Nalgonda	Kangal	Peddakaparthy	Rice, Cotton & Redgram
	Narketpally	Pothinenipally, Chinnathummalagudem, Akkinipalli, Jajikunta, Pallepahad, Ammanabolu, Perumandlabavi, Podichedu	
	Nalgonda	G.K.Annaram, Thoragal	
	Nampally	Pasnoor, Tungapathi Gouraram	
Nagarkurnool	Bijinepally	Palem, Vattem, Velgonda, Khanapur, Bayapur, Venkatapur, Gudlanarva, Vasanthapur	Rice, Groundnut, Coconut & Vegetables
	Tadur	Gunthakodur, Medipur, Kommera, Tadur	
	Thimmajipet	Ippayipally, Mariepally, Thimmajipet	
	Uppunthala	Gattukodipally, Devadarikunta	
	Kalwakurthy	Kalwakurthy, Raghupathipet	
	Nagarkurnool	Gagallapally	
	Telkapally	Karwanga, Tallapalli	
	Amrabad	Mannanur, Maddimadugu	

During the study period, the abundance and diversity of rodent species were assessed through wonder trap catches, revealing that *B. bengalensis* was the most abundant species, followed by *F. palmarum* in all three districts. In each district, rice emerged as the predominant crop, benefiting from the availability of irrigation water through canals. The highest percent occurrence of *B. bengalensis* was observed in all districts. However, in Nalgonda, the percent occurrence of *F. palmarum* was recorded at 25.5percent, which can be attributed to the cultivation of mango and guava orchards in that district (Table 1.7).

Table 1.7. Percent Composition of Rodent Species in Vikarabad, Nagarkurnool, and Nalgonda Districts

Rodent species*	Vikarabad (per cent)	Nagarkurnool (percent)	Nalgonda (percent)
Bandicota bengalensis	34.5	44.2	36.4
Mus musculus	11.5	6.5	7.3
Bandicota indica	14.9	13	10.9
Rattus rattus	18.4	15.6	14.5
Mus booduga	6.9	2.6	5.5
Funambulus palmarum	13.8	18.2	25.5

*****Data based on wonder trap catches

1.1.3. Punjab (PAU, (RC) Ludhiana)

The assessment of rodent density in Punjab was conducted using a combination of trapping and burrow count methods across various districts during 2023–24. Trapping (n=3 fields/district or block and 16 traps/acre field) and burrow count (n=9 fields in 3 villages/district/crop field) methods were used to ensure accurate data collection. Trapping was done for three trap nights. The survey also incorporated the recording of GPS coordinates for each location, enabling precise mapping of rodent diversity and distribution patterns (Fig. 1.2).

In Mohali district, Kharar block, the most predominant rodent species was *Bandicota bengalensis*, whereas in block Derabassi, *Millardia meltada* was the most dominant species.
In Patiala district, *B. bengalensis*, followed by *Tatera indica*, was found to be prevalent. Additionally, *Rattus rattus* was also trapped in crop fields near commensal areas in both districts. However, no rodents were trapped from the Krishi Vigyan Kendra (KVK) in Fatehgarh Sahib (Table 1.8).

The rodent diversity was estimated in Kharar block (Mohali dist.) in villages Silkapur, Batta, Rora, Dharek Kalan, Mehmoodpur, and Chotla Khurdh. The survey, conducted in fields of paddy/basmati, bajra, and sugarcane crops, revealed the presence of *B. bengalensis* and *Mus* spp. Notably, a higher concentration of *B. bengalensis* burrows was observed on bunds surrounding paddy fields compared to bajra and sugarcane crops (Fig. 1.3). After the harvest of paddy crop, the rodent population shifted significantly towards basmati fields, indicating a preference for this crop after the paddy harvest.

In the districts of Moga, Faridkot, and Ludhiana, rodent species such as *B. bengalensis*, *Mus* spp., and *Tatera indica* were trapped in field crops, orchards, and refuge areas. The population of *Tatera indica* was notably higher in dry grassland areas near crop fields. Additionally, *Suncus murinus* (an insectivore) was also trapped in the Ludhiana district. In crop fields located near commensal areas, *R. rattus* was frequently trapped, suggesting its migration to these fields in search of food (Table 1.9). Rodent diversity was assessed using the burrow count method in various crop fields, including rice, wheat, sugarcane, potato, mustard, and mung bean, across 28 villages in nine districts (Jalandhar, Ludhiana, Moga, Nawanshahar, Hoshiarpur, Ferozepur, Faridkot, Malerkotla, and Patiala). The burrow dynamics revealed the presence of *B. bengalensis*, *T. indica*, *Millardia meltada*, and *Mus* spp. The predominance of these species varied across geographical areas, likely influenced by soil characteristics and crop types (Table
1.10).
The data of rodent trapping recorded from 1999 to 2024 in Ludhiana district on rodent abundance and diversity revealed that *B. bengalensis* was the most predominant rodent species during this period (Fig. 1.4). The data on rodent abundance, diversity, and distribution recorded from 1999-2000 to 2023-24 across 63 villages in each of the 21 districts of Punjab using the burrow count method, revealed the presence of four rodent species – *B. bengalensis*, *Mus* spp., *Tatera indica*, and *Millardia meltada* - in various crop fields, highlighting the widespread distribution of these species in the region's agricultural landscapes (Fig. 1 .5). The data analysis revealed that *B. bengalensis* was the predominant rodent species across most districts, except in Sangrur, Barnala, Mansa, Moga, Ferozepur, Faridkot, and Mohali, where other species such as *Tatera indica*, *Mus* spp., and *Millardia meltada* were more prevalent. Additionally, in harvested sugarcane fields, nests and burrows of the Indian bush rat (*Golunda ellioti*) were also observed, indicating its presence in these specific habitats.

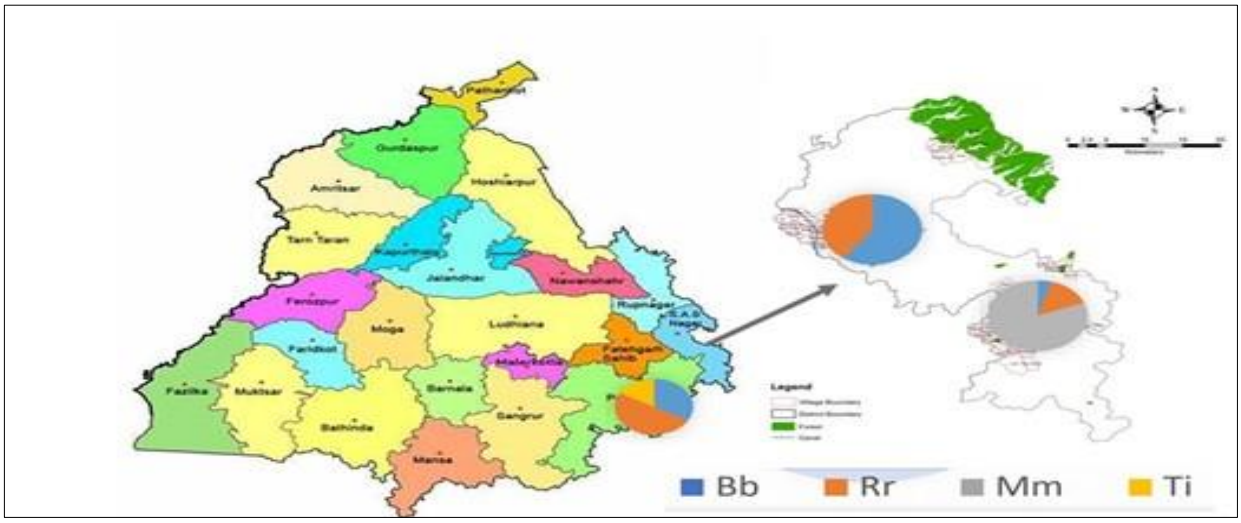


Fig. 1.2. Trap index of rodent species in districts Patiala and blocks Derabassi and Kharar of district Mohali

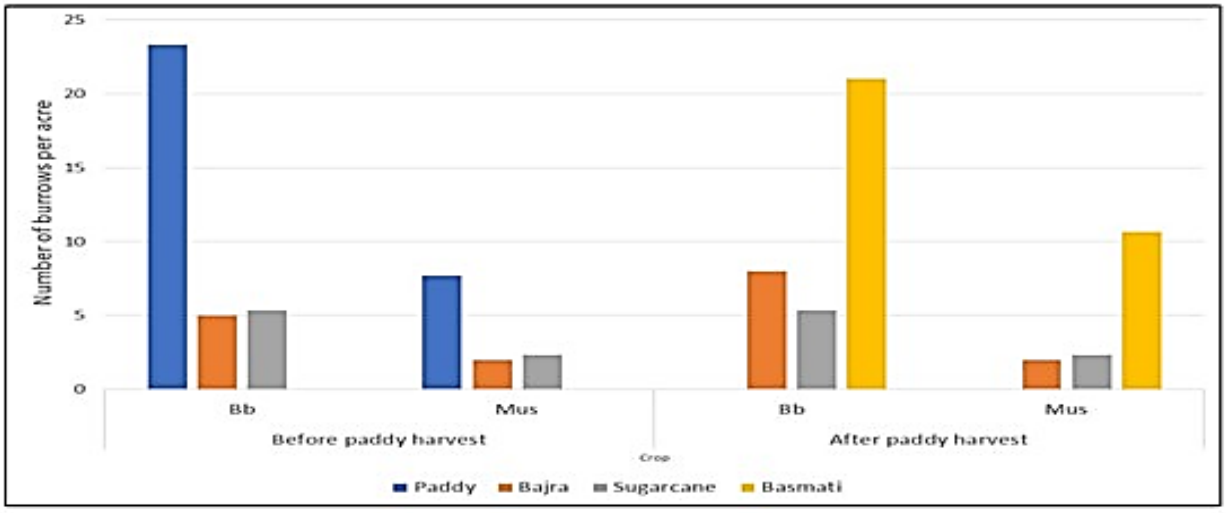


Fig. 1.3. Rodent diversity and abundance in different crops before and after paddy harvest in district Mohali

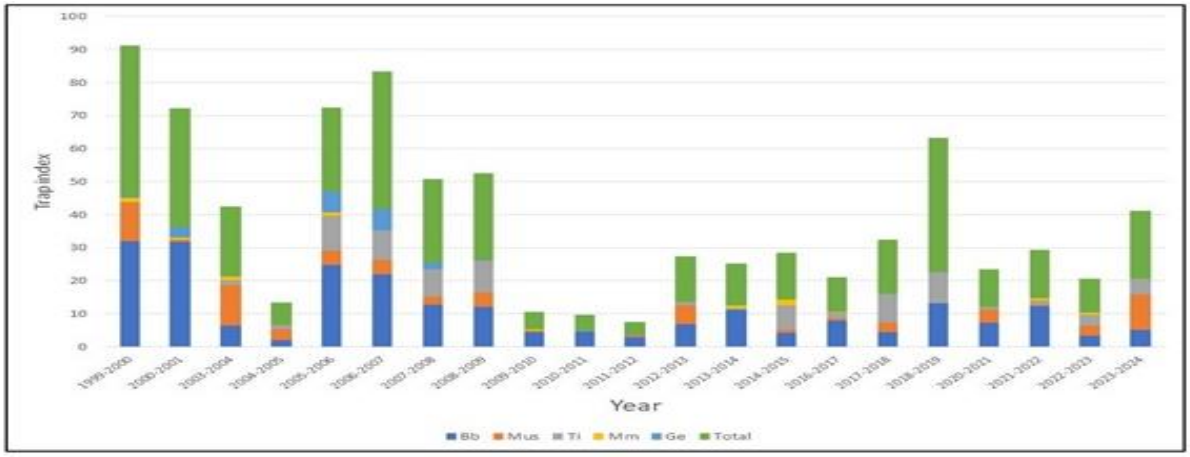


Fig. 1.4. Rodent diversity and abundance in district Ludhiana from 1999-2024

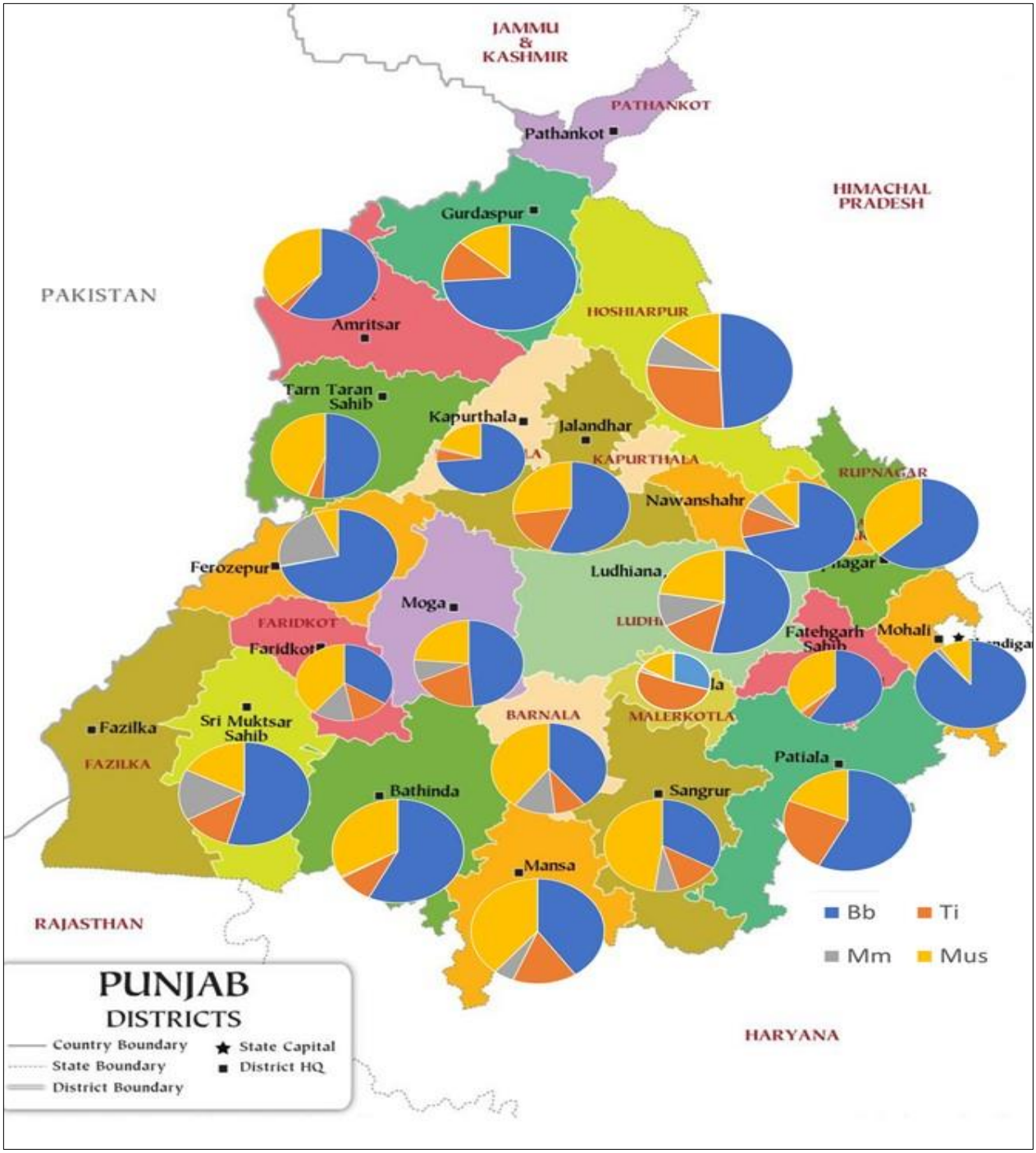


Fig. 1.5. Mapping of rodent diversity and distribution in Punjab state

Table 1.8. Trap index of rodent species in crop fields of districts Patiala, Fatehgarh Sahib and Mohali

District (Block) (n=3 fields)	Village	Crop	Surrounding crop	Trap index (No. of animals trapped per 100 trap nights) (Body weight in g)										Sex ratio (Male: Female)
				Bandicota bengalensis		*Rattus rattus*		*Millardia meltada*		*Tatera indica*		Total		
				Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	
Patiala	KVK	Paddy	Fodder, basmati, paddy	2.08 (200)	2.08 (250)	4.17 (155, 150)	2.08 (130)	-	-	2.08 (135)	-	6.25	4.16	1:0.66
Mohali (Derabasi)	Chandiala	Wheat	Wheat open area	-	1.4 (153-224)	2.1 (85-170)	2.3 (84-106)	14.88 (31-79)	9.75 (35-64)	-	-	16.98	13.45	1:0.79
Mohali (Kharar)	Landran	Wheat	Barseem, Garlic, Wheat husk	4.2 (196-226)	2.1 (130)	2.1 (186)	2.1 (171)	-	-	-	-	6.3	4.2	1:0.67
Fatehgarh Sahib	KVK	Wheat	Wheat	-	-	-	-	-	-	-	-	-	-	-

Table 1.9. Trap index of rodent species in crop fields, orchards, refuge and commensal areas in districts Moga, Faridkot and Ludhiana

District (Block)	Village	Crops	Surrounding crops	Trap index (No. of animals trapped per 100 trap nights)						
				Bandicota bengalensis	*Millardia meltada*	*Mus* spp.	*Tatera indica*	*Rattus rattus*	*Suncus murinus*	Total
Moga	KVK	Commensal	Sugarcane	-	-	-	-	0.20	-	0.20
Moga	KVK	Sugarcane, Jute	Wheat	-	-	-	-	-	-	-
Faridkot	KVK	Sugarcane	Harvested fields	0.12	-	-	-	-	-	0.12
Ludhiana	IIMR	Wheat	Mango orchard	6.90	-	11.2	5.10	-	-	23.20
Ludhiana	IIMR	Wheat, Open area	Uncultivated	1.00	-	6.30	-	-	3.10	10.40
Ludhiana	Talwandi Khurd	Rice, commensal area	Rice	0.60	-	2.20	11.10	0.60	-	14.50
Ludhiana		Rice, Guava orchard	Rice	4.20	-	8.30	12.50	-	10.00	35.00

Table 1.10. Rodent diversity and distribution based on burrow count in crop fields of 28 villages of 9 districts of Punjab along with GPS Coordinates

S.No.	District	Villages	Crop	Rodent species	Number of burrows/acres	Latitude	Longitude
1	Jalandhar	Paddi Jagir	Rice	Bb>Mus spp.	7.00±1.20	31.141314	75.813197
		Bara Pind	Rice	Bb>Mus spp.	11.30±0.30	31.121295	75.814964
		Duleta	Rice	Bb>Mus spp.	3.70±1.60	31.116516	75.852672
2	Ludhiana	Tawandi Khurd	Rice	Bb>Ti>Mus spp.	17.0±0.90	30.969902	75.788175
		Ladian	Rice	Bb>Ti>Mus spp.	10.30±1.50	30.988218	75.732123
		Barewal Dogra	Rice	Bb>Mus spp.>Ti	12.30±0.90	30.964192	75.78724
3	Moga	Budh Singh Wala	Wheat	Ti>Mus>Mm>Bb	24.70±5.50	30.753712	75.167214
		Jhandewala	Wheat, Potato	Mm>Mus>Ti>Bb	25.30±1.20	30.758136	75.162451
		Tarewals	Wheat, Mustard	Mus>Bb>Ti>Mm	21.00±2.40	30.763422	75.185003

		Ghall Kalan	Mung bean	Ti>Mb>Mus>Mm	50.00±0.00	30.827019	75.124437
4	Nawanshehar	Jagatpur	Wheat	Bb>Mus	9.70±1.20	31.125947	75.925727
		Jagatpur	Sugarcane	Bb>Mus	7.30±0.90	31.125947	75.925727
		Munder	Sugarcane	Bb>Mus	15.00±1.60	31.134726	75.943648
		Talwandi Fattu	Sugarcane	Bb>Mus	3.00±0.50	31.135115	75.962696
5	Hoshiarpur	Dagam	Sugarcane	Bb>Mus	6.00±0.80	31.197589	76.104541
		Dagam	Wheat	Bb	2.00±0.50	31.197589	76.104541
		Dagam	Mustard	Bb	0.70±0.50	31.197589	76.104541
		Fatehpur Kalon	Sugarcane	Bb>Mus	2.30±0.70	31.20048	76.123708
		Fatehpur Kalon	Wheat	Bb>Mus	3.20±0.50	31.20048	76.123708
		Garhshankar	Sugarcane	Bb	5.30±0.70	31.22814	76.141924
		Garhshankar	Wheat	Bb	3.30±0.70	31.22814	76.141924
6	Ferozepur	Mudki	Wheat	Ti>Bb>Mus	12.70±0.70	30.789882	74.891078
		Mudki	Mustard	Ti>Bb	19.00±6.00	30.789882	74.891078
		Tumber Bhan	Wheat	Ti>Bb>Mus	14.00±6.50	30.808129	74.898815
		Pattu	Wheat	Ti>Bb>Mus	7.70±0.70	30.823157	74.877767
7	Faridkot	KVK Faridkot	Sugarcane	Bb>Ti>Mus	34.30±14.10	30.674975	74.745598
		Nathewala	Sugarcane	Bb>Ti>Mus	9.00±1.20	30.642778	74.843314
		Nathewala	Wheat	Bb>Ti>Mus	5.00±0.50	30.642778	74.843314
		Devi Wala	Wheat	Ti>Bb>Mus	10.70±0.70	30.626166	74.865785
8	Malerkotla	Kup Kalan	Wheat	Ti>Bb>Mus	21.33±8.15	30.69743	75.875678
		Ahmadbad	Wheat	Bb	2.00±1.20	30.511696	75.916144
		Upoki	Wheat	Bb>Mus	3.00±0.50	30.50234	75.926621
9	Patiala	Rabhara	Wheat	Bb>Ti>Mus	12.70±2.20	30.370336	76.255937
		Rohti Mauran	Wheat	Bb>Mus	4.00±0.50	30.383987	76.204025
		Dhingri	Wheat	Bb>Mus	6.00±0.50	30.39622	76.107825

Bb-*Bandicota bengalensis*, Ti-*Tatera indica*, Mm-*Millardia meltada*

1.1.4. Kerala (KAU, Thrissur)

Rats are a major threat to rice production in wetland and deep-water rice ecosystems in Kerala. We selected nine fields, three each in Thrissur (Vettikkal, State Seed Farm Mannuthy, and Madakkathara), Malappuram (Tavanur, Kuttippuram, and Pookottur), and Alappuzha (RRS Mancompu, Thekke-900, and Thekkekara), and observed the Live Burrow Count (LBC) percentage during the period from October 2023 to September 2024. A field with a total area of one acre was selected from each location, and 40 burrows per acre were identified. These burrows were closed with mud in the evening hours, and the number of freshly opened burrows was observed and recorded the next morning. The number of active burrows out of the total number of burrows was used to calculate the percent live burrow count. The data (Table 1.11) on LBC (percent) from nine locations was transformed and subjected to statistical analysis using the GRAPE software. Significant differences were observed in the LBC (percent) across the nine study locations. The highest LBC (percent) was recorded in rice fields at RRS Mancompu (12.47percent) followed by Thekke-900 (9.37percent), whereas the lowest LBC (percent) was recorded at Madakkathara (3.33percent) and Kuttippuram (3.78percent).

Table 1.11. Rat incidence in rice ecosystem of selected localities

S No	Name of the district	Name of the place	GPS coordinates	Density/ha (Mean ± S.Em)
1	Thrissur	Vettikkal	10.5401, 76.2735	6.25^{bc}
2		SSF Mannuthy	10.52822,76.2623	6.6^{bc}
3		Madakkathara	10.5612, 76.2624	3.33^{d}
4	Alappuzha	RRS Mancompu	9.4430, 76.4245	12.47^{a}
5		Thekke 900	9.2067, 76.5332	9.37^{b}
6		Thekkekara	9.2177, 76.5546	7.65^{b}
7	Malappuram	Tavanur	10.8412, 75.9938	4.25^{cd}
8		Kuttippuram	10.8423, 76.0299	3.78^{d}
9		Pookottur	11.0973, 76.0627	5.74^{cd}

The data (Fig. 1.6 and Table 1.13) on rat population density across various districts in Kerala indicates significant variation, with the highest density recorded in Alappuzha's Moncompu (30 rats/ha), followed by Champakulam (25 rats/ha) and Thekkeakkara (23 rats/ha), suggesting favourable conditions for rats in these areas. In contrast, locations in Thrissur and Thiruvananthapuram, such as Vellanikkara (6 rats/ha) and Palode (5 rats/ha), show relatively low densities, potentially due to less available food or effective pest management. Districts like Palakkad and Kannur exhibit moderate densities, indicating significant rat populations that could impact local agriculture.

In the Union Territory of Lakshadweep, the effectiveness of rat traps (Table 1.12) varies across different islands, with Kiltan showing the highest trap success rate at 10.48 percent, followed by Kavaratti at 9.18 percent, Minicoy at 4.58 per cent, and Agatti had the lowest trap success rate at 3.16percent. These differences suggest varying rat population densities or trapping efficiencies across the islands.

Table 1.12. Trap success per cent in Lakshadweep

Union Territory	Islands	GPS coordinates		Trap success (percent)
Lakshadweep	Minicoy	8.2726286	73.0477906	4.58
	Agatti	10.8630182	721947562	3.16
	Kavaratti	10.5675869	72.642581	9.18
	Kiltan	11.485407	73.004004	10.48

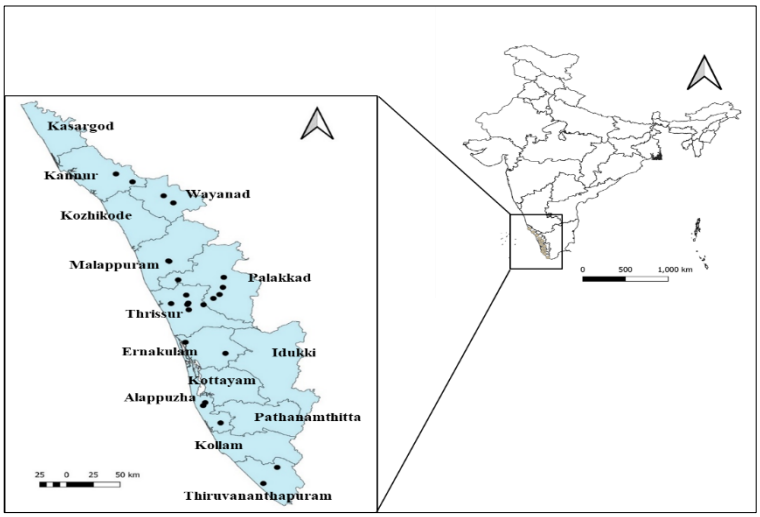


Fig 1.6. Spatial distribution of rats in Kerala

Table 1.13. Population density of rat in Kerala

Sl No	Name of the district	Name of the place	GPS coordinates	Density/ha (Mean ± S.Em)
1	Palakkad	Kuzhalmannam	10.7230, 76.5741	15± 0.1
2		Mundoor	10.8339, 76.5816	14±0.20
3		Alathur	10.6434, 76.5453	8±0.01
4		Vadakkanchery	10.6003, 76.4938	12±0.30
5		Pattambi	10.8057, 76.1957	13±0.10
6	Thrissur	Vellanikkara	10.5481, 76.2812	6±0.01
7		Mannuthy	10.4739,76.2853	9±0.07
8		Vettikal	10.5321, 76.2734	7±0.30
9		Punamparambu	10.6367, 76.2645	12±0.15
10		Adatt	10.5426, 76.1363	17±0.61
11	Thiruvananthapuram	Sreekaryam	8.54491, 76.9161	14±0.40
12		Palode	8.72362, 77.0329	5±0.14
13	Alappuzha	Moncompu	9.4430, 76.4245	30±0.36
14		Thekkeakkara	9.2177, 76.5546	23±0.70
15		Champakulam	9.4095, 76.4071	25±0.40
16	Ernakulam	Varapuzha	10.1132, 76.2575	13±0.76
17		Koothattukulam	9.9894, 76.5957	7±0.10
18	Malappuram	Valambor	11.0119,76.1201	8±0.04
19		Valanchery	10.5301,76.4102	11±0.15
20	Kozhikode	Omassery	11.1801,75.5830	9±0.06
21		Mavoor	11.1535,75.5655	10±0.24
22	Kannur	Iritti	11.9819,75.6700	18±0.26
23		Kelakam	11.8945,75.8098	13±0.14
24	Wayanad	Meenangadi	11.6607,76.1551	21±0.37
25		Kuruva	11.0166,76.1131	17±0.8
26		Panamaram	11.7391,76.0730	12±0.4

1.1.5. Karnataka (UAS, Bengaluru)

The dataset provides insights into rodent densities, trapping indices, and related parameters across various crops and districts in Karnataka during different crop stages (Fig 1.7). The data reveals significant patterns that can inform pest management strategies. In Tumkur district, paddy (kharif) experienced a steady increase in rodent density and trap index from the tillering stage in August (18.78 LBC/ha, trap index 7.68) to the harvesting stage in October/November (56.45 LBC/ha, trap index 23.65). This growth correlates with crop maturation, as increased food availability attracts rodents. The diversity index (H') also rose consistently, with the male-to-female ratio remaining close to parity during panicle formation but skewing slightly in the tillering and harvesting stages. In the same field during winter pulse crop (cowpea) was sown. In cowpea fields, the LBC/ha ranged from 9.64 to 31.25 per ha with a trap index of 3.26 to 15.68 from the sowing to harvesting stages, respectively. The shannon-wiener diversity index was also worked out (Table 1.14). The population was male dominant, however in wet seasons the population was female dominant.

The cropping pattern of ragi during kharif, followed by field bean during winter, was predominant in the southern dry zone (Ramanagara district). In ragi (kharif) crop significant escalation in rodent densities was observed, with 7.32 LBC/ha during the sowing stage (July/August) to 46.98 LBC/ha during the harvesting stage (October/November), and the trap index from 3.16 to 19.87. This sharp increase during the harvesting stage highlights the importance of implementing crop protection measures during this period. The sex ratio remained relatively stable, with minor fluctuations. Similarly, field bean showed peak rodent densities during harvesting (37.65 LBC/ha), compared to sowing period (8.72 LBC/ha) with an unusual skew in the male-to-female ratio during the pod formation stage, where males dominated significantly (1:0.4). The highest trap index recorded was 16.57 during the harvesting stage of the field bean. The population was male dominant, however in wet seasons the population was female dominant.

In Mysore district, the rodent density in paddy varied from 20.13 to 64.98 LBC/ha. Paddy (kharif) recorded the highest rodent densities among the studied crops, with maximum density during the harvesting stage (64.98 LBC/ha, trap index 22.66). The data showed a consistent rise in both rodent activity and diversity index across crop stages. In the same field, cucumber was cultivated, and rodent densities and trap indices increased significantly from the seedling stage (18.47 LBC/ha, trap index 5.68) to the harvesting stage (46.98 LBC/ha, trap index 20.57). The male-to-female ratio remained relatively balanced, with minor fluctuations favouring males at earlier stages.

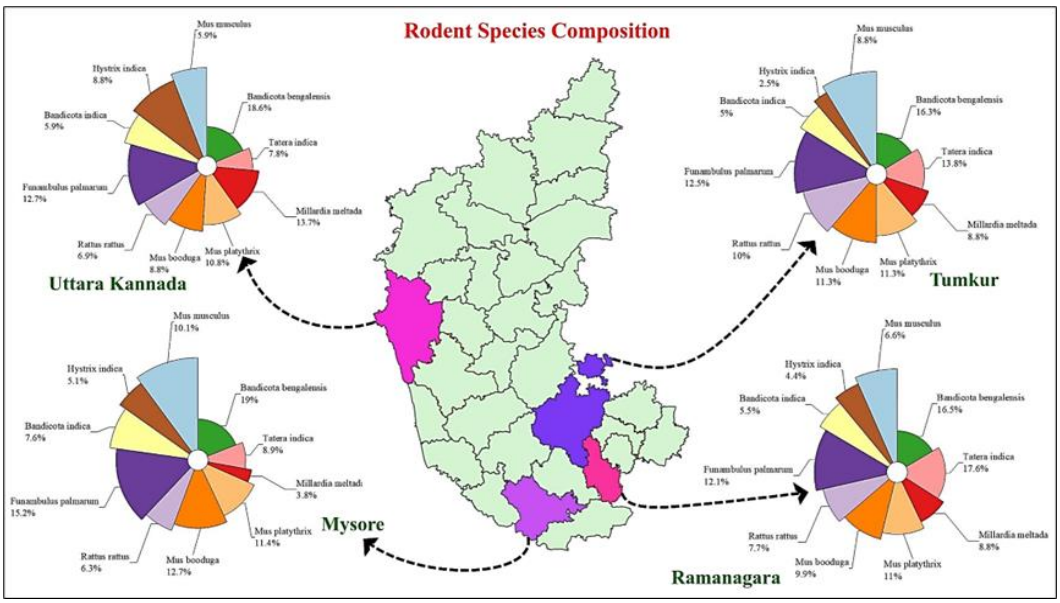


Fig. 1.7. Rodent species composition in cereal, pulses and Vegetable cropping system

The rodent mapping across Tumkur, Ramanagara, and Mysore districts revealed distinct patterns in pest prevalence. In Tumkur, *Bandicota bengalensis*, *Tatera indica*, and *Mus platythrix* emerged as the predominant rodent pests, while *Millardia meltada* and *Mus booduga* were recorded as minor pests. In the Mysore district, *Bandicota bengalensis* and *Mus booduga* were dominated, with *Mus platythrix* and *Millardia meltada* were present in smaller numbers. In Ramanagara, *Tatera indica* and *Bandicota bengalensis* were the primary species, whereas *Millardia meltada*, *Mus booduga*, and *Mus platythrix* were observed as minor pests. Across all districts, *Bandicota indica*, *Rattus rattus*, and *Mus musculus* were identified as the predominant commensal rodent pests (Fig. 1.8). In horticultural crops, the Indian palm squirrel (*Funambulus palmarum*) was the most significant pest, with the Indian crested porcupine (*Hystrix indica*) also reported in a few talukas across the surveyed regions.

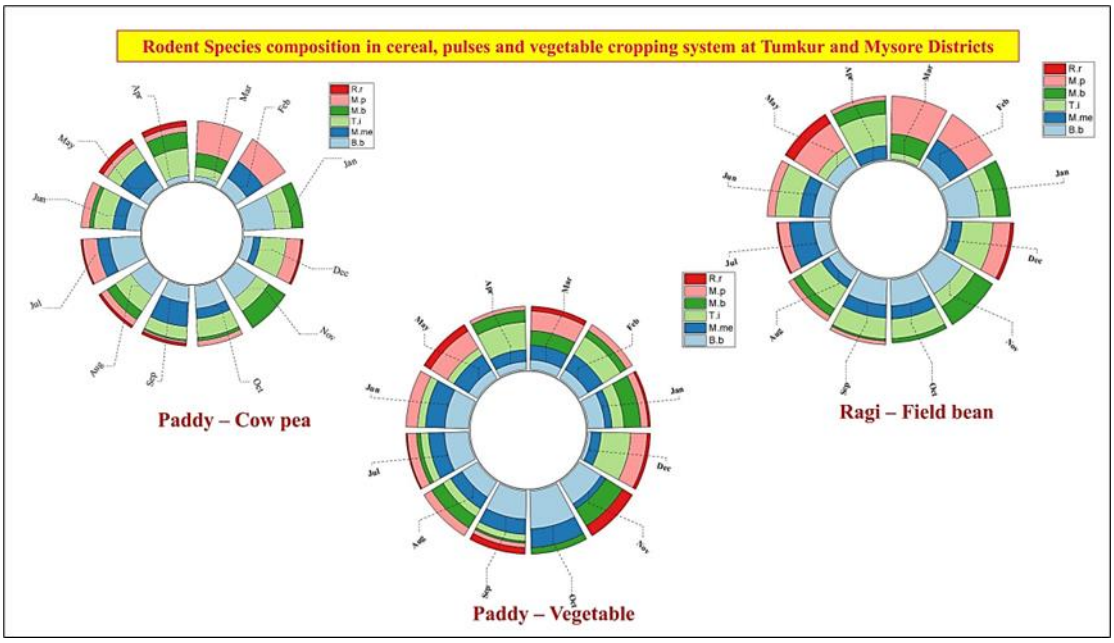


Fig. 1.8. Rodent species composition in Tumkur, Mysore, Uttara Kannada and Ramanagara District

Table 1.14. Population dynamics of rodent pests in Tumkur, Ramanagar and Mysore Districts

District	Crop	Month	Crop stage	Rodent density (LBC/ha)	Trap index	H'	M: F
Tumkur	Paddy (*Kharif*)	August	Tillering	18.78	7.68	0.46	1:0.60
		September	Panicle formation	38.94	13.54	1.23	1:1.13
		October/November	Harvesting	56.45	23.65	1.98	1:0.85
	Cowpea	Nov/Dec	Sowing	9.64	3.26	0.25	1:0.71
		December	Pod formation.	20.68	7.59	1.31	1:1.11
		Jan/feb	Harvesting	31.25	15.68	1.65	1:0.73
Ramanagara	Ragi (*Kharif*)	July / August	Sowing	7.32	3.16	0.38	1:0.72
		September	Ear head formation.	21.54	13.24	1.31	1:1.06
		October/November	Harvesting	46.98	19.87	1.82	1:0.77
	Field bean	Oct/Nov	Sowing	8.72	2.98	0.41	1:0.73
		December	Pod formation.	22.68	8.64	1.17	1:0.4
		Jan/feb	Harvesting	37.65	16.57	1.38	1:0.84
Mysore	Paddy (*Kharif*)	July / August	Tillering	20.13	6.95	0.51	1:0.79
		September	Panicle formation	40.68	14.65	1.36	1:1.00
		October/November	Harvesting	64.98	22.66	1.87	1:0.89
	Vegetable (Cucumber)	Nov/Dec	Seedling stage	18.47	5.68	0.63	1:0.68
		December	vegetative / crop maturity	29.74	12.65	1.38	1:0.86
		Jan/feb	Harvesting	46.98	20.57	1.86	1:0.85

1.1.6. Andhra Pradesh (ANGRAU, RARS, Maruteru)

During 2023–24, surveys were conducted across various agricultural and horticultural crops and poultry sheds in the Krishna-Godavari Zone, encompassing Krishna, Guntur, East Godavari, and West Godavari districts. Additionally, routine surveillance was also carried out at the RARS research farm in Maruteru. The results revealed that *Bandicota bengalensis* was the predominant rodent species in rice fields, followed by *Mus booduga*. In contrast, *Rattus rattus* and *Funambulus palmarum* were more prevalent in coconut and cocoa plantations. In poultry farms, *B. bengalensis* was observed around the exterior premises, while *R. rattus* was more common inside the premises (Table 1.15). The coordinates of the surveyed locations were recorded, and the distribution of rodent species across these areas was mapped using GIS software. To assess species composition, both butta and Sherman traps were installed in various crops and monitored continuously for three days. Trapped rodents were identified based on their morphological characteristics. The study highlighted the dominance of *B. bengalensis* across all surveyed districts compared to other species. In East and West Godavari districts, where rice is the predominant crop due to canal irrigation, the percentage occurrence of *B. bengalensis* was particularly high. This underscores its adaptability and abundance in irrigated rice ecosystems.

Table 1.15. Rodent Species associated with different crops in Krishna- Godavari zone

Crop	Rodent Species complex	
Paddy	*Bandicota bengalensis*	*Mus booduga*
Pulses (Green and black gram)	*Bandicota bengalensis*	*Mus booduga*
Cotton	*Bandicota bengalensis*	
Coconut	*Rattus rattus*	*Funambulus palmarum*
Cocoa	*Rattus rattus*	*Funambulus palmarum*
Banana	*Bandicota bengalensis*	
Poultry	*Rattus rattus* (Inside)	*Bandicota bengalensis* (Outside)

Based on trap catches shown in Table 15, *B. bengalensis* was the most common rodent species in both Guntur and Krishna districts, accounting for 49.6percent to 52.5percent of the rodent population. This indicates that *B. bengalensis* is the predominant species in the area. *M. booduga* was also relatively common, with a percentage range of 12.5percent to 15.5percent, though it is less frequent than *B. bengalensis*. Other species, such as *B. indica*, *R. rattus*, and *F. palmarum*, were found in much smaller numbers.

Table 1.16. Relative abundance of rodent Species in Guntur and Krishna Districts

Rodent species	Guntur dist. (percent)	Krishna dist. (percent)
Bandicota bengalensis	49.6	52.5
Mus booduga	12.5	15.5
Bandicota indica	4.0	6.0
Rattus rattus	17.6	14.0
Funambulus palmarum	16.3	12.0

The population density of rodent species in rice fields at RARS, Maruteru, is shown in Table 1.17. It indicates that *B. bengalensis* was the dominant rodent species throughout the year in rice fields, accounting for an average of 98.5percent of the total rodent population trapped. The highest abundance of *B. bengalensis* was observed in September, November, and December when it comprised 100percent of the trapped rodents. *Mus booduga* showed a much lower occurrence, averaging only 1.5percent of the total rodent population. Its population was maximum in July (7.91percent), but it was scarcely observed in subsequent months. The consistently high percentage of *B. bengalensis* across all months underscores its dominance in the surveyed areas, while the low occurrence of *M. booduga* suggests that it either has a smaller population in the rice field habitats or is outcompeted by *B. bengalensis*.

Table 1.17. Rodent Population Density in Rice Fields at RARS, Maruteru during 2023-24

Months	No. of rodents trapped			percent species composition	
	Total	*B. bengalensis*	*M. booduga*	*B. bengalensis*	*M. booduga*
July, 2023	139	128	11	92.09	7.91
August, 2023	159	157	2	98.74	1.26
September, 2023	244	244	0	100.00	0.00
October, 2023	247	246	1	99.60	0.40
November, 2023	123	123	0	100.00	0.00
December, 2023	127	127	0	100.00	0.00
January, 2024	128	123	5	96.09	3.91
February, 2024	97	97	0	100.00	0.00
March, 2024	19	19	0	100.00	0.00
MEAN	**142.56**	**140.44**	**2.11**	**98.50**	**1.50**

Population studies of *B. bengalensis* was carried out through monthly trapping and the total number of rodents ranging from 19 in March 2024 to 244 in September 2023 were captured with monthly average of 140.44 (Table 1.18, Fig. 1.9). Females consistently outnumber males, with the male-to-female (M) ratio ranging from 1:0.73 in March to 1:1.86 in November. Live burrow count/ha (LBC/ha) was also highest in September 2023 (17.41) and the lowest in March 2024 (4.95), corroborating with the captures

of individuals across the months. The overall mean LBC/ha was 11.00, suggesting moderate rodent activity across the surveyed months. The Population growth estimates computed from breeding parameters indicated that the *B. bengalensis* infesting paddy could breed @ 3.89 times in *Kharif* with seasonal productivity of 32.26 young ones per female (Table 1.19, 1.20).

Table 1.18. Monthly Variations in Sex ratio of *B. bengalensis* at RARS, Maruteru during 2023-24

Months	Total no. of animals	Males (♂)	Females (♀)	M: F Ratio	No. of Juveniles	LBC/ha
July, 2023	128	56	72	1: 1.29	96	12.38
August, 2023	157	65	92	1: 1.42	6	13.45
September, 2023	244	116	128	1: 1.10	2	17.41
October, 2023	246	99	147	1: 1.48	0	15.29
November, 2023	123	43	80	1: 1.86	71	9.33
December, 2023	127	53	74	1: 1.40	102	13.21
January, 2024	123	51	72	1: 1.41	98	7.70
February, 2024	97	48	49	1: 1.02	42	5.25
March, 2024	19	11	8	1: 0.73	5	4.95
TOTAL	**1264**	**542**	**722**	**-**	**422**	**98.97**
MEAN	**140.44**	**60.22**	**80.22**	**-**	**46.89**	**11.00**

The data revealed significant variation in pregnancy prevalence among female rodents, with the highest percentage (55percent) observed in September, October, and February. The average number of litters per female ranged from 6.92 to 10, with the highest average of 10 litters per female recorded in July 2023 (Table 1.19).

Table 1.19. Reproductive parameters of *B. bengalensis* at RARS, Maruteru during 2023-24

Months	Females (♀)	No. of Pregnant ♀ (n=20)	percent Pregnancy	prevalence of pregnancy	No. of ♀ with litter	No. of litter	Avg. No. of litter/female
July, 2023	72	7	35	0.35	1	10	10.00
August, 2023	92	2	10	0.10	2	15	7.50
September, 2023	128	10	50	0.50	3	23	7.67
October, 2023	147	11	55	0.55	9	80	8.89
November, 2023	80	8	40	0.40	9	66	7.33
December, 2023	74	5	25	0.25	10	83	8.30
January, 2024	72	4	20	0.20	13	90	6.92
February, 2024	49	11	55	0.55	8	69	8.63
March, 2024	8	4	20	0.20	0	0	0

In conclusion, the rodent population shows significant seasonal variation in reproductive parameters, with higher reproductive rates and average litter sizes observed during the Kharif season compared to the Rabi season. This results in a much higher seasonal productivity in Kharif (32.26) compared to Rabi (9.55), contributing to an overall annual productivity of 41.81. The findings highlight the importance of seasonality in rodent population dynamics, which may influence control strategies and management efforts in agricultural areas (Table 1.20).

Table 1.20. Population growth parameters of *B. bengalensis* at RARS, Maruteru during 2023-24

S. No.	Population growth parameter	Values	
		***Kharif*, 2023**	***Rabi*, 2023-24**
1.	Reproductive rate F*	3.89	2.26
2.	Average litter/female	8.28	4.23
3.	Productivity per season (F x Avg. litter/ female)	32.26	9.55
Annual Productivity		**41.81**	

Fig 1.9. Rodent catches during the study

1.1.7. Assam (AAU, Jorhat)

1.1.7.1. Surveillance of rodent pests in the CBVZ (Nagaon District) of Assam

Surveillance of rodent pests in rice-toria cropping system was carried out at CBVZ of Assam. The data presented in Table 1.21 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 (8.76) and damage (9.21 percent) were recorded at ripening stage

of the rice, followed by milky stage with mean LBC/ha of 34.86, trap index of 6.55 and cut tillers of 6.11 percent. The lowest LBC/ha (16.11), trap index (2.91) and tiller damage
e (3.01 %) was recorded at vegetative stage of the crop. From the tillering stage, rodent activity started in the field. Losses due to field rat, *Bandicota bengalensis* were recorded in terms of per cent tillers damage at different crop growth stages. It was revealed from (Table 1.21) that the rodent damage also gradually increased with the advancement of crop growth. The tillers damage at tillering stage was 3.01 percent which was increased to 9.21 percent at ripening stage followed by 6.11 percent at milky stage. Incidence of rodents in toria was recorded between November to February (Table 1.21). The highest incidence in terms of live burrow count (LBC/ha) was recorded at maturity stage (29.33) followed by flowering stage (17.71). In early growth of toria, the LBC/ha was low (8.81). The trap index revealed that highest trapping was recorded at siliqua formation stage (3.66 percent), followed by flowering stage. No damage was recorded up to vegetative stage of the crop. The predominant rodent species recorded were *B. bengalensis*, *B. indica*, *Mus booduga* in rice and *B. bengalensis* in toria

1.1.7.2. Surveillance of rodent pests in UBVZ (Sivsagar District) of Assam

The data presented in Table 1.22 reveal that live burrow count (LBC), trap index (TI) and rodent damage recorded at different crop growth stages of pumpkin increased with the advancement of the crop growth. Maximum LBC/ha (49.40), and damage (14.67 percent) was recorded at maturity stage of the pumpkin followed by fruiting stage with mean LBC/ha of 36.61 and damage of 8.11 percent. The lowest LBC/ha (14.46) was recorded at vegetative stage of the crop. From the vegetative stage, rodent activity started in the field. It was revealed (Table 1.22) that the rodent damage also gradually increased with the advancement of crop growth. The damage was nil at vegetative stage which was increased to 14.67 percent at maturity stage. Incidence of rodents in potato was recorded between Novembers to February. The highest incidence in terms of live burrow count (LBC/ha) was recorded at maturity stage (46.01) followed by tuber formation stage (34.81). In early growth of potato, the LBC/ha was low (16.61). The data on rodent damage at different growth stages of potato revealed significant differences among them. The highest damage was recorded at maturity stage (11.44 percent) followed by tuber formation stage (6.11 percent). No damage was recorded in potato at early growth stages.

1.1.7.3. Surveillance of rodent pests in UBVZ (Golaghat District) of Assam

In Golaghat district highest rodent damage (9.76) was percent at ripening stage of rice followed by milky stage (6.87 percent). The recorded species were *B. bengalensis* and *Mus booduga*. Comparatively a low damage of 2.33 percent was recorded at tillering stage. In pea crop grown after rice the highest rodent damage of 9.51 percent was recorded at pod formation stage followed by flowering stage (Table 1.23). In vegetative stage, no rodent damage was recorded in the pea crop grown after rice. The only species *B. bengalensis* was recorded in pea crop.

1.2.7.4. Species compositions of rodent pest under different habitats of Sivsagar district

The species composition of rodent pest in different habitats of Sivsagar district under Upper Brahmaputra Valley Zone of Assam revealed that *Rattus rattus* was the predominant species in household and rural stores; *Bandicota bengalensis* in urban godowns, kitchen garden, paddy fields and crop fields. *Dremomys lokriah macmillani* was the predominant rodent species in homestead gardens and orchards (Table 1.24). *Bandicota indica* have been recorded from orchards and crop fields' near to human habitats, homestead gardens with a species composition of 5.83%, 6.61% and 10.81%, respectively. In house and rural store, *Mus musculus* was recorded predominately with a species composition of 30.04% and 34.66 % and 23.54% in houses, rural store and urban godown, respectively. *Mus booduga* was the only field mouse have been recorded from crop fields mainly paddy (11.11%), homestead garden (6.61%) and forests (9.98%). The rodent species composition in food grain stage in Sivsagar were *Rattus rattus*, *B.bengalensis*, *Mus musculus.* All these three species were found in both rural and commercial storage along with *D. lokriah* (9.91%) in rural store. However, in godowns in urban areas, the highest percentage of *B. bengalensis* (61.80%) have been recorded whereas in rural store, *the B. bengalensis* percentage was only (14.44%) (Table 1.24)

Table: 1.21 Surveillance of rodent pest during 2023-24(CBVZ)

District	Crop	Crop stage	LBC/ha	TI	Damage (%)	Species recorded
Nagaon	Rice	Maximum tillering	16.11	2.91	3.01	*B. bengalensis* *B. indica* *M booduga*
		Milky	34.86	6.55	6.11	
		Ripening	46.11	8.76	9.21	
	Toria	Vegetative	8.81	-	-	*B. bengalensis*
		Flowering	17.71	2.41	2.86	
		Maturity	29.33	3.66	4.11	

Table 1.22. Surveillance of rodent pest during 2023-24 (UBVZ)

District	Crop	Crop stage	LBC/ha	TI	Damage (%)	Species recorded
Sivsagar	Pumpkin	Vegetative	14.46	2.96	-	*B. bengalensis* *D. lokriah*
		Fruiting	36.61	4.26	8.11	
		Maturity	49.40	7.82	14.67	
	Potato	Vegetative	16.61	2.81	-	*B. bengalensis* *M. booduga*
		Tuber formation	34.81	4.11	6.11	
		Maturity	46.01	5.66	11.44	

Table 1.23. Incidence of rodent pest during 2023-24 (UBVZ)

District	Crop	Crop stage	LBC/ha	TI	Damage (%)	Species recorded
Golaghat	Rice	Maximum tillering	11.86	2.76	2.33	*B. bengalensis* *M. booduga*
		Milky	31.32	4.76	6.87	
		Ripening	42.66	8.66	9.76	
	Pea	Vegetative	06.62	-	-	*B. bengalensis*
		Flowering	16.66	3.56	4.66	
		Pod formation	38.86	6.72	9.51	

Table 1.24. Species composition of rodents in different habitats of UBVZ of Assam (Sivsagar district)

Habitats	Rodent species					
	B. bengalensis	***B. indica***	***M. musculus***	***M. booduga***	***R. rattus***	***D. lokriah***
Houses	3.35	-	30.04	-	66.61	-
Store (rural	14.44	-	34.66	-	40.96	9.91
Godowns (urban)	61.80	-	23.54	-	14.66	-
Homestead garden	46.61	10.81	-	6.11		36.47
Crop fields (paddy)	71.46	6.61	-	11.11		10.82
Orchards	48.06	5.83	-	-		46.11
Forest	50.11	8.33	-	9.98		31.58

1.2. BIRDS

1.2.1. Telangana (PJTSAU, Hyderabad)

The survey was conducted across three districts, Nalgonda, Vikarabad, and Nagarkurnool in Telangana with the aim to assess the diversity of bird species, in Bajra (Pearl Millet), Maize, Sorghum, and Sunflower. A total of three districts, 15 mandals, and 60 villages were surveyed. The survey recorded a total of 150 bird species across all districts. In Bajra (Pearl Millet), 37 species were recorded across all districts, with a higher concentration in Nagarkurnool and Nalgonda followed by Sorghum with 45 species, mostly found in Nagarkurnool. In Sunflower, 38 species, with Nagarkurnool showing the greatest diversity of birds followed by Nalgonda. In Maize a total of 30 species were observed, and highest number of species were observed in Nagarkurnool which had favorable conditions for maize cultivation while lowest were found in Vikarabad (Table 1.25).

Table 1.25. District wise locations surveyed and the species richness in each crop

District	No of mandals covered	No of villages surveyed	No of species recorded			
			Bajra	Maize	Sorghum	Sunflower
Nalgonda	5	20	12	10	15	13
Vikarabad	4	15	10	8	12	10
Nagarkurnool	6	25	15	12	18	15
Total	**15**	**60**	**37**	**30**	**45**	**38**

Table 1.26. Mean number of individuals recorded from different crops in different districts

District	No of Villages Surveyed	Bajra (Mean Individuals)	Maize (Mean Individuals)	Sorghum (Mean Individuals)	Sunflower (Mean Individuals)
Nalgonda	20	1200 (60)	800(40)	1500(75)	1000 (50)
Vikarabad	15	900 (60)	1000 (66)	1300 (86)	1100 (73)
Nagarkurnool	25	1400 (56)	1200(48)	1600(64)	1300 (52)

The mean number of individuals in Bajra was quite consistent across the districts, with a slight decrease in Nagarkurnool (56 individuals per village). In Maize crop Vikarabad recorded highest average number of individuals compared to Nalgonda and Nagarkurnool, suggesting a preference for Maize crop or more intensive farming practices by farmers in the district. Sorghum cultivation is mostly concentrated in Vikarabad and the crop recorded highest mean of individuals (86). Similarly, Sunflower crop in Vikarabad also recorded highest mean number of individuals (Table 1.26).

1.2.1.1. Percent Relative Abundance of Peafowls, Pigeons and Parrots

The relative abundance of the three-bird species (Peafowls, Pigeons, Parrots) across different crops and districts revealed that Peafowls was the most abundant species in Bajra and Maize crops in most districts, while Pigeons and Parrots exhibited variable distribution patterns depending on the district and crop type. In Nalgonda**,** Peafowls were the most abundant species, comprising 55.56 percent of the individuals observed, followed by Pigeons at 27.7 percent in Bajra crop and parrots recorded least percentage of 16.67 percent. Similarly, in Maize also Peafowls were dominated with 54.55percent, while Parrots recorded a least percentage of 18.18percent and pigeons were 27.27percent. Similar, trend was observed in Sorghum and sunflower however, mean percentage of peafowls were comparatively low in sorghum with 47.83percent compared to rest of the crops, followed by pigeons (31.58 percent) and parrot (21.74 per cent), In Vikarabad district maize recorded highest percentage of peafowls with 52.63percent followed by sunflower crop. In Nagarkurnool district, Bajra and sunflower recorded highest incidence of Peafowls, with over 55 and 50 percent, respectively, while maize recorded highest incidence of pigeons of 33.33 percent among all the crops surveyed. The parrot population was comparatively more in all the crops of Nagarkurnool district with even distribution ranging from 20- 25 percent (Table 1.27).

Table abundance for Each Species Across Crops in Three Districts

District	Crop	Peafowls (percent)	Pigeons (percent)	Parrots (percent)
Nalgonda	Bajra	55.56	27.78	16.67
	Maize	54.55	27.27	18.18
	Sorghum	47.83	30.43	21.74
	Sunflower	56.25	25.00	18.75
Vikarabad	Bajra	42.11	31.58	26.32
	Maize	52.63	26.32	21.05
	Sorghum	47.37	31.58	21.05
	Sunflower	50.00	31.25	18.75
Nagarkurnool	Bajra	55.00	25.00	20.00
	Maize	41.67	33.33	25.00
	Sorghum	48.00	28.00	24.00
	Sunflower	50.00	27.78	22.22

1.2.2. Punjab (PAU (AO), Ludhiana)

A total of 53 bird species were observed during the study period at selected villages of Punjab and Haryana during the study period (Table 1.28).

Table 1.28. Overall annual relative abundance (percent) of avian species observed in villages of Punjab and Haryana

Sr. No.	Species	Punjab	Haryana
1.	Alexandrine Parakeet	0.09	0.50
2.	Asian Koel	0.18	0.60
3.	Bank Myna	3.56	-
4.	Baya Weaver	0.32	-
5.	Black Drongo	0.27	0.25
6.	Black Kite	0.09	-
7.	Black-headed Ibis	0.09	0.05
8.	Black-winged Kite	0.05	0.05
9.	Black-winged Stilt	1.42	0.20
10.	Brahminy Starling	0.27	0.10
11.	Brown Rock Chat	1.05	2.42
12.	Brown-headed Barbet	0.14	0.10
13.	Cattle Egret	6.94	11.13
14.	Common Hoopoe	-	0.20
15.	Common Moorhen	0.05	0.10
16.	Common Myna	18.95	11.03
17.	Common Tailorbird	0.09	0.10
18.	Eurasian Collared Dove	5.94	3.38
19.	Greater Coucal	0.05	0.10

20.	Green Bee-eater	1.28	2.77
21.	House Crow	4.79	2.32
22.	House Sparrow	2.56	0.76
23.	Indian Black Ibis	0.23	0.55
24.	Indian Grey Hornbill	0.50	-
25.	Indian Peafowl	-	1.56
26.	Indian Pond Heron	0.37	0.25
27.	Indian Robin	0.32	0.50
28.	Indian Roller	0.05	0.05
29.	Indian Silverbill	-	0.10
30.	Jungle Babbler	4.57	2.17
31.	Laughing Dove	1.32	0.81
32.	Little Egret	0.09	-
33.	Oriental Magpie Robin	0.18	0.25
34.	Plain Prinia	0.09	0.10
35.	Purple Sunbird	0.32	0.81
36.	Red-vented Bulbul	0.96	1.51
37.	Red-wattled Lapwing	3.42	4.08
38.	Rock Pigeon	26.30	29.57
39.	Rose-ringed Parakeet	9.50	11.79
40.	Rufous Treepie	0.09	0.10
41.	Spotted Owlet	-	0.45
42.	White Wagtail	0.64	1.71
43.	White-breasted Waterhen	0.37	0.60
44.	White-browed Wagtail	0.32	-
45.	White-throated Kingfisher	0.41	1.01
46.	Wire-tailed Swallow	1.55	4.48
47.	Yellow-legged Green Pigeon	-	0.10
48.	Asian Pied Starling	0.09	1.01
49.	Common Sandpiper	0.14	-
50.	Western Yellow Wagtail	-	0.05
51.	Great Egret	-	0.05
52.	Little Cormorant	-	0.10
53.	Coppersmith Barbet	-	0.05
	Jaccard's similarity index	**0.70**	

Total bird species recorded from villages of Punjab and Haryana were 44 (11, orders; 27 families) (Fig. 1.10) and 46 (13, orders; 28 families) (Fig. 1.11).

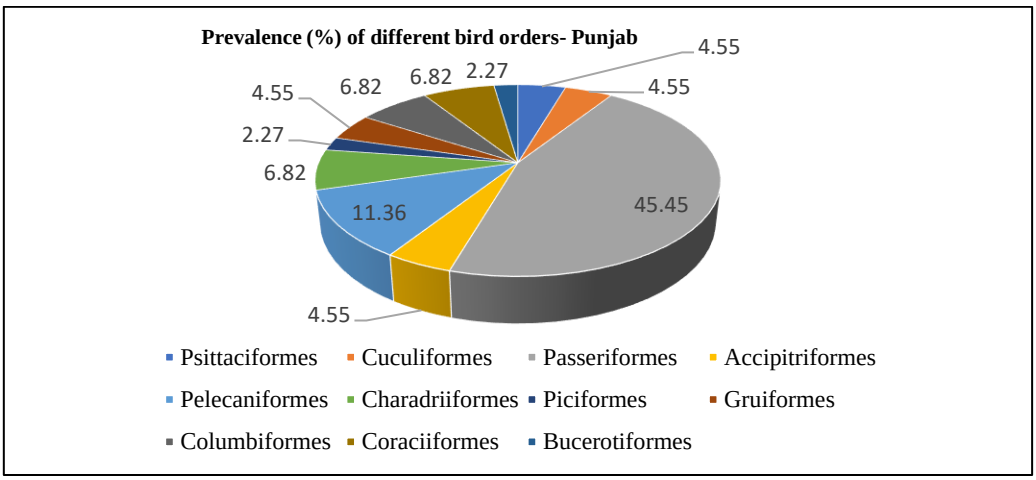


Fig. 1.10. Percent prevalence of different bird orders observed in villages of Punjab

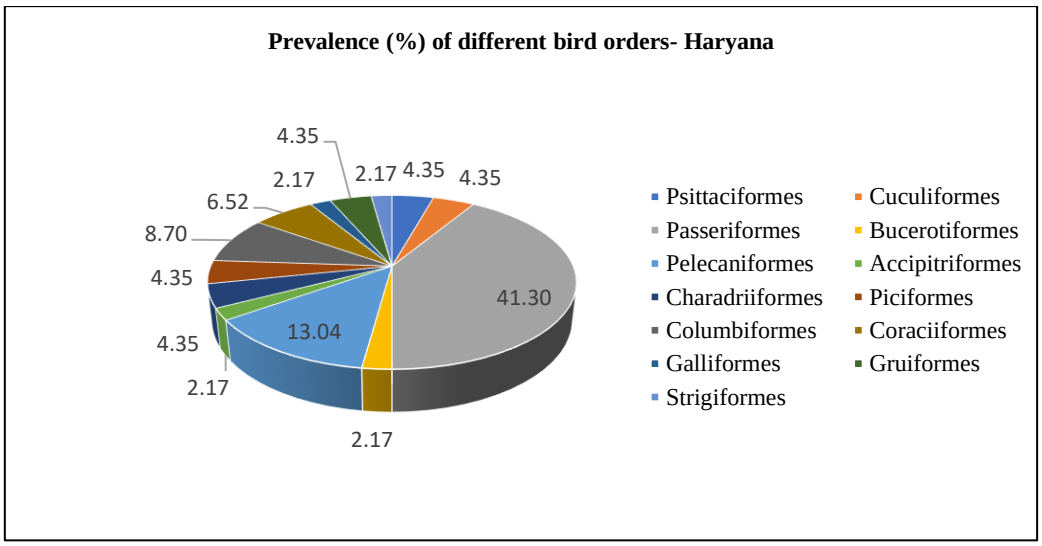


Fig 1.11. Percent prevalence of different bird orders observed in villages of Haryana

1.2.2.1. Nesting activities of different avian species in wheat and rice crop fields of Punjab and Haryana

Nesting sites of 7 avian species were found in wheat and rice crop fields of Ludhiana, Punjab out of which 2 nesting sites belonged to insectivorous birds. Similarly, nesting sites of 6 avian species were found in wheat and rice crop fields of Sirsa, Haryana out of which 2 nesting sites belonged to insectivorous birds. Majority of nesting species preferred thorny trees like *Acacia nilotica, Acacia albida, Acacia tortilis* and *Ziziphus mauritiana* as nesting sites surrounded by agricultural lands as thorns seem to deter predators and agricultural fields provide them with abundant food resources.

Table 1.29. Egg Parameters of different breeding avian species in selected Wheat *(Rabi)* and Rice *(Kharif)* crop fields in Mirpur, Haryana

Species	Clutch Size	Egg length (mm)	Egg width (mm)	Egg weight (gm)	Egg Volume (cm^3)	Egg specific gravity (gm/cm^3)	Egg shape index
Baya Weaver	2.75±0.25	16.10±0.07	12.50±0.13	1.60±0.06	1.15±0.03	1.40±0.08	77.61±0.62
House Sparrow	2.80±0.20	20.15±0.23	12.05±0.27	2.30±0.16	1.34±0.07	1.71±0.04	59.80±0.85
Laughing Dove	2.00±0.00	23.92±0.14	14.45±0.11	12.01±0.11	2.28±0.02	5.26±0.10	60.43±0.80

Plain Prinia	3.00±0.00	7.05±0.07	4.79±0.11	0.93±0.06	0.07±0.00	12.52±0.07	67.86±0.82
Purple Sunbird	4.00±0.00	16.02±0.04	10.87±0.11	1.20±0.04	0.86±0.02	1.39±0.02	67.87±0.54
Red-vented Bulbul	3.50±0.50	20.35±0.11	15.21±0.03	1.18±0.05	2.15±0.02	0.55±0.02	74.74±0.26
Red-wattled Lapwing	2.75±0.25	40.63±0.26	29.14±0.16	16.18±0.11	15.77±0.26	1.03±0.01	71.74±0.25
Rock Pigeon	2.00±0.00	32.10±0.09	26.58±0.11	15.30±0.16	10.36±0.05	1.48±0.02	82.80±0.57
White-eared Bulbul	2.00±0.00	17.98±0.30	15.71±0.15	1.14±0.02	2.03±0.07	0.56±0.03	87.36±0.65

Egg parameters of nine avian species in wheat *(Rabi)* and rice *(Kharif)* crop fields in Mirpur, Haryana was recorded, Purple Sunbird (4.00±0.00) was having the largest clutch size and Red-wattled Lapwing was having the largest egg length (40.63±0.26 mm), width (29.14±0.16 mm), weight (16.18±0.11 gm) and volume (15.77±0.26 cm^3). Insectivores were the dominant feeding guild followed by partially insectivores and granivores in wheat and rice crops (Table 1.29).

Table 1.30. Egg Parameters of different breeding avian species in selected Wheat *(Rabi)* and Rice *(Kharif)* crop fields of Sirsa, Haryana

Species	Clutch Size	Egg length (mm)	Egg width (mm)	Egg weight (gm)	Egg Volume (cm^3)	Egg specific gravity ($gm/cm^{3)}$	Egg shape index
House Sparrow	2.50±0.29	20.27±0.68	13.66±0.55	2.50±0.90	1.75±0.19	1.46±0.30	67.34±1.73
Laughing Dove	2.00±0.00	24.03±0.11	14.02±0.19	12.36±0.17	2.16±0.07	5.73±0.11	58.33±0.53
Purple Sunbird	2.00±0.00	15.92±0.10	10.84±0.06	1.18±0.02	0.85±0.01	1.38±0.00	68.06±0.08
Red-vented Bulbul	2.33±0.33	20.12±0.08	15.20±0.10	1.24±0.05	2.13±0.04	0.58±0.02	75.57±0.21
Red-wattled Lapwing	3.17±0.40	41.46±0.29	29.52±0.15	17.04±0.28	16.51±0.26	1.03±0.01	71.19±0.35
Rock Pigeon	2.00±0.00	32.13±0.23	26.42±0.37	15.96±0.06	10.25±0.36	1.56±0.05	82.22±0.53

Egg parameters of six avian species in selected wheat *(Rabi)* and rice *(Kharif)* crop fields of Sirsa, Haryana were recorded, Red-wattled Lapwing was having the largest clutch size (3.17±0.40), egg length (41.46±0.29 mm), width (29.52±0.15 mm), weight (17.04±0.28 gm) and volume (16.51±0.26 cm^3) (Table 1.30).

1.2.2.2. Avian species in wheat crop fields of Punjab and Haryana

A total of 29 and 27 avian species were recorded belonging to 9 and 8 orders, 18 and 21 families in Wheat (*Rabi*) crops in Punjab and Haryana, respectively. Order Passeriformes was dominant and constituted 52percent of total species richness at both the locations. Study had revealed six trophic levels (insectivorous, omnivorous, granivorous, partial insectivorous, carnivorous and frugivorous), Insectivorous (30percent, 33percent) being dominant followed by Omnivorous (22percent, 26percent) and Granivorous (19percent, 19percent) in Punjab and Haryana respectively (Fig. 1.12).

1.2.2.3. Avian species in rice crop fields of Punjab and Haryana

A total of 33 and 30 avian species were recorded belonging to 9 and 9 orders, 20 and 21 families in rice (*Kharif*) crops in Punjab and Haryana, respectively. Order Passeriformes was dominant and constituted 50percent of total species richness at both the locations. Study had revealed six trophic levels (insectivorous, omnivorous, granivorous, partially insectivorous, carnivorous and frugivorous),

Insectivorous (30percent,33percent) being dominant followed by Omnivorous (20percent, 30percent) and Granivorous (19percent, 13percent) in Punjab and Haryana, respectively (Fig. 1.13).

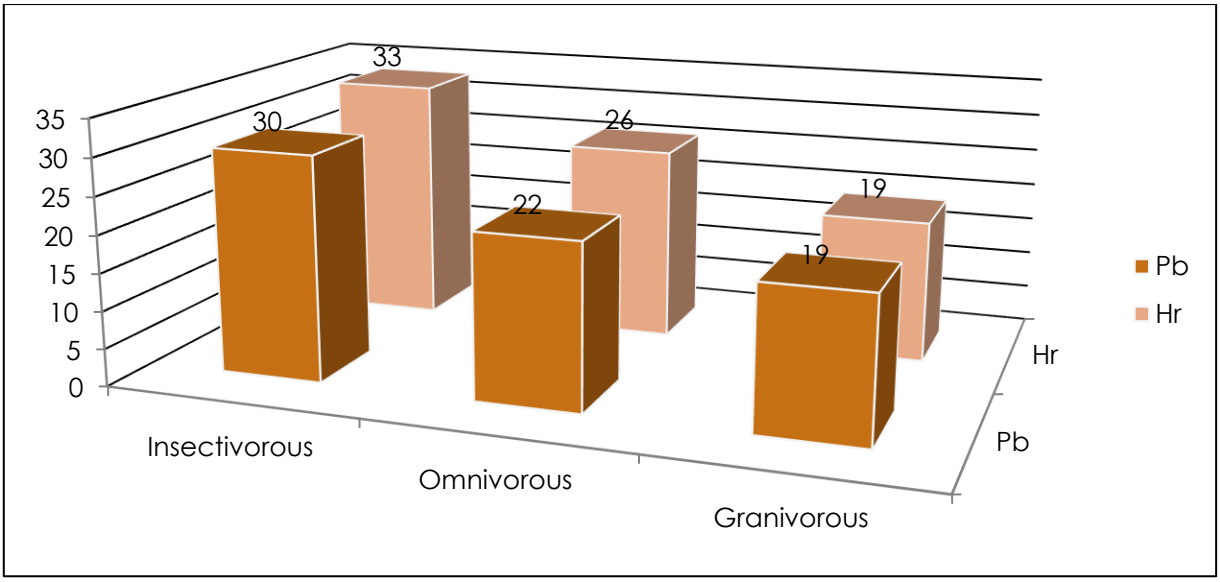


Fig. 1.12. Feeding guilds of avian species (percent) in Wheat (*Rabi*) crop fields Punjab and Haryana

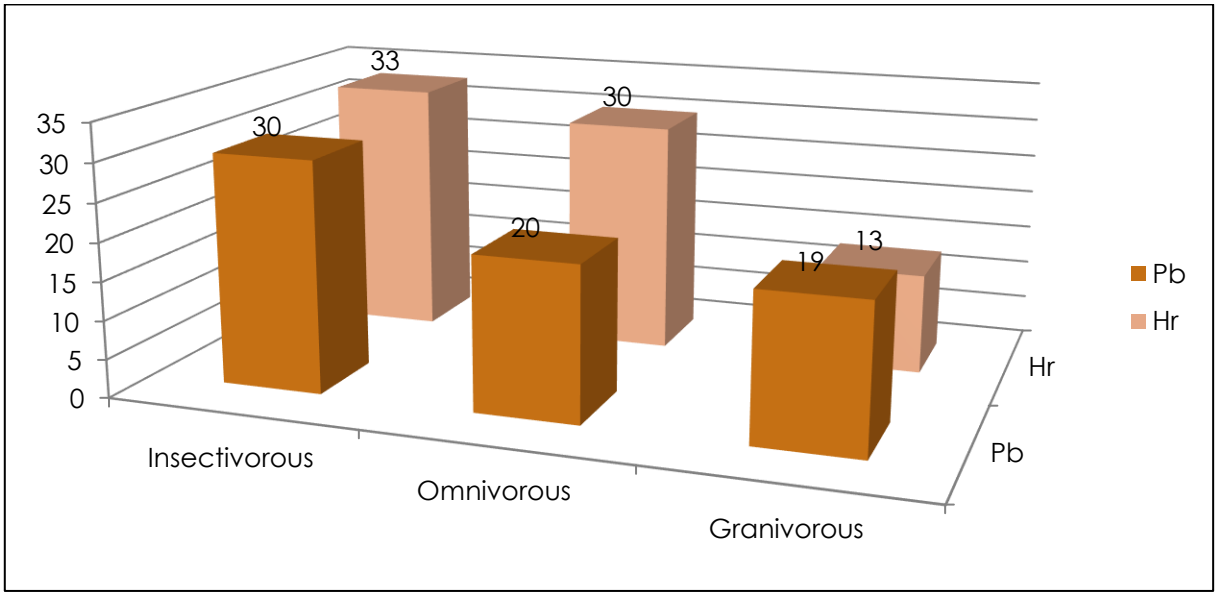


Fig. 1.13. Feeding guilds of avian species (percent) in Rice (*Kharif*) crop fields of Punjab and Haryana

1.2.2.4. Avian diversity in Green Gram crop fields

A total 44 species were recorded associated with green gram crop in selected organic and conventional fields i.e. L1 Ladhowal, L2- Ghelewal and L3-Pakhowal villages of district Ludhiana. Passeriformes was the most predominant order of birds and mostly birds were Resident in status with few exceptions of Resident Migrants. In organic green gram, 75 percent birds were insectivorous, 17 percent were granivorous, 6percent plant feeder and 3 percent omnivorous whereas in conventional green gram, 72 percent were insectivorous, 20 percent were granivorous, 4 percent were omnivorous and plant feeder, respectively (Fig. 1.14).

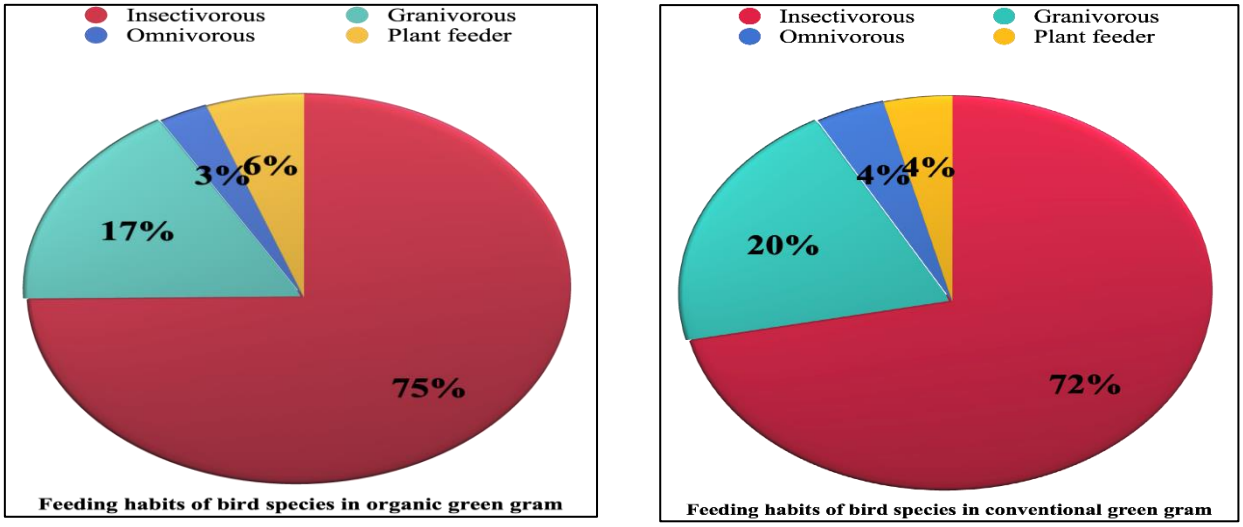


Fig. 1.14. Order- wise relative abundance (percent) of bird species in green gram (organic and conventional) crop fields

Table 1.312. Avian species richness in organic and conventional fields of green gram

Locations	Species in Organic field	Species in Conventional field	Species in common	Sorensen's index
L1 (PAU)	31	27	20	0.68
L2 (Ghelewal)	32	24	23	0.82
L3 (Pakhowal)	32	26	21	0.72

Organic fields have more species at each location as compared to conventional fields. Sorensen's index was calculated to measure overlap between two populations of avian species in organic and conventional fields of green gram. The index varies between 0 (no overlap) and 1 (complete overlap). Sorensen's index for PAU was 0.68, for Ghelewal was 0.82, and Pakhowal was 0.72. PAU had less overlap among these three locations and Ghelewal had maximum overlap (Table 1.31).

1.2.3. Kerala (KAU, Thrissur)

1.2.3.1. Depredatory birds (Peafowl) in rice and vegetable fields in Kerala

A study was conducted to assess the occurrence and damage caused by Indian Peafowl in rice and vegetable fields across Kerala and parts of Tamil Nadu from September 2023 to April 2024. The study followed a two-phase approach, beginning with a roving survey to assess Peafowl density in selected districts using line transect and point count methods with GPS tracking. Subsequently, fixed plot surveys were conducted in rice and vegetable fields, implementing line transect methods for monitoring peafowl across three villages in each block/district, with GPS tagging to record spatial distribution (Fig 1.15). Table 1.32 represents the roving survey on peafowl density across various districts in Kerala reveals significant variations in population distribution. Idukki stands out with the highest average density of 5.34 peafowl per block, suggesting favourable conditions such as abundant habitat and lower human disturbances, making it an ideal environment for peafowl. Palakkad and Wayanad also exhibit relatively high densities, with 4.67 and 4.06 peafowl per block, respectively, indicating stable and thriving populations in these areas. On the other hand, districts like Ernakulam and Kollam show the lowest densities, with 1.73 and 2.03 peafowl per block, respectively. In Table 1.33. The Coimbatore district of Tamil Nadu has population density of 1.14.

The results of fixed plot survey of the peafowl density from various districts in Kerala provide insights into the population distribution and environmental conditions supporting peafowl. Each district is represented by multiple locations, with different crops and varying densities of peafowl observed per square kilometre. Thrissur recorded the highest densities, especially in Velappya with 8.33 peafowl per km² and Chelakkara with 7.33 peafowl per km², likely reflecting favourable agricultural landscapes,

especially in cowpea and watermelon fields. Palakkad is another district with high densities, especially in Shornur (8.00 peafowl per km²) and Malampuzha (6.67 peafowl per km²), where cowpea and okra cultivation seem to provide suitable habitats for peafowl. Idukki, known for its varied topography, also shows significant peafowl densities, particularly in Chalassery (6.25 peafowl per km²) and Devikulam (5.33 peafowl per km²), indicating that cowpea fields in these hilly regions support healthy peafowl populations. Ernakulam, Wayanad, and Kasargod show lower peafowl densities, with most locations reporting densities between 1.33 and 3.33 peafowl per km². For example, Kunnampetta in Wayanad recorded just 1.33 peafowl per km², possibly reflecting less suitable habitats or environmental pressures in these districts. Kasargod locations, particularly Kuttikkol, had one of the lowest densities at 1.39 peafowl per km², which may be attributed to less favourable crop types or habitat conditions. The data also shows that peafowl density can vary based on the type of crop being cultivated. Cowpea, watermelon, and okra appear to attract more peafowl, as reflected in high-density areas like Thrissur and Palakkad, while fields with crops like rice and cucurbits tend to support fewer peafowl, particularly in districts like Kasaragod and Wayanad (Table 1.34).

Table 1.32. Peafowl population density across Kerala (Roving survey)

S. No	District	No of blocks	No of locations covered in each block	Average Density
1	Thiruvananthapuram	11	3	2.75 ± 0.01^{fg}
2	Kollam	11	3	2.03 ± 0.06^{i}
3	Pathanamthitta	8	3	3.28 ± 0.02^{e}
4	Alappuzha	12	3	2.06 ± 0.05^{i}
5	Kottayam	11	3	2.36 ± 0.04^{h}
6	Idukki	8	3	5.34 ± 0.20^{a}
7	Ernakulam	14	3	1.73 ± 0.06^{j}
8	Thrissur	16	3	3.93 ± 0.04^{cd}
9	Palakkad	13	3	4.66 ± 0.09^{b}
10	Malappuram	15	3	2.02 ± 0.04^{i}
11	Kozhikode	12	3	2.70 ± 0.01^{fg}
12	Wayanad	4	3	4.06 ± 0.18^{c}
13	Kannur	11	3	2.94 ± 0.00^{f}
14	Kasargod	6	3	3.36 ± 0.04^{e}

Table 1.33. Peafowl population density in Coimbatore district of Tamil Nadu

Distt.	Location	GPS Coordinates	Crops	Area of transect (Km2)	No Peafowl cited (n)	No of Peafowl/Km 2
Coimbatore	Madhukkarari	10.8896003, 76.9473587	Cucumber	0.5	3	6.00
	Meenakshipuram	10.6269842, 76.8729566	Bottle gourd	0.45	4	8.89
	pollachi	10.6390391, 76.9932497	Okra	0.55	3	5.45
	Kinathukadavu	10.7945693, 77.0099613	Cucurbits	0.5	3	6.00
	Kottur	10.5265047, 76.9776445	Bitter gourd	0.5	3	6.00
	Anaimalai	10.5869447, 76.9412084	Cowpea	0.48	2	4.17
	Mean population density					**1.14±0.02**

Table 1.34. Peafowl population density in rice and vegetable crops across Kerala

S No	District	Location	GPS Co-ordinates	Crops	Area of transect (Km 2)	No Peafowl cited (n)	No of Peafowl /Km2	Average Density (Mean±S. Em)
1	Thiruvananthapuram	Vellanad	8.5668, 77.0629	Cowpea	0.5	7	14.00	4.67±0.03
		Ponmudi	8.6806, 77.0891	Cucumber	0.48	3	6.25	2.08±0.01
		Venganoor	8.3880, 76.9790	Okra	0.5	5	10.00	3.33±0.10
2	Kollam	Punalur	8.9555, 77.0338	Watermelon	0.5	4	8.00	2.67±0.03
		Anchal	8.9177, 76.9085	Cowpea	0.48	4	8.33	2.78±0.01
		Ramankulangara	8.9080, 76.5605	Cowpea	0.5	3	6.00	2.00±0.3
3	Pathanamthitta	Konni	9.3720, 77.0294	Yam	0.5	6	12.00	4.00±0.10
		Nilakkal	9.3930, 77.0097	Okra	0.48	3	6.25	2.08±0.30
		Enadimangalam	9.1310, 76.7950	Cucumber	0.5	4	8.00	2.67±0.01
4	Alappuzha	Karumathra	9.5010, 76.4721	Rice	0.5	3	6.00	2.00±0.04
		Perumpalam	9.8527, 76.3593	Rice	0.48	4	8.33	2.78±0.02
		Changaram	9.7975, 76.2890	Picking melon	0.48	5	10.42	3.47±0.40
5	Kottayam	Thidanad	9.6682, 76.7550	Cowpea	0.5	4	8.00	2.67±0.60
		Chovoor	9.7560, 76.8092	Amaranthus	0.5	5	10.00	3.33±0.40
		Vembanad	9.5968, 76.3945	Rice	0.5	4	8.00	2.67±0.30
6	Idukki	Devikulam	10.0098, 76.9154	Cowpea	0.5	8	16.00	5.33±0.12
		Chalassery	9.9082, 76.7659	Cowpea	0.48	9	18.75	6.25±0.26
		Thekkumbhagam	9.8657, 76.7331	Cucumber	0.5	4	8.00	2.67±0.30
7	Ernakulam	Kallimedu	10.1908, 76.8147	Bitter gourd	0.5	4	8.00	2.67±0.40
		Kotamanagalam	10.0512, 76.7697	Amaranthus	0.48	3	6.25	2.08±0.10
		Ayyampuzha	10.2943, 76.4790	Cowpea	0.5	5	10.00	3.33±0.03
8	Thrissur	Chelakkara	10.3942, 76.2124	Cowpea	0.5	11	22.00	7.33±0.06
		Velappya	10.6052, 76.2077	Watermelon	0.48	12	25.00	8.33±0.04
		Panjal	10.4149, 76.2137	Cucumber	0.5	8	16.00	5.33±0.04
9	Palakkad	Malampuzha	10.8259, 76.7338	Cowpea	0.5	10	20.00	6.67±0.04
		Shornur	10.7952,	Okra	0.5	12	24.00	8.00±0.09

			76.2624					
		Pattambi	10.8082,76.1924	Rice	0.48	8	16.67	5.56±0.04
10	Malappuram	Amarambalam	11.2365, 76.3544	Amaranthus	0.5	6	12.00	4.00±0.36
		Thavanur	10.8551, 76.0056	Cowpea	0.5	5	10.00	3.33±0.4
		Angadippuram	10.9721,76.2073	Pumpkin	0.48	4	8.33	2.78±0.2
11	Kozhikode	Chekkiad	11.7517, 75.6659	Cowpea	0.5	5	10.00	3.33±0.10
		Chakkittappara	11.5724, 75.8227	Yams	0.5	6	12.00	4.00±0.35
		Kallor kavu	11.1528, 75.4726	Amaranthus	0.48	5	10.42	3.47±0.46
12	Wayanad	Kenichira	11.7280, 76.1486	Rice	0.5	3	6.00	2.00±0.4
		Vaalad	11.8068, 75.8903	Okra	0.48	3	6.25	2.08±0.10
		Kunnampetta	11.5782, 76.0971	Cowpea	0.5	2	4.00	1.33±0.30
13	Kannur	Peravoor	11.8862, 75.7500	Yams	0.48	5	10.42	3.47±0.20
		Aralam	11.9671, 75.7990	Cowpea	0.5	7	14.00	4.67±0.30
		Kattamppally	11.9447, 75.3849	Cucumber	0.5	4	8.00	2.67±0.30
14	Kasargod	Vellarikundu	12.4346, 75.2466	Cowpea	0.5	3	6.00	2.00±0.01
		Kuttikkol	12.4825, 75.2120	Cucurbits	0.48	2	4.17	1.39±0.11
		Manjampothi	12.3377, 75.1173	Okra	0.5	5	10.00	3.33±0.21

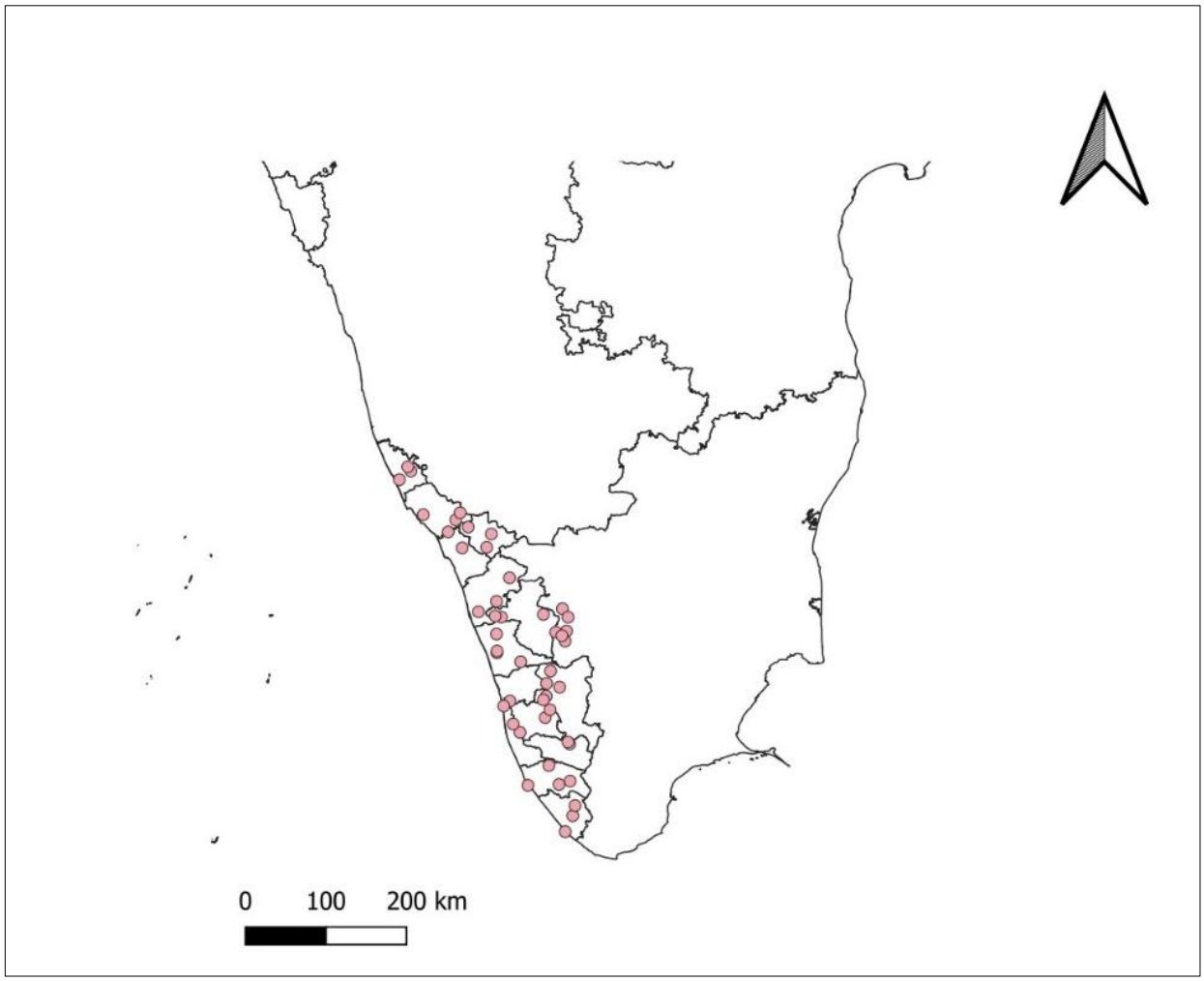


Fig. 1.15. Spatial distribution of Peafowl

1.2.3.2. Occurrence of depredatory and beneficial birds

Regular surveys were conducted to monitor predatory and beneficial birds in the predominant cropping systems of central plains and deep-water rice ecosystems (Fig. 1.16 & 1.17). The study sites included the State Seed Farm at Mannuthy, Vellanikkara (KAU), and two Kole lands (Enamavu and Pullu). Furthermore, surveys were carried out in farmers' fields to assess crop damage caused by birds. An average of thirty-two bird species were observed weekly in both the Olericulture Field and Orchard at the KAU Main Campus in Vellanikkara. Notable sightings during the survey period included the Blue-bearded Bee-eater, Jungle Owlet, Bronze Drongo, Grey Wagtail, Chestnut-tailed Starling, Emerald Dove, Grey-fronted Green Pigeon, Indian Bush Lark, Indian Pitta, Blue-faced Malkoha, and Oriental Honey Buzzard. Various crops, such as cowpea, brinjal, okra, cabbage, bitter gourd, and watermelon (Sugar Baby), were cultivated in the field during this time.

Bird diversity in the Enamavu Kole wetland varied seasonally during 2023-2024. During the flooding period from June to August, averagely thirty-five bird species were observed. This number increased to 40-50 species between September and December as water levels receded. The survey documented nesting sites of the Oriental Darter and roosting locations of Black-crowned Night Heron and Purple Swamphen. Notable observations included raptors such as Brahminy Kite and Marsh Harrier, along with other species including Chestnut-tailed Starling, Rosy Starling, Painted Stork, Black-headed Ibis, various species of herons and egrets, Stilt Sandpiper, Common Sandpiper, Clamorous Reed Warbler, Barn Swallow, various Munia species, and Baya Weaver.

The Pullu Kole wetland hosted an average of fifty bird species during November and December 2023. Notable observations included raptors such as Brahminy Kite, Greater Spotted Eagle, and Black-winged Kite. Other recorded species included Common Sandpiper, Painted Stork, various species of egrets, Black-headed Ibis, herons, Stilt Sandpiper, Clamorous Reed Warbler, Barn Swallow, various Munia species, and terns.

Weekly bird surveys at the State Seed Farm, Mannuthy documented an average of fifteen bird species. The farm cultivates rice varieties Uma and Jyothi, along with okra, bitter gourd, and cowpea. In addition to resident bird species, the surveys recorded several notable visitors including Spot-billed Duck, Changeable Hawk-Eagle, Pompadour Green Pigeon, Lesser Whistling Duck, Black-winged Stilt, Western Yellow Wagtail, flocks of Common Sandpiper, Woolly-necked Stork, and Painted Stork.

The bird diversity across different locations is represented by various indices. Pullu shows the highest Shannon-Weiner Index (H') and Richness Index for both depredatory and beneficial birds, indicating the most diverse bird population (H' = 2.65 and 3.12) and a large number of species (51 total species). Vellanikkara also has high diversity for both categories but with fewer species (32). Enamavu shows moderate diversity with **35** total species**,** while SSF exhibits the lowest species richness and diversity (15 species, H' = 1.82 for depredatory birds). The Evenness Index (J') is consistently high across locations, indicating a relatively balanced distribution of bird species (Table 1.35).

Table 1.35. The depredatory and beneficial bird's diversity indices in Kerala

Location	Coordinates	Category of birds	Shannon-Weiner Index (H')	Evenness Index (J')	Richness index	Total species
Vellanikkara	10°33'4"N 76°16'54"E	Depredatory birds	2.6560	0.9374	5.8291	32
		Beneficial Birds	2.4579	0.9076		
SSF	10°32'27"N 76°15'48"E	Depredatory birds	1.8238	0.9372	3.9436	15
		Beneficial Birds	2.2709	0.8853		
Pullu	10.472304N 76.162961E.	Depredatory birds	2.6454	0.915245588	8.59079	51
		Beneficial Birds	3.1256	0.901857524		
Enamavu	10.5118N, 76.0936E	Depredatory birds	2.1919	0.9141	6.2724	35
		Beneficial birds	2.9481	0.9276		

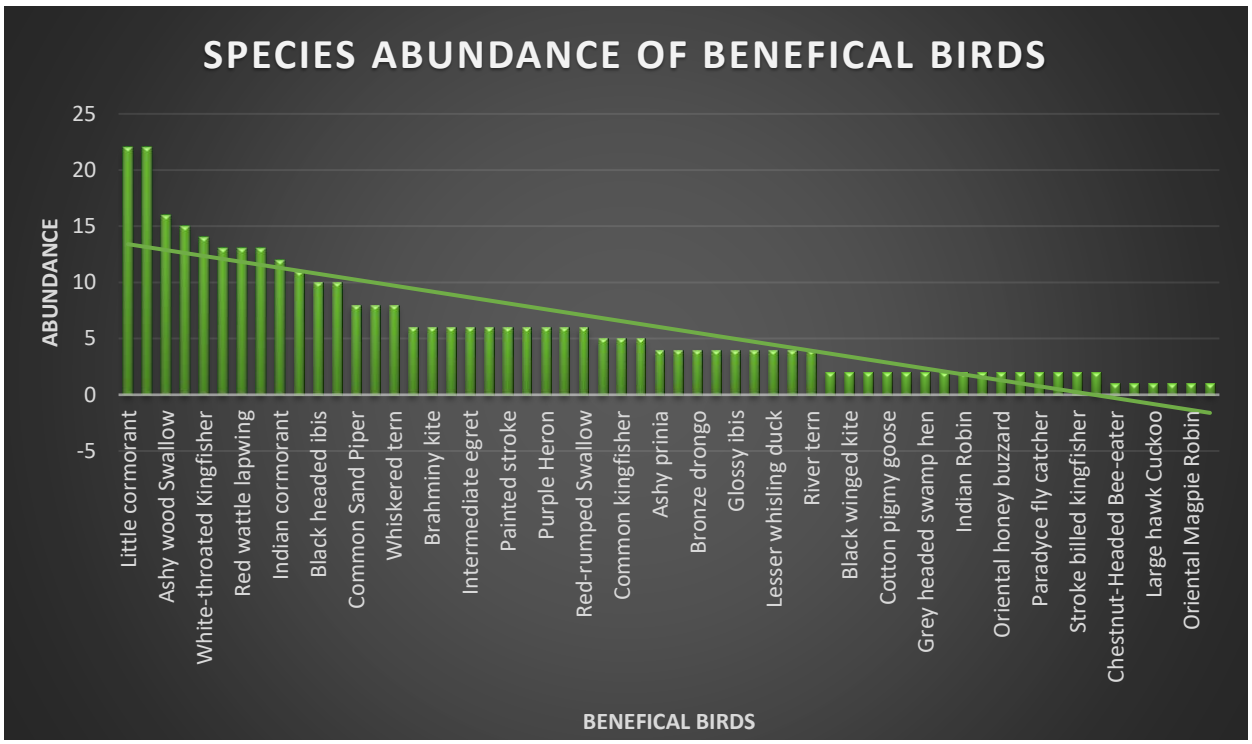


Fig. 1.16. Species abundance of beneficial birds

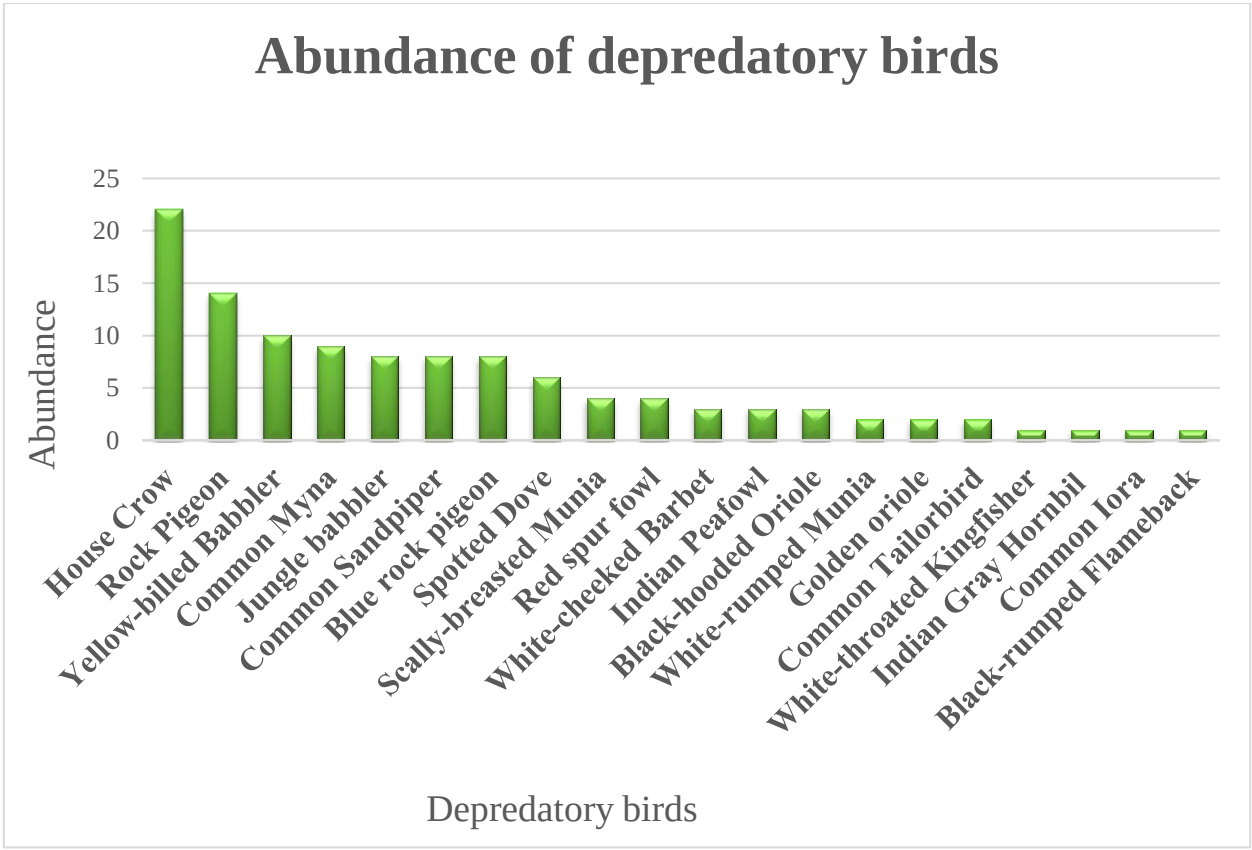


Fig 1.17. Abundance of depredatory birds in selected locations

1.2.4. Karnataka (UAS, Bengaluru)

A comprehensive surveillance of bird activity was conducted in ragi, maize, sunflower, bajra, and sorghum crops across Mysore and Tumkur districts. The study documented the incidence of various bird species, their diversity indices, and their impact on these crops, as summarized below:

Ragi: In ragi crops, bird activity was observed from the sowing to the harvesting stage. A total of 24 different bird species were recorded, with a Shannon diversity index of 1.76 and a Berger-Parker index of 0.84. The predominant bird pests identified in ragi included Indian peafowl, munias, and pigeons. These species posed significant threats throughout the crop growth cycle (Table 1.36).

Maize: Bird activity in maize was dominated by Indian peafowl and parakeets, especially during the milky stage of the crop. The Shannon diversity index for maize was 1.39, and the Berger-Parker index was 0.78. The incidence of bird damage ranged from 5.97percent to 16.53percent, highlighting the presence of a diverse bird population that targeted maize cobs (Table 1.36).

Sunflower: Bird incidence in sunflower was prominent during the sowing and grain-filling stages. A total of 31 bird species were recorded, with the Shannon index at 1.69 and the Berger-Parker index at 0.62. The most predominant bird species were Indian peafowl, followed by parakeets, sunbirds, and green bee-eaters. These species posed a significant threat during critical growth stages of the crop (Table 1.36).

Bajra: In bajra fields, the predominant bird pests included parakeets, sparrows, blue rock pigeons, and spotted munias. The incidence of bird damage ranged from 2.26percent to 17.98percent. The Shannon diversity index for bajra was 1.82, and the Berger-Parker index was 0.69, indicating a moderately diverse bird population affecting the crop (Table 1.36).

Sorghum: Bird pests in sorghum were observed during the sowing/germination and harvesting stages. The damage incidence ranged from 1.98percent to 16.43percent, with parakeets, sparrows, blue rock pigeons, spotted munias, and babblers being the most significant bird species. The Shannon index for sorghum was 1.98, while the Berger-Parker index was 0.73, indicating high bird activity during these critical stages (Table 1.36).

Relative abundance of agricultural important birds in Tumkur, Mysore, and Ramanagara District shown in Fig. 1.17.

Table 1.36. Surveillance of birds in Sunflower, Maize, Groundnut and Ragi, in Bangalore rural and Shivamogga District

Place	Crop	Ear head / Cob Damage (percent)	Predominant species	No. of species observed	Shannon index H'	Berger-Parker Index
Mysore	Ragi	1.26-14.63	Indian peafowl, Indian roller, Spotted Munia, Green Bee eater	24	1.76	0.84
	Maize	5.97-16.53	Parakeet, Indian peafowl, Myna, bubbler,	17	1.39	0.78
Tumkur	Sun flower	3.83 -19.25	Parakeet, Indian peafowl, Sun bird, Green bee eater	31	1.69	0.62
	Bajra	2.26-17.98	Parakeet, sparrow, blue rock pigeon, spotted munia	28	1.82	0.69
	Sorghum	1.98-16.43	Parakeet, sparrow, blue rock pigeon, spotted munia, bubbler	27	1.98	0.73

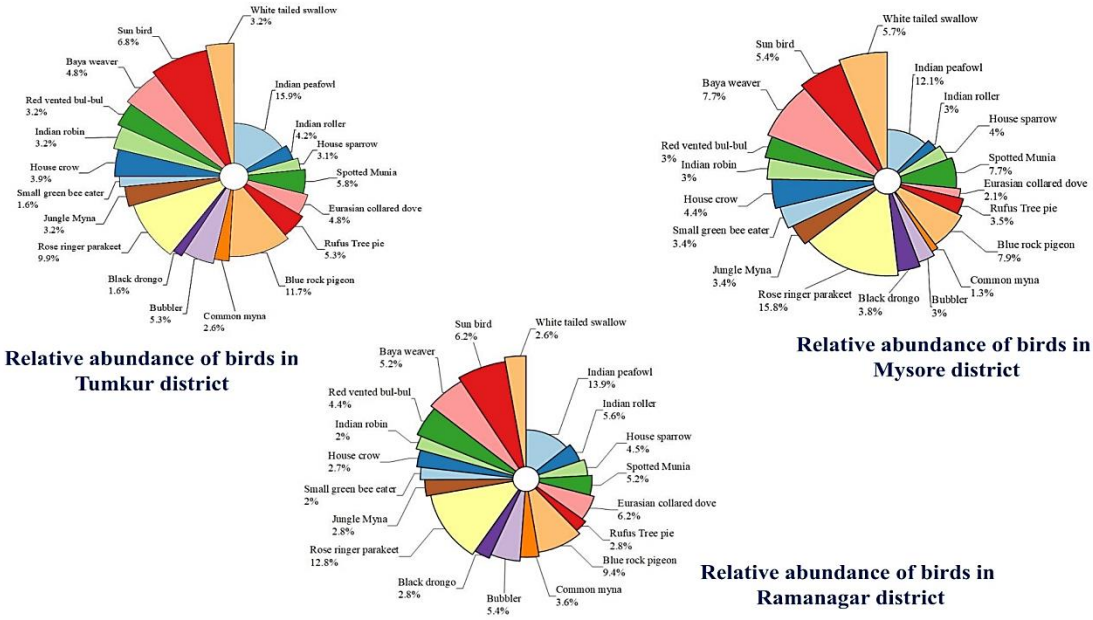


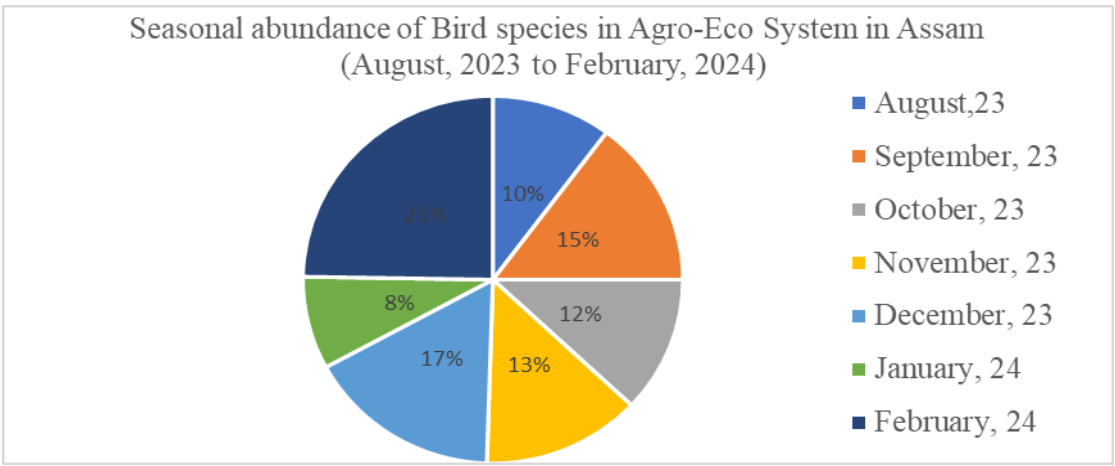
Fig. 1.17. Relative abundance of agricultural important birds in Tumkur, Mysore, and Ramanagara District

1.2.5. Assam (AAU, Lakhimpur)

During August 2023 to February 2024, a habitat analysis and distribution study were conducted across 25 locations spanning nine districts in four agro-climatic zones, viz., Lower Brahmaputra, Central, North Bank Plain, and Upper Brahmaputra Valley of Assam. The study, carried out in agricultural landscapes, homestead, paddy-mustard, and paddy-fallow cropping systems using transect and point count methods.

A total of 185 species of birds were recorded during the seven-month extensive survey, with highest beneficial omnivorous individual was found to be Common Myna (185), followed by Asian pied starling (172) and Cattle Egret (111) and among depredatory birds Spotted Dove (142) was maximum, followed by Rose Ringed Parakeet (79). A total of 2717 individual Bird were recorded. In *rabi* season maximum population of birds was recorded in February followed by November and in *Kharif* season the bird population was maximum in the month of September followed by August (Fig. 1.18 and 1.19).

The Barpeta district recorded highest Shannon index of 3.28 with 37 bird species followed by Lakhimpur with 2.8 Diversity index for 26 species (Table 1.37).



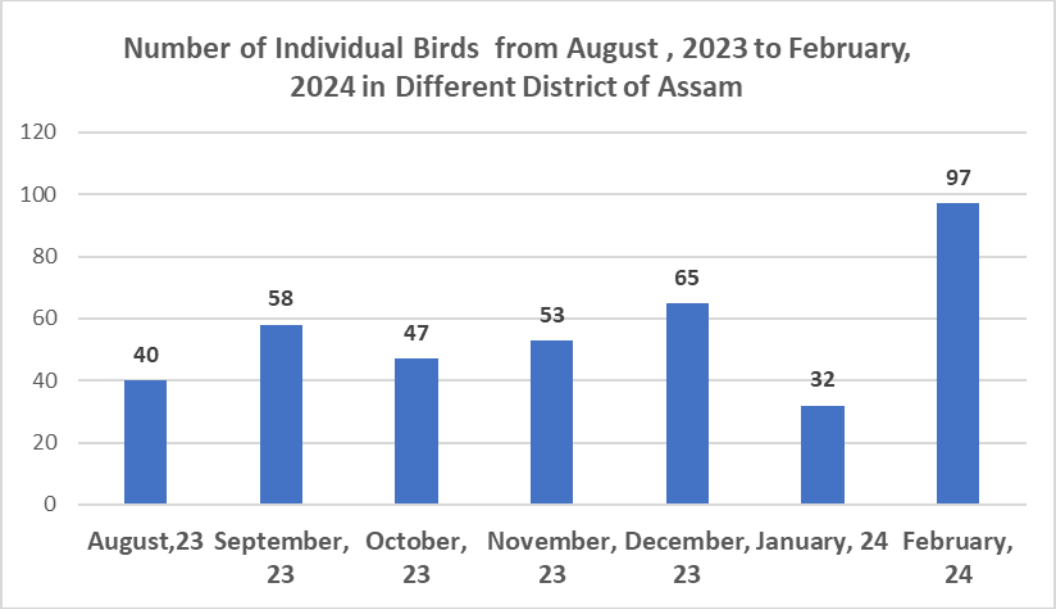


Fig. 1.18 and 1.19. Spatial distribution of birds in agro climatic zones of Assam

Table 1.37. Population estimation and spatial distribution of birds in Agricultural landscape in Agro-climatic zones of Assam 2023-24

Indices	Darrang	Nagaon	Charaido	Borpeta	Sonitpur	Lakhimpur	Sivasagar
Species richness	15	17	9	**37**	23	26	15
Shannon H	2.48	2.59	2.04	3.12	2.8	2.8	1.3
Evenness	0.16	0.14	0.2	0.08	0.12	0.1	0.09

1.2.6. Gujarat (AAU, Anand)

The study was conducted to estimate the birds' diversity, population and distribution in Vadodara district from September 2023 to September 2024. During crop growing season Total 21 species of birds in agroecosystem were recorded from the study area during the year. The relative abundance in the bird community of the Vadodara district ranged from 0.09 percent (Comb duck) to 30.29 percent (Rose-ringed parakeet) (Table 1.38). The dominant species recorded in bird community in the agroecosystem of the Vadodara district were Rose-ringed parakeet (30.29percent), common myna (13.34percent), jungle babbler (12.31percent), and cattle egret (9.47percent).

Table 1.38. Bird diversity in Vadodara district

S.No.	Birds Observed	Bird Number	Relative Abundance (percent)
1	Black crown night heron	5	0.43
2	Black Drongo	15	1.29
3	Black Headed ibis	37	3.18
4	Black ibis	50	4.30
5	Black winged stilt	24	2.07
6	Cattle egret	110	9.47
7	Comb duck	1	0.09

8	Common Myna	155	13.34
9	Great egret	10	0.86
10	Jungle Babbler	143	12.31
11	Lesser whistling duck	60	5.16
12	Little Cormorant	38	3.27
13	Painted stork	60	5.16
14	Purple Hern	8	0.69
15	Red Napped ibis	6	0.52
16	Red Vented Bulbul	18	1.55
17	Rock Pigeon	25	2.15
18	Rose ringed parakeet	352	30.29
19	Ruddy shelduck	20	1.72
20	Spot billed duck	16	1.38
21	Spotted Dove	9	0.77
Total		**1162**	**100.00**

1.3. WILD BOAR (*SUS SCROFA*)

The study on wild boar populations was conducted from September 2023 to October 2024 across several states, including Andhra Pradesh, Assam, Gujarat, Karnataka, Kerala, Telangana, and Tamil Nadu. Roving surveys were implemented to assess wild boar density in different crops within selected districts, providing insights into population distribution and potential interactions with local agriculture. Density was measured using line transect and point count methods, with GPS coordinates to precisely record locations. Monthly surveys were conducted in various crop types to monitor wild boar activity and population density trends over time. The collected data was mapped using ArcGIS and QGIS software to visualize distribution patterns across surveyed areas. All results have been presented as Mean ± SE, with statistical significance determined using a one-way ANOVA and Least Significant Differences (LSD) post-hoc test. Significance was set at $P < 0.05$ to ensure the robustness of the findings. The categories were defined as follows: villages with less than 2percent wild boar presence were classified as "Negligible," those with a 2–5 per cent presence as "Low," a 5–10 per cent presence as "Medium," and an occurrence rate above 10 per cent as "High." Indirect evidence, collected through a questionnaire survey, indicated that the wild boar population in these villages generally ranged from 5 to 10 per cent.

1.3.1. Telangana (PJTSAU, Hyderabad)

The survey was conducted across multiple villages in different mandals of Nalgonda, Vikarabad and Nagarkurnool districts through footprint and scat analysis (Fig. 1.20). Data was collected through direct observations and secondary information through farmer interviews and agricultural officers. On the basis of occurrence of the wild boars in different villages they were classified as low (<10 percent), Medium (10-30 percent), and High (31-50 percent).

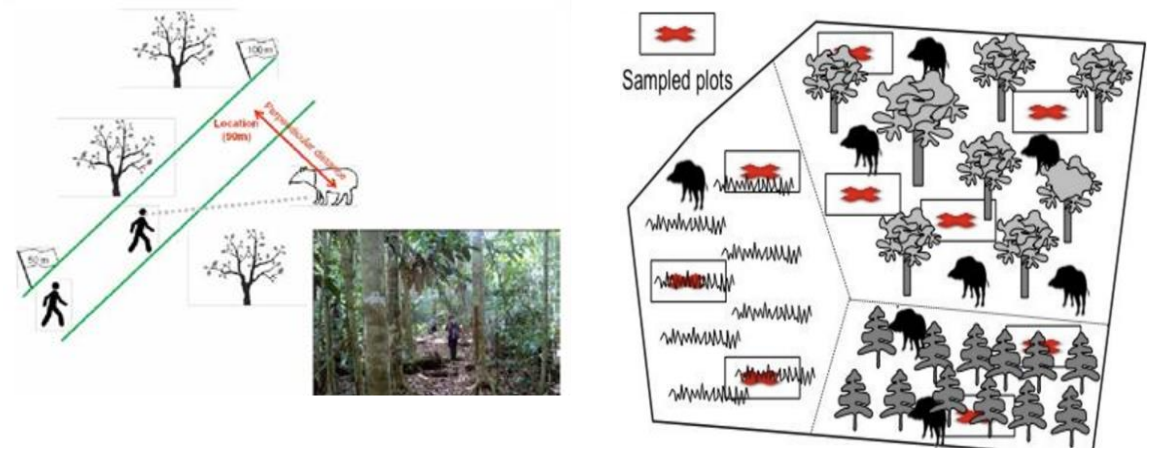


Fig. 1.20. Footprint and scat analysis method

1.3.1.1. Nalgonda District

In Nalgonda district out of 139 clusters, the wild boar was noticed in 15 clusters which are adjacent to forest fringe areas. Out of 15 clusters surveyed the wild boar presence was noticed high in Shaligouraram mandal (Nellikal) with extensive damage recorded in cotton and chilli crops. Medium presence was reported in Kambala palli, Pole palli Mallareddi palli villages in Chandampeta mandal and Peddamunigal and Vaddipatla (Pedda adisharla palli) of Neredugommu mandal affecting cotton, paddy, and jowar crops. Low Presence of wild boar was recorded in Chinthapalli (cotton, paddy, and groundnut), Devarakonda **(**cotton and paddy), Panagallu (Nalgonda) (paddy and cotton) and Nampally **(**Mustipalli**) (**Groundnut) (Table 1.39).

Table 1.39. Locations surveyed for the presence of wild boar in different agroecosystem habitats of Nalgonda District

S. No.	Mandal	Village	Wild boar presence
1	Chandampeta	Kambala palli, Pole palli	Medium
2	Chintha palle	Chintha palli	Low
3		Godukondla, Mallareddi palli	Medium
4	Devarakonda	Devarakonda	Low
5	Gundla palle	Dindi	Low
6	Gurrampode	Gurram pode	Low
7	Nalgonda	Panagallu	Low
8	Nampally	Musti palli	Low
9	Neredugommu	Peddamunigal, Kchrajupalle, Buggathanda	Medium
10	Peda adisharla palli	Vaddipatla	Medium
11	Peddavoora	Sirasana gandla	Low
12	Shaligouraram	Nellikal	High
13	Tirumalagiri	Tirumalagiri	Medium

1.3.1.1.1. Population details in Nalgonda District

1.3.1.1.1.1. Footprint analysis: A survey was conducted to estimate the population of wild boars (*Sus scrofa*) across various locations in Nalgonda district using footprints of wild boars. The data collected from different sites provided the presence and density of wild boars. The survey covered five locations, each with varying survey areas, and transect lengths of 2 km. The highest counts were found in Shaligouraram (25-foot prints/km) and the lowest in Vaddipatla Peddaadisharlapalli (12 footprints/km). The estimated number of wild boars based on the footprint counts ranged from 240 to 440 individuals across the surveyed areas, suggesting a robust population density in the region. Specific estimates per location show considerable variability, with Nellikal, and Shaligouraram indicating the highest potential

population of 100 to 200 individuals, whereas Thirumalagiri suggested a medium population size (55 to 90 individuals), and low population was estimated in Mustipally of Nampally and Vaddipatla of Peddaadisharlapalli (Table 1.40).

Table 1.40. Estimation of Wild boar population in Nalgonda district based on foot print analysis

Location	Survey Area (km^2)	Length of Transect (km)	Average Tracks Counted per km	Total footprints	Estimated Individuals (1-2 per footprint)
Mustipalli, Nampally	10	2	20	40	40 - 80
Vaddipatla, Peddaadisharlapalli	15	2	12	36	45 - 70
Nellikal, Shaligouraram	25	4	25	100	100 - 200
Thirumalagiri	20	3	15	45	55 - 90
Total				**221**	**240- 440**

1.3.1.1.1.2. Scat analysis: A scat analysis was conducted in Nalgonda district to estimate the population of wild boars. Scat density data was collected from various areas. The analysis covered four distinct locations, with varying survey areas and scat density. The total number of scats collected across all surveyed areas was 876**.** The average scat density varied by location, with the highest density found in Polepally, Chandampet (18 scats/km^2) and the lowest in Devarakonda (6 scats/km^2). Based on the scat data, the estimated number of wild boars ranged from 1,732 to 2,598 individuals across the surveyed areas, indicating a robust population, with Gurrampode indicating the highest potential population (700 to 1,050 individuals), while Devarakonda estimated a smaller population (180 to 270 individuals). Large surveyed areas, like Gurrampode (25 km^2), yielded the highest total scat counts, reflecting greater habitat use and inhabitation of wild boars (Table 1.41)

Table 1.41. Estimation of Wild boar population in Nalgonda district based on scat analysis

Location	Survey Area (km^2)	Average Scat Density (scats/km^2)	Total Scats Collected	Estimated Individuals (2-3 per scat)
Polepally Chandampet	12	18	216	432 - 648
Mallareddy pally Chinthapalle	20	11	220	440 - 660
Devarakonda	15	6	90	180 - 270
Gurrampode	25	14	350	700 - 1,050
Total			**876**	**1,732 - 2,598**

1.3.1.2. Vikarabad District

Out of 100 clusters 28 clusters spread in 14 mandals of Vikarabad district recorded presence of wild boars. Among the 28 clusters, higher presence of wild boar was recorded in 16 clusters, medium was recorded in 5 clusters and 7 clusters recorded lowest population. Wild boar presence was high in Tandur (Redgram, Green gram, and Maize), Belkatur **(**Redgram, Rice, and Groundnut**),** Peddemul (Rice, Redgram, and Cotton**),** Gopalpur (cotton and redgram), Pargi (Cotton, Maize, and Redgram), Mominpet (Tekulapalle**)** (Cotton and Maize), Mekavanampalle (Cotton and Redgram), Marpalle (Patloor) (Maize, Redgram), Kodangal (Parsapur) (Redgram, Cotton, and Groundnut) of Vikarabad District. Medium presence of wild boar was observed in Dadapur **(**Rice and Groundnut crops**)** and Dharur (Munnurusomaram) **(**Maize and Redgram**),** whereas low Presence was recorded in Yelal (Juntpalle) (Green gram, Black gram, and Cotton**).** Kotbaspalle (Redgram and Cotton**),** Kulkacharla (Mujahidpur) **(**Maize and Redgram**)** and Doma (Doma-2) **(**Rice and vegetables**)** (Table 1.42).

Table 1.42. Locations surveyed for the presence of wild boar in different agro ecosystem habitats of Vikarabad District.

Sl. No	Mandal	Village	Wild boar presence
1	Yelal	Juntpalle	Low
2	Tandur	Tandur, Belkatur	High
3		Kotbaspalle	Low
5	Peddemul	Peddemul	High
6		Gopalpur	Low
7	Pargi	Naskal, Madharam	High
8	Mominpet	Tekulapalle, Mekavanampalle	High
9	Marpalle	Patloor, Kalkoda, Shapur, Damasthapur	High
10	Kulkacharla	Mujahidpur	Low
11		Kulkacharla	High
12	Kotepally	Rampur	Low
13		Mothkupalle, Kotpalle, Indoor Oglapur, Hirapur	High
14	Kodangal	Parsapur	High
15	Doma	Doma II, Dadapur, Brahmanapalli	Low
16	Dharur	Munnurusomaram, Gurudotla	Medium
17		Mominkalan, Dharur	High
18	Chowdapur	Markal	Medium
19	Chowdapur	Chowdapur	High
20	Bantwaram	Bantwaram	Low

1.3.1.2.1. Population details in Vikarabad District

1.3.1.2.1.1. Footprint analysis: The footprint analysis covered four distinct locations within Vikarabad district. The total number of footprints recorded across all surveyed locations was 127. This indicates a significant presence of wild boars in Vikarabad district. The average number of footprints counted per kilometre varied among the locations, with Chowdapur having the highest average (15 footprints/km) and Bantwaram showing the lowest average (8 footprints/km). The estimated number of wild boars based on the total foot prints ranged from 127 to 254 individuals across the surveyed areas, reflecting a considerable population density. Specific location estimates suggest that Chowdapur (30 to 60 individuals) and Parsapur (48 to 96 individuals) support larger populations, while Munnurusomaram and Bantwaram estimate smaller populations (25 to 50 and 24 to 48 individuals, respectively) (Table 1.43).

Table 1.43. Estimation of Wild boar population in Vikarabad district based on foot print analysis

Location	Survey Area (km²)	Length of Transect (km)	Average Tracks Counted per km	Total Tracks	Estimated Individuals (assuming 1-2 per track)
Chowdapur	10	2	15	30	30 - 60
Munnurusomaram Dharur	15	2.5	10	25	25 - 50
Bantwaram	20	3	8	24	24 - 48
Parsapur Kodangal	25	4	12	48	48- 96
Total				**127**	**127-254**

1.3.1.2.1.1.2. Scat analysis: The scat analysis covered four distinct locations within Vikarabad district. A total of **590 scats** were estimated across the surveyed areas. The average scat density varied among the

locations, with Kotepalle having the highest average density (12 scats/km²) and Doma-2 showing the lowest (5 scats/km²). The estimated number of wild boars based on the total scat counts ranged from 1,230 to 1,770 individuals, with Mominkalan supports the largest population (500 to 750 individuals), followed by Kotepalle and Dadapur (240 to 360 individuals each), and Doma-2 (200 to 300 individuals) (Table 1.44).

Table 1.44. Estimation of Wild boar population in Vikarabad district based on scat analysis

Location	Survey Area (km²)	Average Scat Density (scats/km²)	Estimated Total Scats	Estimated Individuals (assuming 2-3 per scat)
Kotepalle, Kotepally	10	12	120	240 - 360
Dadapur, Doma	15	8	120	240 - 360
Doma-2, Doma	20	5	100	200 - 300
Mominkalan, Dharur	25	10	250	500- 750
Total			**590**	**1475-1770**

1.3.1.3. Nagarkurnool District

In Nagarkurnool district a total of 140 clusters are present. Among the 140 clusters only 21clusters in 7 mandals recorded presence of wild boar. High presence of wild boar was present in 9 clusters Tandur (Red gram, Green gram, Bengal gram, Maize, and Safflower), Belkatur (Red gram, Rice, Cotton, Groundnut, and Chickpea), Peddemul (Rice, Red gram, and Cotton), Gopalpur (Cotton, Red gram, and Sugarcane), Pargi (Naskal) (Cotton, Maize, and Rice), Mominpet (Tekulapalle) (Cotton and Maize), Mekavanampalle (Cotton and Red gram), Marpalle (Patloor) (Maize, Red gram, Black gram, Jowar, Bengal gram, Onion, and Potato), Kodangal (Parsapur) Red gram, Cotton, Rice, Groundnut, Green gram, and Cowpea). Medium presence was recorded in two clusters *i.e.*, Dadapur (Rice and Groundnut) and Dharur (Munnurusomaram) (Maize and Cotton), whereas low presence was observed in four clusters, Yelal (Juntpalle) (Green gram, Black gram, Cotton, Rice, and Red gram. Kotbaspalle (Doma -2) (Rice and various vegetables) (Table 1.45).

Table 1.45. Locations surveyed for the presence of wild boar in different agro ecosystem habitats of Nagarkurnool District.

S.No	Name of the Mandal	Name of the cluster	wild boar damage	Crops grown
1	Amrabad	Amrabad Madhavanipally Kothapally-2 Lakshmapur B.K Laxmapur-2 Mannanur Mannanur 1	High	Cotton Maize, rice
4	Balmoor	Balmoor Ambagiri, ananthavaram	High	Cotton Maize, Groundnut
5		Banala Banala, billakal	Medium	Cotton
6		Gattuthumman Gattutghummen	Low	Maize groundnut
7		Godal Narsaipally	High	Maize groundnut cotton Rice
8		Kondareddipalle	Low	Ground nut paddy maize cotton

		Kondareddipalle Veeramraipalli Ramaiipalle		jowar
9		Polesettipalle Ramnagar thanda Chennaram	Medium	Paddy maize groundnut cotton mango
10		Thummanpeta Polepalle Thummanpeta	Low	Ground nut paddy maize cotton jowar
11	Lingal	Lingal Chennampally	Medium	Maize paddy ground nut cotton
12		Anbatpalle	Medium	Maize groundnut paddy black gram
13		Appaipally		
14		Komatikunta	Medium	Maize paddy groundnut
15		Lingal	High	Maize paddy
16		Surapur	High	Cotton maize paddy
17		Vallabhapur	Low	Cotton paddy groundnut
18	Padara	Ippalapalle	Low	Cotton paddy maize red gram
19	Vangoor	Vangoor Velmalapally	Low	Cotton paddy vegetable mango
20	Veldanda	Kotra	Low	Cotton maize paddy jowar Veg red chilli
21	Telkapally	Vathipalle Boppalle	Medium	Ground nut black gram paddy maize cotton

1.3.1.3.1. Population details in Nagarkurnool District

1.3.1.3.1.1. Footprint analysis: The footprint analysis covered four locations within Nagarkurnool district. A total of 237-foot prints were recorded across the surveyed areas. The average number of tracks counted per kilometre varied across locations, with the highest count in Lakshmapur B.K (18-foot prints /km) and the lowest in Ippalapalle, Padara (10-foot prints/km). The estimated number of wild boars based on the total track counts ranged from 237 to 474 individuals. Specific estimates per location indicate that Mannanur has the highest potential population (110 to 220 individuals), while Ippalapalle has the lowest estimated population (25 to 50 individuals) (Table 1.46)

Table 1.46. Estimation of Wild boar population in Nagarkurnool district based on footprint analysis

Location	Survey Area (km^2)	Length of Transect (km)	Average Tracks Counted per km	Total Tracks	Estimated Individuals (1-2 per track)
Lakshmapur B.K Laxmapur-2	12	3	18	54	54 - 108
Ippalapalle Padara	15	2.5	10	25	25 - 50
Thummanpeta Polepalle Thummanpeta	20	4	12	48	48 - 96
Mannanur Mannanur 1	30	5	22	110	110 - 220
Total				**237**	**237- 474**

1.3.1.3.1.2. Scat analysis: The scat analysis covered four distinct locations within Nagarkurnool district. A total of 850 scats were collected across the surveyed locations, indicating a significant presence of wild boars in Nagarkurnool district. The average scat density varied among locations, with Vathipalle,

Boppalle having the highest density (16 scats/km²) and Lingal showing the lowest (8 scats/km²). The estimated number of wild boars based on the total scat counts ranged from 1,700 to 2,520 individuals, reflecting a healthy population density in the region, with Surapur, and Boppalle supports the large population (700 to 1,050 individuals), and Lingal small populations (320 to 480 individuals each) (Table 1.47).

Table 1.47. Estimation of Wild boar population in Nagarkurnool district based on scat analysis

Location	Survey Area (km²)	Average Scat Density (scats/km²)	Total Scats Collected	Estimated Individuals (2-3 per scat)
Vathipalle, Boppalle	10	16	160	320 - 480
Godal, Narsaipally, Balmoor	15	12	180	360 - 540
Lingal, Lingal	20	8	160	320 - 480
Surapur Lingal	25	14	350	700-1050
Total			**850**	**1700-2550**

The analysis of wild boar populations through footprint and scat analysis across Nalgonda, Vikarabad, and Nagarkurnool districts reveals varying population densities, with significant numbers of wild boars present in all three districts. The combined estimates suggest that, Nalgonda and Nagarkurnool districts supports the highest estimated wild boar population (1,937-3,008 and 1,937-3,024, respectively) driven by areas with dense vegetation and suitable habitat followed by Vikarabad district which shows moderate population estimates (1,602 - 2,024).

1.3.2. Kerala and Tamil Nadu (KAU, Thrissur)

A study was conducted to assess the occurrence and impact of wild boars on banana and tuber crops across Kerala and parts of Tamil Nadu from September 2023 to April 2024. Table 1.48 presents the roving survey results on wild boar density across various districts in Kerala, revealing significant variations in population distribution. Idukki shows the highest average density of wild boars (12.98 ± 0.88), followed by Pathanamthitta (9.12 ± 0.54) and Kottayam (8.87 ± 0.37). Ernakulam records the lowest average density (2.90 ± 0.04), suggesting either a smaller wild boar population or a habitat less conducive to their presence. Alappuzha (4.22 ± 0.07) and Malappuram (3.66 ± 0.03) also displayed relatively low densities. The fixed plot survey (Table 1.50) spanned over 14 districts, revealed the presence of wild pig at several locations. The density of wild pigs varied considerably across locations, reflecting differing population levels. The highest average density was in Idukki, particularly in Adimali (15.97 pigs/km²) and Pannimattom (13.19 pigs/km²), suggesting a robust population that may lead to increased agricultural impacts. Kottayam also recorded significant densities, with Kumarakom (10.67 pigs/km²) and Puthupally (8.67 pigs/km²) indicating a similar trend. In contrast, districts like Ernakulam and Kasargod showed the lowest densities, such as Nileshwar, which had an average density of only 2.00 pigs/km², possibly due to less favourable habitats or lower population levels. Wild pig sightings vary by location; for example, Balaramapuram had a density of 7.64 pigs/km², while Sree Karyam had a lower density of 4.67 pigs/km². Areas like Sadanandapuram reported a higher density (8.00 pigs/km²), indicating greater wild pig activity in certain agricultural regions. Other locations, such as Meenangadi, showed moderate densities, suggesting that the terrain can support wild pig populations without significant competition.

Table 1.48. Wild boar density across various districts in Kerala

S. No.	District	No of blocks	No of locations covered in each block	Average density (Mean ± S.Em)
1	Thiruvananthapuram	11	3	4.99 ± 0.12^{g}
2	Kollam	11	3	5.34 ± 0.15^{f}
3	Pathanamthitta	8	3	9.12 ± 0.54^{c}
4	Alappuzha	12	3	4.22 ± 0.07^{h}
5	Kottayam	11	3	8.87 ± 0.37^{cd}

6	Idukki	8	3	12.98±0.88[a]
7	Ernakulam	14	3	2.90±0.04[j]
8	Thrissur	16	3	4.67±0.07[h]
9	Palakkad	13	3	5.94±0.16[f]
10	Malappuram	15	3	3.66±0.03[i]
11	Kozhikode	12	3	5.80±0.16[f]
12	Wayanad	4	3	11.14±1.43[b]
13	Kannur	11	3	6.61±0.23[e]
14	Kasargod	6	3	5.06±0.24[f]

Table 1.49. Wild boar population density in the Coimbatore district of Tamil Nadu

District	Location	GPS Coordinates	Crops	Area of transect (Km2)	wild boar (n)	No of wild boar/Km 2
Coimbatore	Madhukkarari	10.8896003, 76.9473587	cassava	0.5	3	6.00
	Meenakshipuram	10.6269842, 76.8729566	cassava	0.5	5	10.00
	pollachi	10.6390391, 76.9932497	cassava	0.48	4	8.33
	Kinathukadavu	10.7945693, 77.0099613	cassava	0.5	5	10.00
	Kottur	10.5265047, 76.9776445	cassava	0.48	6	12.50
	Anaimalai	10.5869447, 76.9412084	cassava	0.5	2	4.00

In Tamil Nadu, a similar survey presented in Table 1.49 indicates that in Coimbatore district, Kottur had the highest wild boar density, while Annamalai had the lowest.

Table 1.50. Fixed plot survey of wild boar population density in tuber and banana fields across Kerala

S. No.	District	Location	GPS Coordinates	Crops	Area of transect (Km2)	No Wild pig cited (n)	No of wild pig/Km2	Average Density (Mean ± S. Em)
1	Thiruvananthapuram	Neyyattinkara	8.4027, 77.0861	16±1.63	0.5	9	18.00	9.15±0.05
		Balaramapuram	8.4321, 77.0503	11.3±2.49	0.48	11	22.92	
		Sree karyam	8.5488, 76.9173	7±0.81	0.5	7	14.00	
2	Kollam	Parippally	8.8123, 76.7589	7.6±1.24	0.5	8	16.00	9.79±0.01
		Sadanandapuram	9.0056, 76.7831	12.6±1.24	0.5	12	24.00	
		Chadamangalam	8.8731, 76.8694	8±0.81	0.48	9	18.75	
3	Pathanamthitta	Elanthoor	9.2892, 76.7279	8.67±2.49	0.5	13	26.00	12.17±0.10
		Aranmula	9.3265, 76.6840	7.6±1.24	0.48	12	25.00	

		Pullad	9.3550, 76.6730	10.3±1.69	0.5	11	22.00	
4	Alappuzha	Kayankulam	9.1748, 76.5013	8±0.91	0.5	9	18.00	8.46±0.12
		Krishnapuram	9.1506, 76.5311	8.6±2.86	0.48	9	18.75	
		Mavelikara	9.2506, 76.5401	12.25±1.24	0.5	7	14.00	
5	Kottayam	Kumarakom	9.6175, 76.4301	15±0.81	0.5	16	32.00	16.26±0.30
		Puthupally	9.5653, 76.5662	10.66±2.49	0.5	13	26.00	
		Pannimattom	9.5385, 76.5221	16±0.81	0.48	19	39.58	
6	Idukki	Thodupuzha	9.8959, 76.7184	12±2.1	0.5	13	26.00	17.32±0.50
		Adimali	10.0115, 76.9528	20.3±1.69	0.48	23	47.92	
		Arakulam	9.8138, 76.8245	13±2.16	0.5	15	30.00	
7	Ernakulam	Nedumbassery	10.1679, 76.3978	6±0.81	0.5	7	14.00	6.78±0.01
		Athani	10.1530, 76.3549	4.3±1.24	0.5	5	10.00	
		Kalamassery	10.0531, 76.3528	7.6±1.69	0.48	8	16.67	
8	Thrissur	Ponnukkara	10.5725,76.5228	7±0.81	0.5	8	16.00	12.46±0.14
		Vaniyampara	10.5760,76.4014	8.3±1.24	0.48	9	18.75	
		Chelakkara	10.7753,76.4781	13±7.36	0.5	20	40.00	
9	Palakkad	Wadakancherry	10.6008, 76.4904	8 ±1.63	0.5	9	18.00	12.88±0.52
		Thonippadam	10.6723, 76.5069	14±0.81	0.48	15	31.25	
		Attappady	11.0681, 76.5662	12.3±1.24	0.5	14	28.00	
10	Malappuram	Agandipuram	10.9773, 76.2014	9±0.91	0.5	9	18.00	9.15±0.09
		Vettam	10.8611, 75.9151	10±0.94	0.48	11	22.92	
		Edakkara	11.3615, 76.3027	6±0.94	0.5	7	14.00	
11	Kozhikode	Marikkunnu	11.2985, 75.8403	9.6±1.69	0.48	11	22.92	11.61±0.01
		Kuduvally	11.3599, 75.9129	11.3±2.49	0.5	14	28.00	
		Ulliyeri	11.4502, 75.7711	8±0.81	0.48	9	18.75	
12	Wayanad	Meenangadi	11.6607,76.1551	18±2.94	0.5	9	18.00	7.43±0.21
		Sulthan bathery	11.6629, 76.2570	20±2.96	0.48	7	14.58	
		Ambalavayal	11.6197, 76.2103	16.4±1.78	0.5	6	12.00	
13	Kannur	Thalassery	11.7491, 75.4890	12.7±1.69	0.5	13	26.00	12.13±0.64
		Mala	11.9383, 75.7292	18.6±1.71	0.48	9	18.75	

		Payyannur	12.0972, 75.1934	14.2±11.8	0.5	14	28.00	
14	Kasargod	Padannakkad	12.2598, 75.1130	12.3±1.28	0.48	5	10.42	5.07±0.70
		Nileshwar	12.2557, 75.1341	3.8±0.48	0.5	3	6.00	
		Kanhangad	12.3311, 75.0915	7.8±1.12	0.5	7	14.00	

1.3.3. Karnataka (UAS, Bangalore)

The population density of wild boars was estimated across various talukas in Uttara Kannada, Mysore, Tumkur, and Ramanagara districts of Karnataka (Fig. 1.21). The highest population density, with over 80 groups per four transects, was recorded in Sirsi, Siddapura, Kumta, Ankola, and Karwar talukas of Uttara Kannada District; Nanjangud and H.D. Kote talukas of Mysore District; Kunigal and Madhugiri talukas of Tumkur District; and Magadi and Kanakapura talukas of Ramanagara District. Medium population densities, ranging from 40 to 80 groups per four transects, were observed in Honnavara, Bhatkal, Yellapura, Supa, Mundgod, and Haliyal talukas of Uttara Kannada District; T.N. Pura and K.R. Nagara talukas of Mysore District; Tiptur, Koratagere, Turuvekere, and Sira talukas of Tumkur District; and Ramanagar taluka of Ramanagara District. The lowest population density, with fewer than or equal to 40 groups per four transects, was recorded in Channapatna taluka of Ramanagara District; Mysuru, Hunsur, and Piriyapatna talukas of Mysore District; and Chikkanayakanahalli, Gubbi, and Tumkur talukas of Tumkur District. The wild boar population was predominantly composed of adult females.

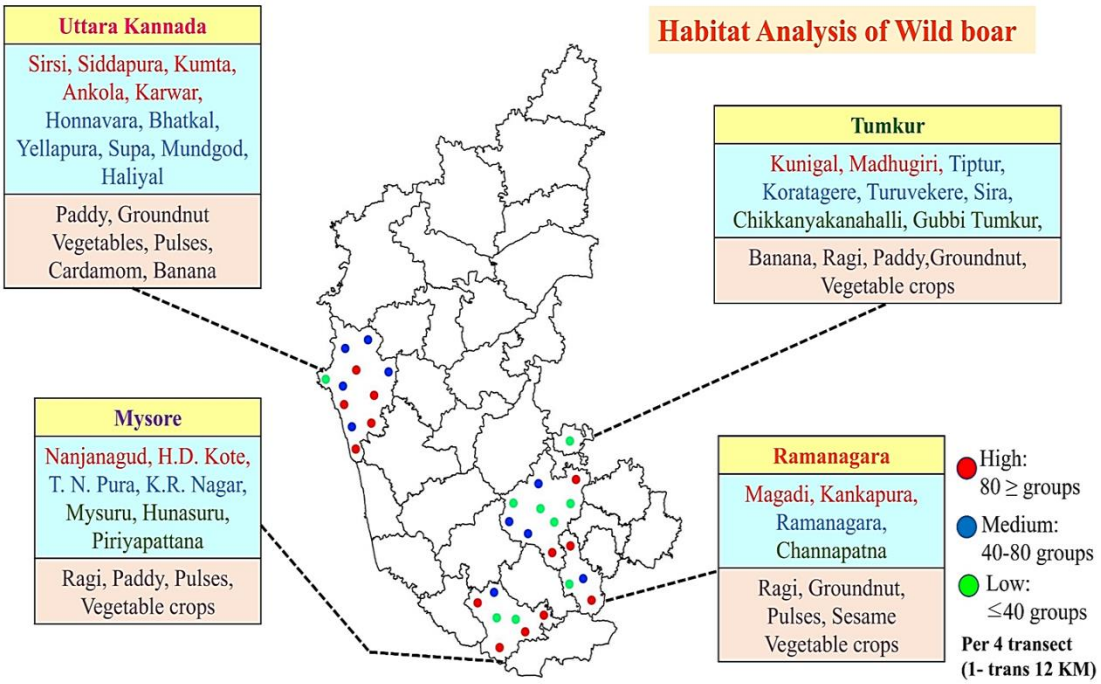


Fig 1.21. Habitat analysis of wild boar in Uttara Kannada, Mysore, Ramanagara, Tumkur

1.3.4. Andhra Pradesh (ANGRAU, RARS, Maruteru)

A roving survey was conducted in Krishna and Guntur districts to assess the population density of wild boars. Data on wild boar presence were gathered using both direct observation techniques and indirect methods, including structured interviews with farmers and consultations with local agricultural officers. In a survey across districts in Andhra Pradesh, wild boar activity levels were assessed in selected mandals and villages. In Guntur district, 5 mandals and 15 villages were surveyed, revealing varied levels of wild boar presence: 6 villages reported low activity, 4 villages

experienced medium activity, and 5 villages had high levels of wild boar presence. In Krishna district, 5 mandals and 10 villages were surveyed, with the majority (6 villages) reporting negligible wild boar activity and the remaining 4 villages experiencing low activity. No villages in Krishna reported medium or high levels of wild boar activity, indicating a generally lower impact in this district compared to Guntur. The high prevalence of wild boars in Guntur district was attributed to village fields being in proximity to forests and hilly areas (Fig. 1.22). The greater incidence of wild boar problems was primarily associated with agricultural fields located closer to forest habitats.

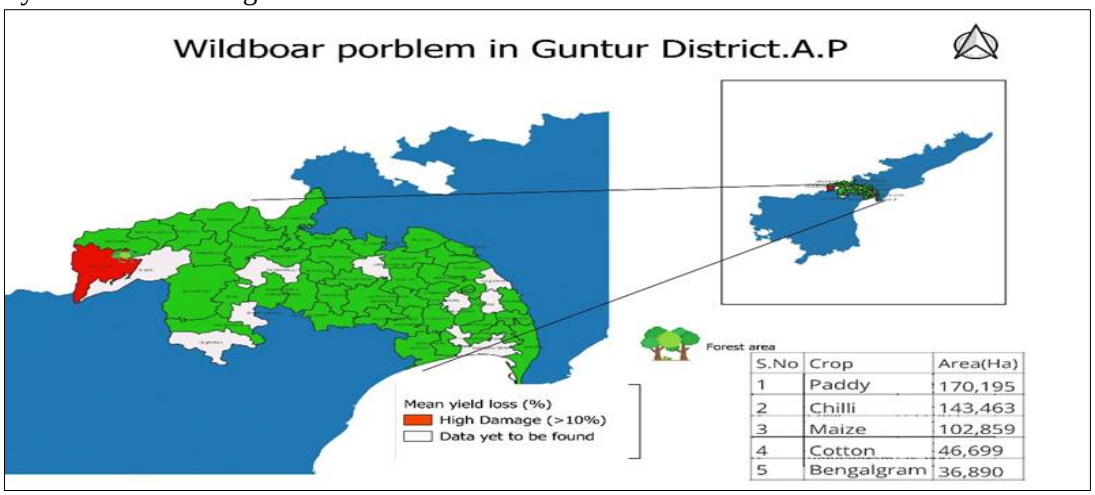


Fig 1.22 Wild boar incidence in Guntur district of Andhra Pradesh

1.3.5. Assam (AAU, Lakhimpur)

A survey on wild boar incidence in Assam was conducted from April to June 2024. The survey covered three development blocks—Orang, Biswanath, and Behali—in the North Bank Plain, and two blocks—Raja Mayong (Pobitora) in Morigaon district and Kaliabor in Nagaon district—in the Central Brahmaputra Valley zone (Fig. 1.23; Table 1.51). Crop fields affected by wild boar were located near Kazi Ranga National Park and Pobitora Wildlife Sanctuary. The survey documented significant damage to various crops, including paddy, maize, vegetables, chili, and colocasia. A transect walk conducted in five villages (Table 1.51) in Bedeti block, Biswanath district, during June revealed that wild pigs showed a preference for crops such as pumpkin, potato, and maize.

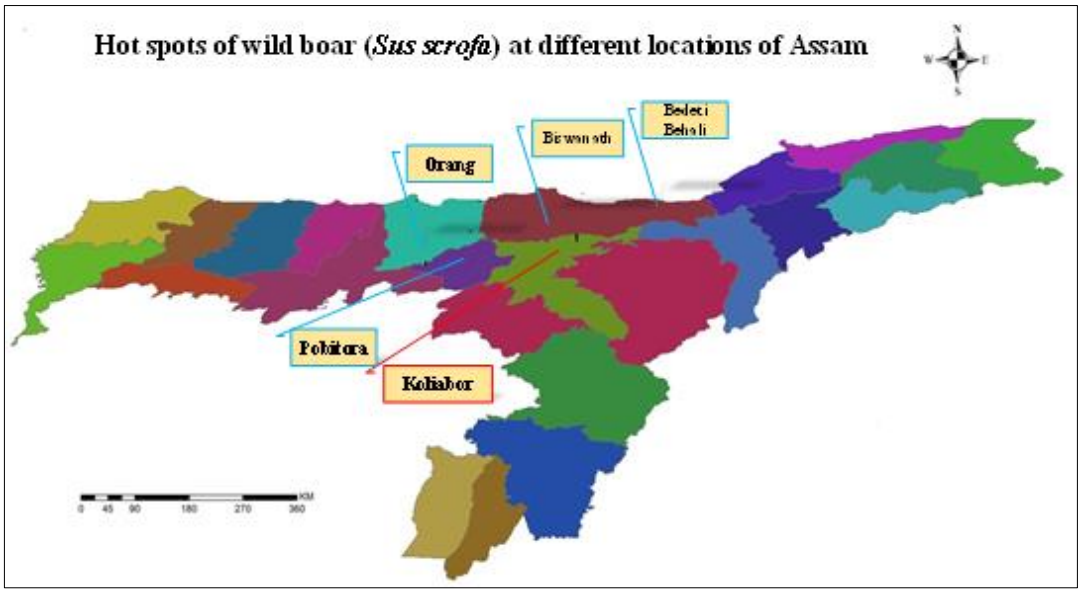


Fig. 1.23. Wild boar hotspots in North Bank Plain Zone of Assam

In the North Bank Plain Zone of Assam, wild boars were a notable threat to various crops, causing extensive damage through their feeding and rooting behaviours. In pumpkin crops, they rapidly consumed most fruits, leading to partial fruit damage and making the yield unmarketable. In potato fields, wild boars dug up and gorge on tubers, often ruining the entire crop. Although they avoided damaging the vegetative parts of chilli plants, they disturb the soil around the plants while rooting. Maize crop, although a preferred food source especially at the dough stage, yet the boars harmed the entire crop in their search for cobs. Colocasia plants are similarly vulnerable, with wild boars feeding on the corms and stems, resulting in complete crop destruction. This pattern of crop damage highlights the need for effective strategies to manage wild boar activity in the region.

Table 1.51. Wild boar hotspots in In the North Bank Plain Zone of Assam

Sl. No	Agroecological zone	Name of the District & Block	Date of observation	Name of the village	GPS coordinates
1.	North Bank Plain Zone	Biswanath Bedeti	11-06-2024	No 7 Batia Mari	
			11-06-2014	No 5 Batia Mari	Lat 26.802058° Long 93.383522°
			11-06-2024	Nepali Bari	Lat 26.783413° Long 93.386323°
			11-06-2024	BedetiGuri	Lat 26.783413° Long 93.383622°
			12-06-2024	Rangsali	Lat 26.783413° Long 93.384225°

1.4. NILGAI/ BLUE BULL (*BOSELAPHUS TRAGOCAMELUS)*

1.4.1. Rajasthan (CAZRI, Jodhpur)

The only animal sighted during the survey was the Nilgai, *Boselaphus tragocamelus*. This species was observed across all surveyed regions, with Nilgai sightings recorded in the Sumerpur, Mundwa, and Kawas regions. The consistent presence of Nilgai in these areas highlights its prevalence within the surveyed habitats.

Line transect surveys were conducted to assess the population of vertebrate pests in the study area. A total of 219 km in Pali and 149 km in Nagaur and Barmer districts were surveyed. The transects were laid along available roads in the survey area, including fallow and cultivated habitats. Surveys were carried out using vehicles during early morning, late evening, and occasionally at night, especially in agricultural areas. The distance between the observers and the animals was estimated using ocular measurements, and the location coordinates were recorded. Group sightings were classified based on (i) species, (ii) group size, (iii) group composition, and (iv) perpendicular distance from the transect line. The data collected during the line transect surveys were analysed using Distance v. 7.4 software to estimate the density of vertebrate pests. The data from all surveys contributed to refining the detection function. Perpendicular distances to group sightings were considered for analysis, and the data were evaluated using half-normal, hazard rate, and negative exponential models with cosine, simple polynomial, and Hermite polynomial adjustments. Based on the minimum delta Akaike information criterion (Delta AIC = 0), the best model was selected for the final analysis. The population of Nilgai was highest in Sumerpur tehsil, with an estimated density of 16.7 individuals per square kilometre (Table 1.52), followed by Mundwa tehsil at 10.85 individuals per square kilometre, and Kawas tehsil at 6.54 individuals per square kilometre. The lower or rarer sightings of Nilgai in certain regions may be attributed to either the species' lower abundance in those areas or its preference for different locations for hiding, feeding, or resting at various times of the day and night.

Table 1.52. Distance analysis of vertebrate population status

Area	Species	Best Fitted Model	Density	Average Cluster Size	Estimate of Density of Cluster	ESW
Sumerpur	Nilgai	negative exponential/cosine	16.7	5.2	1.98	70.06
Mundwa	Nilgai	negative exponential/cosine	10.85	1.98	1.8	69.14
Kawas	Nilgai	negative exponential/cosine	6.54	1.58	2.1	65.25

1.4.2. Punjab (PAU, (RC) Ludhiana)

Surveys were conducted, in a total of 30 habitat clutches (68 villages and 11 forests) of 12 blocks of district Ludhiana to estimate blue bull population density. GPS coordinates of each village were recorded. The survey was done via road transect method using a vehicle. A total of 24 fortnightly visits were conducted in each habitat clutch and 386 transects were covered during the study period to record herd type, herd size, composition, number of herds and age and sex ratio.

Earlier surveys revealed that 68 villages out of a total of 897 (agrarian land) and 11 forest patches, predominantly located along water holes (indicated by the blue line in Fig. 1.24) in district Ludhiana are inhabited by blue bulls. Further surveys revealed that the maximum density of blue bull was found in clusters of block Ludhiana 2, and the minimum in block Samrala cluster (Fig. 1.24). The number of blue bull clusters was also highest in the blocks, Ludhiana 2 and Machhiwara. Whereas, blue bull clusters were not found in block Khanna indicating the presence of blue bulls in 12 out of 13 blocks. Similarly, the maximum encounter rate (individuals/km) was found in block Ludhiana 2 and the minimum in block Samrala. The absence of harem groups (male in the female group) in Summer & Monsoon indicates non-breeding seasons (May-Aug). Winter, Spring, Autumn & Pre-winter, winter, and spring are breeding seasons (Sep-April). There was a total of 849 sightings in 386 transects during the study period. Minimum sightings in Monsoon & Autumn may be due to the preference of animals to stay in their habitat due to sufficient availability of food and water (Table 1.53). Female biased sex ratio in adults and sub-adults indicates a high rate of population growth. However, the birth rate was 01 calf/female (Table 1.54).

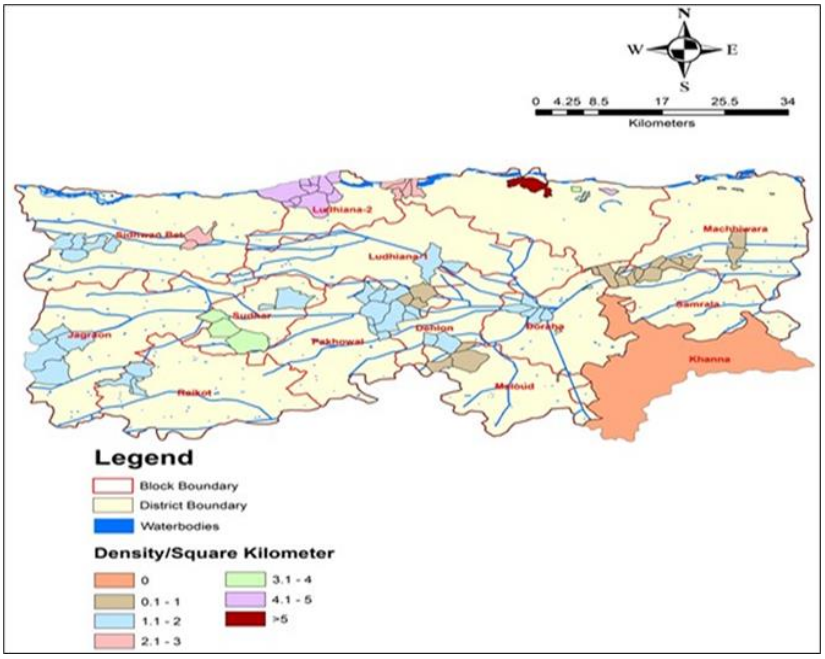


Fig 1.24. Blue bull population density in Ludhiana district (Blue lines indicate clutches located near water bodies)

1.4.2.1. Distribution of Blue bull population in district Mohali (SAS Nagar) Identified habitat forests of blue bull in collaboration with Agriculture Development Officers (ADOs) of district Mohali, forest department staff members, and farmers. Crop fields of villages raided by the blue bull in district Mohali were also identified after physical surveys of villages surrounding forests. Their presence was confirmed from the faecal pellets and foot marks in 11 forests of blocks Kharar, Derabassi, and Majri. A survey was done of 73 villages around these forests for blue bull damage caused in crop fields. Coordinates of identified habitat villages and forests of blue bull were recorded and mapped (Fig. 1.25).

Table 1.53. Total sightings and number of groups during different seasons in district Ludhiana

Seasons	Total sightings	Solitary Male	Harem large gp (> 10 animals)	Harem small gp (≤ 10 animals)	Non-harem large gp (>10 animals)	Non-harem small gp (≤ 10 animals)	Bachelor male gp
Winter (J-F)	72	10	23	14	0	11	14
Spring (M-A)	342	35	84	27	19	132	45
Summer (M-J)	218	44	0	0	38	92	44
Monsoon (J-A)	62	7	0	0	21	17	17
Autumn (S-O)	45	11	6	0	20	0	8
Prewinter (N-D)	110	12	47	4	0	38	9
Overall	**849**	**119**	**160**	**45**	**98**	**290**	**137**

Table 1.54. Age and sex ratios in harem and non-harem groups in different seasons

Seasons	Harem group			Non-harem group	
	AF:AM	AF:C	SAF: SAM	AF:C	SAF: SAM
Winter (J-F)	1:0.40	1:1.16	2.25:1	1: 2	3.39:1
Spring (M-A)	1: 0.27	1:1.13	2.49:1	1: 0.83	4.33:1
Summer (M-J)	0	0	0	1: 0.63	2.82:1
Monsoon (J-A)	0	0	0	1: 0.37	3.2:1
Autumn (S-O)	1:0.17	1:0.85	3.56:1	1: 1.08	2.43:1
Prewinter (N-D)	1:0.25	1:1.18	2.04:1	1: 0.44	4.47:1
Overall Ratio	**1: 0.18**	**1:0.72**	**2.58:1**	**1:0.89**	**3.44:1**

AF:AM- Adult female: Adult male, AF:C- Adult female: Calves, SAF: SAM- Sub-adult female: Sub-adult male

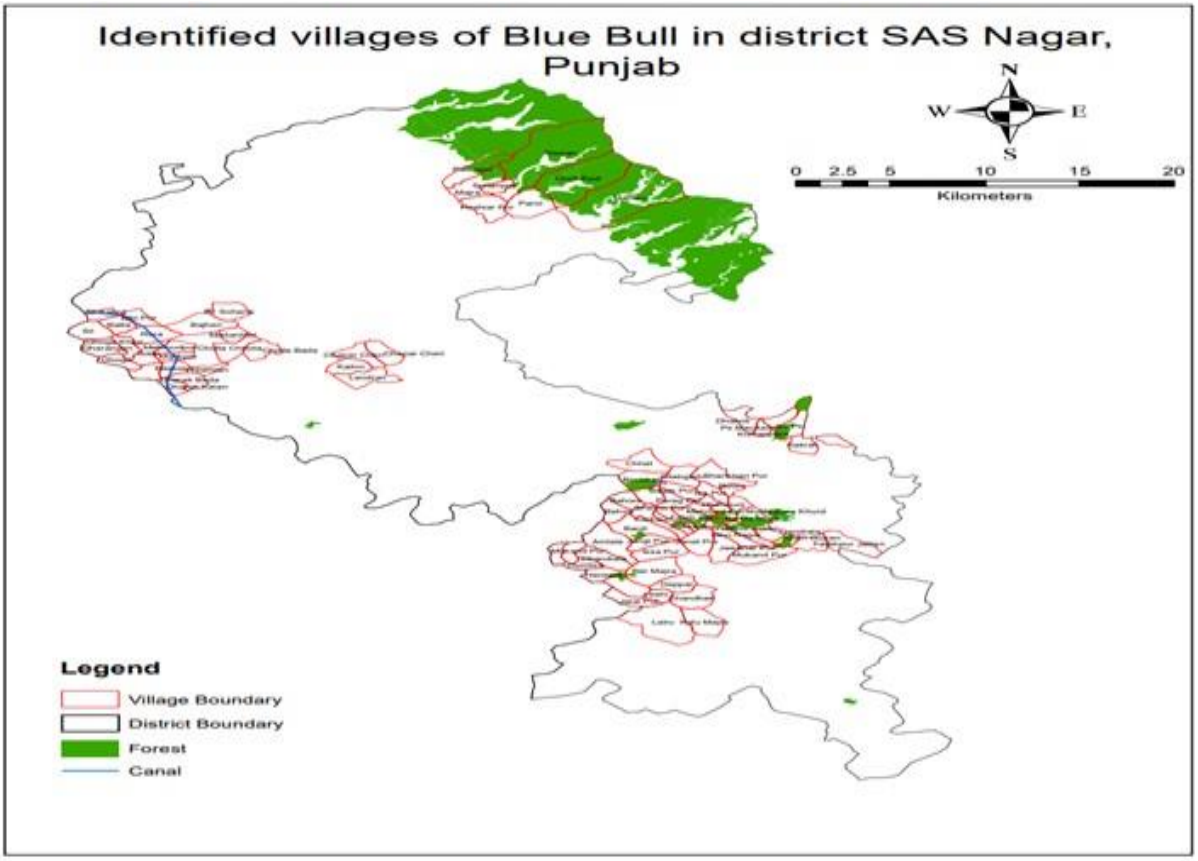


Fig 1.25. Forests inhabited by blue bull in district SAS Nagar

1.4.2.2. Behaviour and daily activity patterns of blue bull

Study on different behaviour patterns of blue bulls in villages of district Ludhiana and Hisar revealed that crop feeding and running activities were maximum in winter, and feeding on herbs and shrubs was more common in monsoon, indicating that animals cause more damage to crops in winter, and feed more on their natural food (herbs and shrubs) during monsoon because of its increased availability. Social activities of both sexes were maximum in winter, indicating the breeding season. Their preferred habitat in winter was crop fields, and in summer and monsoon, they preferred barren land in Hisar, Haryana, and poplar fields in Ludhiana, Punjab. They remain vigilant throughout the year. Their home range varied from 0.96 to 2.87 km/day and was maximum in the summer, followed by winter and monsoon season. Percent resting was maximum in the afternoon, crop raiding, walking, defecation, and fighting more in the morning and evening, indicating crepuscular behaviour whereas standing was more common in the evening, indicating an increase in vigilance in dim light.

1.4.3. Gujarat (AAU, Anand)

The study was conducted to estimate the nilgai population and its distribution in the four blocks *i.e.* Dabhoi, Vadodara, Vaghodiya and Savli of Vadodara district from September 2023 to September 2024 (Fig. 1.26). The nilgai population was monitored using a combination of direct sighting by scan sampling methods. Observations were made by the direct method, to avoid disturbances to animals with the help of Nikon Action 10-22×50 binocular. The total numbers of nilgai were recorded along with the age, sex, habitat, activity and migratory behaviour during the course of the study period. All nilgai groups encountered were classified as an adult male and adult female and calves as juvenile and sub-juvenile. The data were analysed by using a standard statistical formula.

The group composition of blue bull in the study area with number of males, female, sub adults and juveniles in a single group is given in (Table 1.55). The minimum number of nilgai observed in a group was one whereas, maximum was 21 individuals. Out of total 464 blue bulls observed throughout the year, 57 males, 284 females and 123 calves were noted.

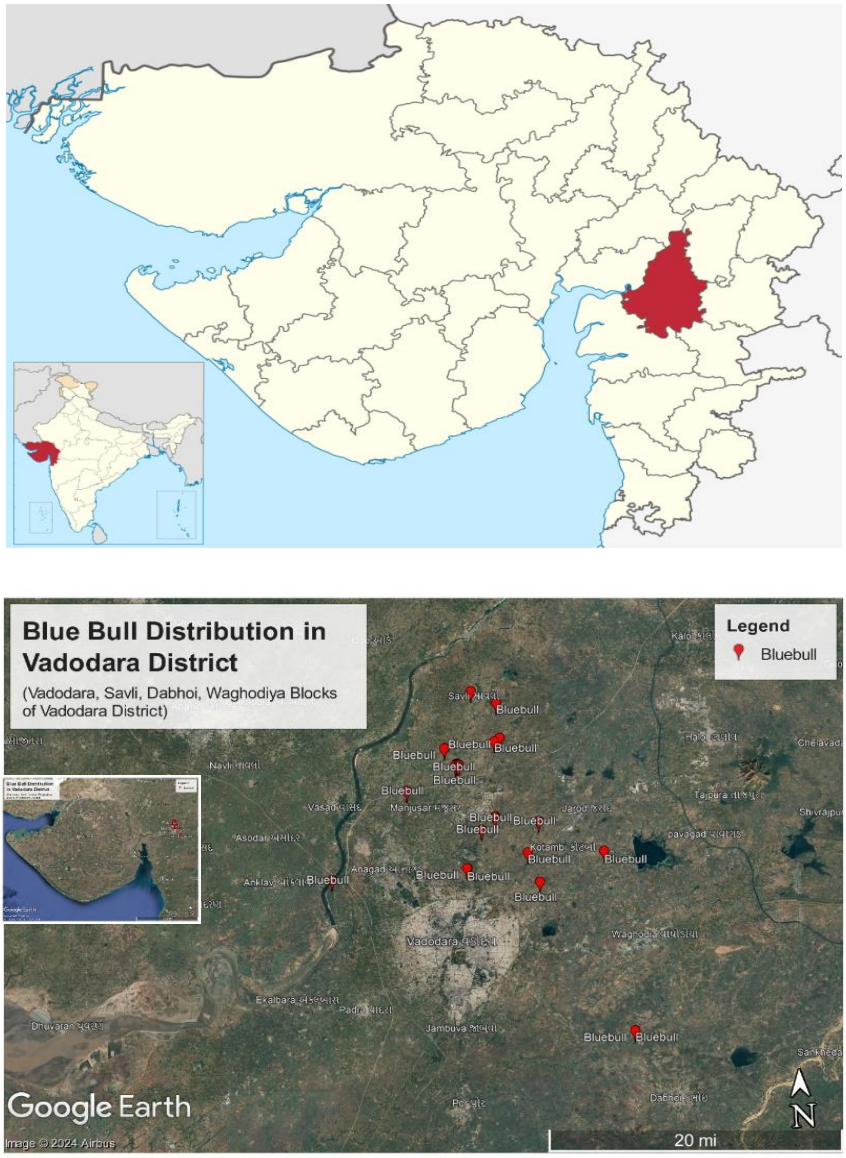


Fig. 1.26. Maps of study area of four blocks *i.e.* Dabhoi, Vadodara, Vaghodiya and Savli of Vadodara district

Table 1.55. Number of blue bull average, range, and number of groups for male, female and juvenile/sub-adult present in the group

Particular	Male	Female	Juvenile/Sub-adult	Total
Total number of blue bulls	57	284	123	464
Average of blue bull	0.57	2.84	1.23	4.64
Range of blue bull	0-9	0-11	0-8	--
Number of groups	26	53	25	--
Per cent (percent) in group	12.28	61.20	26.50	100
SD	2.88	1.27	2.41	1.82
SEM ±	2.03	0.90	1.70	0.91

About 73 percent of animals were distributed in fallow land, river belt areas, and forest area while the remaining 27 percent were distributed in various crops. Among agricultural crops, the crops like castor, drumstick, pigeon pea, cucurbitaceous vegetables, cotton, pearl millet, maize, and sorghum were damaged more, whereas, damage in paddy, flower crops, and cruciferous vegetables was negligible.

1.5. MONKEYS

1.5.1. Telangana (PJTSAU, Hyderabad)

A total of 12,859 individuals of *Rhesus macaque* were recorded in three districts, *Viz.,* Vikarabad, Nagarkurnool, Nalgonda, and the highest number of individuals were recorded from Nagarkurnool district with 4425 individuals, followed by Nalgonda (3948) and Vikarabad (3786). Among the 12,859 individuals recorded, the highest numbers of individuals were recorded from the category adult females (6399), followed by adult males (3374) and young ones (3086) with the M: F sex ratio of 1:1.89 and Female young one ratio of 1:2.1 (Table 1.56).

Table 1.56. Social structure of *Rhesus macaques* in different districts

District	Mandal	Troop size	No. of Troops	Males	Females	Sub-adults/ Juveniles	Sex ratio (M: F)
Vikarabad	Pargi, Mominpet Kotepally, Dharur Doma, Chowdapur, Nawabpet	96	12	1090	1572	1124	1:1.44
Nagarkurnool	Achampet, Amrabad, Uppunthula, Tadur, Bijinepally, Thimmajipet, Balmur, Nagarkurnool, Telkapally	124	16	1235	2986	1004	1:2.41
Nalgonda	Devarakonda, Nakrekal, Nalgonda, Munugode, Chandampeta, Dameracherla, Gattuppal, Kethepally, Narketpalle, Shaligouraram, Tipperthy	127	18	1049	1841	958	1:1.75
Total		**347**	**46**	**3374**	**6399**	**3086**	**1:1.89**
Mean		**115.6**	**15.3**	**1124.6**	**2133**	**1028.6**	

1.5.2. Karnataka (UAS, Bengaluru)

The population density of monkeys was estimated at different talukas of Uttara Kannada, Mysore, Tumkur, and Ramanagara districts of Karnataka. The highest population of monkey 120 ≥ groups per 4 transects were recorded in Sirsi, Siddapura, Kumta, Karwar talukas of Uttara Kannada District, Nanjanagud H. D Kote, K. R. Nagara talukas of Mysore district, Kunigal, Turuvekere, Tiptur, Madhugiri talukas of Tumkur District and Magadi, Kanakapura talukas of Ramanagara District. In Honnavara, Ankola, Bhatkal, Yellapura, Supa, talukas of Uttara Kannada District, T. N. Pura taluka of Mysore district, Koratagere, taluka of Tumkur District and Ramanagar and Cannapattana taluka of Ramanagara District recorded the medium population of 80-123 groups per 4 transect. However, Mysuru, Hunusuru, Piriyapattana talukas of Mysore District and Chikkanayakanahalli, Gubbi, Sira, Tumkuru talukas of Tumkur District, Mungod, Haliyal talukas of Uttara Kannada District recorded the lowest monkey groups ≤80 groups per 4 transect. The population was female dominant (Figure 1.24).

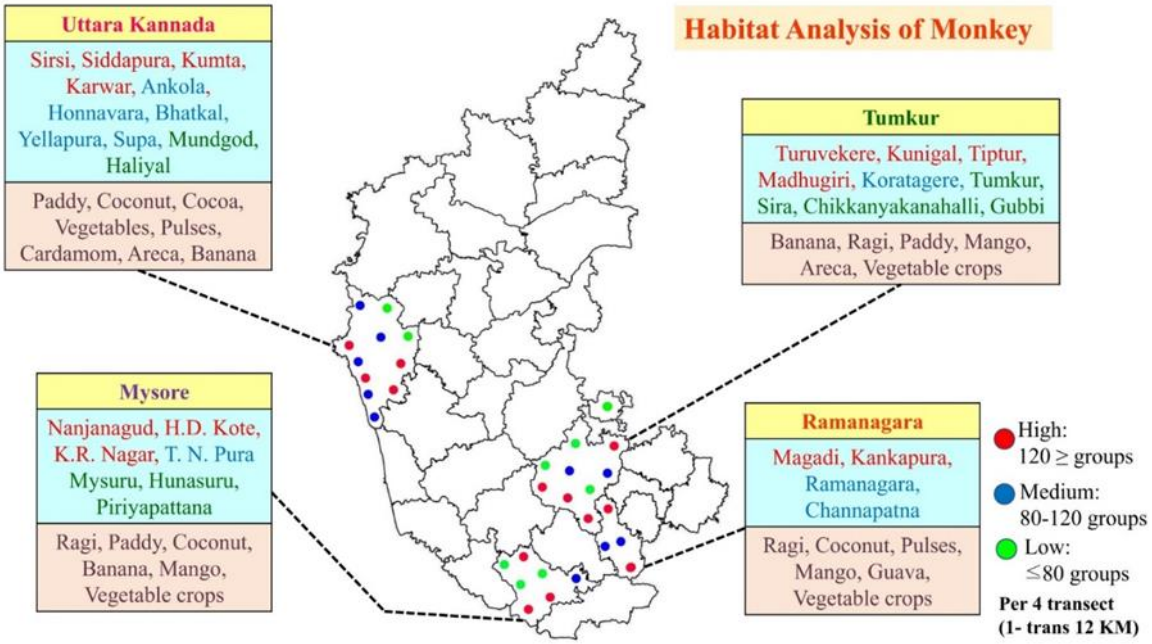


Fig. 1.24. Population density of Monkey in Tumkur, Mysore, Uttara Kannada and Ramanagara Dist.

1.5.3. Andhra Pradesh (ANGRAU, RARS, Maruteru)

Among the macaque species, rhesus macaque was found dominant in crop fields with about 13 troops were assessed for their structure and composition, in east and West Godavari in which a total of 612 animals were observed with a mean troop size of 51 animals. The male female ratio was recorded as 1:3.3. In a mean troop size of 51 animals, the composition of infants was more with 25.3 young ones followed by females with 20.5 females and 6.16 males. In Krishna district five troops in different mandals were assessed with mean troop size 46.6 and male to female ratio, 1:3.30. Similarly, in Guntur district also five troops in different mandals were assessed with mean troop size was 51.6 and male to female ratio, 1:4.10 (Table 1.57, Fig. 1.25). The pestilence status of macaques in different districts were also presented on map (Fig. 1.26, 1.27, 1,28, 1.29). Daily activity of macaques was recorded for period of 12 hrs a day; it was observed that macaques made 1.53 to 3.3 visits to crop fields and maximum time they spent for taking rest (7.82 to 9.12 hr.). The time spent for crop raiding was very less, it varied between 0.46 to 1.04 hrs only (Table 1.5841).

Fig. 1.25. Group of *Rhesus macaque*

Table 1.57. Daily time activity by macaques in crop fields of Krishna –Godavari Zone

Location	Ecosystem	Mean No of visits/day in crop period	Mean Time spent (Hrs.)/ 7 day (12hrs) Mean±Sem		
			crop Raiding	wandering	Resting
Eluru district					
Kamavarapukota	Maize - Rice Oil palm – vegetables	2.80	0.85±0.12	3.32±0.36	7.82±0.51
Buttayagudem	Maize - Oil palm	3.03	1.04±0.15	2.24±0.24	8.81±0.45
Alluri district					
R. Chodavaram	Rice – Vegetables	1.53	0.64±0.17	3.04±0.60	8.31±0.41
Kakinada district					
Pitapuram	Rice - Oil palm	3.13	0.58±0.17	2.32±0.60	9.12±0.41
Krishna district					
Chandrupatla (V)&Vissanapeta (M)	Maize - Oil palm	1.60	0.51±0.26	2.35±0.06	8.80±0.17
Chandragudem (V) Mylavaram (M)	Oil palm-vegetables	3.30	0.58±0.018	2.99±0.31	8.13±0.34
Guntur district, Edlapadu mandal					
Kondaveedu	Mango	2.20	0.55±0.04	3.17±0.31	8.80±0.17
Changeeskhan peta	Sapota	1.80	0.46±0.03	3.075±0.26	7.825±0.344

Table 1.58. Habitat analysis and distribution of macaques in Krishna- Godavari zone

Location	Geo Location	Troop size	No. of troops	M	F	Infant	Sex-ratio
East Godavari							
Kamavarapu kota (1),V&M Eluru Dist	16°58'44"N 1°10'48"E	42	1	6	11	25	1:1.8
Rampa (V),R.Choda varam (M), Alluri Dist	17°22'43"N81°47'28"E	119	2	10	41	70	1:4.1
Rampachodavaram, Alluri Dist	17°22'43"N81°47'28"E	51	1	7	23	21	1:3.2
Kourkonda (V) & (M), East Godavari Dist	17°16'88"N81°83'10"E	46	1	6	22	18	1:3.6
Kolanka (v)Pitapuram (M), Kakinda Dist	17°07’0.48’’N82°15’10’’E	28	1	2	12	14	1:6
Prattipadu (V)& (M), Kakinda Dist	17°13’59.88’’N 82°12’E	36	1	4	16	16	1:4

Mean		**46**		**5**	**17.85**	**23.42**	**1:3.24**
West Godavari							
Kamavarapu kota (3)V&M Eluru Dist	16°58'44"N81°10'37"E	56	1	11	17	28	1:1.5
Kamavarapu kota (4)V&M Eluru Dist	16°58'45"N81°10'35"E	45	1	8	15	22	1:1.8
Kamavarapu kota (5)V&M Eluru Dist	16°58'44"N81°10'51"E	54	1	9	25	20	1:2.7
V.R. gudem(V), TP gudem (M), W.G. Dist	16°53'21"N81°27'20"E	71	1	4	31	36	1:7.7
Diricenapalli (v), Buttayagudem (M), Alluri Dist	17°20'44"N81°49'08"E	42	1	4	16	22	1:4
Buttayagudem (V) & (M) Alluri Dist	17°20'36"N81°3201"E	22	1	3	17	12	1:5.6
Mean		**48.33**	**-**	**6.5**	**20.16**	**23.3**	**1:3.88**
Krishna							
Kanchekarla(V) & (M)	16.6833° N, 80.3904° E	45	1	12	33	28	1:2.75
Chandrlapadu(V) & (M)	16.6930° N, 80.2018° E	52	1	14	38	25	1:2.71
Chandrupatla (V) & Vissanapeta (M)	16.9426° N, 80.7796° E	38	1	6	32	20	1:5.3
Chandragudem(V) Mylavaram (M)	16.8014° N, 80.6299° E	62	1	14	48	25	1:3.42
Gampalagudem (V) Gampalagudem (M)	16.9879° N, 80.5181° E	36	1	10	26	22	1:2.66
Mean		**46.6**		**11.2**	**35.4**	**24**	**1:3.30**
Guntur							
Nudurupadu (V) Pirangipuram (M)	16.2798° N, 80.2089° E	50	1	11	39	28	1:3.54
Takkellapadu (V) Peddakakani (M)	16.3111° N, 80.4910° E	48	1	8	40	30	1:5
Peddanandhipadu(V)&(M)	16.0706° N, 80.3301° E	54	1	12	42	32	1:3.5
Kondaveedu(V), Edlapadu (M)	16.2564° N, 80.2489° E	42	1	8	34	22	1:4.25
Changeeskhan peta(V), Edlapadu (M)	16.1007°N 80.1339°E	64	1	12	52	30	1:4.3
Mean		**51.6**		**10.20**	**41.4**	**28.4**	**1:4.11**

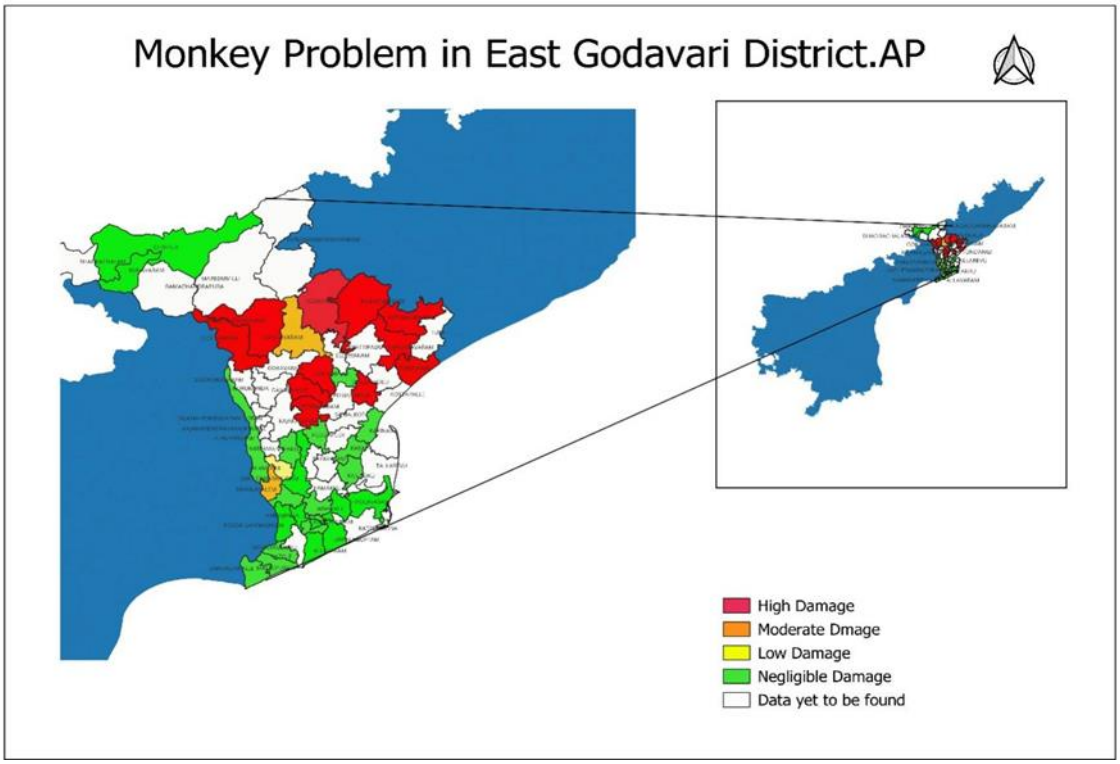


Fig. 1.26. Macaque Distribution map of East Godavari Dist., Andhra Pradesh

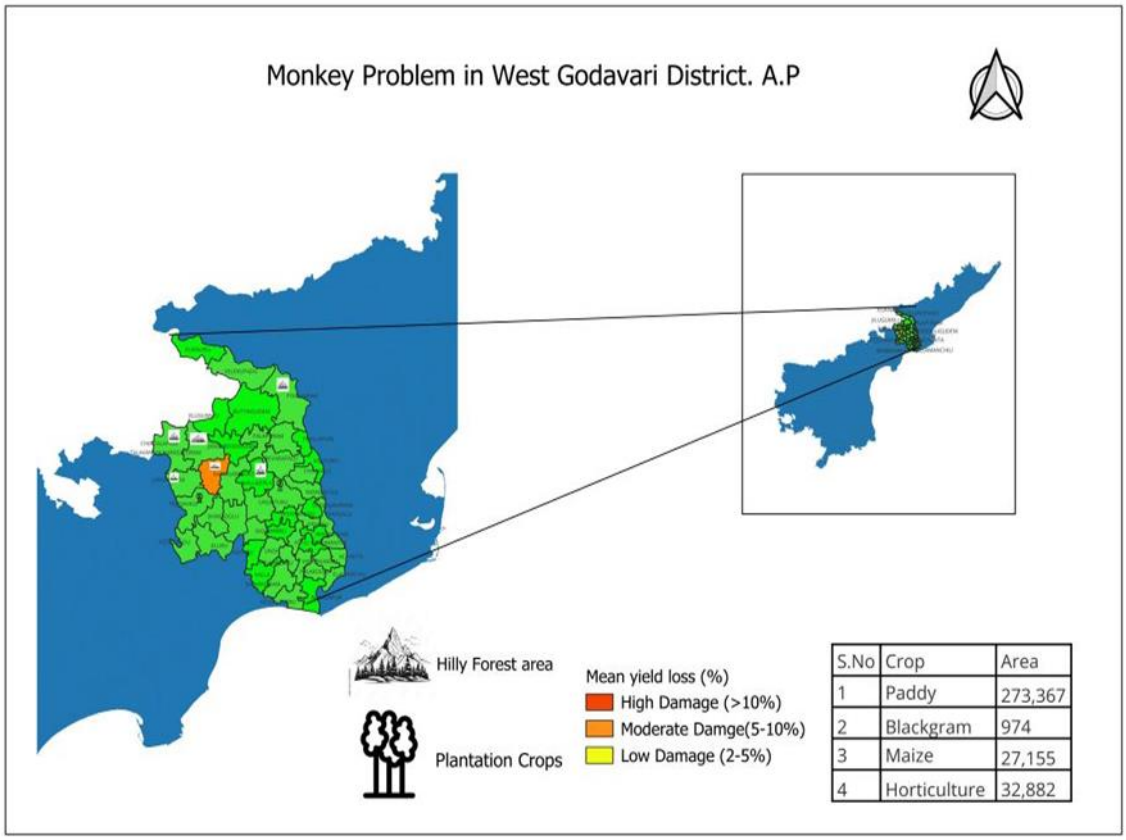


Fig. 1.27. Macaque Distribution map of West Godavari Dist., Andhra Pradesh

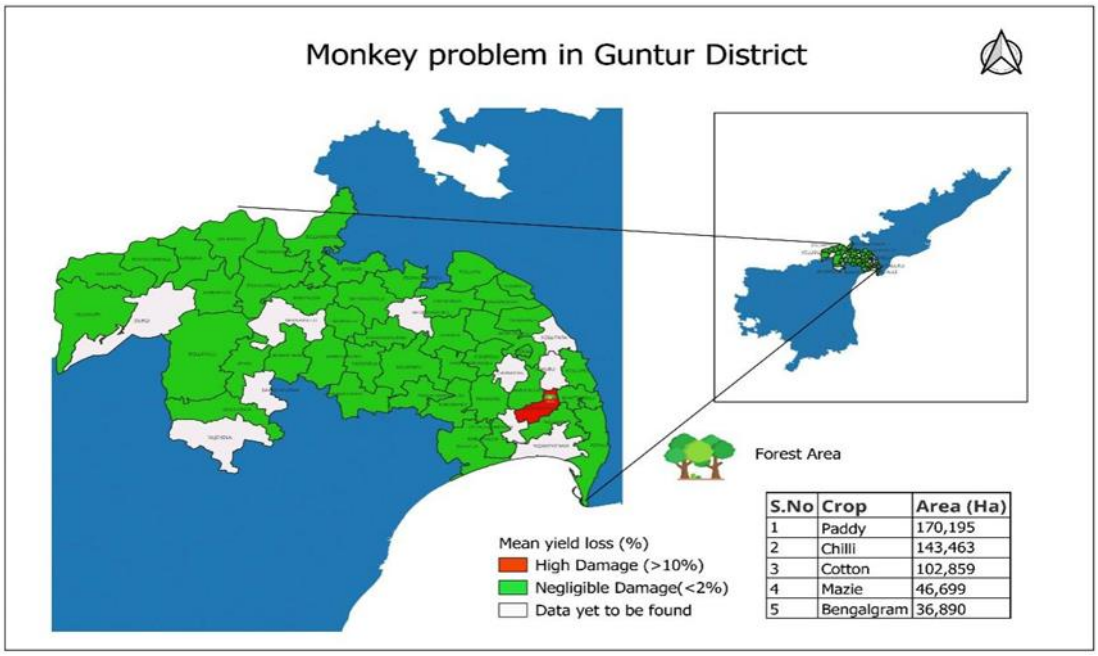


Fig. 1.28. Macaque Distribution map of Guntur Dist., Andhra Pradesh

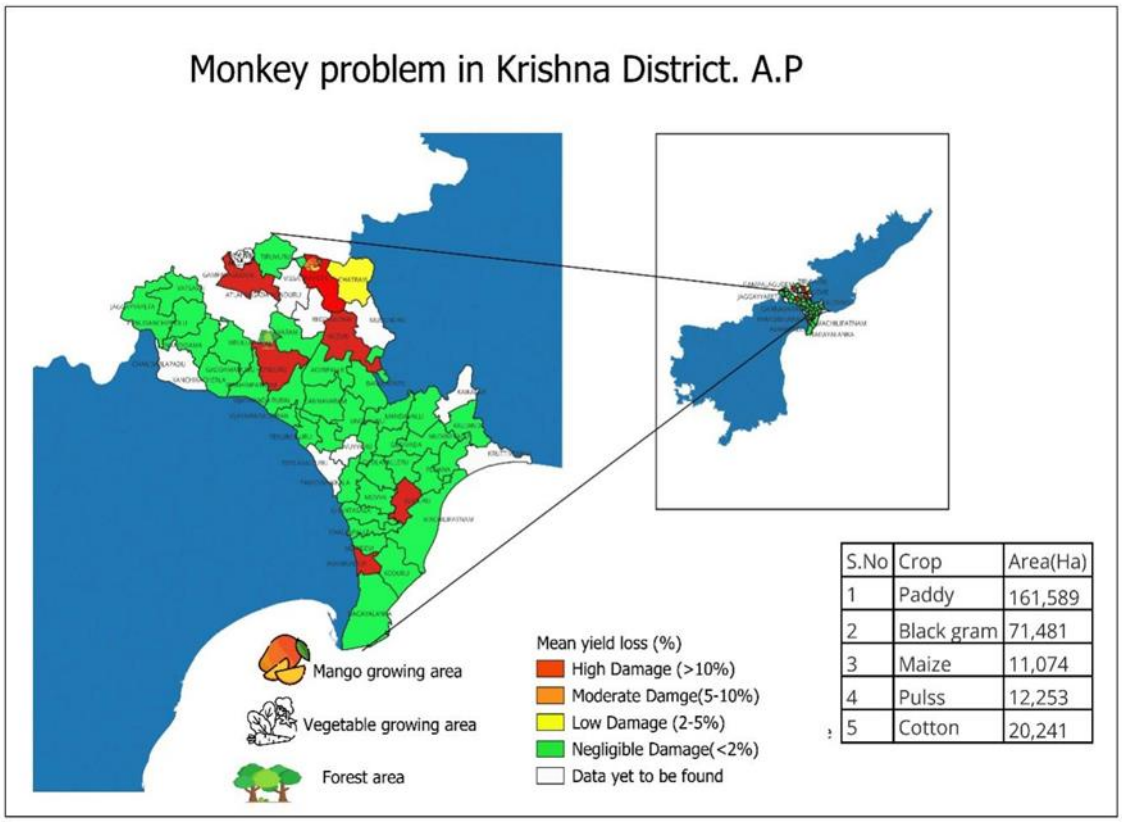


Fig. 1.29. Macaque Distribution map of Krishna Dist., Andhra Pradesh

1.5.4. Assam (AAU, Lakhimpur)

The population density of monkeys was estimated at different locations of the Sivasagar and Charaideo districts of Assam (Tables 1.59 & 1.60, Fig. 1.30). A total of 25 km transect walk was performed in 9 villages to estimate the population density. 195 individuals were encountered with a group size of 8-40.

The density of Male, female, and juvenile populations was also recorded. The female and juvenile population was recorded higher indicating an alarming situation in the village surveyed.

Table 1.59. Habitat analysis of *Macaca mullata* in different areas of UBVZ district of Assam

Variables	Categories	Dhaibari, Nitaipukhuri	Jogorahabi	Siripuria, Sivasagar
Area of damage(km)		3	2	2
Group no.		2	1	1
Group size	Total	30	20	15
	Male	8	3	4
	Female	**15**	**12**	**7**
	Juvenile	7	15	4
crop damage		50 percent	90 percent	60 percent

Table 1.60. The density of Rhesus macaque population in different locations UBVZ, Assam

Location	Transact (km)	No. of groups	Population density/ km			Total
			Male	Female	Juvenile	
Dhaibari, Nitaipukhuri	3	2	2.6	5.0	2.33	30
Jogorahabi, Sivasagar	2	1	1.5	6.0	2.5	20
Siripuria, Sivasagar	2	1	2.0	3.5	2.0	15
Tiok, rajabari, Sonari	4	2	1.25	2.0	1.0	17
kujibali, hanhsora, Sivasagar	1	1	1.33	2.67	1.33	8
Solapothar, charaideo	3	1	2.00	3.33	3.0	25
Dimou, kinargoan	4	4	1.75	5.0	3.25	40
Nakatoni, kalugoan	3	1	0.67	2.0	2.33	15
Charaideo, Sonari	3	3	2.00	3.33	3.0	25
Total	**25**	**16**	**-**	**-**	**-**	**195**

Fig 1.30. Groups of Rhesus macaque

1.5.5. Assam (AAU, Jorhat)

1.5.5.1. Distribution and social composition of Rhesus macaque in UBVZ of Assam (Sivsagar district)

In Sivsagar district, the highest monkey population were observed in Kalugaon with 225 numbers of individuals with 51 adult males, 91 adult females, 61 Juveniles and 22 infants followed by Amguri where monkey population was 195 with 6 groups with 34 adult males, 73 adult females, 57 juveniles and 31 infants (Table 1.61).

1.5.5.2. Population of Rhesus macaque in Sivsagar district under UBVZ of Assam

Classification of monkey individuals in different age-sex categories gave an idea of the population composition of different groups. In Sivsagar district, the monkey population constituted 10.69 percent adult males, 30.19 percent adult females, 11.95 percent sub-adults and juveniles and 8.81 percent infants (Table 1.62). It was also observed that the population composition changed due to births, deaths and age variation of the Rhesus monkey during this study period.

The number of females was similarly higher in the case of sub-adults; male: female ratio was approximately 1:2.82 (1 male to 3 female) and the overall average number of sub-adults was higher than the number of adult individuals; adult male to juvenile ratio was 1:1.29 and juveniles to infants ratio was approximately 1:1.07 (1 juvenile to 1.07 infant individuals), sub-adult male to sub-adult female ratio was 1:2.05 (1 sub-adult male to 2 sub-adult female) and adult male to infant ratio was 1:0.82. Sex ratio of study period (adults, sub-adults, and juvenile) revealed shifts among young offspring. There was no significant variation in the proportion of adult males and adult females ($\chi2 = 2.91$, df = 4, p= 0.72), adult females and infants ($\chi2 = 1.25$, df = 4, p = 0.68), adult females and juveniles ($\chi2 = 2.31$, df = 4, p = 0.52), and juveniles and infants ($\chi2 = 1.42$, df = 4, p = 0.44) among the groups (Table 1.63).

Table 1.62. Average group composition of Rhesus macaques in Sivsagar district (2023-24) district

Village name	AM	AF	SAM	SAF	JUV	INF	TOTAL
Kalugaon	6	14	6	13	4	6	49
Vachelimari	3	9	2	8	5	4	31
Amguri	5	12	3	10	7	1	38
Nokotani	2	9	5	5	3	2	26
Jogorhabi	1	4	3	3	3	1	15
Total	17	48	19	39	22	14	159
%	10.69	30.19	11.95	24.53	13.84	8.81	100.00
Mean	31.8						
SD	6.31						
Mean±SD	31.8±6.31						

Table 1.63. Age sex ratio of Rhesus macaque in Sivsagar district during 2023-24

Village name	AM:AF	AM:JUV	AM:INF	SAM:SAF	AF:JUV	AF:INF	JUV:INF
Kalugaon	2.33	0.67	1.00	2.17	0.29	0.43	1.50
Vachelimari	3.00	1.67	1.33	4.00	0.56	0.44	0.80
Amguri	2.40	1.40	0.20	3.33	0.58	0.08	0.14
Nokotani	4.50	1.50	1.00	1.00	0.33	0.22	0.67
Jogorhabi	4.00	3.00	1.00	1.00	0.75	0.25	0.33
TOTAL	2.82	1.29	0.82	2.05	0.46	0.29	0.64
$\chi2$ value	2.91	2.52	3.04	1.52	2.31	1.25	1.42
P value	0.72	0.76	0.94	0.77	0.52	0.68	0.53

Table 1.61. Distribution and social composition of Rhesus macaque in Sivsagar district (2023-24)

Village Name	No of groups	Population size (Number)	Total no. of sighting	% Sighting	Size (Mean±SE)	Male	Female	Juvenile	Infant	Total
Kalugaon	7	12-47	225	29.68	22.5±8.99	51	91	61	22	225
Vachelimari	3	9-44	102	13.45	10.2±4.91	16	47	30	09	102
Amguri	6	12-45	195	25.72	19.5±5.48	34	73	57	31	195
Nokotani	4	13-40	174	22.95	17.4±9.03	37	82	44	11	174
Jogorhabi	2	6-26	62	8.17	6.2±5.02	11	36	08	07	62
Total	**22**	-	**758**			**149**	**329**	**200**	**80**	**758**

1.6. BLACKBUCK

1.6.1. Telangana (PJTSAU, Hyderabad)

A total of 47 observations covering 14 villages of two mandals in Nalgonda Jogulamba Gadwal district each and one mandal in Narayanpet district, showed an average herd size of 13.4 animals. The minimum herd size was 3.4 and the maximum was 14.2. The herd size range was maximum in Damera (2-28) followed by Khammaguda (2-22) and Nemallagudem (2-21) (Table 1.64, Fig. 1.31). In all the villages the herd size classes 2-7 and 8-13 are in maximum association followed by 14-19, while 20-25 and above (26) are recorded in Nalgonda district (Table 1.65). During the period sex ratio in all the villages was 1:1.46 to 1:3.30 (Table 1.66). The percent occurrence of different social groups showed a maximum of the pseudo harem (25.5 percent), territorial male (21.3 percent), females (21.3.1 percent) followed by bachelor group (14.9 percent), mixed herd (10.6 percent) and mother with fawn (6.4 percent) (Fig. 1.32). The habitats used by different social groups were predominantly high in crop fields (42.2 percent) followed by open fields (31.7 percent), thorny scrub (19.2 percent), and rocky outcrops (6.4 percent) (Table 1.67) among the social groups the crop fields were predominantly utilized by pseudo harem and female groups while territorial male utilized the open fields.

Table 1.64. Mean Herd size of Blackbuck in Nalgonda, Narayanpet, and Gadwal Districts

Name of the Village (14)	Total observations (N=47)	Mean herd size	Range
Lenkapalli	6	12.4	3-26
Sarrampeta	3	6.4	2-15
Khammaguda	5	10.2	2-22
Bheemunipalli	5	9.0	2-19
Ramdas Thanda	2	4.6	3-12
Bheemula Thanda	2	5.2	3-15
Damera	8	14.2	2-28
Nerellipalli	2	4.6	2-10
Nemallagudem	4	5.1	2-21
Maganoor	3	7.2	2-14
Mudumal	4	8.8	3-17
Itikyala	2	4.6	1-10
Yerravalli	1	3.4	1-10
Maldakal	1	5.2	1-12

Fig. 1.31. Herds of blackbuck, farmers interaction and pug marks

Table 1.65. Black Buck Herd size classes in Nalgonda, Narayanpet and Gadwal Districts

Name of the village	Herd Size					
	1	2-7	8-13	14-19	20-25	>26
Lenkapalli	-	1	2	1	-	2
Sarrampeta	-	2	-	1	-	-
Khammaguda	-	-	2	1	2	-
Bheemunipalli	-	2	1	2	-	-
Ramdas Thanda	-	1	-	1	-	-
Bheemula Thanda	-	-	2	-	-	-
Damera	-	3	1	-	1	3
Nerellipalli	1	1	-	-	-	-
Nemallagudem	-	2	2	-	-	-
Maganoor	-	2	-	1	-	-
Mudumal	-	2	-	1	1	-
Itikyala	-	1	-	-		
Yerravalli	-	-	1	-		
Maldakal	-	1	-	-		
Total	**1**	**18**	**11**	**8**	**4**	**5**

Table 1.66. Sex ratio of the Blackbuck population in different villages

Name of the Village	Total males	Total females	Sex ratio
Lenkapalli	40	65	1:1.63
Sarrampeta	24	35	1:1.46
Khammaguda	36	69	1: 1.91
Bheemunipalli	52	78	1:1.50
Ramdas Thanda	28	56	1:2.0
Bheemula Thanda	15	38	1:2.53
Damera	67	110	1:1.64
Nerellipalli	46	75	1:1.63
Nemallagudem	32	57	1:1.78
Maganoor	35	87	1:2.49
Mudumal	214	79	1:3.30
Itikyala	10	15	1:1.5
Yerravalli	4	6	1:1.5
Maldakal	12	20	1:1.7

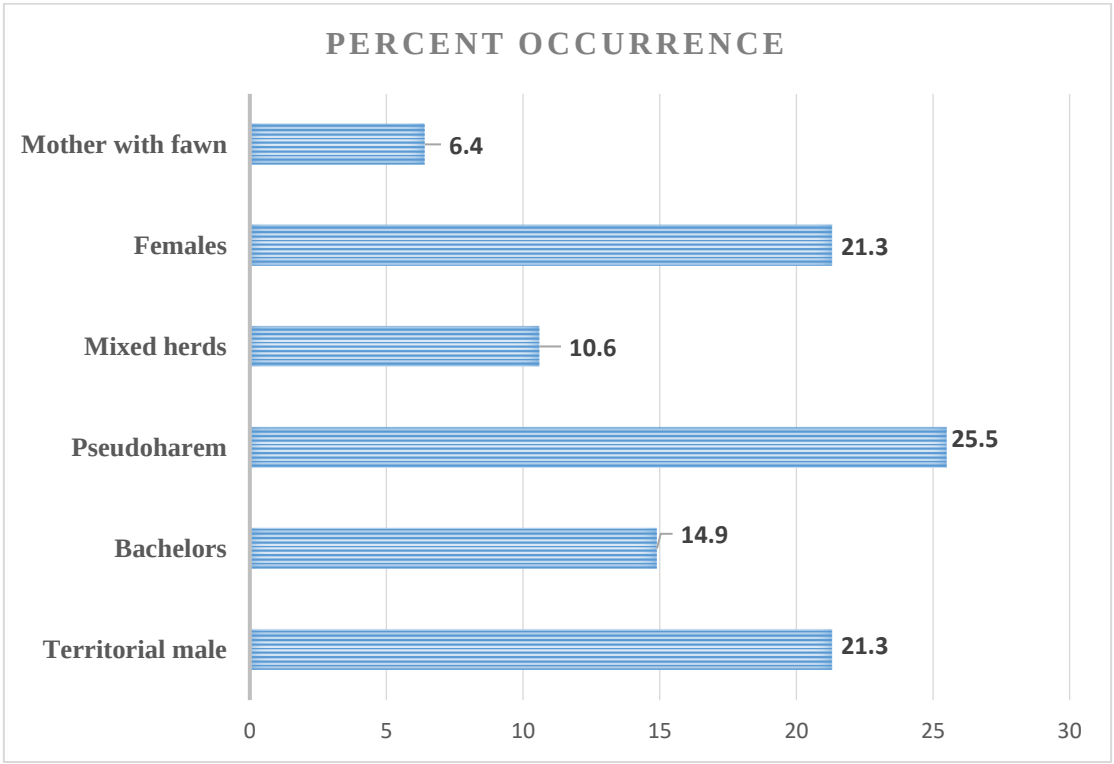


Fig. 1.32. Percent occurrence of social groups

Table 1.67. Habitat use by number of groups (n=47)

Social Group	Crop fields	Open fields	Thorny scrub	Rocky out crops
Territorial male	3 (6.3)	5 (10.5)	2 (4.3)	-
Bachelors	2 (4.3)	3 (6.3)	2 (4.3)	-
Pseudo harem	7 (14.7)	3 (6.3)	2 (4.3)	-
Mixed herds	1 (2.1)	2 (4.3)	1 (2.1)	1 (2.1)
Females	5 (10.5)	2 (4.3)	1 (2.1)	2 (4.3)
Mother with fawn	2 (4.3)	-	1 (2.1)	-
Total	**42.2**	**31.7**	**19.2**	**6.4**

2. ASSESSMENT OF LOSSES DUE TO VERTEBRATES IN PREDOMINANT CROPPING SYSTEMS

2.1. RODENTS

2.1.1. Telangana (PJTSAU, Hyderabad)

In Vikarabad, Nagarkurnool and Nalgonda districts of Telangana percent rodent damage particularly in rice was recorded during the critical periods of crop sowing, nursery tillering, milking and grain hardening stages. A total of 38 villages were surveyed covering an area of 72 ha. Out of which 10 locations were selected by diagonal method and data was recorded on incidence and damage was also calculated which showed that average yield loss of 19.5 percent, 28.6 percent and 22.3 percent and with the yield loss of 1365, 2003, 1561 kg/ha in Vikarabad, Nagarkurnool and Nalgonda districts, respectively (Table 2.1).

Table 2.1. Percent Rodent damage in Rice and yield losses in different districts

District	No. of villages surveyed	Total area surveyed (Ha)	percent damage	Yield loss (Kg/ha)
Vikarabad	10	18	19.5	1365
Nagarkurnool	15	30	28.6	2002.5
Nalgonda	13	24	22.3	1561

2.1.2. Punjab (PAU (RC), Ludhiana)

Rodent damage was observed across rice and wheat crops (n=3 fields in each village) in the studied villages of SAS Nagar, Bathinda, Malerkotla, and Patiala districts. The damage percentages ranged from 0.20 percent to 1.40 percent, with variations based on crop type and surrounding agricultural landscapes. Rice crops in SAS Nagar exhibited minimal damage, with values of 0.29 percent for rice and 0.40 percent for basmati rice fields surrounded by diverse crops such as bajra, sugarcane, maize, and forested areas. Wheat crops generally showed higher damage, particularly in Malerkotla (1.40 per cent in Kup Kalan) and SAS Nagar (1.27 percent in fields surrounded by fodder crops). Villages having wheat as major and surrounding crop received less damage from rodent damage (Ahmadabad (0.20 per cent) and Upoki (0.34 per cent)). Districts like Patiala showed moderate rodent damage, with values ranging from 0.40 percent to 0.60 percent in villages where wheat was both the major and surrounding crop. These findings suggest that the extent of rodent damage may be influenced by the diversity of surrounding

crops, with monoculture wheat systems experiencing moderate to high damage and diversified crop landscapes potentially mitigating rodent impact (Table 2.2).

Table 2.2. Rodent damage to rice and wheat in different districts of Punjab

District (Block)	Villages (n = 3 fields each)	Major crop	Surrounding crops	Damage (percent)
SAS Nagar (Kharar)	Silkapra, Batta, Rora	Rice	Rice, Bajra, Sugarcane	0.29±0.061[a]
	Dharek kalan, Mehmodpur, Chotla Khurd	Basmati	Maize, Bajra, Sugarcane, harvested rice, forest area	0.40±0.04[a]
	Landran, Baroli, Hasanpur	Wheat	Fodder	1.27±0.49[a]
Bathinda	KVK	Wheat	Fodder, mustard	0.32±0.05[a]
Malerkotla	Kup Kalan	Wheat	Wheat	1.40±0.20[a]
	Ahmadbad	Wheat	Wheat	0.20±0.10[a]
	Upoki	Wheat	Wheat	0.34±0.10[a]
Patiala	Rahbra	Wheat	Wheat	0.60±0.20[a]
	Rohti Mauran	Wheat	Wheat	0.40±0.20[a]
	Dhingri	Wheat	Wheat	0.50±0.30[a]

2.1.3. Kerala (KAU, Thrissur)

Table 2.3 shows the result of study on rice plant damage and yield loss across various locations in Kerala due to rodents. In Thrissur, Vettikkal reported 4.73 per cent plant damage with a yield loss of 196 kg/plot (485 kg/ha), and SSF Mannuthy had 4.52 per cent damage and loss of 187 kg/plot (463 kg/ha). Madakkathara experienced the lowest damage at 3.49 percent, losing 144 kg/plot (357 kg/ha). In Alappuzha, RRS Mancompu had the highest damage at 13.07 percent and the highest yield loss of 540 kg/plot (1,334 kg/ha), while Thekke 900 had 6.50 percent damage with a yield of 270 kg/plot (667 kg/ha), and Thekkekara reported 5.48 per cent damage yielding 227 kg/plot (560 kg/ha). In Malappuram, Tavanur saw 4.35 per cent damage with a yield loss of 167 kg/plot (412 kg/ha), Kuttippuram showed 5.7 per cent damage with loss of 242 kg/plot (597 kg/ha), and Pookottur had 3.84 per cent damage, yield loss of 162 kg/plot (400 kg/ha) (Fig. 2.1).

Table 2.3. Rat incidence in rice ecosystem

District	Location	Plant damage (percent)	Yield (plot/ha)	Yield(kg/ha)
Thrissur	Vettikkal	4.73[bcd]	196	485
	(10.5401, 76.2735)			
	SSF Mannuthy	4.521[cd]	187	463
	(10.52822,76.2623)			
	Madakkathara	3.488[d]	144	357
	(10.5612,76.2624)			
Alappuzha	RRS Mancompu	13.07[a]	540	1334
	(9.4430, 76.4245)			

	Thekke 900 (9.2067, 76.5332)	6.50[b]	270	667
	Thekkekara (9.2177, 76.5546)	5.48[bc]	227	560
Malappuram	Tavanur (10.8412, 75.9938)	4.35[cd]	167	412
	Kuttippuram (10.8423, 76.0299)	5.7[bc]	242	597
	Pookottur (11.0973, 76.0627)	3.84[d]	162	400
CV=28.17				

Fig. 2.1. Rat damage in paddy

The rat incidence in Lakshadweep in coconut fields was significantly different. The Kavaratti Island has more per cent nut damage in coconut fields and Agatti has lowest per cent nut damage (Table 2.4).

Table 2.4. Rat incidence in coconut fields in Lakshadweep

Union territory	Island	GPS Co-ordinates	Per cent nut damage
Lakshadweep	Minicoy	8.2726286; 73.0477906	15.85±0.10
	Agatti	10.8630182; 721947562	13.71±0.30
	Kavaratti	10.5675869; 72.642581	24.57±0.20
	Kiltan	11.485407; 73.004004	20.04±0.15

2.1.4. Andhra Pradesh (ANGRAU, RARS, Maruteru)

Rodent damage in rice crop was assessed using Unmanned Aerial Vehicle (Drone), the techniques was used for first time in assessment of rodent damage in rice fields in India. The study area was carefully delineated, prioritizing regions historically affected by rodent activity and significant crop losses. A high-resolution drone camera was employed for image acquisition. Initially, the total area of the rice field was measured, providing a baseline for subsequent calculations. Drone flights were then conducted over the field, capturing detailed images of rodent-damaged patches, each with precise GPS coordinates. By using GPS-enabled georeferencing, these images were accurately mapped, allowing for consistent, location-specific data collection across the study area. The captured images were subsequently processed using

specialized software to analyse the extent of damage caused by rodents. Within this software, damaged areas were outlined and quantified, with calculations made to determine the percentage of the total field area affected. Using this data, crop compensation estimates were generated based on the severity and extent of rodent damage. This process provided an efficient and accurate method for quantifying rodent impacts in rice cultivation, facilitating data-driven decision-making for crop loss compensation and pest management. This methodology is easy and accurate when compared with diagonal method, in diagonal method chances of errors in collecting data is more (Fig. 2.2).

Fig.2.2. DRONE picture to show rat damage

2.1.5. Assam (AAU, Jorhat)

2.1.5.1. Yield loss caused by rodent pest in different crops at UBVZ of Assam during 2023-24 (Golaghat district)

The damage and yield loss caused by rodents in different crops under UBVZ of Assam revealed a yield loss of 0.96-2.64q/ha in Sali rice with an average damage of 9.11percent and 0.68-2.44 q/ha yield loss with a mean damage of 8.06 percent in boro. In pea, the yield loss of 0.61-0.89q/ha have been recorded with a mean damage of 8.89 percent whereas in potato the yield loss was 0.41-1.86q/ha with a damage of 6.89 percent. In sugarcane, the yield loss was in between 2.01-3.87q/ha with an average damage of 7.79 percent whereas in pumpkin, the damage was 9.96 percent with a yield loss of (0.79-2.91q/ha) (Table 2.5).

Table 2.5. Yield loss caused by rodent pest in different crops at UBVZ of Assam during 2023-24

Sl No	Crops	Damage (%)	Yield loss(q/ha)
1	Rice(Sali)	9.11±1.11	(0.96-2.64)
2	Rice(boro)	8.06±1.06	(0.68-2.44)
3	pea	8.89±1.24	(0.61-0.89)
4	Toria	3.67±1.99	(0.44-0.78)
5	Potato	6.89±2.06	(0.41-1.86)
6	Black gram	3.43±0.89	(0.11-0.56)
7	Green gram	4.41±1.11	(0.43-0.87)
8	Sugarcane	7.79±2.81	(2.01-3.87)
9	Pumpkin	9.96±1.05	(0.79-2.91)

2.1.5.2. Extent of damage caused by rodents in rice in Sivsagar district

In rice, the highest damage of 8.86 & 6.26 percent was recorded at maturity stage in *kharif* and *boro* rice, respectively followed by milky stage. In the early tillering stage of rice, the damage caused by rodents was low. From maximum tillering stage the rodents caused 4.11 & 2.21 percent damage in *kharif* and *boro* rice, respectively. The mean damage caused by rodents in *kharif* and boro rice was 5.33 & 3.83 percent, respectively (Table 2.6).

Table 2.6. Extent of damage caused by rodents in rice

Sl no.	Crop stage	Damage (%) (Mean±SD)	
		Kharif	***Boro***
1	Early tillering	1.88±0.87	0.67±0.11
2	Maximum tillering	4.11±6.67	2.21±0.34
3	Flowering	5.07±4.41	3.86±0.82
4	Milky	7.76±4.51	4.11±0.18
5	Maturity	8.86±3.36	6.26±1.06
	Mean±SD	**5.33±2.88**	**3.86±1.76**

2.2. BIRDS

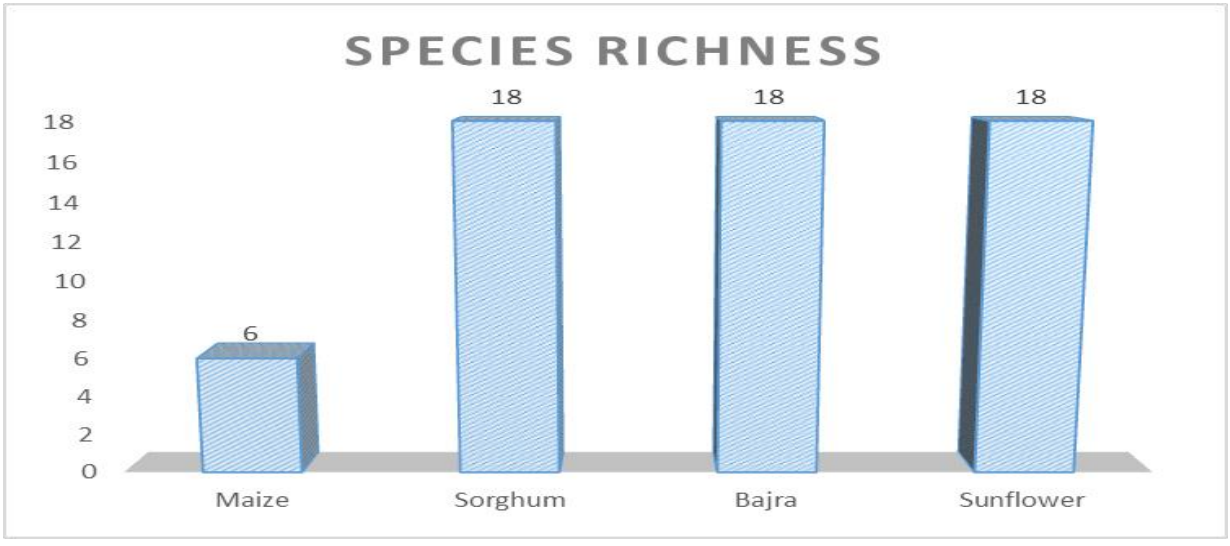
2.2.1. Telangana (PJTSAU, Hyderabad)

Birds prey on crops during various growth stages and causes significant impact on production. The extent of damage varies by crop type, growth stage, and bird species present in the area. The percentage of crop damage caused by depredatory birds is alarming during the sprouting stage and the milking stage in four major crops **(**Maize, Sorghum, Bajra and Sunflower**)** grown in Telangana. Birds like crows and pigeons tend to damage maize early during sprouting but the damage decreases once the crop reaches the milking stage (when the grain is developing). Sorghum is similar to maize, but sorghum might be more prone to damage at both stages due to its open seed heads. Generally, Bajra crop is more resistant to bird damage, especially at the sprouting stage. Birds are often attracted to sunflowers, especially when seeds begin to mature at the milking stage. Bird damage is most significant during the sprouting stage and milky stage, which are critical periods for crop growth and yield. Maize and sunflower are particularly vulnerable to high levels of bird damage at both the sprouting and milking stages. Sorghum and bajra are also affected but to a lesser extent, especially during the early stages of growth (Table 2.7).

Table 2.7. Percent incidence of damage by depredatory birds in different crops

S. No	Name of the crop	Per cent damage(N=54)	
		Sprouting stage	**Milky stage**
1	Maize	15-25%	2-5%
2	Sorghum	5-15%	3-8%
3	Bajra	1-4%	15-20%
4	Sunflower	10-12%	10-30%

Fig. 2.3. Number of depredatory Bird species found in different crops



Depredatory bird populations observed in Maize, Sorghum, Bajra, and Sunflower fields across Telangana. Rose-ringed parakeets are commonly found in both Maize and Sunflower fields, particularly during the grain maturation stage. Their primary feeding on seeds and mature grains contributes to significant crop damage. Scaly-breasted Munias species is most active in Sorghum and Bajra fields, where they feed on seeds and young plants. Scaly-breasted munias can form large flocks and cause considerable damage, especially during the early growth stages. Baya weavers are significant in Sorghum and Bajra fields, often found during the sprouting and grain ripening phases. They typically damage seeds and young plants. Pigeons are a major problem in Maize fields, particularly at the seedling and sprouting stages. They are known for feeding on seeds and tender shoots, which reduces plant establishment. Indian silver bills prefer Sorghum and Bajra, where they feed on seeds and young plants. This species is particularly damaging to Bajra, where they consume seeds and young plants. They are also known to damage flowering heads in Sunflower. Laughing doves can cause moderate damage to Sorghum and Sunflower during the seedling and grain maturation stages. They feed on seeds and developing grains. This species is more frequently observed in Sorghum and Bajra fields. They primarily feed on seeds and can cause moderate damage to crops during early growth stages. Although fewer in number compared to Rose-ringed Parakeets, Plum-headed Parakeets still feed on Maize, Sorghum, Bajra, and Sunflower seeds, particularly during the maturation stages. Red-vented bulbuls are mostly found in Sorghum fields, where they feed on seeds and developing grains. They cause moderate to significant damage to the crop during the early and maturation stages. Tri-coloured munias are often seen in Sorghum and Bajra fields, where they feed on seeds and young plants, particularly causing damage during the germination and early growth stages. Common crows are widespread across Maize, Sorghum, Bajra, and Sunflower fields. Their feeding habits target seeds, tender shoots, and mature grains, making them significant pests during various growth stages. The Maize and Bajra crops tend to suffer the most significant damage, with large populations of Rose-ringed Parakeets, Blue Rock Pigeons, and Common Crows among the primary offenders (Table 2.8).

Table 2.8. List of depredatory birds in different crops

S.no	Common Name	Scientific Name	Maize	Sorghum	Bajra	Sunflower
1	Rose ringed parakeet	*Psittacula krameri*	24	10	5	15
2	Scaly breasted munia	*Lonchura punctulata*	-	26	16	2
3	Baya weaver	*Ploceus philippinus*	-	5	8	6
4	Blue rock pigeon	*Columba livia*	52	8	9	+6
5	Indian silver bill	*Euodice malabarica*	-	7	13	2
6	Yellow billed babbler	*Turdoides affinis*	-	14	21	6
7	Laughing dove	*Spilopelia senegalensis*	-	5	-	5
8	Spotted dove	*Spilopelia chinensis*	-	2	6	6
9	Plum headed parakeet	*Psittacula cyanocephala*	+	1	2	2
10	Red-vented bulbul	*Pycnonotus cafer*	-	8	2	2
11	Tri coloured munia	*Lonchura malacca*	-	16	12	-
12	Eurasian collard dove	*Streptopelia decaocto*	-	4	-	3
13	Common crow	*Euploea core*	20	5	6	6
14	Black headed bunting	*Emberiza melanocephala*	-	-	-	3
15	House sparrow	*Passer domesticus*	-	5	6	6
16	Red avadavat	*Amandava amandava*	-	2	2	-
17	common myna	*Acridotheres tristis*	15	6	5	2
18	Indian peafowl	*Pavo cristatus*	5	-	6	6
19	Large billed crow	*Corvus macrorhynchos*	-	5	9	2
20	Braminy starling	*Sturnia pagodarum*	-	-	2	-
21	Grey francolin	*Ortygornis pondicerianus*	-	2	3	1

Among the crops, Maize had the lowest species richness (11 species), but it still supported a diverse range of birds, particularly Rose-ringed Parakeets and Blue Rock Pigeons. However, the Shannon-

Wiener Index and Simpson's Index indicate a relatively high degree of diversity in comparison to the number of species present, largely due to the even distribution of individual species across the crop. Sorghum exhibited the highest species richness (15 species), with a Shannon-Wiener Index (H') of 3.20, suggesting that this crop supports a more varied bird population. The Simpson's Index of 0.85 further suggests moderate diversity, with several species contributing to the overall bird population. Bajra and Sunflower had similar levels of species richness (13 species each), but their diversity indices varied slightly. Both crops supported significant numbers of Yellow-billed Babblers and Common Crows, which are known to cause substantial damage to crops. The Shannon-Wiener Index (H') values for these crops were slightly lower than Sorghum, indicating a bit less diversity in comparison. The diversity of bird species across Maize, Sorghum, Bajra, and Sunflower crops in Telangana varies, with Sorghum supporting the highest diversity and Maize showing a slightly lower diversity. These variations are influenced by the type of crop and the availability of food resources for the birds (Table 2.9).

Table 2.9. Diversity Indices

Crops	Species Richness (S)	Shannon-Wiener Index (H')	Simpson's Index (D)
Maize	11	2.99	0.88
Sorghum	15	3.20	0.85
Bajra	13	3.15	0.84
Sunflower	13	3.08	0.86

2.2.2. Punjab (PAU (AO), Ludhiana)

2.2.2.1. Depredatory bird damage assessment in maize, mustard and green gram crops

During the depredatory bird damage assessment in traditional maize crop at selected villages i.e. Gorsian (L-1) and Rajjapur (L-2) of district Ludhiana; Ajitwal (L- 3) and Dhudika (L- 4) of district Moga and Kathgarh (L-5) and Khaktan (L- 6) of district Patiala revealed that Rose-ringed Parakeet and House Crow caused 5.53±0.78-6.63±0.32 % damage at germinating stage and 8.06±0.24-15.46±0.41% damage at cob formation stage (Table 2.10; Fig. 2.3).

Table 2.10. Depredatory bird damage at germinating and cob formation stage in Maize crop

Locations	Germinating stage	Cob formation stage
L-1	6.16±0.67	10.33±0.63
L-2	5.73±0.08	10.93±1.17
L-3	5.63±0.08	8.06±0.24
L-4	5.90±0.61	11.13±1.83
L-5	6.63±0.32	15.46±0.41
L-6	5.53±0.78	10.40±1.22

The depredatory bird damage was also studied in organic and conventional crop fields of maize, mustard and green gram crop at PAU, Ghelewal and Pakhowal of district Ludhiana. Damage in maize crop fields was ranging from 4.20±0.01 to 7.20±0.15 at germinating stage and 8.06±0.19 to 15.46±0.12 during cob formation stage. Damage in mustard crop ranged from 5.43±0.01 to 7.20±0.01 at germinating stage and 12.25±0.14 to 24.72±1.50 during maturing stage. In Green gram crop fields, the crop ranged from 1.63±0.05 to 5.63± 0.36 at germinating stage and 7.20± 0.86 to 9.80±1.29 during maturing stage. Assessment of bird damage carried out in mustard crop revealed that Rose-ringed Parakeet and House Crow were major bird species causing damage. Rose-ringed Parakeet caused 7.15-19.23% damage

(Table 2.11; Fig. 2.4). The observations on the depredatory bird damage in dragon fruit crops was also initiated at orchard of PAU (Ludhiana) and Ballowal Saunkhari (SBS Nagar).

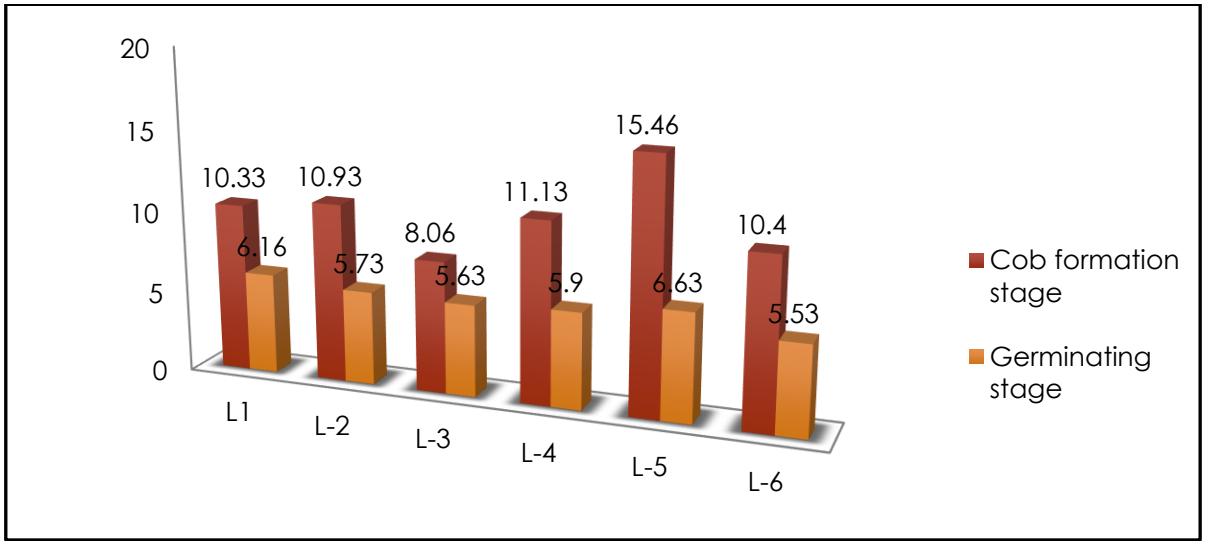


Fig. 2.3. Depredatory bird damage observed in maize crop fields

Table 2.11. Depredatory bird Damage assessment in maize, mustard and green gram crops

Locations/villages	Maize		Mustard		Green gram	
	Germination stage	Cob formation stage	Germination stage	Maturity stage	Germination stage	Maturity stage
PAU Organic	7.20±0.15	10.33±0.26	7.20±0.01	24.72±1.50	4.56± 0.10	8.80± 2.35
PAU Conventional	4.20±0.01	10.93±1.31	5.43±0.01	17.65±0.36	1.63±0.05	8.10±2.03
Ghelewal Organic	5.50±0.10	8.06±0.19	5.50±0.10	14.45±0.25	5.63± 0.36	7.20± 0.86
Ghelewal Conventional	6.30±0.17	11.13±0.32	6.30±0.10	12.25±0.14	3.73±0.21	9.10±2.52
Pakhowal Organic	6.50±0.10	15.46±0.12	6.50±0.01	13.83±0.76	4.13 ±0.89	7.50±0.58
Pakhowal Conventional	6.80±0.21	10.40±0.10	6.80±0.01	16.17±0.40	2.83±0.72	9.80±1.29

Values are expressed as Mean±S.D.; Mean value followed with different superscripts are significantly different ($p < 0.05$) using Tukey's test. Values given was the mean values of damage (Sample plot method) at different developmental stages of the crops (Maize- germination, cob formation stage; Mustard and Green gram (germination and maturing stage) in selected fields of district Ludhiana.

Maize			
			
Mustard			
Green gram			
Miscellaneous crops			
Dragon fruit			

Fig. 2.4. Depredatory bird damage in different agricultural crops

2.2.3. Kerala (KAU, Thrissur)

2.2.3.1. Peafowl damage in rice and vegetable fields of Kerala

The data (Table 2.12) on crop damage (Fig. 2.5) reveals significant yield losses across various crops in the surveyed districts. The highest crop damage was observed in Idukki district, where cowpea in Chalassery showed a damage percentage of 19.3 percent. In Kannur district, cowpea in Aralam also had significant damage, with a value of 18.8 percent. In Kottayam, amaranthus at Chovoor experienced 17.2 percent damage. Additionally, in Kannur, yams in Peravoor were affected by 16.2 percent damage, and rice in Alappuzha district at Perumpalam faced 15.6 per cent damage. These locations represent the highest crop damage percentages across the districts studied. The lowest crop damage was observed in Wayanad district, where cowpea at Kunnampetta experienced only 4.3 percent damage. In Kasargod district, cucurbits at Kuttikkol had a damage percentage of 4.2 percent, and in Malappuram district, amaranthus at Amarambalam showed 5.01 percent damage. These locations represent the areas with the lowest crop damage percentages across the districts studied. Cowpea exhibited the highest damage of 19.3 percent in Idukki district (Chalassery) and the lowest at 4.3 percent in Wayanad district (Kunnampetta). For cucumber, damage peaked at 14.1 percent in Thrissur district (Panjal) and was lowest at 7.01 percent in Thiruvananthapuram district (Ponmudi). Okra faced the highest damage of 14.9 percent in Palakkad district (Shornur), with a minimum of 7.01 percent in Kozhikode district (Chakkittappara). In the case of rice, the most significant damage was 15.6 percent in Alappuzha district (Perumpalam), while the least was 7.5 percent in Wayanad district (Kenichira). For yam, the highest damage was recorded at 18.8 percent in Kannur district (Aralam) and the lowest at 7.01 percent in Kozhikode district (Chakkittappara). Amaranthus showed the highest damage of 17.2 percent in Kottayam district (Chovoor) and the lowest at 5.01 percent in Malappuram district (Amarambalam).

Table 2.12. Peafowl damage and yield losses in different crops of Kerala

Sl No	District	Location	GPS Co-ordinates	Crops	Damage (percent) (Mean±S.Em)	Yield loss (kg/plot)	Yield loss (kg/ha)
1	Thiruvananthapuram	Vellanad	8.5668, 77.0629	Cowpea	12.5±0.10	6.25	156.25
		Ponmudi	8.6806, 77.0891	Cucumber	7.01±0.02	14.02	467.29
		Venganoor	8.3880, 76.9790	Okra	10.9±0.03	5.45	201.8
2	Kollam	Punalur	8.9555, 77.0338	Watermelon	6.2±0.26	18.6	309.88
		Anchal	8.9177, 76.9085	Cowpea	8.1±0.20	4.05	101.25
		Ramankulangara	8.9080, 76.5605	Cowpea	6.9±0.10	3.45	86.25
3	Pathanamthitta	Konni	9.3720, 77.0294	Yam	8.5±0.15	2.55	255.00
		Nilakkal	9.3930, 77.0097	Okra	8.4±0.41	4.2	155.5
		Enadimangalam	9.1310, 76.7950	Cucumber	9.01±0.10	18.02	600.61
4	Alappuzha	Karumathra	9.5010, 76.4721	Rice	11.8±0.20	1.77	589.9
		Perumpalam	9.8527, 76.3593	Rice	15.6±0.3	2.34	779.9
		Changaram	9.7975, 76.2890	Picking melon	12.2±0.01	24.4	813.25
5	Kottayam	Thidanad	9.6682, 76.7550	Cowpea	9.1±0.60	4.55	113.75
		Chovoor	9.7560, 76.8092	Amaranthus	17.2±0.40	21.3	91.73

		Vembanad	9.5968, 76.3945	Rice	9.1±0.10	0.091	303.33
6	Idukki	Devikulam	10.0098, 76.9154	Cowpea	13.95±0.10	6.975	174.38
		Chalassery	9.9082, 76.7659	Cowpea	19.3±0.1	9.65	241.25
		Thekkumbhagam	9.8657, 76.7331	Cucumber	10.2±0.20	20.4	679.93
7	Ernakulam	Kallimedu	10.1908, 76.8147	Bitter gourd	13.7±0.76	20.55	513.75
		Kotamanagalam	10.0512, 76.7697	Amarathus	10.02±0.30	9.1	53.44
		Ayyampuzha	10.2943, 76.4790	Cowpea	12.9±0.51	6.45	161.25
8	Thrissur	Chelakkara	10.3942, 76.2124	Cowpea	11.01±0.20	5.505	137.63
		Velappya	10.6052, 76.2077	Watermelon	9.9±0.11	29.7	494.80
		Panjal	10.4149, 76.2137	Cucumber	14.1±0.36	28.2	939.91
9	Palakkad	Malampuzha	10.8259, 76.7338	Cowpea	12.7±0.41	6.35	158.75
		Shornur	10.7952, 76.2624	Okra	14.9±0.12	7.45	275.9
		Pattambi	10.8082,76.1924	Rice	9.3±0.11	1.395	465.00
10	Malappuram	Amarambalam	11.2365, 76.3544	Amaranthus	5.01±0.4	4.5	26.72
		Thavanur	10.8551, 76.0056	Cowpea	12.1±0.3	6.05	151.25
		Angadippuram	10.9721, 76.2073	Pumpkin	14.10±0.01	70	777.70
11	Kozhikode	Chekkiad	11.7517, 75.6659	Cowpea	11.01±0.10	5.505	137.63
		Chakkittappara	11.5724, 75.8227	Yams	7.01±0.10	2.103	210.30
		Kallor kavu	11.1528, 75.4726	Amaranthus	8.9±0.20	8.5	47.47
12	Wayanad	Kenichira	11.7280, 76.1486	Rice	7.5±0.19	0.075	250.00
		Vaalad	11.8068, 75.8903	Okra	9.3±0.19	4.65	172.2
		Kunnampetta	11.5782, 76.0971	Cowpea	4.3±0.27	2.15	53.75
13	Kannur	Peravoor	11.8862, 75.7500	Yams	16.2±0.36	4.86	486.00
		Aralam	11.9671, 75.7990	Cowpea	18.8±0.7	9.4	235.00
		Kattamppally	11.9447, 75.3849	Cucumber	10.9±0.6	21.8	726.59
14	Kasargod	Vellarikundu	12.4346, 75.2466	Cowpea	7.6±0.01	3.8	95.00
		Kuttikkol	12.4825, 75.2120	Cucurbits	4.2±0.12	8.4	279.97
		Manjampothi	12.3377, 75.1173	Okra	12.9±0.3	6.35	238.8

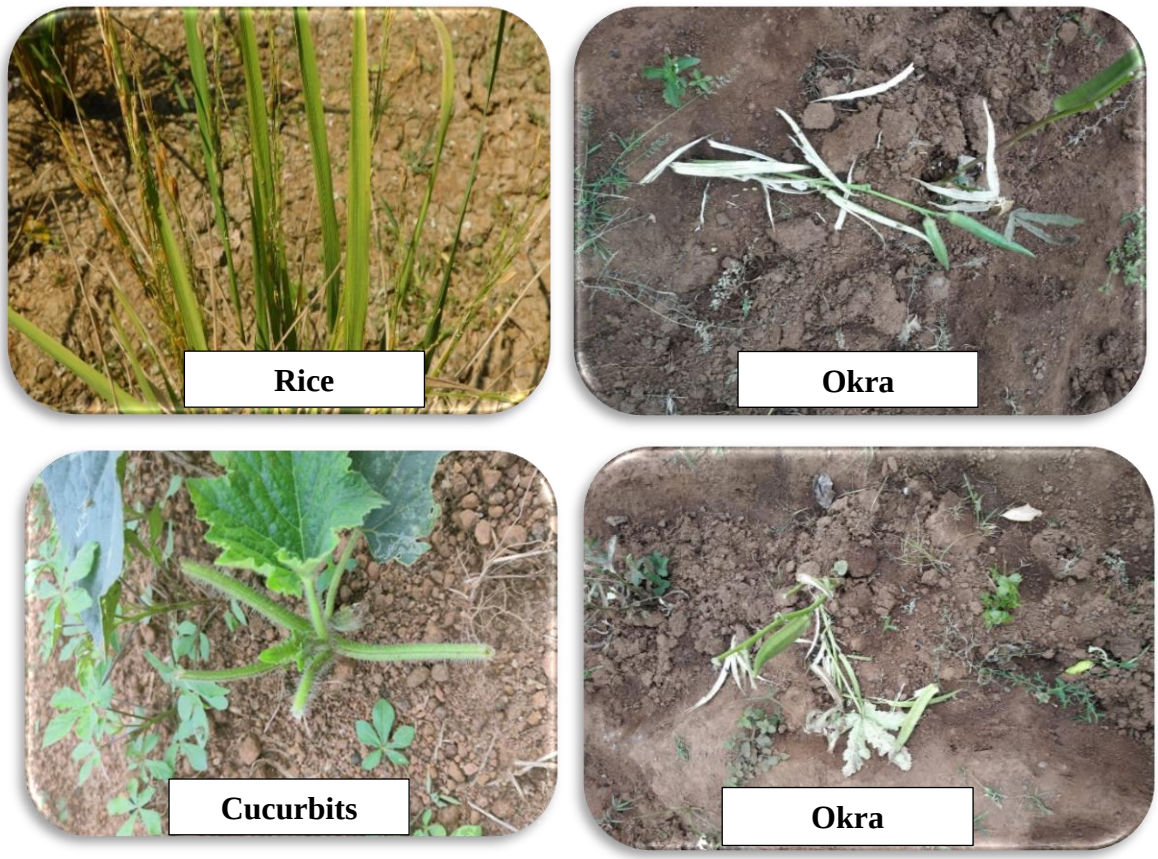


Fig 2.5. Peafowl damage in different crops

In Coimbatore district (Table 2.13), crop damage varies by location and type. The highest damage was reported in Meenakshipuram for bottle gourd at 9.01 percent, resulting in a yield loss of 600.61 kg/ha. Pollachi followed with 7.2 percent damage to okra, leading to a significant yield loss of 1,33.33 kg/ha. Madhukkarari recorded 6.5 per cent damage in cucumber, causing a loss of 325.00 kg/ha. Kottur and Kinathukadavu had lower damage rates of 5.6 percent and 5.5 percent, with yield losses of 280.00 kg/ha and 183.26 kg/ha for bitter gourd and cucurbits, respectively. The least damage was in Anaimalai, where cowpea faced 4.8 percent damage, resulting in a small yield loss of 60.00 kg/ha. Overall, bottle gourd and okra experienced the most severe impacts from damage.

Table 2.13. Peafowl damage and yield losses in Coimbatore district of Tamil Nadu

District	Location	GPS Coordinates	Crops	Damage (percent)	Yield loss (kg/plot)	Yield loss (kg/ha)
Coimbatore	Madhukkarari	10.8896003, 76.9473587	Cucumber	6.5±0.01	13	325.00
	Meenakshipuram	10.6269842, 76.8729566	bottle gourd	9.01±0.20	18.02	600.61
	Pollachi	10.6390391, 76.9932497	Okra	7.2±0.03	3.6	133.3
	Kinathukadavu	10.7945693, 77.0099613	Cucurbits	5.5±0.14	11	183.26
	Kottur	10.5265047, 76.9776445	bitter gourd	5.6±0.10	11.2	280.00
	Anaimalai	10.5869447, 76.9412084	Cowpea	4.8±0.73	2.4	60.00

2.3. WILD BOAR

2.3.1. Telangana (PJTSAU, Hyderabad)

2.3.1.1. Damage assessment to crop in Nalgonda District

In Nalgonda District damage of wild boars was assessed in the four primary crops, viz., rice, sorghum, cotton, and groundnut. Groundnut was the most affected crop, with significant yield loss of 40 percent, flowed by Rice (30 percent) Sorghum (25 percent) and Cotton (20 percent). The data indicates that wild boar activity had a considerable impact on crop yields in Nalgonda district, particularly for rice and groundnut. The statistically significant results (< 0.05) demonstrate the need for urgent management strategies to mitigate wild boar-related damage (Table 2.14).

Table 2.14. Analysis of crop damage caused due to wild boar in Nalgonda district

Crop Type	Area Affected (ha)	Sample Size (n)	Mean Damage (%)	Standard Deviation (%)	Estimated Yield Loss (kg/ha)	Total Yield Loss (kg)	Statistical Significance (p-value)
Rice	100	20	30	5	240	24000	< 0.01
Sorghum	80	15	25	7	560	44800	< 0.05
Cotton	50	10	20	8	1200	60000	< 0.01
Groundnut	60	12	40	4	1450	87000	0.15
Average damage %			**28.75**				

2.3.1.2. Damage assessment to crop in Vikarabad District

Groundnut fields exhibit the highest mean damage percentage (45 percent), underscoring the severe impact of wild boar foraging. Similarly, rice fields were significantly affected by wild boar damage, (35 percent) showing a high yield loss with very strong statistical significance followed by sorghum (28 percent). While cotton fields were less impacted compared to other crops, the statistical significance is marginal, indicating least damage of (22%) (Table 2.15).

Table 2.15. Analysis of crop damage caused due to wild boar in Vikarabad district

Crop Type	Area Affected (ha)	Sample Size (n)	Mean Damage (%)	Standard Deviation (%)	Estimated Yield Loss (kg/ha)	Total Yield Loss (kg)	Statistical Significance (p-value)
Rice	150	25	35	6	2800	420000	< 0.01
Sorghum	100	20	28	5	630	63000	< 0.05
Cotton	70	15	22	7	900	63000	< 0.01
Groundnut	80	18	45	4	1630	130400	0.10
Average damage %			**32.5**				

2.3.1.3. Damage assessment to crop in Nagarkurnool District

The analysis includes four major crops (Rice, sorghum, cotton, and groundnut) affected by wild boars in Nagarkurnool district. Groundnut fields face severe damage, with the highest mean damage of 40 percent, followed by sorghum (25%) and rice (20%) indicating a substantial economic impact on these crops. Damage in cotton crop was comparatively less severe (10%) (Table 2.16).

Table 2.16. Analysis of crop damage caused due to wild boar in Nagarkurnool district

Crop Type	Area Affected (ha)	Sample Size (n)	Mean Damage (%)	Standard Deviation (%)	Estimated Yield Loss (kg/ha)	Total Yield Loss (kg)	Statistical Significance (p-value)
Rice	150	20	20	10	1600	240000	0.01
Sorghum	120	15	25	8	562	67500	0.03
Cotton	100	10	10	5	600	60000	0.02
Groundnut	180	25	40	12	1450	261000	0.005
Average damage %			**23.75**				

The wild boar damage was recorded high in groundnut (40-45 percent) followed by Rice (20-35 percent), Sorghum (25-28 percent), and Cotton (10-22 percent) (Table 2.17).

Table 2.17. Mean per cent damage by wild boar in three districts

Crop Type	Mean damage percent		
	Nalgonda	Vikarabad	Nagarkurnool
Rice	30	35	20
Sorghum	25	28	25
Cotton	20	22	10
Groundnut	40	45	40

2.3.2. Punjab (PAU (AO), Ludhiana)

Wild boar survey was conducted in >200 villages of Punjab and 20 villages of Himachal Pradesh to assess the prevalence and damage caused by wild Boar in the different crop fields. During the survey it was observed that wild boar was predominantly causing damage to maize, wheat, vegetable (Fig. 2.6) which ranged from 5.53-37.12 percent in sugarcane, potato, and agro-forestry plantations depending upon the crop and surrounding habitat (Fig. 2.7). The incidence of damage was very high in crop fields adjacent to forest area and areas near river bank sides. The farmers also used some traditional methods to minimize the damage of animals over the agricultural crops.

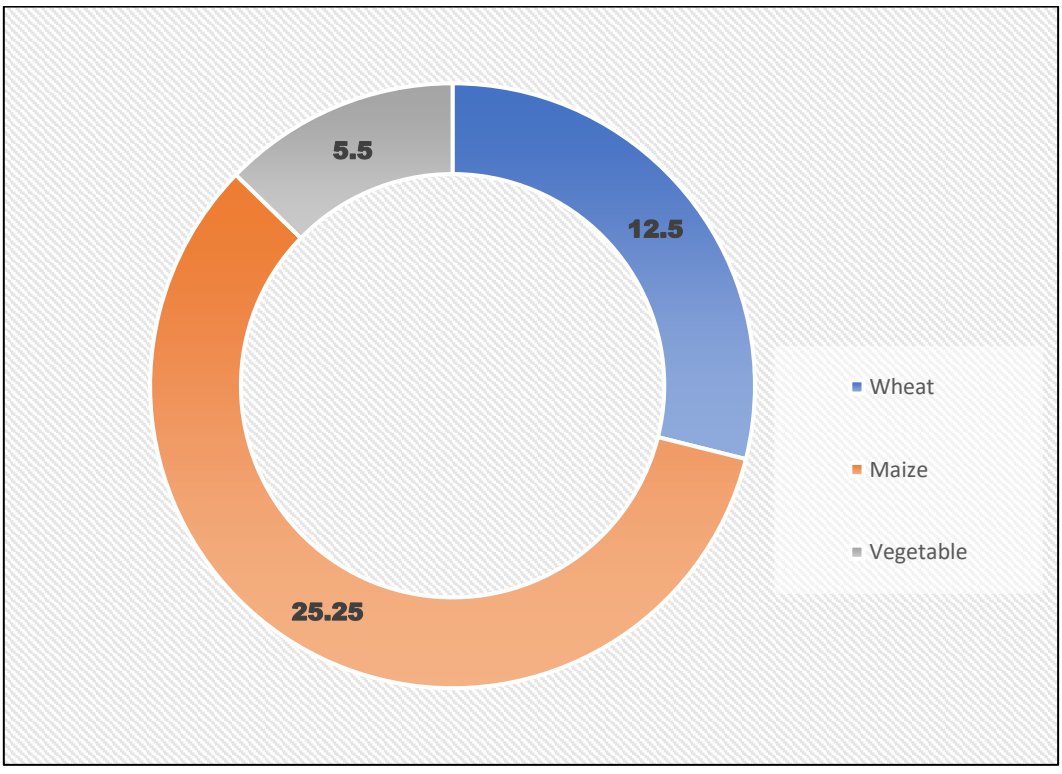


Fig. 2.6. Wild boar damage to various crops (data is location specific where the activities of wild boar was higher)

Wild boar was observed in the villages adjoining the forest areas of Lower Shiwalik Hills and banks of rivers mainly Sutlej and Beas. The number of individual animals observed in various crops varies from location to location and crop specific i.e. Wheat Crop at vegetative (9-13) and maturing (7-10) stage; Maize crop at vegetative (12-16) and maturing (13-17) stage, Vegetable crops i.e. Cucurbits sp., tomato & potato (12-16) individual respectively. Damage by wild boar was most evident in maize crop fields followed by wheat and vegetables although the damage was location specific and should not be generalized.

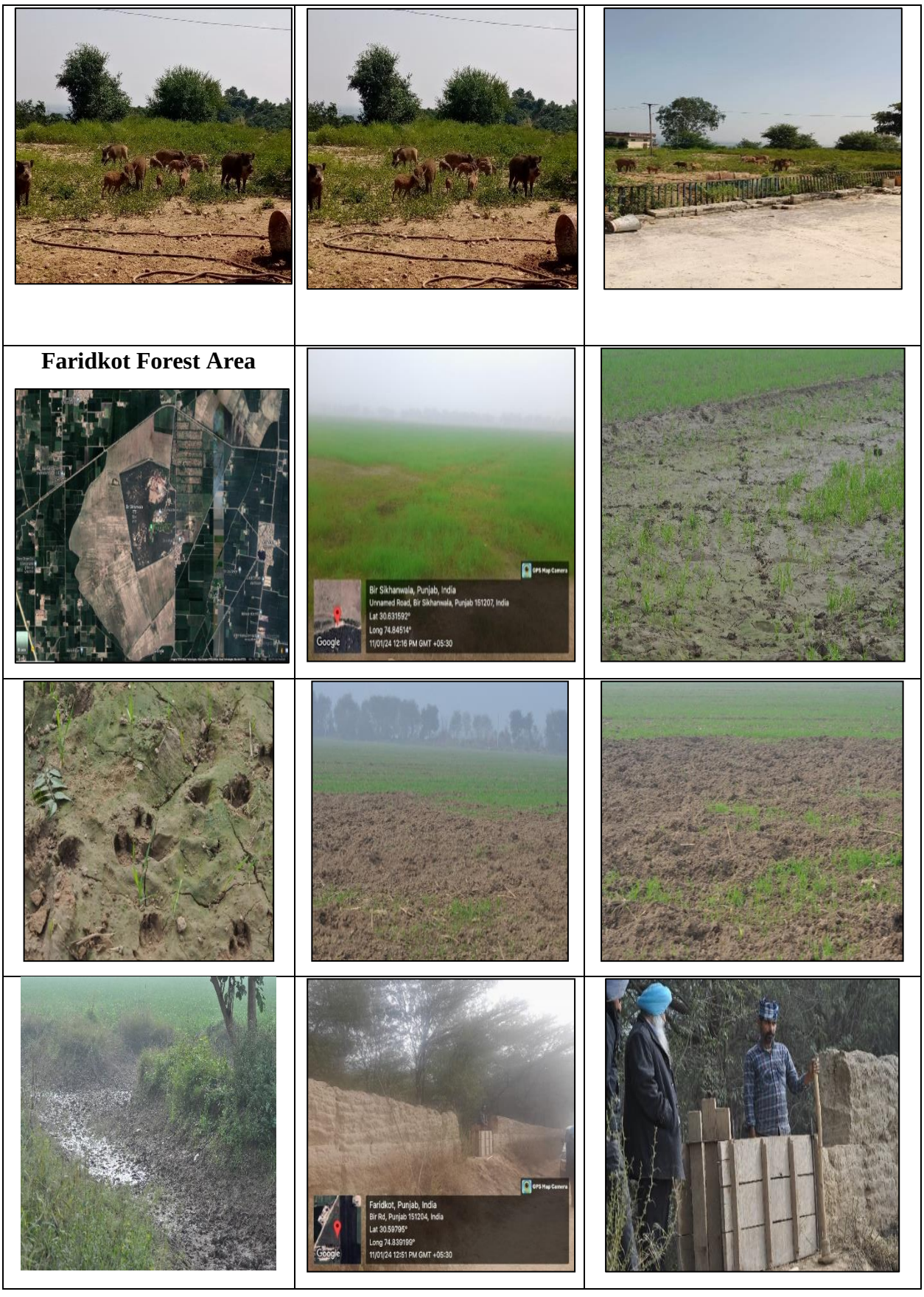


Fig. 2.7. Wild boar and its damage at different agricultural crop field areas (pug marks and wallowing activities)

2.3.3. Kerala (KAU, Thrissur)

The assessment of cassava crop damage (Fig. 2.8) in Kerala (Table 2.18) shows a range of yield losses across various locations. The incidence of wild pig damage in cassava across various districts demonstrates considerable variation in both damage percentages and associated yield losses. The highest damage recorded was 10.1percent in Idukki district (Adimali), resulting in a significant yield loss of 1,870.27 kg/ha. Other notable high damages include 8.9percent in Idukki district (Thodupuzha) and 8.9percent in Malappuram district (Agandipuram), with yield losses of 1,648.06 kg/ha. Conversely, the lowest damage was observed in Pathanamthitta district (Elanthoor) at just 2.4percent, leading to a yield loss of 444.42 kg/ha. Additionally, Kasargod district (Padannakkad) reported a damage percentage of 2.9percent and 3.5percent in Kanhangad. Overall, wild pigs have a notable impact on cassava yields, with the highest incidences primarily seen in Idukki district and lower occurrences in Pathanamthitta and Kasargod districts.

Fig 2.8. Wild boar incidence in different crops (Cassava and Banana)

Table 2.18. Wild boar incidence in cassava

Sl No	District	Name of the place	GPS co-ordinates	Damage (percent)	Yield loss (kg/plot)	Yield loss (kg/ha)
1	Thiruvananthapuram	Neyyattinkara	8.4027, 77.0861	5.3	7.95	9.78
		Balaramapuram	8.4321, 77.0503	4.4	6.6	814.77
		Sree karyam	8.5488, 76.9173	7.9	11.85	1462.88
2	Kollam	Parippally	8.8123, 76.7589	7.4	11.1	1370.30
		Sadanandapuram	9.0056, 76.7831	4.1	6.15	759.22
		Chadyamangalam	8.8731, 76.8694	4.36	6.54	807.36
3	Pathanamthitta	Elanthoor	9.2892, 76.7279	2.4	3.6	444.42

		Aranmula	9.3265, 76.6840	5.9	8.85	1092.53
		Pullad	9.3550, 76.6730	6.1	9.15	1129.57
4	Alappuzha	Kayankulam	9.1748, 76.5013	7.9	11.85	1462.88
		Krishnapuram	9.1506, 76.5311	2.52	3.78	466.64
		Mavelikara	9.2506, 76.5401	2.2	3.3	407.39
5	Kottayam	Kumarakom	9.6175, 76.4301	4.3	6.45	796.25
		Puthupally	9.5653, 76.5662	2.8	4.2	518.49
		Pannimattom	9.5385, 76.5221	3.9	5.85	722.18
6	Idukki	Thodupuzha	9.8959, 76.7184	8.9	13.35	1648.06
		Adimali	10.0115, 76.9528	10.1	15.15	1870.27
		Arakulam	9.8138, 76.8245	9	13.5	1666.58
7	Ernakulam	Nedumbassery	10.1679, 76.3978	5.6	8.4	1036.98
		Athani	10.1530, 76.3549	3.5	5.25	648.11
		Kalamassery	10.0531, 76.3528	8.5	12.75	1573.99
8	Thrissur	Ponnukkara	10.5725, 76.5228	7.9	11.85	1462.88
		Vaniyampara	10.5760, 76.4014	8.3	12.45	1536.95
		Chelakkara	10.7753, 76.4781	8.5	12.75	1573.99
9	Palakkad	Wadakancherry	10.6008, 76.4904	8.01	12.015	1483.25
		Thonippadam	10.6723, 76.5069	7.5	11.25	1388.81
		Attappady	11.0681, 76.5662	6.6	9.9	1222.16
10	Malappuram	Agandipuram	10.9773, 76.2014	8.9	13.35	1648.06
		Vettam	10.8611, 75.9151	5.3	7.95	981.43
		Edakkara	11.3615, 76.3027	4.1	6.15	759.22
11	Kozhikode	IISR	11.2985, 75.8403	6.6	9.9	1222.16
		Kuduvally	11.3599, 75.9129	8.7	13.05	1611.02
		Ulliyeri	11.4502, 75.7711	9.01	13.515	1668.43
12	Wayanad	Meenangadi	11.6607, 76.1551	8.9	13.35	1648.06
		Sulthan bathery	11.6629, 76.2570	6.58	9.87	1218.45
		Ambalavayal	11.6197, 76.2103	5.7	8.55	1055.50
13	Kannur	Thalassery	11.7491, 75.4890	7.6	11.4	1407.33

		Mala	11.9383, 75.7292	5.4	8.1	999.95
		Payyannur	12.0972, 75.1934	7.8	11.7	1444.37
14	Kasargod	Padannakkad	12.2598, 75.1130	2.9	4.35	537.01
		Nileshwar	12.2557, 75.1341	4.3	6.45	796.25
		Kanhangad	12.3311, 75.0915	3.5	5.25	648.11

2.3.4. Gujarat (AAU, Anand)

The study was conducted to estimate the wild boar damage in cultivated land of four blocks *i.e.* Savli, Vadodara, Vaghodiya and Dabhoi of Vadodara district from September 2023 to September 2024. The crop fields were monitored regularly and observations on number of damaged plants, total plant stand and control measure(s) taken to manage the wild boar damage were recorded. The percent damage to the crops due to wild boar was derived on the basis of damaged plants and healthy plants and interview of farmers through structured questionnaire.

In Vadodara district the assessment of damage in different crop fields (Fig. 2.9) revealed that rice crop suffered maximum damage of 12 percent (0 to 20.00 per cent) due to wild boar, followed by maize crop (11.76 percent, range 0.10 to 13.00 percent), and banana crop 10.00 percent. The unattended maize fields were found vulnerable to boar damage and recorded higher damage (Table 2.19, Fig. 2.10).

The regional and farm level survey on impact of wild boar in different crops were done. The incidence of damage recorded at the regional level was very low. The crop fields near their roosting site were vulnerable due to their daily movement. The damage observed in the field was mostly due to trampling and lodging of crops and negligible due to feeding activity. Farmers also supplemented that damage was more due to trampling activity.

Fig 2.9. Wild boar distribution in Vadodara district

Figure 2.10. Damage caused by wild boar

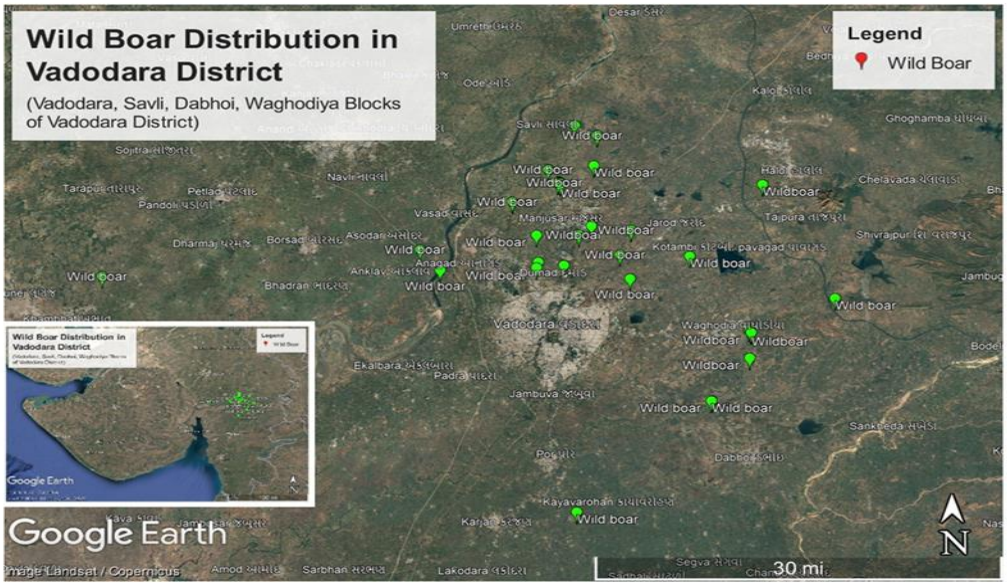


Table 2.19. Damage by wild boar to agricultural crops

S. No.	Name of the crop cultivated	No. of farm surveyed	No. of quadrate laid	No. of quadrate in which damage noticed	Total No. of damaged plant in all quadrat	damage (%)	Frequency	Range	Damaging stages in the crop
1	Rice	35	175	12	21	12.00	06.86	0.00-18.00	All stages of the crop
2	Maize	17	85	08	10	11.76	09.41	0.10-13.00	Later stage
3	Sorghum	03	15	01	03	20.00	06.67	0.02-23.00	Later stage
4	Pearl millet	04	20	01	05	25.00	05.00	0.65-28.00	Later stage
5	Pigeon pea	07	35	005	08	22.86	14.29	0.00-26.00	All stages of the crop
6	Castor	08	40	01	02	5.00	02.50	0.00-08.00	All stages of the crop
7	Cucurbitaceous vegetables	06	30	02	06	20.00	06.67	0.00-09.50	All stages of the crop
8	Banana	10	50	05	05	10.00	10.00	0.00-10.00	Total stages of the crop
9	Drumstick	03	15	2	01	06.67	13.33	0.00-16.00	All stages of the crop
10	Cotton	13	65	03	02	03.08	04.62	0.00-06.50	All stages of the crop
11	Chilli	02	10	005	01	10.00	50.00	0.00-65.00	All stages of the crop
12	Brinjal	07	35	02	20	05.71	05.71	0.00-10.00	All stages of the crop
13	Cruciferous and leafy vegetables	02	10	00	00	0.00	0.00	0.00	No damage noted
	Total / Average	**117**	**585**	**--**	**--**	**11.70**	**10.39**	**0-65**	**--**

The majority of surveyed fields were protected against wild boar by one or more techniques along with the manual scaring. All most all farmers used the manual scaring along with other protection techniques. The various techniques used by farmers involve electric fence, and wire/string fencing, saree fence etc (Table 2.20, Fig. 2.11). Most of device used alone were reported unsatisfactory to control wild boar.

Fig. 2.11. Solar fencing and sarees to protect field from wild boar

Table 2.20. The fields protected by various methods followed by farmers to control wild boar damage

Protection Techniques	No. of fields observed	Field protected (percent)
Saree fencing	28	23.93
Wire/string fencing	33	28.21
Nylon net fencing	2	1.71
Barbed wired fencing	3	2.56
Chain-link fencing	8	6.84
Electric fencing	8	6.84
Solar fencing	19	16.24
Wall fencing	2	1.71
Watchdogs	8	6.84
Opuntia as live fence	1	0.85
Rajgira as a live fence	2	1.71
Repellent application	3	2.56
Total	**117**	**100**

2.4. BLUE BULL

2.4.1. Punjab (PAU (RC), Ludhiana)

Three villages each were selected in districts Hisar (Haryana) and Ludhiana (Punjab) for assessment of blue bull damage in different crops. Damage in each crop was recorded at fortnightly intervals (three fields in each village i.e. n=9 fields for each crop) from sowing till harvesting except in the poplar crop, where damage was recorded every month. Yield loss (quintal/hectare), percent yield loss and monetary loss were also calculated for different crops.

Blue bull damage was found throughout the crop growth period but maximum damage was observed during fruiting stage of crops. Hence special attention to the management of blue bulls is needed at the fruiting stage. Cotton and mustard crops were mainly used for hiding purposes. Animals caused maximum damage to maize followed by oat, wheat, moong, mustard, cotton, and paddy indicating maize as the preferred crop (Fig. 2.12a, 2.12b). In Haryana, monetary loss due to blue bull was more to cotton followed by wheat and mustard crops. In Punjab, monetary loss due to blue bull was maximum for maize followed by wheat and moong crops (Table 2.21). Damage to poplar cop was maximum from nursery to 2-year-old plants and at later stages, poplar fields were preferred for resting (Fig. 2.12c). Fig. 2.13 shows the kind of blue bull damage to different crops.

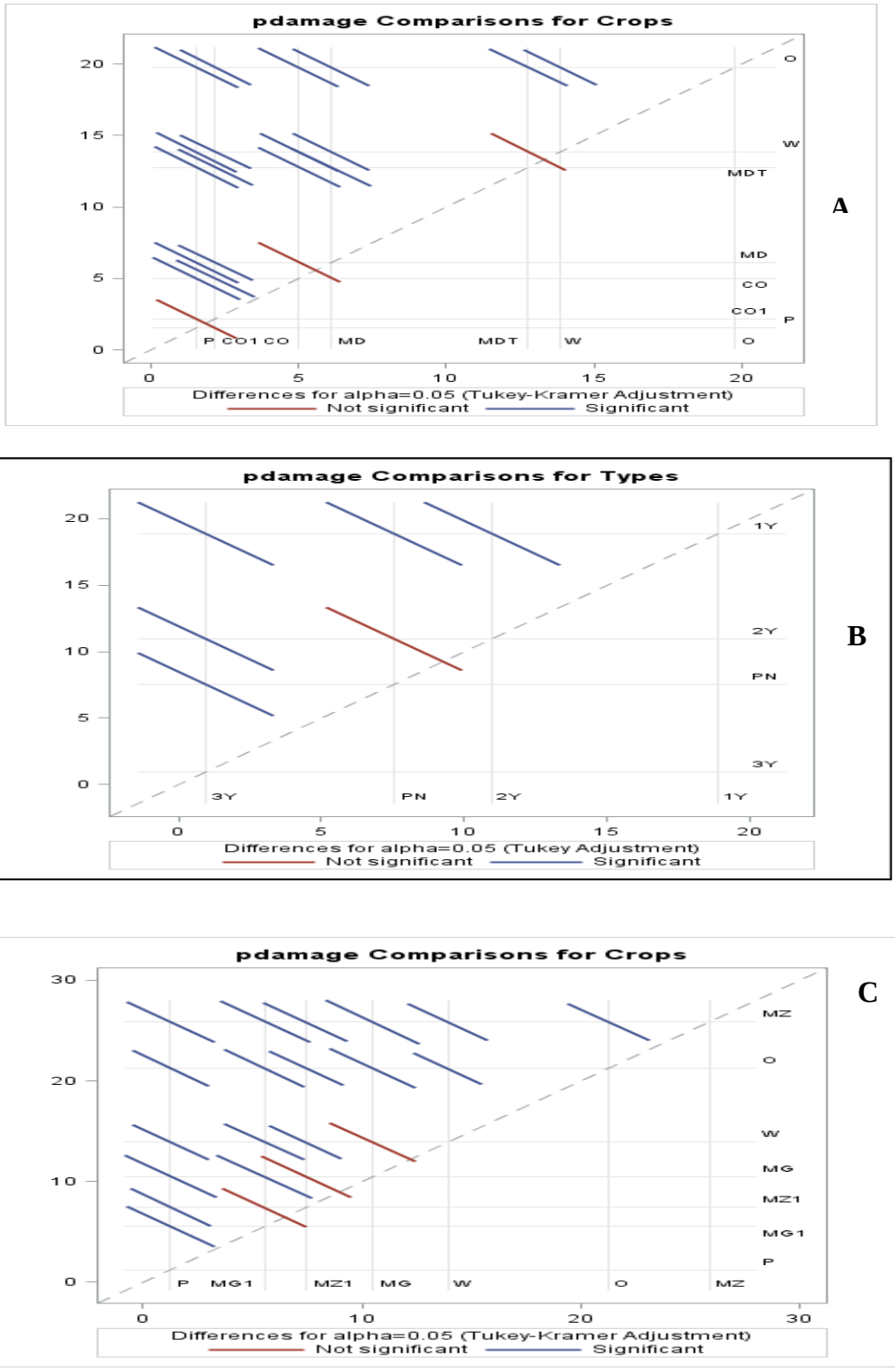


Fig. 2.12 Diffograms Showing Multiple Comparisons of Overall Percent Damage Between Crops in (a) Hisar District, Haryana, (b) Ludhiana District, Punjab, and (c) Poplar Crop Stages/Types

Note: Red lines represent non-significant differences, and blue lines indicate significant differences in overall percentage damage among crops and crop stages/types. Crop codes: CO: Cotton ball, CO1: Cotton plant, W: Wheat, O: Oat, MD: Mustard plant, MDT: Mustard tiller, P: Paddy.

Table 2.21. Yield loss and economic loss to various crops by blue bull in districts Hisar (Haryana) and Ludhiana (Punjab)

Crops	Hisar (Haryana)			Ludhiana (Punjab)		
	Yield loss (q/ha)	*Monetary loss/ha (Rs)*	*Monetary loss/ha (US$)*	*Yield loss (q/ha)*	*Monetary loss/ha (Rs)*	*Monetary loss/ha (US$)*
Wheat	7.79±0.51^{a}	16552.38	199.21	8.77±0.66^{b}	18634.27	224.27
Paddy	2.05±0.11^{b}	4498.58	54.14	2.21±0.63^{c}	4875.67	58.68
Mustard	2.41±0.20^{b}	13104.92	157.72	--	--	--
Cotton	2.59±0.25^{b}	17144.39	206.34	--	--	--
Maize	--	--	--	29.13±2.9^{a}	60872.55	732.61
Moong	--	--	--	1.76±0.40^{c}	15066.79	181.33

Values are Mean±SE; Different superscripts along the columns indicate significant differences

Fig. 2.13. Blue bull damage to different crops

2.5. MONKEYS

2.5.1. Telangana (PJTSAU, Hyderabad)

The percent damage caused by monkeys in various agricultural crops along with the month wise monkey activity was recorded in in Vikarabad, Nagarkurnool and Nalgonda districts by comparing the activity data in 4 locations for each crop. Among all the monkey activities feeding activity was found more during the critical stages of the crops (Table 2.22, 2.23, 2.24).

Table 2.22. Month wise monkey activity during sensitive stages of Rice crop

Activity	Percentage			Damage percent
	Jun-Jul	Aug-Sep	Oct	
Resting	11.2	23.9	8.6	NA
Feeding	**35.6**	**7.8**	**43.9**	**14.8***
Moving	13.2	28.4	11.1	NA
Grooming	13.5	15.3	10.0	NA
Playing	12.3	16.7	10.9	NA
Vocalization	7.5	5.6	7.8	NA
Aggression	6.8	2.3	7.8	NA

*Nursery stage to tillering stage during Jun-July months
Milking stage to harvesting stage during Oct month

Table 2.23. Month wise monkey activity during critical stage of boll formation in cotton

Activity	Percentage			Damage percent
	August	September	October	
Resting	12.8	7	9.9	NA
Feeding	**14**	**51.8**	**32.9**	***24.6**
Moving	16.7	8.6	12.7	NA
Grooming	18.4	8.7	13.6	NA
Playing	23.2	11.4	17.3	NA
Vocalization	8.5	5.9	7.2	NA
Aggression	6.4	6.5	6.5	NA

*Boll formation stage in cotton during August,September & October months

Table 2.24. Month wise monkey activity during critical stage of fruiting in Guava

Activity	Month wise Percentage (percent)				Damage (percent)
	Aug	Sept	Oct	Nov	
Resting	15.7	10.2	10.1	12.0	NA
Feeding	**13.1**	**37.7**	**25.8**	**13.2**	**33.3**
Moving	21.6	11.4	16.3	28.0	NA
Grooming	16	12.2	13	13.0	NA
Playing	26.4	17.1	23.2	27.9	NA
Vocalization	4.6	5.7	5.4	4.9	NA
Aggression	2.7	5.8	6.2	1.7	NA

*Fruiting stage during Sept & Oct months

2.5.2. Andhra Pradesh (ANGRAU, RARS, Maruteru)

In crop fields and plantation crops macaques are causing extensive damage to maize, banana, coconut, cashew, oil palm etc. The damage caused by macaques in various crops in Krishna – Godavari was

estimated as: Oil palm- The rate of infestation was 34.60 percent trees with 2.45 percent nut/fruit damage. Macaque damage was noticed in rice fields (1.95 percent damage), mostly in the rice fields adjoining plantations/ orchards. The mean yield loss due to macaques in maize was recorded as 1.65 q/acre with a damaged area of 0.67 percent. Among the field crops, maize was highly vulnerable to macaque attack. In banana plantations, the infestation rate was recorded as 13.3 with fruit damage up to 13.85 percent. (Tables 2.25 to 2.28, Fig. 2.14). Macaque damage was mostly recorded in forest fringe areas. In recent years their continued presence has been also observed in plain areas. Increase in oil palm plantations in plain areas providing them ideal habitat like forest fringe and establishing, hiding and habituating the oil palm plantations. As a result, the adjoining field crops suffer high macaque attacks besides conflicting with humans.

Table 2.25. Assessment of Macaque damage in rice crop

Location	Area (acre)	Damaged area (acre)	Damaged Area (%)	Yield loss (Q/acre)
K Kota (1) V& M Eluru dist.	12.0	0.25	2.08	4.5
D.Tirumala, Eluru dist.	8.0	0.20	2.5	3.8
Pitapuram, Kakinada dist.	8.0	0.15	2.25	4.0
R.Chodavaram, ASRM dist.	5.5	0.10	1.81	1.5
Chandragudem Krishna dist.	6.0	0.10	1.61	2.5
Peddakakani Guntur dist.	3.5	0.05	1.42	2.2
Total	39.5	0.85	--	18.5
Mean	--	--	1.945	3.08

Table 2.26. Assessment of Macaque damage in Oil palm

Location	Area (acre)	RI	percent Pod damage
K Kota (1) V& M Eluru Dist.	8.0	25.5	3.4
D.Tirumala, Eluru Dist.	14.0	32.8	2.8
Prattipadu (V)& (M), Kakinda Dist.	6.5	32.6	2.2
Pitapuram (V)& (M), Kakinda Dist.	9.0	46.6	1.6
Gokavaram (V)& (M), East Godavari Dist.	8.5	40.0	2.8
Nuzuveedu (V)& (M), Krishna Dist.	6.0	30.50	1.9
Mean	--	34.60	2.45

Table 2.27. Assessment of macaque damage in maize

Location	Area (acre)	percent damaged area (acre)	yield Loss (Q) /acre
K Kota Eluru dist.	15.0	0.48	1.8
D.Tirumala, Eluru dist.	10.0	0.58	1.4
Buttayagudem, Alluri dist.	6.0	0.68	2.1
Konalova (V), Addateegala (M), Alluri dist.	20.0	1.02	2.4
Singampalli(V), Addateegala (M), Alluri dist.	10.0	0.84	1.2
Phirangipuram, Guntur dist.	5.0	0.40	1.0
Total	66.0	4.0	9.9
Mean	-	0.67	1.65

Fig 2.14. Crop-Specific Damage Patterns Caused by Macaques

Table 2.28. Assessment of Macaque damage in banana

Location	Area assessed	RI	percent Fruit damage
Kamavarapukota, Eluru dist.	6.5 acres	9.0	12.0
Kamavarapukota, Eluru dist.	20.0 acres	12.0	6.0
D. Tirumala, Eluru dist.	8.0 acres	12.0	16.0
Singampalli(V), Addateegala (M), Alluri dist.	12.0 acres	15.0	15.0
Addateegala, Alluri dist.	6.0 acres	20.0	22.0
Gudlavalleru. Krishna dist.	6.0 acres	15.0	16.0
Bhattiprolu, Guntur dist.	4.50 acres	10.0	10.0
Total	63.0 ac	-	-
Mean	-	13.30	13.85

2.5.3. Assam (AAU, Jorhat)

The Rhesus macaque mainly raid paddy, potato, pulses, (pea), cabbage & cauliflower, Tomato, cucurbitaceous vegetables, fruits and maize crop fields in the morning, afternoon and late afternoon and maize, paddy, fruits and vegetables were the preferred crops. It has been observed that garlic, lemon, bhindi, bitter gourd, sour gourd, chilli, turmeric, mustard and colocasia was not preferred by Rhesus macaque (Table 2.29).

The yield loss due to Rhesus macaque in paddy crop at a damage level of 2.63-4.82 percent was 0.68-2.06 q/ha, in potato, at a damage level of 2.46-6.61 percent was 1.11-3.46 q/ha, in vegetables like cabbage and cauliflower, it was 1.11-2.97 q/ha with a mean damage of 0.11-3.88 percent and in fruit crops, damage up to 0.46-6.61 percent results in an average yield loss of 1.11-4.86 q/ha (Table 2.30).

Table 2.29. Crops raided by monkeys and their raiding time

Monkey species	Raid crops	Preferred crops	Stage of crops	Time of riding	Non preferred crops
Rhesus monkey	Paddy	Maize	All stages	Early morning, late morning and late afternoon	Garlic
	Potato	Paddy			Lemon
	Pulses (Peas)	Fruits			Bhindi
	Cabbage and cauliflower	Vegetables			Bitter gourd
	Tomato				Sour gourd (Kunduli)
	Cucurbitaceous vegetables				Chilli
					Turmeric
	Fruits				Mustard
	Maize				Colocasia

Table 2.30. Crop raiding and yield loss by *Rhesus macaque* in Sivsagar district

Sl No	Crops	Damage (%)	Yield loss(q/ha)
1	Paddy	2.63-4.82	0.68-2.06
2	Potato	2.46-6.61	1.11-3.46
3	Pulses (Peas)	0.86-3.46	0.86-1.67
4	Cabbage and cauliflower	0.11-3.88	1.11-2.97
5	Tomato	0.24-0.86	0.66-1.11
6	Cucurbitaceous vegetables	0.66-3.66	1.36-2.34
7	Fruits	0.46-6.61	1.11-4.86
8	Maize	0.36-2.86	0.99-3.01

2.6. BLACKBUCK

2.6.1. Telangana (PJTSAU, Hyderabad)

The phenological events of crops were depicted and the parts eaten by blackbuck were recorded during the field studies. The proportion of crop damage by blackbuck in different growth stages showed that in maize the extent of damage was high during sprouting stage (36.2 percent) followed by vegetative stage (26.6 per cent), in case of cotton blackbuck caused more damage during flowering stage (38.5 percent) where as in groundnut the extent of damage was noticed in all stages ranged between 14.8 percent (sprouting stage) to 34.5 percent (maturity stage) (Table 2.31).

Table 2.31. Damage pattern of Black buck in different crops

Crop (n=10)	Total No. of plants damaged/ acre	Sprouting stage	Vegetative/ Flowering stage	Pod/ Cob/boll formation stage	Maturity stage
Groundnut	42616 (42.6 %)	14.8 %	21.6 %	29.1 %	34.%
Maize	6324 (18.9 %)	36.2 %	26.6 %	23.9 %	13.3 %
Cotton	1689 (30.4 %)	28.6 %	38.5 %	27.4 %	5.5 %

2.7. VERTEBRATES (RODENTS, BIRDS, MONKEY, NILGAI AND WILD BOAR)

2.7.1. Rajasthan (CAZRI, Jodhpur)

2.7.1.1. Damage in Pomegranate and Date Palm

In pomegranate, damage to flowers and fruits was assessed through a total count of damaged and healthy flowers and fruits from four tagged plants. Initially, all damaged and fallen flowers and fruits were removed from the tagged plants. After every 24 hours, records of healthy, damaged including fallen flowers and fruits, were noted. The observations on damaged and healthy flowers and fruits were taken for seven days during each month from September to December. The eaten and fallen flowers and fruits were recorded as damaged flowers and fruits, and the intact flowers and fruits were recorded as healthy. The mean damage to flowers and fruits across the month was 9.97±3.98 and 13.20±3.16 percent, respectively (Table 2.32).

Damage to mature doka stage fruits of date palm was assessed through direct observation in the morning and evening hours on five plants by individual observers for ten days. The leftover or fallen fruits were then collected after 24 hours. On the basis of mean weight, yield was calculated per plant for 10 plants, and likewise, damage per plant was also assessed. The mean yield loss was 80.47 gm per bunch per plant with a deviation of ±53.47 indicating that the damage varied significantly from bunch to bunch and plant to plant (Table 2.33).

Table 2.32. Monthly damage assessment in Pomegranate

Month	Flower	Fruit
September	5.28	10.25
October	11.36	16.10
November	6.99	9.84
December	15.52	16.61
Mean	**9.79**	**13.20**
SD±	**3.98**	**3.16**

Table 2.33. Damage assessment in Date Palm

Sample date plant	Damage nuts number		Weight of damage nuts (grams)	Species*
	1 bunch	2 bunch		
1	27	33	127.26	F+++, P++, K+,C+
2	17	30	90.66	F+++, P++, K+,C+
3	40	16	103.68	F+++, P++, K+,C+
4	12	13	52.26	F+++, P++, K+,C+
5	14	40	98.52	F+++, P++, K+,C+
6	5	7	25.86	F+++, P++, K+,C+
7	1	2	5.70	F+++, P++, K+,C+
8	3	2	9.84	F+++, P++, K+,C+
9	36	33	141.30	P+++, C++, F+,E+
10	38	35	149.58	P+++, C++, F+,E+
Total	**19.3**	**21.1**	**80.47**	
SD±	14.94	14.65	53.74	

*Parakeet-**P**, Northern palm squirrel-**F**, Asian koel-K, Indian house crow-**C**

2.7.1.2. Damage to Rabi and Kharif

The damage in rabi and kahrif crops in five districts of Western Rajasthan due to vertebrate pests was assessed during the survey. In canal command area of Jaisalmer damage due to higher vertebrates was not observed, as most of the field were protected with different kind of fencings. However, rodent infestation was noticed in kharif crop, assessment of damage by quadrate method in an area of about 05 ha revealed a very meagre damage of 1-2 percent in bajra, moong and guar due to s 5-7 percent and due to trampling activity of nilgai 1-2 percent in these crops (Fig. 2.15).

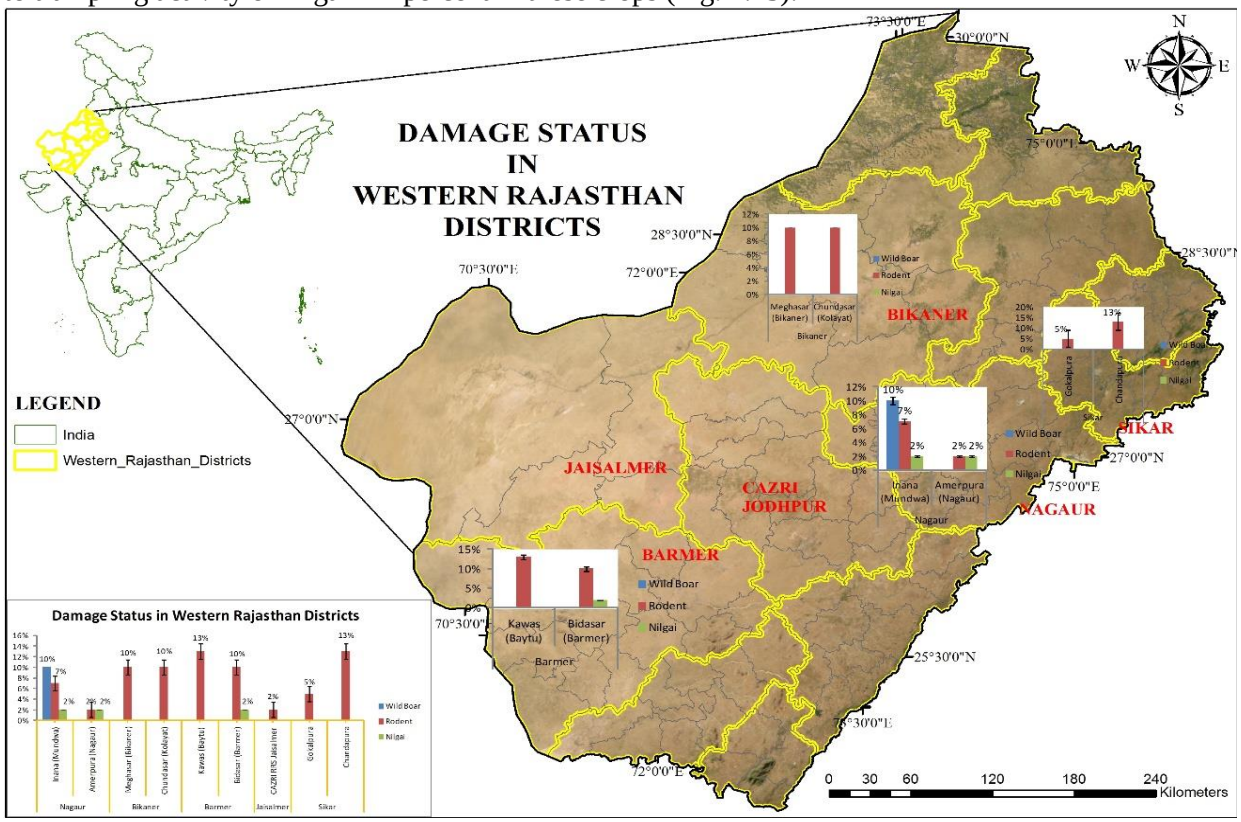


Fig. 2.15. Damage to various crops in arid districts of Western Rajasthan by, Rodents, Nilgai and wild boar

7.2. Karnataka (UAS, Bengaluru)

Crop loss estimation by rodents, birds, wild boar and monkey in ragi, cowpea and coconut crops by comparative method i.e., protected v/s unprotected by recording in 10 plots of one acre each in Tumkur, Mysore, and Ramanagar district of Karnataka. In Tumkur, the data from Table 2.34 indicates that the damage in ragi from rodents' birds, wild boar and monkeys ranged from 4.21–7.9 percent (0.79-1.86g/ha), 2.65–7.23 percent (0.13–1.98 g/ha), 3.43–13.65 (0.98–3.68 g/ha) and 1.63–4.4 percent (0.13–1.98 g/ha), respectively, whereas in cowpea it ranged from 1.63–6.96 percent, 1.71–4.65 percent, 3.14–12.65 percent and 1.76-3.70 percent, respectively. While in case of coconut the loss by rodents, wild boars and monkeys ranged from 3.72–11.65 percent (17. 535 nuts /ha/year), 1.66 – 2.32 percent (23-55 nuts/ha/year) and 3.56–17-98 percent (163-927 nuts/ha/year), respectively.

In Mysore district the incidence (incidence and yield loss) due to rodents, birds, wild boar and monkeys ranged between 4.91–9.85 percent (0.98–2.59 g/ha), 2.65–7.23 percent (0.13–1.98 g/ha), 3.43-13.65 percent (0.98–3.68 g/ha), 1.63–4.4 percent (0.12–1.96 g/ha), respectively in paddy (Table 2.35). In field beans the crop loss ranged from 1.78–5.8 percent, 0.61–3.98 percent, 1.12– 4.78 percent and 0.71–2.31, due to rodents' birds, wild boars and monkeys, respectively. In bananas the incidence of rodents, wild boar, and monkeys ranged from 1.26–6.38 percent, 1.96–14.26 percent and 3.68–18.26 percent, respectively with yield loss of 0.48–1.87 t /ha, 0.78–4.78 t/ha and 1.17 to 6.28 t/ha, respectively (Table 2.35).

In Ramanagara district the incidence and yield losses due to vertebrates were recorded (Table 2.36) in ragi, mango and groundnut crops. In ragi the loss due to rodents, birds, wild boars and monkeys ranged

from 3.79-7.23 percent (0.96-1.48 q/ha), 2.59–8.23 percent (0.45–1.78 q/ha), 1.29-12.68 percent (0.47-3.16 q/ha) and 1.08–7.52 (0.45–1.78 q/ha), respectively. While in mango there was no wild boar incidence, however, due to incidence of rodents (1.78-6.72 percent), birds (2.03-7.96 percent) and monkey (3.78-16.87 percent) the yield loss was 0.32-1.23 t/ha, 0.37-1.45 t/ha and 0.69 to 3.08 t/ha, respectively. In groundnut the incidence and yield losses due to rodents were 4.68-9.65 percent and 126 - 480 kg/ha, respectively, while due to birds, wild boar and monkey the incidence ranged between 1.66-3.58 percent, 4.68-15.68 percent and nil, respectively (Table 2.36).

Table 2.34. Crop losses due to vertebrate pests in Tumkur District

Crop	Crop damage % (Yield loses)			
	Rodents	***Birds***	***Wild boar***	***Monkey***
Ragi	4.21-7.90 % (0.79-1.86 q/ha)	1.29-6.48% (0.30-1.53 q/ha)	2.63-11.65% (0.61-2.74 q/ha)	2.61-8.72% (0.61-2.05 q/ha)
Cow pea	1.63-6.96% (0.22-0.94 q/ha)	0.71-4.65% (0.10-0.63 q/ha)	3.14-12.65% (0.42-1.73 q/ha)	1.76-3.70% (0.22-0.51 q/ha)
Coconut	3.72-11.65% (170.20-535.90 nuts/ ha/year)	-	1.66-2.32% (23.60-55.80 nuts/ ha/year)	3.56-17.98% (163.76-927.08 nuts/ ha/year)

Table 2.35. Crop losses due to vertebrate pests in Mysore District

Crop	Damage % (Yield loses)			
	Rodents	***Birds***	***Wild boar***	***Monkey***
Paddy	4.91-9.85% (0.98-2.59 q/ha)	2.65-7.23% (0.13-1.98 q/ha)	3.43-13.65% (0.98-3.68 q/ha)	1.63-4.4% (0.12-1.96 q/ha)
Field bean	1.78-5.8% (0.34- 1.48 q/ha)	0.61-3.98% (0.21- 1.28 q/ha)	1.12-4.78% (0.38-0.55 q/ha)	0.71-2.3% (0.13-1.03 q/ha)
Banana	1.26-6.38% (0.48-1.87 t/ha)	-	1.96-14.26% (0.78-4.78 t/ha)	3.68-18.26% (1.17-6.28 t/ha)

Table 2.36 Crop losses due to vertebrate pests in Ramanagar District

Crop	Damage % (Yield loses)			
	Rodents	***Birds***	***Wild boar***	***Monkey***
Ragi	3.79-7.23 % (0.96-1.48 q/ha)	2.59-8.23% (0.45-1.78 q/ha)	1.29-12.68% (0.47-3.16 q/ha)	1.08-7.52% (0.42-1.78 q/ha)
Mango	1.78-6.72% (0.32-1.23 t/ha)	2.03-7.96% (0.37-1.45 t/ha)	-	3.78-16.87% (0.69-3.08 t/ha)
Groundnut	4.68-9.65% (126.27-480.36 kg/ha)	1.66-3.58% (43.17-96.59 kg/ha)	4.68-15.68% (126.27-423.05 kg/ha)	-
Banana	1.26-6.38percent (0.48-1.87 t/ha)	-	1.96-14.26percent (0.78-4.78 t/ha)	3.68-18.26percent (1.17-6.28 t/ha)

2.7.3. Assam (AAU, Lakhimpur)

The Yield loss by Rhesus Monkey was assessed in vegetable and fruit crops in Sivasagar district and by Parakeet in sugarcane crop at AAU- SMAPRS in Golaghat district (Table13). Survey based estimation reveals the higher crop damage by wild pig in villages nearer to National parks and Wildlife sanctuary (Table 2.37). A maximum avoidable loss of 76.13 percent can be achieved in Papaya by protecting crop from Monkey with HDPE net (Table 2.38). Varietal preference by parakeet was observed in Sugarcane (Fig 2.16). A maximum of 16.26 percent cane damage was recorded in Borak variety against 7.92 per cent in Kolong. The percent loss in weight basis was observed maximum 12.86 percent in Doria (Table 2.39)

Table 2.37. Assessment of crop loss due to *Rhesus macaque* at Sivasagar (N=9)

Crops	Crop produced (kg) in protected field	Damaged crops (kg) in control plot	Avoidable Crop Loss (%)
Lady's finger	25	0	0
White gourd	890	340	38.20
Papaya	880	670	**76.13**
Lemon	770	0	0
Pumpkin (*kharif)*	90	60	66.66
Brinjal	65	49	**75.38**
Chilli	35	0	0
Bottle gourd	110	70	63.63
Orange	210	90	42.85
Guava	20	15	**75.0**
Spine gourd	100	40	40.0
Jackfruit	10	0	0

Table 2.38. Per cent crop loss due to different vertebrates in different locations.

Sl. No.	Agro ecological Region	Village	Name of Vertebrates	Percent damage
1.	North Bank Plan Zone	Nalbari, Rangagara,Bessimari, Rahmanpur, Shyampur	**Wild boar**	**20-50%**
			Parrot	**30-50%**
			Rodents	5-10%
2.	Central Brahmaputra valley Zone	Ooguri, Burhamayong, Sotibhati, Kalsilapar, Noonmati	**Wild boar**	**10-30%**
			Parrot	**20%**
			Rodents	5-10%
			Rhino	5-10%
3.	Upper Brahmaputra valley Zone	Hatigaon, Doosuck, Darigoji, Ulani, UparUlani	**Wild boar**	**30-60%**
			Monkey	10-20%
			Squirrel	10%
			Rodents	5%

Table 2.39. Damage assessment due to parakeets in certain sugarcane varieties

Sl no.	Variety	No. of damage cane	Damage percent No. basis	Weight of damage cane (Kg)	Damage per cent weight basis
1	Dhansiri	23	10.60	10.3	8.66
2	Doiyang	39	15.48	15	12.10
3	Kakodunga	24	9.06	11.4	7.26
4	Nambor	26	10.74	9.5	7.85
5	Kolong	21	7.92	9.1	7.78
6	Luhit	20	9.22	8.9	5.86
7	Doria	42	15.11	18	12.86
8	Borak	47	16.26	19	11.88
9	Kopilipar	21	8.82	10.2	6.50
	't'- value		**4.87****		**5.64****

Fig. 2.16. Damage by Parakeet in sugarcane and maize

3.DEVELOPMENT AND REFINEMENT OF MANAGEMENT TECHNOLOGIES FOR PROBLEMATIC RODENTS, BIRDS, AND HIGHER VERTEBRATES (PHYSICAL, BIOLOGICAL, MECHANICAL, CULTURAL, ITKS, AND CHEMICAL METHODS)

3.1. RODENTS

3.1.1. Rajasthan (CAZRI, Jodhpur)

3.1.1.1. Evaluation of Kalmegh, king of bitterent against Indian Gerbil

To develop more safe and eco-friendly rodent management technology, phytochemicals from certain promising plants are best alternate. An attempt has been made by exposing pest rodents to bait mixed with extracts/powder of such plants in choice and no-choice test. Kalmegh, king of bitterent (panchang) was evaluated for repellent/deterrent effect against Indian gerbil, *Tatera indica.* Panchang of kalmegh was mixed in different concentration (1, 2, 3, 4, 5, 6, 8, and 10 percent) in bajra bait and offered to the Indian gerbil in replication of 4 under no-choice condition for five days. Data on consumption during pre-treatment, treatment and post treatment period was recorded. It was in the range of 1.38-3.28g/100 body weight in treated bait against 5.03-8.16 g/100 g body weight in pre-treatment and 6.03-9.60g/100g body weight in post-treatment bait. Though in post-treatment plain bait consumption, no imprinting effect was notice, yet a weight reduction in the range of 5.50-13.00g was recorded (Table 3.1). The minimum concentration (1-3 percent) of panchang in bait was having good deterrent effect as the consumption of treated bait with these concentrations was in the range of 1.67-2.10g/100g body weight. These were further evaluated in choice and no-choice conditions. In choice condition, when plain bait was offered to test animal with treated bait, the consumption of treated bait was nil during the exposure of 10 days with all the concentrations, whereas it was in the range of 2.32-3.9g/100g body weight in no-choice condition (Tables 3.2 & 3.3).

Table 3.1. Evaluation of Kalmegh panchang in bait in different concentrations against Indian gerbil in no-choice condition

Conc. (percent)	Initial body weight (g)	Mean consumption (g/100g bwt) (5 days)			Final body weight	Difference in body weight (g)
		Pre-treatment	Treatment	Post treatment		
1 percent	93.00±15.71	5.03±1.59	2.10±0.04	6.03±1.04	80.00±13.75	13.00±1.96
2 percent	109.50±30.94	5.86±1.14	1.67±0.50	6.61±0.98	100.50±29.95	9.00±0.98
3 percent	160.00±12.77	8.16±0.18	2.01±0.11	9.60±0.94	149.50±12.28	10.50±0.49
4 percent	139.00±15.71	7.32±0.13	3.28±0.03	8.20±0.11	131.50±12.28	7.50±3.44
5 percent	139.50±24.06	7.48±1.64	2.84±0.06	8.57±1.94	134.00±23.57	5.50±0.49
6 percent	123.00±4.91	7.42±2.70	1.84±0.28	8.03±1.47	114.00±6.87	9.00±1.96
8 percent	127.00±16.70	7.07±0.18	1.38±0.29	8.51±0.09	116.00±17.68	11.00±0.98
10 percent	126.50±23.08	6.44±0.22	1.98±0.57	7.85±0.36	115.00±21.61	11.50±1.47

Values are Mean±SEM

Table 3.2. Evaluation of Kalmegh Panchang in selected concentrations against Indian gerbil in choice condition

Conc. (percent)	Body Weight (g)	Number of animals	Mean consumption (g/100g bwt)			Mortality
			Pre-treatment	Treatment consumption		
				plain bait	Treated bait	
1	127.75±7.31	06	6.11±0.09	6.03±0.09	0.00	Nil
2	150.0±6.67	06	6.50±0.41	5.98±0.38	0.00	Nil
3	123.0±10.91	06	5.03±0.53	5.12±0.41	0.00	Nil

Table 3.3. Evaluation of Kalmegh Panchang in selected concentrations against Indian gerbil in no-choice condition

Conc. (percent)	Body weight (g)	Number of animals	Mean consumption g/100g bwt)		Mortality
			Pre-treatment	Treatment	
1	132.50±6.67	06	5.64±0.67	3.90±0.21	Nil
2	190.70±9.20	06	5.31±0.20	2.32±0.02	Nil
3	210.50±6.66	06	5.80±0.20	3.47±0.22	Nil

3.1.2. Punjab Agricultural University (Rodent Control)

3.1.2.1. Evaluation of toxicity of ready-to-use brodifacoum bait in the laboratory

Developing tolerance against bromadiolone may hinder rodent management in bromadiolone-dependent regions. This highlighted the need to evaluate the rodenticide efficiency of other commercially available second-generation anticoagulants like brodifacoum. The study was conducted to evaluate the efficacy of ready-to-use brodifacoum bait (0.005 percent) against two rodent species, *B. bengalensis* and *R. rattus*, predominant in agricultural and commensal situations. Mature rats of both sexes (n = 36 each) were fed on brodifacoum bait under no-choice and bi-choice conditions for 1, 2, and 3-day durations. From the daily bait consumption data, the mean daily bait consumption (g/100 g body weight (bwt) of plain bait and ready-to-use brodifacoum bait was determined. Rats were observed for changes in levels of Prothrombin time (PT), Activated Partial Thromboplastin time (APTT), International normalized ratio (INR) in the blood after 24 hours of treatment, effect on liver and kidney histology, organ weight, body weight and mortality. The lethal feeding periods (LFP_{10}, LFP_{50}, and LFP_{90}) based on bi-choice tests were calculated for male and female rats separately using Probit analysis. Data was analysed statistically using SPSS version 16.0. Differences in means were considered significant at a 5 percent level of significance.

The study revealed 100 percent mortality of male and female *R. rattus* in no-choice tests within 3-6 days and 33.33-66.67 percent mortality in bi-choice tests within 3-9 days. 100 percent mortality was observed in no-choice tests in male and female of *B. bengalensis* within 2-3 days while 50-83.33 percent mortality was observed in bi-choice tests within 5-8 days (Tables 3.4 and 3.5). No significant difference was found in the toxicity of brodifacoum between male and female rats and between the two species. LFP_{50} was determined to be 1.81 and 1.82 days in male and female *R. rattus* and 2.10 and 2.33 days in male and female *B. bengalensis*, respectively. Toxicity signs observed were bleeding from the nose and gums, and bruises on the feet due to ruptured blood vessels.

A significant increase was observed in Prothrombin time (PT) and Activated Partial Thromboplastin time (APTT) in the blood of rats after brodifacoum treatment in no-choice tests. The increase in PT and APTT varied from 79.33-182.33 and 81.83-183.00, respectively under no-choice tests and from 35.50-80.83 and 35.33-82.00, respectively under bi-choice tests in male and female *R. rattus.* While the increase in PT and APTT varied from 148.33-204.50 and 156.00-201.33, respectively under no-choice tests and from 25.33-45.83 and 22.50-55.33 respectively under bi-choice tests in male and female *B. bengalensis*. The International Normalized Ratio (INR) was also found to increase significantly in rats treated under the no-choice test. The post-treatment INR was 6.21-13.60 in no-choice and 2.00-6.16 in bi-choice tests in male and female *R. rattus*. While it was 9.45-14.20 in no-choice and 1.52-3.03 in bi-choice tests in male and female *B. bengalensis* (Tables 3.6 and 3.7). No significant difference was found in the effect of brodifacoum between *R. rattus* and *B. bengalensis*. Also, no significant difference was found in the effect of brodifacoum on blood coagulation parameters between the male and female rats.

No significant effect of brodifacoum treatment was observed on body weight and weight of the liver, kidney, and spleen of both *R. rattus* and *B. bengalensis* rats. A significant effect of treatment was, however, observed on the histology of the liver and kidney. There were mild to severe necrotic changes in the liver (Fig. 3.1) of treated rats in the form of fluid-filled and dilated central veins, degenerated hepatocytes, de-arrangement of hepatic cords, vacuolar spaces, dilated sinusoids, deposition in portal triads, congestion, and deposition of melanomacrophages along with toxic debris. In the kidneys of treated rats also there were mild to severe necrotic changes in the form of abnormal uriniferous tubules, fused glomeruli, intermingled and fused tubules, evacuated glomeruli, reduced size and changed shape of Bowman's capsule, ruptured and degenerated tubules with exudate and overall atrophy of tubules (Fig. 3.2).

Table 3.4. Toxicity of ready-to-use brodifacoum bait against *Rattus rattus*

Choice	Sex	Treatment Duration (days)	Mortality (percent)	Total poison consumed (g/100 gbwt)	Days to death (Range)
No-choice	Male	1	100.00	3.04±0.32[a]	5-6
		2	100.00	13.99±0.72[b]	3-4
		3	100.00	18.83±1.64[b]	3-4
	Female	1	100.00	3.73±0.22[a]	5-6
		2	100.00	15.02±0.53[b]	3-4
		3	100.00	22.01±1.26[c]	3-4
Bi-choice	Male	1	33.33	1.54±0.86[a]	6-7
		2	50.00	1.33±0.49[a]	6-9
		3	66.67	5.71±1.89[b]	3-5
	Female	1	33.33	1.27±0.75[a]	7-9
		2	50.00	2.27±0.88[a]	7-8
		3	50.00	3.22±1.49[a]	6-7

Table 3.5. Toxicity of ready-to-use brodifacoum bait against *Bandicota bengalensis*

Choice	Sex	Treatment Duration (days)	Mortality (percent)	Total poison consumed (g/100 gbwt)	Days to death (Range)
No-choice	Male	1	100.00	5.98±0.15[a]	2-3
		2	100.00	10.98±0.49[b]	3
		3	100.00	9.86±0.92[b]	2-3
	Female	1	100.00	6.78±0.48[a]	2
		2	100.00	11.99±1.10[b]	3
		3	100.00	16.95±1.03[c]	2-3
Bi-choice	Male	1	0.00	0.34±0.22[a]	---
		2	83.33	3.08±0.57[b]	6-8
		3	50.00	2.67±1.07[b]	5-6
	Female	1	0.00	0.41±0.27[a]	---
		2	66.67	2.58±0.74[a]	6-8
		3	50.00	4.43±2.79[a]	5-8

Values are Mean±SE, Values with different superscripts (a-c) in a column indicate a significant difference in poison bait consumption and mean days to death among 1-, 2-, and 3-days treatment in male and female rats under no-choice and bi-choice tests ($P<0.05$).

Table 3.6. Comparison of changes in blood clotting factors after 24 hours of ready-to-use brodifacoum treatment in *Rattus rattus*

Choice	Sex	Treatment duration (days)	PT before Treatment (s)	PT after 24 hours of Treatment (s)	APTT before treatment (s)	APTT after 24 hours of treatment (s)	INR
No-choice	Male	1	16.67±1.02^{a1}	90.33±5.87^{a2}	20.00±0.77^{a1}	84.17±5.97^{a2}	6.43±0.46^{a}
		2	18.67±1.31^{a1}	174.17±15.28^{b2}	19.00±0.37^{a1}	167.50±14.21^{b2}	8.54±1.06^{a}
		3	17.00±0.97^{a1}	182.33±8.04^{b2}	18.50±0.56^{a1}	183.00±8.07^{b2}	13.60±0.66^{b}
	Female	1	17.67±0.49^{a1}	79.33±3.48^{a2}	22.00±0.89^{a1}	81.83±4.15^{a2}	6.21±0.32^{a}
		2	16.17±0.95^{a1}	178.50±5.25^{b2}	18.17±0.70^{a1}	179.33±6.27^{b2}	12.74±1.02^{b}
		3	18.17±0.98^{a1}	170.50±11.78^{b2}	18.67±0.92^{a1}	172.83±11.60^{b2}	10.30±0.94^{b}
Bi-choice	Male	1	17.83±1.14^{a1}	41.00±7.76^{a2}	20.00±1.18^{a1}	43.17±6.82^{a2}	2.53±0.52^{a}
		2	19.80±3.40^{a1}	41.17±13.46^{a1}	18.83±0.70^{a1}	42.17±13.26^{a1}	2.30±0.82^{a}
		3	15.83±0.60^{a1}	80.83±22.89^{a2}	17.50±0.43^{a1}	82.00±22.92^{a2}	6.16±1.85^{a}
	Female	1	18.33±0.88^{a1}	43.33±16.16^{a1}	19.17±0.95^{a1}	44.00±14.47^{a1}	2.66±1.09^{a}
		2	19.00±1.15^{a1}	35.50±5.26^{a2}	19.17±1.01^{a1}	35.33±5.58^{a2}	2.00±0.32^{a}
		3	18.50±1.12^{a1}	48.50±13.91^{a1}	19.67±1.12^{a1}	48.50±13.45^{a1}	3.68±1.63^{a}

Values are Mean±SE, PT = Prothrombin time, APTT = Activated partial thromboplastin time, INR = International normalized ratio

Values with different superscripts (a, b) in a column indicate a significant difference in different parameters among 1, 2, and 3 days of exposure (P<0.05)

Values with different superscripts (1, 2) in a row for PT and APTT indicate a significant difference between these values before and after treatment (P<0.05)

Table 3.7. Comparison of changes in blood clotting factors after 24 hours of ready-to-use brodifacoum treatment in *Bandicota bengalensis*

Choice	Sex	Treatment duration (days)	PT before Treatment (s)	PT after 24 hours of Treatment (s)	APTT before treatment (s)	APTT after 24 hours of treatment (s)	INR
No-choice	Male	1	17.33±0.95^{a1}	157.33±5.73^{a2}	20.67±1.56^{a1}	156.83±5.53^{a2}	11.85±0.60^{a}
		2	19.83±0.75^{a1}	162.00±16.31^{a2}	21.33±0.76^{a1}	156.00±10.37^{a2}	9.45±1.47^{a}
		3	20.83±1.33^{a1}	188.50±7.05^{a2}	20.50±1.48^{a1}	187.17±9.97^{a2}	11.28±0.47^{a}
	Female	1	19.00±1.15^{a1}	171.17±13.25^{a2}	19.83±0.95^{a1}	171.50±14.77^{ab2}	11.24±0.96^{ab}
		2	16.83±0.60^{a1}	148.33±12.28^{a2}	20.33±0.80^{a1}	158.33±9.91^{a2}	10.18±1.32^{a}
		3	18.33±1.48^{a1}	204.50±7.98^{b2}	19.83±1.76^{a1}	201.33±8.95^{b2}	14.20±0.61^{b}
Bi-choice	Male	1	17.50±0.89^{a1}	25.33±4.92^{a1}	19.00±0.93^{a1}	27.50±5.12^{a1}	1.52±0.33^{a}
		2	16.50±0.99^{a1}	44.33±12.48^{a1}	18.83±1.11^{a1}	53.33±12.51^{a1}	3.03±0.94^{a}
		3	18.17±0.70^{a1}	45.83±10.89^{a2}	17.50±076^{a1}	47.33±11.32^{a2}	2.81±0.73^{a}
	Female	1	18.67±1.41^{a1}	27.33±5.32^{a1}	19.50±0.56^{a1}	22.50±2.77^{a1}	1.54±0.33^{a}
		2	17.50±0.99^{a1}	43.33±11.94^{a1}	19.33±1.12^{a1}	48.33±14.22^{a11}	2.77±0.82^{a}
		3	16.83±0.54^{a1}	40.83±12.40^{a1}	18.00±0.58^{a1}	41.17±13.70^{a}	2.76±0.89^{a}

Values are Mean±SE, PT = Prothrombin time, APTT = Activated partial thromboplastin time, INR = International normalized ratio

Values with different superscripts (a, b) in a column indicate a significant difference in different parameters among 1, 2, and 3 days of exposure (P<0.05)
Values with different superscripts (1, 2) in a row for PT and APTT indicate a significant difference between these values before and after treatment (P<0.05)

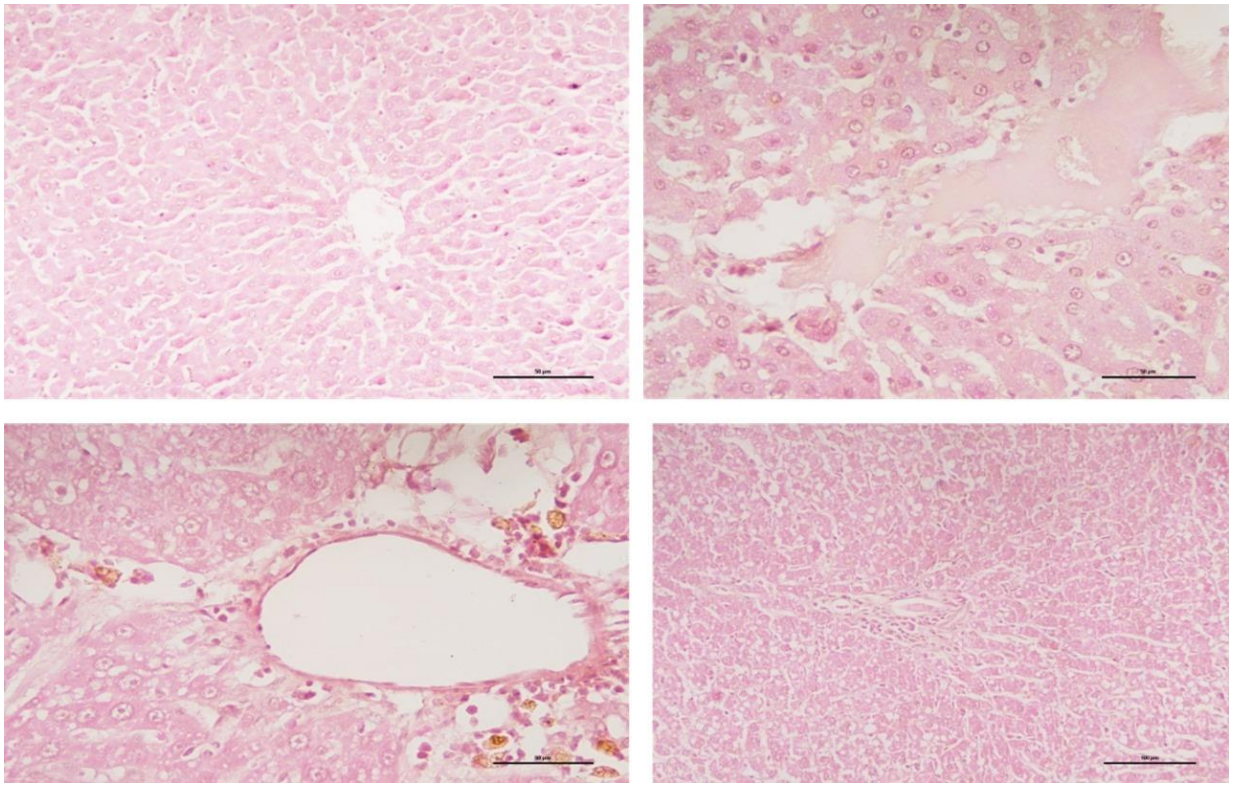


Fig. 3.1. H&E-stained section of liver showing histological changes at 200x magnification

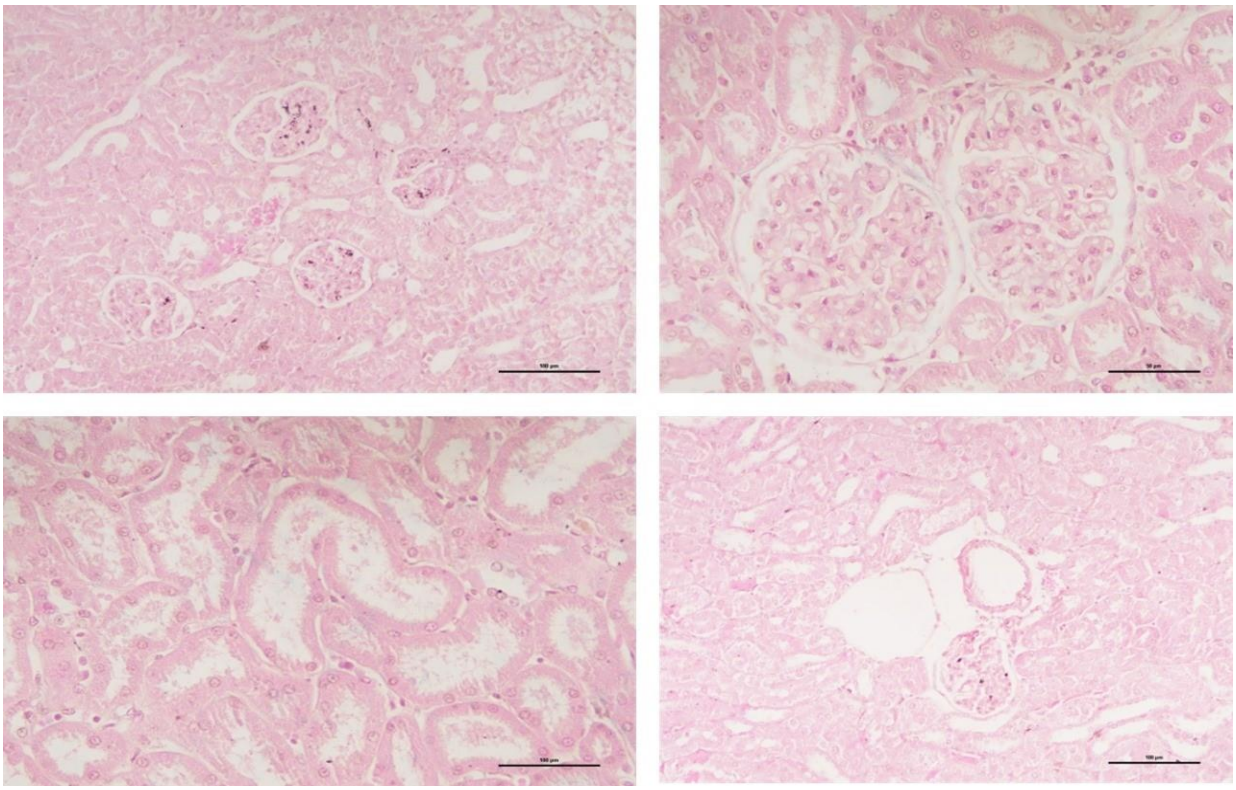


Figure 3.2. H&E-stained section of kidney showing histological changes at 200x and 400x magnifications

3.1.2.2. Evaluation of toxicity of ready-to-use brodifacoum bait against rodents in poultry farms

The poultry farms infested with *R. rattus* were selected for evaluating the efficacy of ready-to-use brodifacoum bait (0.005 percent) in comparison to the recommended 02 percent zinc phosphide and 0005 percent bromadiolone baits. The pre-census bait consumption in all the blocks of poultry farms varied from 89.67 to 100 percent indicating high rodent infestation. Poison bait consumption was also very high (77.67 to 99.83 percent). The percent rodent control success was significantly high in the block treated with zinc phosphide (66.68 percent) as compared to blocks treated with bromadiolone (21.82 percent) and brodifacoum 13.66 percent) (Table 3.8). Keeping in view the very low control success in blocks treated with anticoagulants, a second treatment with similar rodenticide baits was conducted after a gap of one month. The pre-census bait consumption varied from 77.08 to 100 percent in all the blocks. Significantly higher rodent control success was achieved with ready-to-use brodifacoum and 0.005 percent bromadiolone bait as compared to 02 percent zinc phosphide bait after two treatments. This may be due to bait aversion developed in rats against zinc phosphide. Results indicate that for managing rodents in highly infested poultry farms, two treatments of anticoagulant rodenticides are required, while the interval between two subsequent baiting of zinc phosphide should be greater than 30 days.

Table 3.8. Efficacy of ready-to-use brodifacoum bait in comparison to already recommended rodenticide baits in poultry farms highly infested with *Rattus rattus*

Treatment	Pre-census bait consumption (percent)	Control success (percent) after first treatment	Pre-census bait consumption (percent)	Control success (percent) after second treatment
Untreated control	100.00±0.00^{a}	-	100.00±0.00^{a}	-
Bromadiolone (0.005 percent)	89.67±9.35^{a}	21.82±11.09^{a}	88.75±1.25^{a}	60.16±2.85^{a}
Ready-to-use brodifacoum (0.005 percent)	95.33±3.71^{a}	13.66±5.70^{a}	86.92±1.61^{a}	67.98±8.56^{a}
Zinc phosphide (2 percent)	100.00±0.00^{a}	66.68±24.14^{b}	77.08±2.08^{a}	16.63±2.55^{b}

Values are Mean±SE, Values with different superscripts (a,b) in a column indicate significant differences (P<0.05)

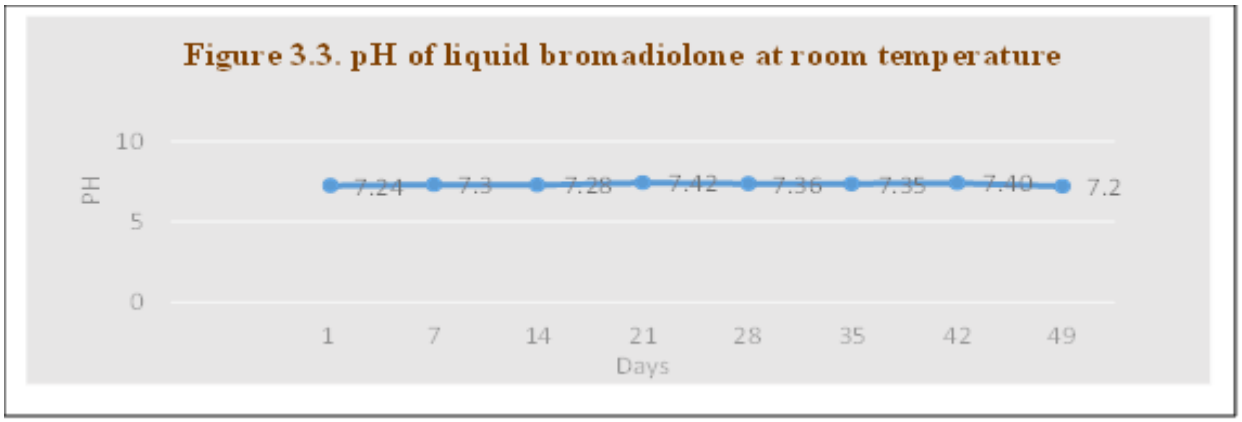
3.1.3. Andhra Pradesh (ANGRAU, RARS, Maruteru)

3.1.3.1. Evaluation of liquid baits for controlling the rodents in storage structures

Bromadiolone-based liquid bait (containing 0.005 percent bromadiolone + solvent (DMF)+preservative (SB)+Jaggery) was evaluated for rodent control in storage godowns (Fig. 3.4). Application of liquid bait recorded a high intake of the poison with 87.5 percent control success, whereas the control success was only 50 percent with bromadiolone 0.005 percent RB and 37.5 percent with bromadiolone CB 0.005 percent (Table 3.9). The stability of the product was also assessed for its pH for 50 days. Not much difference was observed in the pH of the formulation and it varied between 7.2 to 7.4 during the test period (Fig. 3.3). The liquid bait material was sent to various regional agricultural research stations (RARS) for multi-location testing.

Table 3.9. Efficacy of different rodenticide baits for rodent control in storage structure

Treatment	Bait points	Consumption (percent)	Tracking index		Control success (percent)
			Pre-treatment	Post-treatment	
Liquid bait	10	86.6	80.0	10.0	87.5
Rodenticide cake	10	56.6	70.0	35.0	50.0
Loose bait	10	43.3	80.0	50.0	37.5
			t-test	3.3>2.7	



3.1.3.2. Evaluation of various botanicals for their rodenticidal properties against *Bandicota bengalensis* under laboratory conditions

Botanical baits containing gliricidia leaf (GLP) and bark powders (GBP) in broken rice (BR) and in combination with De-Hulled cob Maize Powder (DCMB) (Fig. 3.5) at 2 and 5 percent concentrations recorded 20-60 percent mortality in test animals with mean mortality periods of more than 20 days. The mortality was 100 percent with bromadiolone 0.005 percent treatment with a mean mortality period of 8.14 days. Among the test botanicals, GBP along with DCMB showed superior performance in causing mortality up to 60 percent in the test animals but the higher mean mortality periods, limit its use on a large scale (Table 3.10).

Fig. 3.4. Application of liquid bait in stores

Table 3.10. Toxicity of botanical baits against lesser bandicoot rat

Treatment	Animals treated	consumption (percent)	Mortality (percent)	Mean mortality period
GLP -2 percent in BR	05	60.6	0.0	--
GLP -5 percent in BR	05	58.6	20.0	26.64±8.24
GBP- 2 percent in BR	05	50.3	40.0	21.32±7.24
GBP- 5 percent in BR	05	46.6	40.0	24.64±6.6
GLP-2 percent in DCMB	05	75.3	40.0	32.36±7.8
GLP -5 percent in DCMB	05	66.6	40.0	27.12±8.6
GBP- 2 percent in DCMB	05	53.3	30.0	24.64±12.2
GBP- 5percent in DCMB	05	50.6	60.0	26.0±8.14
Bromadiolone 0.005 percent	05	60.3	100.0	08.14±3.2
Control (Broken rice)	05	70.3	-	-

Fig. 3.5. Gliricidia based bait preparation and administration

3.1.3.3. Evaluation of various botanical smokes against *Bandicota bengalensis* under laboratory conditions

A compact device named 'Rat burrow smoking gun' was developed for easy smoke generation using diesel as a base material and evaluated. Under laboratory conditions, smoke generated from different sources was evaluated and paddy straw smoke caused 100 percent mortality in the test animals, while diesel showed nil mortality in the test animals. Botanical ingredients like pepper, red chili powder, and tobacco extract were also evaluated but none of them exerted mortality in the test animal under laboratory conditions when exposed for 3 min and observed for 30 days. In all the treatments, animals became sick initially but completely recovered later except in smoke generated from paddy straw (75 percent mortality). Methanolic extracts of botanicals (red chili, tobacco, pepper, etc.) in combination with potassium nitrate also could not cause any mortality in the test animal (Table 3.11). Therefore, it can be inferred that paddy husk is best for smoke generation in field to control rats.

Table 3.11. Efficacy of botanical extracts smoke against lesser bandicoot rat

Treatment	Exposure time/ Observation period	No. of animals treated	No. of animals died	Mortality (percent)
Tobacco methanolic extract (TME) 10percent	3 Min/ 30 days	4	0	0
Chilli methanolic extract (CME) 10percent	3 Min/ 30 days	4	0	0
Pepper methanolic extract (PME) 10percent	3 Min/ 30 days	4	0	0
TME+CME (1:1)	3 Min/ 30 days	4	0	0
TME+PME (1:1)	3 Min/ 30 days	4	0	0
CME+PME (1:1)	3 Min/ 30 days	4	0	0
Potassium Nitrate 5g/100ml	3 Min/ 30 days	4	0	0
Paddy straw smoke	3 Min/ 30 days	4	3	75.0
Diesel	3 Min/ 30 days	4	0	0

3.1.4. Assam (AAU, Jorhat)

3.1.4.1. Effect of integrating different treatments on rodent incidence and damage in the boro rice crop

Evaluation of different combinations of treatments in the boro rice crop revealed the highest efficacy of zinc phosphide baiting at the panicle initiation (PI) stage + bromadiolone baiting at the milky grain stage (T_3) in the form of 59.03, 57.66 and 65.31 percent reduction in live burrow count (LBC), Trap index (TI) and damage followed by T_4 treatment (bromadiolone baiting at PI stage + trapping) and T_5 treatment (zinc phosphide baiting at the PI stage+ trapping) (Table 3.12).

Table 3.12. Effect of different treatments on rodent incidence in boro rice crop

Treatment	Pre-treatment			Post-treatment			Reduction (percent)		
	LBC/ ha	TI	Damage	LBC/ha	TI	Damage	LBC/ha	TI	Damage
T_1	18.88	4.52	3.26	18.28	3.66	3.67	45.47	48.52	53.00
T_2	20.06	4.76	2.97	20.61	3.51	3.33	40.16	50.63	57.36
T_3	20.46	4.21	3.66	14.11	3.01	2.71	59.03	57.66	65.31
T_4	18.16	4.46	3.01	16.96	3.31	2.96	50.34	53.44	62.09
T_5	19.49	4.66	2.91	16.11	3.46	3.10	53.22	51.33	60.31
T_6	18.61	3.96	3.11	34.44	7.11	7.81	--	--	--
CD at 5 percent	NS	NS	NS	6.71	2.11	2.31	--	--	--

LBC= Live burrow count, TI= Trap index, T_1: Zinc phosphide baiting at the Panicle initiation stage T_2: Bromadiolone baiting at the Panicle initiation stage, T_3: Zinc phosphide baiting at the Panicle initiation stage+ Bromadiolone baiting at the milky grain stage, T_4: Bromadiolone baiting at Panicle initiation stage + trapping, T_5: Zinc phosphide baiting at Panicle initiation stage+ trapping, T_6: Untreated control

3.1.4.2. Effect of different rodenticidal treatments on rodent incidence in potato crop

Evaluation of different combinations of treatments in the potato crop revealed the highest efficacy of T_3 treatment (2 percent zinc phosphide baiting at tuber formation stage followed by bromadiolone baiting after 15 days) in the form of 64.02 and 55.27 percent reduction in live burrow count (LBC) and trap index (TI), respectively followed by T_4 treatment (bromadiolone baiting at tuber formation and maturity stages) which resulted in 59.83 percent and 50.21 percent reduction in LBC and TI, respectively. The data recorded in untreated control fields revealed an increasing trend in LBC and TI with the advancement of the crop stage (Table 3.13).

Table 3.13. Effect of Different Rodenticidal treatments on rodent incidence in potato crop

Treatments	Pre-treatment		Post-treatment		Reduction (percent)	
	LBC/ha	TI	LBC/ha	TI	LBC/ha	TI
T_1	12.86	3.11	22.06	5.91	45.01	40.06
T_2	11.33	2.88	21.11	5.61	47.36	43.11
T_3	12.61	3.01	14.43	4.41	64.02	55.27
T_4	10.86	3.33	16.11	4.91	59.83	50.21
T_5	11.87	3.07	40.11	9.86	--	--
S.E.	1.68	0.86	2.81	1.01	--	--
CD at 5percent	NS	NS	5.76	2.11	--	--

LBC= Live burrow count, TI= Trap index, T_1: Zinc phosphide baiting at maximum tillering stage+ trapping, T_2: Zinc phosphide baiting at tuber formation stage +trapping, T_3: Zinc phosphide baiting at tuber formation stage followed by bromadiolone baiting after 15 days, T_4: Bromadiolone baiting at tuber formation and maturity stages, T_5: Untreated control

3.1.4.3. Rodent management in a village Cooperative Store

For managing the rodent population in a village Cooperative Store, the efficacy of different treatments (T_1: Cleanliness + Sherman trap, T_2: Cleanliness +Wonder trap, T_3: Cleanliness +Sherman + Ecodon, and T_4: Cleanliness +Wonder + Ecodon) was compared over a period of 3 months. The efficacy was based on census bait consumption before and after treatments and determination of percent control success. The statistical analysis of data revealed significant differences in bait consumption among different treatments over the 3 months periods. The one-way analysis of variance and post hoc analysis confirmed that T_3 (Cleanliness + Sherman trap + Ecodon) treatment had the lowest bait consumption (2.10-2.25g) over a period of 3 months which was at par with T_4 (Cleanliness + Wonder trap + Ecodon) treatment (2.10-3.00g). This resulted in the highest rodent control success with T_3 (64.72-69.21 percent) and T_4 (59.23-67.23 percent) treatments. There was no significant difference in post-treatment bait consumption (4.80-5.00g) and control success (29.71-34.59 percent) among T_1 and T_2 treatments (Table 3.14).

Table 3.14. Effect of different treatments on rodent control success in village Cooperative store

Treatments	Pre-treatment bait consumption (g)	Rodent control success (percent) on bait census basis			
		After 1 month	After 2 months	After 3 months	Average
T	7.40±0.68	31.35±3.30 ^{b}	38.34±5.43 ^{bc}	34.09±5.68 ^{b}	34.59±3.85 ^{b}
T_2	7.20±0 .77	31.78±3.77 ^{b}	31.64 ±2.86 ^{b}	25.70±5.04 ^{ab}	29.71±3.25 ^{b}
T_3	6.80±1.04	64.72±2.97 ^{c}	69.21±2.77 ^{d}	67.13±3.36 ^{c}	67.02±1.87 ^{c}
T_4	7.10±3.31	59.23±4.50 ^{c}	59.91±5.61 ^{c}	67.23±3.46 ^{c}	62.12±3.39 ^{c}
T_5	7.30±0.93	6.59±3.41 ^{a}	6.25±3.35 ^{a}	4.76±3.47 ^{a}	5.86±2.94 ^{a}
p-value at 5 percent	0.989	0.0001	0.0001	0.0001	0.0001

Values with different superscripts (a-d) along a column indicate significant differences at a 5percent level of significance, T_1: Cleanliness+Sherman trap, T_2: Cleanliness+Wonder trap, T_3: Cleanliness+ Sherman+Ecodon, T_4: Cleanliness Wonder+Ecodon

3.2. BIRDS

3.2.1. Telangana (PJTSAU, Hyderabad)

3.2.1.1. Evaluation of different treatments for bird management in maize crop

Evaluation of different treatments to protect the maize crops from birds (Fig. 3.7) at the sowing stage in the *kharif* season revealed the highest germination percentage (87.5 percent) with whole egg solution @ 2 percent followed by ribbon (69.64 percent) and castor oil @ 25ml/lit (74.10 percent) against control (57.14 percent). Whereas in *rabi* season, ribbon usage recorded the highest germination (95.72 percent) followed by azadirachtin (86.79 percent), castor oil (83.22 percent), and whole egg solution (82.5percent) against control (76.79 percent) (Table 3.15). During both the *kharif* and *rabi* seasons, a total of 25 bird species were recorded at the sprouting stage. The relative abundance of Small green bee-eater was highest (29.95 percent) followed by that of babblers (13.11 percent), Blue rock Pigeon (12.29 percent), and Indian peafowl (11.47) (Fig. 3.6).

3.2.1.2. Evaluation of different treatments for bird management in sunflower crop

Evaluation of different treatments in sunflower crops (Fig. 3.8) during *kharif* season at AINP on VPM office premises revealed the least damage in the fields treated with salt solution (25.9 percent) followed by those treated with castor oil (31.7 percent), ribbon (35.95 percent), and egg solution spray (42.6 percent) compared to control (53.8 percent) (Table 26). In *rabi* season, salt solution @25gm/lit and castor oil @20ml/lit were more effective in reducing depredatory bird damage (Table 3.16).

3.2.1.3. Evaluation of different treatments for bird management in bajra crop

To protect the bajra crop (Fig. 3.9) from birds in the *kharif* season, an experiment was conducted in farmers' fields at village Gaddamallaiahgudem. Less damage was observed in fields treated with salt solution @25gm/lit (18.9 percent) and castor oil @25ml/lit (21.3 percent) followed by those treated with Deepam oil @25 ml/lit (29.4 percent), azadirachtin-neem oil @25ml/lit (31.6 per cent), and ginger+garlic @30ml/lit (38.7 per cent) against control (57.2 percent). The crop yield also showed a similar trend (Table 3.17). In *rabi* season, during the milking grain stage, salt solution @25gm/lit and castor oil @25ml/lit showed maximum effectiveness in minimizing crop damage by depredatory birds (Table 3.17).

3.2.1.4. Evaluation of different treatments for bird management in sorghum crop

Evaluation of different treatments in sorghum crop (Fig. 3.10) during *kharif* season at college farm in Rajendranagar revealed least bird damage in fields treated with egg+hing @ 25ml/lit (15.67 percent) followed by those treated with salt spray @ 25ml/lit (24.72 per cent), ginger+garlic @ 30 ml/lit (32.45 per cent), and Deepam oil @ 25ml/lit (42.06 percent) against control (49.56 percent). The crop yield also showed similar results (Table 3.18). During *rabi* season, at milking grain stage, egg + hing @ 25ml/lit followed by salt spray @ 25ml/lit showed at par results when compared to control (Table 3.18).

Table 3.15. Development and evaluation of eco-friendly bird management practices for protection in maize crops

Seed Treatments	Kharif			Rabi	
	Germination percent		Mean	Germination percent	Mean
T1- Azadirachtin (Neem oil) 1500ppm @ 25ml/Kg	95(112)	84.82	67.39	86.79	72.84
T2- Castor oil @ 25ml/kg	83(112)	74.10	59.57	83.22	66.94
T3- whole egg solution @ 25ml/kg	98(112)	87.5	70.47	82.5	66.10
T-4 Ribbon	78(112)	69.64	56.68	95.72	80.19
T5-Control	64(112)	57.14	49.13	76.79	61.27
CD			3.21		12.45
SE (d)			1.47		5.65
CV			3.43		11.5

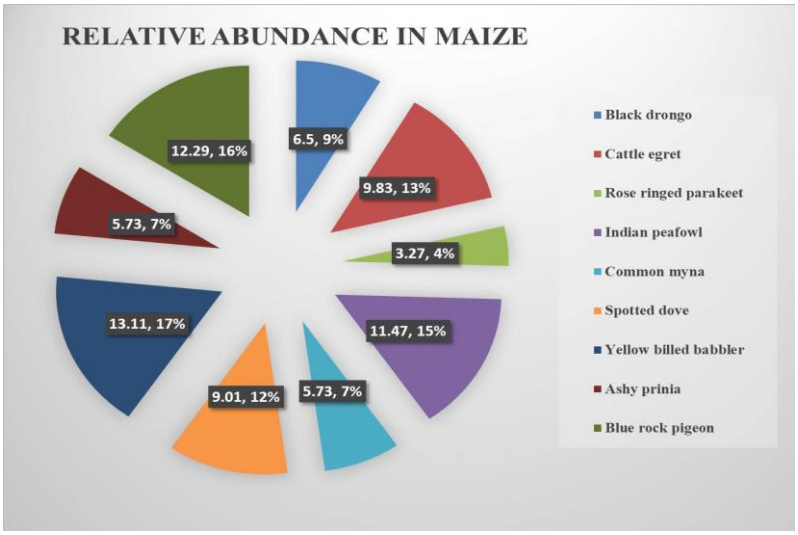


Fig. 3.6. Relative abundance of top 10 bird species during the sprouting stage in maize crop

Fig. 3.7. Infestation of depredatory birds in maize crop

Table 3.16. Evaluation of eco-friendly management methods in sunflower crops in Kharif and rabi seasons

Treatment	Kharif		Rabi	
	Damage (percent)	Yield (Kg/ha)	Damage (percent)	Yield (Kg/ha)
Reflective Ribbon	35.9	1425.7	40.0(39.20)	720
Castor oil@20ml/lt	31.7	1364.30	33.5(35.34)	798
Salt solution @25gm/lt	25.9	1731.13	29.5(32.87)	846
Egg spray 25ml/lt	42.6	1314.18	43.5(41.23)	678
Control	53.8	1274.82	67.0(55.11)	396
CD 5percent	1.823	43.480	4.59	90.35
SE(D)	0.837	19.956	2.08	41.01
CVpercent	3.122	1.985	7.24	8.43

Fig. 3.8. Infestation of depredatory birds in sunflower crop

Table 3.17. Evaluation of eco-friendly management methods in bajra crops during kharif and rabi seasons in farmers' fields at Gaddamalliagudem

Treatment (Maturity stage)	Kharif		Rabi	
	Per cent damage	Yield (Kg/ha)	Per cent damage	Yield (Kg/ha)
T1-Azadirachtin 500ppm @25ml/lt (Neem oil)	31.6	1,891.40	42.5(40.66)	1394.5
T2-Deepam oil @25ml/lt	29.4	1968.6	37.5(37.73)	1560
T3- Salt solution @25gm/lt	18.9	2712.8	27.5(31.59)	1790
T4- Ginger and garlic @30ml/lt	38.7	1,434.50	56.25(47.14)	980
T5- Castor oil @ 25ml/lt	21.3	2,147.30	67.5(55.23)	837.5
T6- Control	57.2	847	0.979	124.3
CD	1.461	68.740	0.44	56.4
SE(D)	0.685	31.549	1.47	6.08
CV	3.053	2.197	42.5(40.66)	1394.5

Fig. 3.9. Infestation of depredatory birds in bajra crop

Table 3.18. Evaluation of eco-friendly management methods in sorghum crops during kharif and rabi seasons at college farm, Rajendranagar

Treatment (Maturity Stage)	Kharif		Rabi	
	Per cent damage	Yield (Kg/ha)	Per cent damage	Yield (Kg/ha)
T1- Salt spray @ 25gm/lt	24.72	2657	18.25(25.27)	1392.855
T2- Egg + Hing @ 25ml/lit	15.67	2963	15.0(22.77)	1470.899
T3-Ginger + Garlic @ 30ml/lit	32.45	2098	20.5(26.91)	1343.915
T4- Deepam oil @ 25ml/lit	42.06	11789	25.0(29.99)	1292.328
T5-Control	49.56	1098	31.5(34.13)	1021.164
CD	1.472	187.215	0.904	23.29
SE(D)	0.676	85.925		10.57
CV	2.762	2.949	2.087	1.146

Fig. 3.10. Infestation of depredatory birds in sorgham crop

3.2.2. Punjab (PAU (AO), Ludhiana)

3.2.2.1. Management of depredatory birds in maize, mustard, and green gram crops

Management depredatory birds in maize, mustard, and green gram crops grown as conventional and organic were carried out using various non-lethal management methods.

In maize crop the lowest damage percentage was recorded in the organic and conventional fields at Ghelewal during the germinating (4.96±0.01) and maturing stage (4.67±0.39), respectively in Bioacoustics treatment (Table 3.19).
In Mustard crop fields also application of bio-acoustic was very effective and the damage was lowest in conventional fields of PAU (4.20±0.01) and (Ghelewal 8.67±0.26) during the germination and maturity stage, respectively (Table 3.20). The percentage of damage to seedlings & pods of the mustard crop was maximum in the control plot followed by rotating head owl, Integrated plot, Dead dummy crow, and Hawk Eye Balloons, while it was minimum in Bioacoustics (Table 3.21). In green gram crops also similar trend was observed and bioacoustics was more effective in conventional fields as compared to their respective organic fields (Table 3.22).

Table 3.19. Damage assessment in maize crop fields at germinating and maturity stages

Locations	Percent damage by birds					
	Germination stage			Maturity stage		
	Reflective ribbon field	Bioacoustics field	Control field	Reflective ribbon field	Bioacoustics field	Control field
PAU Organic	5.90±0.07^{b}	5.70±0.10^{b}	7.20±0.15^{a}	8.30±0.32^{b}	6.50±0.10^{c}	10.33±0.26^{a}
PAU Conventional	4.70±0.10^{b}	5.43±0.80^{a}	4.20±0.01^{c}	9.28±0.08^{b}	6.13±0.25^{c}	10.93±1.31^{a}
Ghelewal Organic	5.10±0.23^{b}	4.96±0.01^{b}	5.50±0.10^{a}	6.90±0.17^{b}	6.26±0.28^{c}	8.06±0.19^{a}
Ghelewal Conventional	5.80±0.10^{b}	5.63±0.01^{b}	6.30±0.17^{a}	8.20±0.10^{b}	4.67±0.39^{c}	11.13±0.32^{a}
Pakhowal Organic	5.72±0.56^{b}	5.33±0.04^{c}	6.50±0.10^{a}	9.50±0.15^{b}	6.36±0.22^{c}	15.46±0.12^{a}
Pakhowal Conventional	5.58±0.01^{b}	5.30±0.18^{c}	6.80±0.21^{a}	10.02±0.20^{b}	5.73±0.14^{c}	10.40±0.10^{a}

Values are expressed as Mean±SD; Mean values followed with different superscripts are significantly different ($p < 0.05$) using Tukey's test

Table 3.20. Damage assessment in mustard crop fields at germinating and maturity stage

Locations	Percent damage by birds					
	Germination stage			Maturity stage		
	Reflective ribbon field	Bioacoustics field	Control field	Ref. ribbon field	Bioacoustics field	Control field
PAU Organic	5.90±0.10^{b}	5.70±0.01^{b}	7.20± 0.01^{a}	12.76± 0.24^{b}	11.42±0.26^{c}	24.72±1.50^{a}
PAU Conventional	4.70±0.01^{b}	4.20±0.01^{c}	5.43± 0.01^{a}	15.33± 1.99^{b}	12.44±0.23^{c}	17.65±0.36^{a}
Ghelewal Organic	5.10±0.01^{b}	4.96±0.10^{b}	5.50± 0.10^{a}	11.54± 0.18^{b}	9.83±0.46^{c}	14.45±0.25^{a}
Ghelewal Conventional	5.80±0.10^{b}	5.63±0.10^{b}	6.30± 0.10^{a}	10.50± 0.67^{b}	8.67±0.26^{c}	12.25±0.14^{a}
Pakhowal Organic	5.72±0.01^{b}	5.33±0.10^{c}	6.50± 0.01^{a}	13.55± 0.32^{b}	12.28±0.31^{c}	13.83±0.76^{a}
Pakhowal Conventional	5.58±0.01^{b}	5.30±0.10^{c}	6.80± 0.01^{a}	14.36± 0.37^{b}	10.50±0.10^{c}	16.17±0.40^{a}

Values are expressed as Mean±SD; Mean values followed with different superscripts are significantly different ($p < 0.05$) using Tukey's test

Table 3.21. Visual deterrents as management methods against depredatory birds in the mustard crop at the PAU crop field

Treatments	Seedling damage (percent)	Pods damage (percent)
Bioacoustics	5.07^{bc}±0.55	1.57^{d}±0.81
Hawk Eye Balloons	6.8^{d}±0.51	2.02^{bc}±0.66
Rotating Head Owl	9.25^{c}±0.37	2.70^{b}±0.49
Dead Dummy Crow	8.88^{bc}±0.86	2.40^{b}±0.58
Methods in integration	7.22^{c}±0.24	2.51^{cd}±0.24
Control	14.12^{a}±0.55	4.89^{a}±0.37

Similar superscripts indicate non-significant differences and different superscripts indicate significant differences between treatment plots and control plots; Values are expressed as Mean±SE

Table 3.22. Damage assessment of pods in green gram crop at germinating and maturity stage

Locations	Percent damage by birds					
	Germinating stage			Maturity stage		
	Reflective ribbon field	Bioacoustics field	Control field	Reflective ribbon field	Bioacoustics field	Control field
PAU Organic	3.85 ±0.53^{b}	3.55 ± 0.01^{c}	4.56± 0.10^{a}	6.80±1.17^{c}	7.30± 1.76^{b}	8.80± 2.35^{a}
PAU Conventional	3.72±0.10^{a}	3.57± 0.51^{b}	1.63±0.05^{c}	5.90±0.82^{c}	6.30±1.10 ^{b}	8.10±2.03^{a}
Gehlewal Organic	4.95±0.23^{b}	4.80± 0.71^{c}	5.63± 0.36^{a}	6.00± 0.38^{b}	5.80± 0.45^{b}	7.20± 0.86^{a}
Gehlewal Conventional	3.42±0.15^{b}	3.07± 0.46^{c}	3.73±0.21^{a}	5.40± 1.08^{b}	5.30± 1.48^{b}	9.10±2.52^{a}
Pakhowal Organic	4.10±0.36^{a}	3.83± 0.25^{b}	4.13 ±0.89^{a}	5.90± 0.43^{c}	6.20± 0.73^{b}	7.50±0.58^{a}
Pakhowal Conventional	1.95±0.27^{b}	1.87± 0.10^{c}	2.83±0.72^{a}	5.37±1.11^{b}	5.30± 0.72^{b}	9.80±1.29^{a}

Values are expressed as Mean±SD; Mean values followed with different superscripts are significantly different ($p < 0.05$) using Tukey's test

3.5.1. Karnataka (UAS, Bangalore)

3.5.1.1. Management of rose-ringed parakeet in sunflower crop

An experiment was conducted at the Agricultural Research Station, Kunigal (Tumkar), Karnataka during Kharif 2023 for the management of rose-ringed parakeets in sunflower crops. There were eight treatments along with a control with three replications each. The observations indicated that netting (1" mesh size) in the entire plot gave 100 percent protection from parakeet damage to ear heads resulting in a significantly higher yield of 1857.25 kg/ha with a C: B ratio of 1:1.26 over other treatments. This was followed by the installation of a bio-acoustic unit (@ one /ha) which recorded 3.26 percent damage to ear heads and 1816.85 kg/ha yield with a C: B ratio of 1:3.94. The next best treatment was covering the crop with reflective tape (4'x 4') which yielded 1767.87 kg/ha and the incidence of parakeet was highest (26.8 percent). All these treatments were imposed only during the grain formation stage of the crop (Table 2.23, Fig. 3.11).

Table 2.23. Management of rose-ringed parakeets in sunflower crops at Kunigal, Tumkur

Treatments	Description of the treatments	Ear head damage %	Yield (Kg/ha)	C: B
T1	Reflective tape (4' x 4')	3.47 ^{de}	1767.87^{b}	1:3.66
T2	Netting (1" mesh size)	0.0 ^{f}	1857.25^{a}	1:1.26
T3	Egg + Hing (1:1) solution (25ml/l) (3 sprays)	7.41 ^{cd}	1536.47^{cd}	1:2.45
T4	Salt + Neem oil (1:1) (25ml/l) (3 sprays)	8.87 ^{c}	1508.78^{cd}	1:2.36
T5	Bioacoustics @ 1/ha	3.26 ^{e}	1816.85^{ab}	1:3.94
T6	Ginger + Garlic + Chilli solution (1:1:1) (25ml/l) (3 sprays)	9.84 ^{c}	1498.47^{d}	1:2.05
T7	Jute ropes in check format (4' x 4')	15.47 ^{b}	1576.47^{c}	1:2.23
T8	Control	26.8 ^{a}	1362.21^{e}	-
	CD at 5percent	3.58	87.45	-
	CV (percent)	9.65	12.54	-

Values with different superscripts (a-f) along a column indicate significant differences at 5percent level of significance

Fig. 3.11. Management of rose-ringed parakeet in sunflower crop

3.2.3.2. Management of rose-ringed parakeet in maize crop

For the management of rose-ringed parakeets in maize crops an experiment was laid out at the Agricultural Research Station, Kunigal (Tumkur) during *kharif* 2023 with eight treatments and three replications each. The data on cob damage and yield were recorded and the C: B ratio was worked out. The results (Table 2) indicated that covering the entire crop with a net (1" mesh size) gave 100percent protection with a maximum yield of 4137.31 kg/ha and C: B ratio of 1:1.18, which is at par with other

next best treatment i.e., installation of bioacoustic unit (@ one/ha) with cob damage of 1.92percent and yield of 3961.74 kg/ha and C: B of 1:2.04. the other best treatments were wrapping the cobs with leaves in the border area along with reflective tape over the crop (5.31percent damage; 4137.31 kg/ha yield) and covering with reflective tape along (3.21percent damage; 3803.12 kg/ha yield). However, in control fields, the damage and yield were 25.9 percent and 220.73 kg /ha, respectively (Table 3.24, Fig. 3.12).

Table 3.24. Management of rose-ringed parakeets in Maize crops at Kunigal, Tumkur

Treatments	Description of the treatments	% Cob damage	Yield (Kg/ha)	C:B
T1	Reflective tape (4' x 4')	3.21 ^{de}	3803.12^{b}	1:1.79
T2	Netting (1" mesh size)	0.0 ^{f}	4137.31^{a}	1:1.18
T3	Wrapping of maize cobs in border and reflective tape in the top	5.31 ^{c}	3840.47^{b}	1:3.41
T4	Egg + Hing (1:1) solution (25ml/l) (3 sprays)	8.92 ^{cd}	3520.89^{c}	1:1.39
T5	Bioacoustics @ 1/ha	1.92 ^{ef}	3961.74^{ab}	1:2.04
T6	Salt + Neem oil (1:1) (25ml/l) (3 sprays)	9.17 ^{c}	3423.61^{cd}	1:1.16
T7	Ginger + Garlic + Chilli solution (1:1:1) (25ml/l) (3 sprays)	14.13 ^{b}	3529.75^{c}	1:1.67
T8	Control	25.9 ^{a}	3220.73^{d}	-
	CD at 5percent	3.74	240.18	-
	CV (percent)	10.45	11.26	-

Values with different superscripts (a-f) along a column indicate significant differences at 5 percent level of significance

Fig. 3.12. Management of rose-ringed parakeet in maize crop

3.5.4. Assam, (AAU, North Lakhimpur)

3.2.4.1. Evaluation of Eco–gun and cob wrapping for management of Parakeet in Maize crop

The bioacoustic Eco-gun and wrapping of maize cobs in the outer three rows of maize crop recorded 13.56percent cob damage against 44.47percent damage in untreated control plots indicating their effectiveness in the management of parakeet population to protect maize crop from at cob formation stage (Table 3.25).

Table 3.25. Evaluation of Eco-gun and cob wrapping methods against Parakeet in Maize crop at Mayong, Pobitora

Treatment	% cob damage (pre-harvest estimation) *
Eco-Gun + wrapping of cobs in outer 3 rows	**13.56**
Control	44. 47
SD	21.11
SEM	4.76
t-value	7.82*

3.2.4.2. Evaluation of Bird repeller in rice-rice farming system

A Bird repeller was evaluated in a large area in the rice-rice farming system and was found effective in driving away the birds from crop fields (Fig. 3.13).

Fig. 3.13. Bird Repeller

3.2.5. Gujarat, (AAU, Anand)

3.2.5.1. Effectiveness of fruit bagging in preventing damage caused by Rose-Ringed Parakeet (*Psittacula krameri*) to guava

The pooled data of two years (2022-23 and 2023-24) of experimentation showed that all the bagging materials (non-woven, muslin, butter paper) were significantly effective in reducing parakeet visits on guava. A total of 40 trees of seven years were selected randomly from VNR- Taiwan pink Guava orchard and 10 trees were selected for each treatment. The total number of fruits in each tree was counted before the application of the treatment. The experiment was set up in September when fruits were in the fully grown stage and bagged after 60 days of flowering. Butter paper bags and non-woven bags with an average of 4.82 and 6.71 parakeets per tree, respectively showed maximum protection against parakeet entry. A minimum average number of damaged fruit (2.32) was observed in the treatment of butter paper bagging which was found superior over the rest of the treatments. The maximum average number of healthy fruit (7978.71 kg/ha) was recorded in the treatment of butter paper bagging which was at par with the non-woven bagging (7667.08 kg/ha) of trees and statistically the best treatment over other treated trees. Finally, it was recommended to the farmers of Gujarat to have guava orchards to bag fruits before maturity in butter paper bags (20 × 24 cm) to reduce the damage caused by rose-ringed parakeets (Tables 3.26-3.29, Fig. 14).

Table 3.26. Impact of different types of bagging on visitation of Rose-ringed parakeets in guava orchard

Treatment		Number of parakeet/Ten-minute interval/tree at weekly interval		
		2022-23	2023-24	Pooled
Non-woven bag (20×24 cm)		2.68 (6.67)	2.69 (6.74)	2.68 (6.71)
Muslin cloth bag (20×24 cm)		3.23 (9.96)	3.21 (9.78)	3.22 (9.87)
Butter paper bag (20×24 cm)		2.26 (4.60)	2.35 (5.04)	2.31 (4.82)
Control		4.15 (16.73)	4.05 (15.90)	4.10 (16.32)
S.E.M	T	0.08	0.07	0.06
	Y	-	-	0.04
	T × Y	-	-	0.08
CD at 5 percent	T	0.24	0.22	0.18
	Y	-	-	-
	T × Y	-	-	NS
CV percent		8.59	7.90	8.25

Note: Figures in the parentheses represent retransformed value of $\sqrt{X+0.5}$, NS= non-significant

Table 3.27. Impact of different types of bagging on damage caused by Rose-ringed parakeets in guava orchard

Treatment		Number of fruits/trees					
		Damaged			Healthy		
		2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Non-woven bag (20 × 24 cm)		2.31 (4.86)	2.53 (5.95)	2.43 (5.40)	8.15 (65.86)	8.07 (64.66)	8.11 (65.27)
Muslin cloth bag (20 × 24 cm)		3.79 (13.90)	3.93 (14.95)	3.86 (14.40)	7.55 (56.45)	7.47 (55.28)	7.51 (55.87)
Butter paper bag (20 × 24 cm)		1.52 (1.82)	1.83 (2.85)	1.68 (2.32)	8.35 (69.28)	8.28 (67.98)	8.31 (68.63)
Control		5.82 (33.39)	5.90 (34.40)	5.86 (33.84)	6.15 (37.30)	6.09 (36.61)	6.12 (36.95)
S.E.M.	T	0.13	0.11	0.10	0.09	0.08	0.07
	Y	-	-	0.06	-	-	0.04
	T × Y	-	-	0.12	-	-	0.09
CD at 5 percent	T	0.38	0.32	0.29	0.27	0.25	0.20
	Y	-	-	0.17	-	-	0.11
	T×Y	-	-	NS	-	-	NS
CV percent		12.47	9.97	11.23	3.88	3.62	3.75

Note: Figures in the parentheses represent retransformed value of $\sqrt{X + 0.5}$, NS= Non significant

Table 3.28. Impact of fruit bagging on guava fruit yield in orchard

Treatment		Damaged fruit weight kg/ha			Healthy fruit weight kg/ha		
		2022-23	2023-24	Pooled	2022-23	2023-24	Pooled
Nonwoven bag (20 × 24 cm)		423.81	506.91	465.36	7805.72	7528.03	7667.08
Muslin cloth bag (20 × 24 cm)		1171.71	1254.81	1213.26	6592.74	6454.65	6523.90
Butter paper bag (20 × 24 cm)		157.89	240.99	199.44	8052.11	7905.03	7978.71
Control		2783.85	2866.95	2825.40	4326.05	4248.35	4287.41
S.E.M.	T	80	74	54.36	278	280	197.29
	Y	-	-	38.44	-	-	139.50
	T × Y	-	-	76.88	-	-	279.01
CD at 5 percent	T	229	212	153.47	798	804	556.91
	Y	-	-	NS	-	-	NS
	T × Y	-	-	NS	-	-	NS
CV percent		23.11	19.87	20.68	13.37	13.84	13.34

Note: Figures represent original values

Table 3.29. Economic and cost-benefit ratio after treatment of guava fruit bagging

Treatment	Price of bag (Rs)	No. of bag	Cost of bag (Rs)	Labour charge (Rs)	Cost of treatment (Rs)	Yield (kg/ha)	Yield increase (kg/ha)	Gross realization over control	Net realization	CBR
Non-woven bag	1.15	19667	22617	10388	33005	7640	3367	286195	253190	1: 8.67
Muslin cloth bag	16.00	19667	314672	10388	325060	6483	2210	187850	-137210	1: -0.58
Butter paper bag	1.21	19667	23797	10388	34185	7954	3681	312885	278700	1: 8.15
Control (Untreated Check)	0.00	0	0	Treatments	0	4273	0	0	0	-

Price of VNR- Taiwan pink guava @ 85 Rs/kg, Labour cost @ 375 Rs. /day, Total Tree= 277 tree/Ha., Bagging= 71/tree, CBR: Cost benefit ratio

Fig. 3.14. Damage in Guava by parakeets

3.3. WILD BOAR

3.3.1. Telangana (PJTSAU, Hyderabad)

3.3.1.1. Evaluation of Agri-solar technology against wild boar

Agri-solar technology has been implemented in different locations to manage wild boar populations and reduce crop damage. In all the locations, where the crops were protected by installing agri-solar devices reported no damage. At the same time, control fields experienced varying percentages of damage, indicating the effectiveness of the technology in deterring wild boar activity. The damage in control fields ranged from 20 percent to 45 percent, underscoring the vulnerability of crops to wild boar foraging. The yield in treated fields was significantly higher compared to control fields. The rice crop in village Maryal reported yields of 8024 kg/ha in treated fields compared to 6800 kg/ha in control fields, demonstrating the positive impact of the management strategy. In treated fields, the highest yield (12500 kg/ha) was observed in the fodder maize crop at Rajendranagar. The incremental cost-benefit ratios ranged from 1:0.98 to 1:6.97, with groundnut yielding the highest return on investment. The average incremental cost-benefit ratio across all locations indicates a positive economic outcome for farmers adopting agri-solar technology (Table 3.30).

Table 3.30. Effectiveness of Agri solar for wild boar management in different Agroecosystems

S.No.	Name of the Location	Crop	Damage in treated (percent)	Damage in control (percent)	Yield in treated (Kg/ha)	Yield in control (Kg/ha)	MSP per Kg	Incremental cost benefit ratio
1	B.Sharan, Sangareddy	Red gram	Nil	36 percent	2032	1450	86.02	1:1.93
2	M.Vishnu, Malkapur, Jogipet Medak	Black gram	Nil	28 percent	1504	800	89.45	1:2.42
3	D.Ravi, Maryal, Bommalaramaram Yadadri Bhuvanagiri	Rice	Nil	20 percent	8024	6800	20.84	1:0.98
4	M.Vijaya, Sirikonda Nizamabad	Rice	Nil	25 percent	7500	5630	20.84	1:1.50
5	D.Mothiram Indriyala Pochampally Nalgonda	Groundnut	Nil	32 percent	3625	1120	72.46	1:6.97
6	Forage crops Rajendranagar Hyderabad	Fodder maize	Nil	20 percent	12500	11200	20.90	1:1.05
7	Agroforestry Rajendranagar Hyderabad	Coconut plantation intercropped with Maize	Nil	35 percent	4500	2925	19.53	1:1.18
8	B.Naresh, Nagarkurnool	Maize	Nil	25 percent	8025	1620	19.53	1:4.81
9	Vikram Reddy Student farm Rajendranagar	Maize	Nil	45percent	7506	4125	19.53	1:2.54
10	Erukala Krishna Marvelly, Vatpally Sangareddy	Jowar	Nil	25 percent	2250	1075	33.71	1:1.52
Average				**29.10 percent**	**574.66**	**367.45**		

3.3.1.2. Impact of different treatments in reducing damage by wild boar in village Pudur

The study analysed the impact of different treatments on the damage caused by wild boars, such as T1 (HDPE Fishnets) – Sorghum**,** T2 (E-Cannon) – Sorghum**,** T3 (Agri Solar), T4 (BoRep**) –** Maize, and T5 (Bioacoustics) – Maize. In the control areas, 20-40 percent damage by wild boar was recorded which was reduced to nil in T1, T2, and T3, while in T4 and T5 the damage was reduced to 15 percent and 5 percent respectively indicating the efficacy of Borep and Bioacoustic in maize crop (Table 3.31).

Table 3.31. Comparison of pre- and post-treatment impacts on damage pattern caused by wild boar in farmer's field at village Pudur, district Vikarabad

Treatment	Farmer Name	Treatment	Control	Yield in Treatment	Yield in control	MSP per Kg	Incremental cost benefit ratio
T1 (HDPE Fishnets)– Sorghum	A.Manaiah	0 percent	20 percent	2365	1800	33.71	3.2
T2 E-Cannon-Sorghum	E.Mohan	0 percent	32 percent	2521	1530	33.71	1.51
T3 (Agri-solar)-Maize	Ramchander singh	0 percent	25 percent	8250	6325	19.53	1.44
T4 Borep-Maize	Balakrishna reddy	15 percent	23 percent	7225	6545	19.53	13.2
T5 (Bio acoustic) - Maize	Md. Raheem	5 percent	40 percent	7962	4920	19.53	2.4

3.3.2. Punjab (PAU (AO), Ludhiana)

3.3.2.1. Evaluation of management methods against wild boar in maize and wheat crops

The damage of wild boar in wheat and maize crop fields was recorded in different villages of Punjab and Himachal Pradesh during the surveys (Table 3.32). Wild boar habitat was observed in the forest belts/birs adjoining the forest areas of Lower Shiwalik Hills and banks of rivers mainly Sutlej and Beas. The part of river Beas in Himachal Pradesh and Punjab has forest areas in patches that harbour wild boar and other vertebrates. Wild boar resulted in damage to the agricultural fields in the adjoining villages of the said areas. For the management of damage caused by wild boar, olfactory repellent (OR) and auditory deterrent (AD) were used. A single application of OR was effective from 7-10 days in the selected crop fields at all the locations. Repeated application of OR was effective in managing wild boar at critical stages of crops. Bioacoustics devices successfully reduced animal visits or percent damage and provided short-term relief, as after some time, animals developed habituation against these methods. At several locations, it was completely effective in preventing damage.

3.3.2.2.1 Application method of Olfactory Repellent (OR): 500 ml of olfactory repellent (Ricinoleic acid 60 per cent, Neelbo®) was mixed with 500 g of wood shavings. 100 pouches/acre were tied with poles/rope at a height of 1 to 1.5 feet from the ground. Cost per acre = Approx Rs 950.

3.3.2.2.2. Application method of Acoustic Deterrent (AD): Bioacoustics (1 unit/ acre) were installed in selected fields and played at the rate of two hours each in the morning (4:00 to 6:00 am) and evening (7:30 to 9:30 pm) times.

Table 3.32. Wild Boar management strategies evaluated in maize and wheat crop fields at selected locations

State (District)	Location	Crop	Methods used	Crop damage (percent) before intervention	Reduction in crop damage (percent)
Punjab (Ludhiana) 5 fields per village	Rajjapur	Wheat	AD	13.71	100
			OR	9.12	76-78
		Maize	AD	16.61	98-99
			OR	12.54	77-78
	Gorsian	Wheat	AD	14.27	98-99
			OR	7.5	75-76
		Maize	AD	17.5	98-99
			OR	13.6	76-77
	Pabbian	Wheat	AD	15.46	100
			OR	5.5	77-78
		Maize	AD	19.75	98-99
			OR	14.83	76-77
	Khera	Wheat	AD	10.67	100
			OR	6.34	75-77
		Maize	AD	25.85	98-99
			OR	16.52	77-78
	Ladhowal	Wheat	AD	14.58	98-99
			OR	8.41	77-79
		Maize	AD	21.63	98-99
			OR	15.47	76-78
Himachal Pradesh (Una) 10 fields per village	Nangada	Maize	OR	17.24	72-73
	Khuthar kalan	Wheat	OR	7.50	70-72
		Maize	OR	12.65	74-76
	Chudowal	Wheat	OR	10.48	71-73
		Maize	OR	11.61	70-71
	Khanpur	Wheat	OR	10.77	73-74
		Maize	OR	13.40	72-73

3.3.3. Kerala (KAU, Thrissur)

3.3.3.1. Development of laser-based scarer for wild boar

Several bio-acoustic devices are available on the market that claims to deter wild animals, however, their constant operation often leads to animals becoming habituated to the sounds they produce. To address this issue, AINPVPM KAU has developed a prototype Laser-Based Animal Repeller. This innovative device utilizes a laser beam to detect the presence of wild animals, triggering pre-recorded distress calls and predator sounds to drive them away. The system consists of two main components: a laser-emitting unit powered by a small battery and a laser-receiving main unit that requires an electrical charge. Both units can operate within a range of 100 meters. When an animal or bird interrupts the laser beam, the device swiftly activates, emitting the distress sounds within milliseconds, effectively encouraging the animal or bird to leave the area.

An experiment was laid out at the AINPVPM experimental field, College of Agriculture Vellanikkara to compare the efficacy of a laser-based animal repeller prototype with other wild boar management methods in cassava, during the period from October 2023 to August 2024. The treatments imposed were, Solar Based Electric Fencing (Physical barrier)-T1, Shade net fencing around the crop fields (Physical barrier)-T2, Bio-acoustic device-T3 (Auditory repellent), Laser-based animal repeller-T4 (Auditory repellent), BoRep (@2Kg/Acre) -(Olfactory repellent)-T5 and control T6- (without any treatment). Among the various treatments evaluated, the plot protected with solar-based electric fencing (T1) recorded the lowest plant damage (1.6 percent) and the highest yield (288.35 kg/plot), with a 45.58 percent increase in yield over the control plot. It was followed by a plot protected with shade net fencing (T2) with 3.19 percent plant damage and a yield of 260.86 kg/plot. Among the auditory repellents evaluated, the bio-acoustic device (T3) recorded 6.89 percent plant damage and a yield of 230.33 kg/plot. However, the laser-based animal repeller (T4) was also found effective in managing wild pig incidence

with moderate plant damage of 4.19 percent and a yield of 239.11 kg/plot. The olfactory repellent, BoRep (T5), recorded comparatively higher plant damage of 7.97, with a yield of 210.88 kg/plot. The control plot recorded the highest plant damage of 16.27 and the lowest yield of 156.91 kg/plot (Table 3.33, Fig. 3.15).

The effectiveness of the Laser-Based Animal Repeller will be further improved by incorporating certain modification in the prototype.

Table 3.33. Comparison of efficacy of Laser-based animal repeller against wild boar

S.No	Treatment	Plant damage (percent)	Average yield (Kg/plot)	Yield increase over control (%)
1	Solar Based Electric Fencing (Physical barrier)- T_1	1.60^{a} (2.01)	288.35^{a}	45.58
2	Shade net fencing around the crop fields (Physical barrier)-T_2	3.19^{ab} (5.41)	260.86^{b}	39.85
3	Bio acoustic device – T_3 Auditory repellent)	6.89^{bc}(7.91)	$230.33b^{c}$	31.88
4	Laser based animal repeller-T_4 (Auditory repellent)	4.19^{b} (5.57)	**239.11^{bc}**	34.38
5	BoRep (@2Kg/Acre) (Olfactory repellent)- T_5	7.97^{b} (8.80)	210.88^{c}	25.59
6	Control -T_6	16.27^{c} (28.39)	156.91^{d}	--
	CD@ 5percent	**3.15**		
	CV	**16.78**		

Fig. 3.15. Laser-based animal repeller

3.3.3.2. Sprayable olfactory repellent (Nano formulations) for wild boars

The AINP on VPM centre at KAU is actively working on developing a sprayable olfactory repellent specifically designed to deter wild boars and rodents (Fig. 3.16). This initiative involves developing a nano formulation of the olfactory repellent, BoRep. A key challenge in this process is achieving a stable, water-miscible product, as oils are a major component of the formulation. To address this, it has been exploring the effectiveness of various surfactants, such as Tween 80 and Tween 20, to enhance the miscibility of the oils with water and create a viable sprayable product.

Fig. 3.16. Sprayable Nano formulation of BoRep

In the previous year, the formulations tested showed particle sizes and Zeta potential measurements that were outside the desired ranges for effective nano-formulations. Ideally, the particle size should be approximately 100 nanometres, and the Zeta potential should be within -30 to +30 to ensure stability and efficacy. This year, it has been focused on experimenting with different ratios of oils and surfactants to achieve these optimal parameters (Table 3.34). Moving forward, the stability of the final product will be assessed during storage, along with its effectiveness in repelling the target animal species. This comprehensive approach aims to refine the formulation and ensure its practical application in managing wildlife interactions.

Table 3.34. Comparison of properties of Nano formulation of BoRep

2023				2024			
Sl No	**Formulation**	**Particle size (nm)**	**Zeta potential**	**Sl No**	**Formulation**	**Particle size (nm)**	**Zeta potential**
1	NE_1	299.2	-17.5	1	NE_7	123.4	-20.31
2	NE_2	450.4	-30.8	2	NE_8	127.5	-20.01
3	NE_3	200.7	-47	3	NE_9	125.7	-19.09
4	NE_4	1573.9	-46.8	4	NE_{10}	114.6	-17.18
5	NE_5	2495.5	-54.9	5	NE_{11}	117	-15.15
6	NE_6	320.2	-69.3	6	NE_{12}	117	-15.28

3.3.4. Gujarat (AAU, Anand)

Wild boar repellent and Kheti Rakshak (Model: KR-18) were installed in the paddy field at Paddy Research Station, AAU, Dabhoi (Vadodara). The composition of wild boar repellant was wood sawdust + Phenyl solution mixed in 25 percent concentration of coal tar acid and tar oil. The mixture was kept for 5 days and used in the fields by wrapping it in a small cloth pouch and hanged it at 1ft height in plastic cups at 10 ft intervals. Observations were recorded on crop damage and entry of wild boar by the presence of foot marks and fecal matter around and within the fields at weekly intervals for four weeks. After the installation of kheti rakshak and repellents (Fig. 3.17) application wild boar entry and activity were not observed in the crop or nearby field area for up to 15 days.

Fig. 3.17. Application of Kheti-rakshak and repellent in paddy field

3.4. BLUE BULL

3.5.1. Punjab (PAU (RC), Ludhiana)

3.5.1.1. Blue bull management in different crop fields

The experimental layout for blue bull management using different methods in crop fields is given in Table 3.35. Various mitigation tactics like physical barriers (barbed wire fencing, chain-linked fencing, electric fencing, and nylon net), mechanical and visual deterrents (bioacoustics devices, LED bulbs, and reflective ribbons) and repellents (phenyl, neelbo, and repellent based formulation (RBF)) were evaluated in different crops against the blue bull. Among physical barriers, chain-linked fencing, electric fencing, and nylon net, each at a height of ≥ 7 feet, had given promising results by providing complete protection for ≥ 2 years with a single application cost, whereas reduction in height of barbed wire fencing and electric fencing to 4-5 feet were not very effective against these animals. All these physical barriers were not cost-effective except in the maize crop, which is the most preferred crop by blue Bull. Bio-acoustic devices and reflective ribbons successfully reduced animal visits or percent damage, but their effect lasted for short period of time. Among chemical repellents, RBF was most effective as it reduced the entry of nilgai in crop field for 21-69 days, while phenyl and neelbo exhibited effectiveness for only 7-14 days. Thus, this study suggests that while comprehensive damage prevention by physical barriers might be difficult or unaffordable for farmers, the use of repellent-based formulation at vulnerable stages of crops can prevent damage for longer durations and is a cost-effective method for blue bull management (Table 3.36).

Table 3.35. Different management methods tested against blue bull

Management method	Treatments	Villages	Evaluated crops fields	Mode of application
Physical barriers (n=3 for each crop)	Barbed wire fencing 1 (BF 1) (4 Feet)	Khaira Bet	Wheat	All barriers were installed around bamboo, cemented or metallic poles
	Barbed wire fencing 2 (BF 2) (5.5Feet)	Khaira Bet	Wheat and paddy	
	Chain-linked fencing (CLF) (7 feet)	BISA	Wheat and paddy	
	Nylon net (7 feet)	Nurpur Bet	Maize and potato	
	Electric fencing 1 (EF 1) (4 Feet)	Khaira Bet	Wheat and paddy	
	Electric fencing 2 (EF 2) (7 Feet)	Nurpur Bet	Maize, potato, wheat, paddy and guava	
Acoustic deterrent (n=3 for each crop)	Bio-acoustic device	Gorsian	Potato, paddy, and guava	Potato and guava: Bioacoustic was fixed in fields. The farmer himself played the bioacoustic at night time from 10:00 p.m. to 5:30 a.m., after standardization by himself he started playing it from 10.00 p.m. to 11.00 p.m. and 3.30 a.m. to 4.30 a.m. only Transplanted paddy: The farmer followed animal with bioacoustic played to chase them away from his fields
Visual deterrent (n=3 for each crop)	Reflective ribbon	Nurpur Bet	Moong	Small pieces of reflective ribbons were tied on nylon rope around the crop field
			Intercropped Wheat & Poplar	Ribbons were directly tied around poplar stems to encircle wheat crop fields
	LED bulb	Gorsian	Potato	Four LED bulbs were placed at all four corners of the field

Table 3.36. Ranking of Tested management methods against blue bull based on C: B ratio

S. No.	Management method applied	Crops	Cost Benefit Ratio	Reduction in damage (percent)
1	Electric fencing (7 feet)	Guava orchard	1:12.04	100

2	Bio-acoustic device	Guava orchard	1:6.99	
3	RBF 2 (20 pouches /200m^2)	Wheat	1:6.06	94.81
4	RBF 3 (40 pouches /200m^2)	Wheat	1:5.39	99.51
5	RBF (200 pouches /Acre)	Maize	1:5.3	82.65
6	RBF 1 (10 pouches /200m^2)	Wheat	1:4.75	69.04
7	Reflective ribbon	Wheat + Poplar	1:4.58	55.08
8	Reflective ribbon	Moong	1:0.89	29.69
8	Nylon net (7 feet)	Maize	1:2.33	100
9	Electric fencing (7 feet)	Maize	1:1.59	100
10	Neelbo (20 pouches /200m^2)	Wheat	1:1.02	22.86
11	Nylon net (7 feet)	Summer moong	1:0.89	100
12	Neelbo (200 pouches/acre)	Maize	1:0.33	28.24
13	Nylon net (7 feet)	Oat	1:0.31	100
14	Barbed fencing (7ft), chain link (7ft), electric fencing (7 feet), nylon net	Wheat, paddy, potato, pigeon pea	nil	100
15	Bio-acoustic device	Paddy, potato	nil	61.62-71.36

3.5.1.2. Development of sensor-based e-scare crow

An electronic sensor-based scarecrow (a prevention and detection system) was developed, and preliminary investigation to confirm its detection efficacy was carried out in guava orchard, PAU, Ludhiana for 7 days in the morning and evening hours. It was found effective in detecting the birds' movement through its sensor and transmitting the signals to main unit for operation of lights and sound attached to it, which in turn ward off the birds from the field. Its efficacy will be further tested to validated the technology.

3.5. MONKEYS

3.5.1. Telangana (PJTSAU, Hyderabad)

Agri-solar units were established in the problem-identified fields and resulted in 100 percent protection (Table 3.37). The monkey scaring device, Agri-cannon was used to scare monkeys which resulted in a decline in damage from 26-42 percent to 7-10 percent in rice and maize crops (Table 3.38).

Table 3.37. Efficacy of Agri-cannon to minimize monkey menace

Name of the Farmer	Village	Name of the crop	Total area (Acres)	Damage before treatment	Damage after treatment
Mr.N. Venu Gopal	Mamidipally	Rice	10	26 percent	8 percent
Mr.A. Srinivas	Hanmajipeta	Maize	2	35 percent	7 percent
Mr. B.Tirupathi	Thurkapalli	Maize	5	42 percent	10 percent

Table 3.38. Comparison of pre- and post-treatment impacts on damage pattern caused by monkeys in farmers' fields at village Pudur, district Vikarabad

S.No	Name of the Location	Crop	Damage in treatment (percent)	Damage in control (percent)	Yield in treatment (Kg/ ha)	Yield in control (Kg/ ha)	MSP per Kg	Incremental Cost Benefit Ratio
1	R. Sathi Reddy Thurkapally, Ramannapet, Nalgonda	Rice	Nil	31.8	7375	5025	20.8	1:1.88
2	O. Ramesh, Narsanagar, Sangem, Warangal	Cotton	Nil	18.4	3250	2650	66.2	1:1.52
3	R.Bharath Kumar Somaram, Hanumakonda	Red gram	Nil	21.8	1375	1075	86.02	1:1.01
4	G.Srinivas Polasa, Jagtial	Sesame	Nil	21.8	700	548	86.4	1:0.51
5	N. Shankar Palem, Nagarkurnool	Groundnut	Nil	18.9	3625	2940	72.4	1:1.91
6	P. Ramesh Varkudpally, Choutuppal	Groundnut	Nil	32.4	3250	2198	72.4	1:2.93
7	G. Narender Reddy Gopalpeta, Wanaparthy	Rice	Nil	24.6	7000	5265	20.8	1:1.40
8	B. Suresh Golanukonda, Alair, Bhongir	Bottle gourd	Nil	31	20000	13800	10	1:2.40
9	T.Prabhakar Reddy Bijenepally	Tomato	Nil	37.9	55000	34250	15	1:11.9
10	K. Ravi Kumar Wyra, Khammam	Poly house Gerbera	Nil	14	4,50,000 stalks	3,85,000 stalks	5	1:12.5
11	V.Chaitanya Wyra, Khammam	Poly house Chrsanthemum	Nil	13.1	2,75,000 stalks	2,38,975 stalks	2	1:2.80

3.5.2. Karnatak (UAS, Bengaluru)

Monkey management practices were evaluated at three locations (Kumta, H.D. Kote, and Kanakapura) in Karnataka. The average reduction in the population due to different treatments indicated that the installation of nylon nets and solar fencing around the crops resulted in a maximum reduction in damage (96.71 and 97.25 percent, respectively) throughout the crop period (Table 3.39). However, the other, treatments like Canon guns, bio-acoustic devices, and gunny bags soaked in Neelbo were moderately effective.

Table 3.39. Management of monkeys at various places in Karnataka

Management measure	Reduction in population (percent)			Average	Number of days effective
	Kumta	H. D. Kote	Kanakapura		
Canon gun	35.26	42.18	48.97	42.14	8.67
Bioacoustics	48.32	55.47	62.41	55.40	16.98
Placement of nylon nets	96.24	98.74	95.14	96.71	Throughout the crop period
Solar fencing	98.47	96.87	96.41	97.25	Throughout the crop period
Placement of gunny bags soaked in Neelbo	43.14	47.41	41.72	43.66	9.24

3.5.3. Andhra Pradesh (ANGRAU, RARS, Maruteru)

3.5.3.1. Evaluation of certain Physical barriers (nets) against Rhesus macaques

Nylon netting as a physical barrier against macaques in maize crops resulted in 45-64 percent protection with a reduced number of visits by the macaques to the netted fields. The crop damage was 8.3 to 10.2 percent in nylon netted fields compared to 18.6 to 23.6 percent damage in non-netted fields. Animal visits to netted fields ranged from 10-30 in various crops, whereas in non-netted fields the visits were 80-100, which is significantly high (Table 3.40, Fig. 3.18).

Table 3.40. Evaluation of nylon net against Rhesus macaques in field crops

S.No.	Location	Crop (Area)	No. of visits		Damage (percent)		Protection (percent)
			Netted	*Non-netted*	*Netted*	*Non-netted*	
1	Kamavarapukota	Maize (4 acres)	24	90	9.6	22.6	57.52
2	R. Chodavaram	Cotton (4acres)	10	110	8.3	20.6	59.71
3	Konalova	Maize (4.5acres)	10	80	8.6	23.6	63.56
4	K.Kota	Banana (3.2 acres)	30	100	10.2	18.6	45.16
t- test			6.2>2.7		5.15 >2.7		
			significant		significant		
*Cost of nylon net: Rs. 800/- Qty required per acre:3kg, Ht 8ft							

Fig. 3.18. Nylon netting as a physical barrier

3.5.3.2. Evaluation of Low-cost solar fencing against Rhesus macaques

Low-cost solar fencing was evaluated for its efficacy in scaring the animals from different crop fields at 8 locations. In the control field, the animal visits were recorded at a minimum of 55 to a maximum of 130 in the entire crop period across all the crops and locations. Solar fencing reduced the number of visits by the macaques to the fields, and it was only 5-15 times across all the crops and locations, which was mainly due to the fear factor of exposure to the solar fence which produces mild shock upon touch by generating a 12 V current. The damage due to macaques in solar-fenced fields across the locations varied from 1.6 to 3.6 percent, whereas it was 16.6 to 26.6 percent in non-solar-fenced fields. Solar-fenced plots also recorded relatively higher yields of 1.5 -77 q/acre across the crops, which is a 15 to 34 percent increase over the control fields. Solar fencing was found highly economical and remunerative in protecting the crops from macaques (Table 3.41 Fig. 3.19). Low-cost solar fences offered significantly higher protection against macaques with a mean cost-benefit ratio of 1:6.2 across all the crops and locations. The animals did not invade the solar-fenced fields due to fear experienced by the dominant animals and social communication with the other animals in the troop.

Table 3.41. Evaluation of low-cost solar fence against macaques in crop fields

S.No.	Location	Crop (Area)	No. of visits		Damage (percent)		Protection (%)	Yield advantage in solar over control		C: B Ratio
			Solar	N-Sol	Solar	N-Sol		Q/ac	percent	
1	Diricinapalli (V) Buttayagudem	Maize (4 acres)	12	110	2.6	18.6	86.02	5.0	25.0	1:6.5
2	Singampalli (V) Addateegala (M)	Maize (2 acres)	10	120	2.3	23.6	90.25	7.0	28.0	1:5.2
3	K.Kota (V&M)	Maize (4.5 acres)	8	110	1.6	26.6	93.98	3.0	16.7	1:4.5
4	K.Kota (V& M)	Coccinia (2.8 acres)	5	60	2.3	18.3	87.43	10.0	31.3	1:8.5
	K.Kota (V& M)	Banana (3.2 acres)	8	55	3.6	16.6	78.31	77.0	33.9	1:9.1
5	Konalova (V), Addateegala (M)	Cotton (4 acres)	15	120	2.3	26.6	91.35	1.3	20.0	1:4.5
6	Kolanka (V) Pitapuram (M)	Rice (4 acres)	5	110	1.6	16.6	90.36	2.7	14.8	1:3.3
7	Rampa (V) R.Chodavaram (M	Rice (4 acres)	10	130	3.3	21.6	84.72	3.0	17.1	1:3.5

8	Korukonda (V) &M)	Maize (4 acres)	08	60	2.3	16.6	86.14	4.0	16.0	1:4.5
		t-test	Significant (8.2 >2.14)		Significant (17.8 >2.14)					1:6.2

Fig. 3.19. Nylon netting as a physical barrier

3.5.3.3. Evaluation of Bear Acoustic for scaring the macaques from the crop fields

Bear acoustic was field evaluated in three different situations. In forest fringe areas, the animals are scared much more and moved 300-500m away immediately, and revisiting of the animals was noticed after 15-30 days only. But in the agricultural landscape, the animals were acclimatized to Bear acoustic much faster within a week. In urban scenarios (man-made ecosystems) the animals are scared very little and immediately they revisit the fields within 5-10 minutes after exposure to the Bear acoustic (Table 3.42). The use of bear dress to scare macaques can be integrated with other techniques during the critical stages of the crop.

Table 3.42. Refinement of Monkey scaring techniques using bear dress acoustic in field and horticultural crops

Location	Move away/ scare away distance	Re-visit period	Remarks
Kamavarapukota	300 m	06 days	Acclimatized to Agricultural landscape
Mukkinada	100 m	10 min.	Urbanized population
Katheru	50 m	05 min.	Urbanized population
Paderu-1	300 m	15 days	Forest fringe areas
Paderu-2	300 m	30 days	Forest fringe areas
Konalova	300m	15 days	Forest fringe areas

3.5.4. Assam (AAU, North Lakhimpur)

3.5.4.1. Evaluation of solar fencing against monkeys

Crops grown inside the solar fencing (AGRI- SOLAR); a potential method to reduce the problem of intrusion by monkeys into the agricultural landscape gave significantly higher yields as compared to crop yields recorded in the same plot without solar fencing in the previous year. Further, the solar fencing with mulch paper enhanced the efficacy and life of the wire by controlling the weeds, a major problem in Assam.

3.5.4.2. Evaluation of HDPE net against monkeys

HDPE net of 5 cm mesh and 1.5 mm thickness using bamboo poles of 8 feet in height was found to protect *rabi* and *kharif* vegetables from monkeys by preventing their entry into the crop fields to the extent of 80-100 percent. It was also found to be cost-effective in managing monkey menace.

3.5.5. Assam (AAU, Jorhat)

Evaluation of different combinations of treatments in crop fields revealed the highest efficacy of T_3 (parachute net+bhut jolokia baiting + agri-cannon) treatment in the form of 68.31 percent control success and 17.86 percent damage followed by T_4 (green net + bhut jolokia baiting+agricannon) treatment which resulted in 64.14 percent control success and 20.21 percent damage by Rhesus macaque. While T_1 (parachute net + bhut jolokia baiting) and T_2 (green net + bhut jolokia baiting) treatments resulted in 42.96-47.84 percent control success and 29.39-32.14 percent damage, respectively. Damage by Rhesus macaque in untreated control fields ranged from 28.33 to 74.11 percent at different crop stages (Table 3.43, Fig. 3.20).

Table 3.43. Effect of different treatments on the incidence of Rhesus macaque in crop fields

Treatment	Damage (percent)			Mean damage (percent)	Control success (percent)
	Vegetative stage	Reproductive stage	Maturity stage		
T_1	14.11	26.01	48.06	29.39	47.84
T_2	12.88	32.81	50.67	32.14	42.96
T_3	10.66	18.81	24.11	17.86	68.31
T_4	10.44	22.06	28.11	20.21	64.14
T_5	28.33	66.61	74.11	56.35	
CD (5percent)	6.61	5.85	7.21		

T_1: Parachute net + bhut jolokia baiting, T_2: Green net + bhut jolokia baiting, T_3: Parachute net+bhut jolokia baiting + agricannon, T_4: Green net + bhut jolokia baiting+agricannon, T_5: Untreated control

Fig. 3.20. Application of different combinations of treatments

3.6. BLACK BUCK

3.6.1. Telangana (PJTSAU, Hyderabad)

To reduce the Blackbuck damage, demonstrations were conducted in farmers' fields of Nampally village of Damera mandal in Nalgonda district. In cotton crops, the installation of HDPE net resulted in a reduction in black damage from 22.3 percent to 5.6 percent while the installation of Agri-solar in groundnut crops resulted in a reduction in damage from 14.8 percent to nil (Table 3.44). In the untreated control fields of cotton and groundnut, damage was increased from 19.2-23.1 percent to 31.6-34.0 percent.

Table 3.44. Efficacy of different methods to minimize Black buck menace

Treatment	Farmer name	Pre-treatment damage (percent)	Post-treatment damage (percent)	Yield (Kg/acre)
T1: HDPE net- Cotton	Koneti Anjaiah	22.3	5.6	1100
T2: Agrisolar - Groundnut	Gadagoni Madhu	14.8	Nil	950
T3: Control- Cotton	Mandala Chandramma	23.1	31.6	810
T4: Control- Groundnut	Mandali Yadagiri	19.2	34.0	525

3.7. DEER

3.7.1. Karnataka (UAS, Bengaluru)

Deer is causing a lot of damage to various crops in Pavagada Taluk of Tumkur. Hence, an experiment was laid out to manage deer in ragi crops with 5 treatments along with control. The observations on ear head damage and yield indicated that solar fencing around the border and bio-acoustic (@ 1/ha) were superior with the lowest ear head damage (1.26 percent and 1.94 percent, respectively) and highest yield (1428.56 and 1379.65 kg/ha, respectively). In the control plot, the damage was 16.87 percent with a yield of 1128.61 kg/ha (Table 3.45).

Table 3.45. Management of Deer in ragi crops (Pavagada)

Treatment	Ear head damage (percent)	Yield (Kg/ha)	Yield saved (percent)
Bioacoustics	1.94	1379.65	22.24
Neelbo	7.68	1277.54	13.20
Binding wire fence with white polythene tape (Itk)	4.78	1328.71	17.73
Solar fence	1.26	1428.56	26.58
Control	16.87	1128.61	-

4. VERTEBRATE PEST MANAGEMENT AS FARMERS PARTICIPATORY ADAPTIVE RESEARCH IN ADOPTED VILLAGES

4.1. Rajasthan (ICAR-CAZRI, Jodhpur)

Training and demonstrations on Vertebrate Pest Management were organized for farmers of villages of Jaisalmer, Chandan and Mohangarh of district Jaisalmer, Inana and Amarpura of district Nagaur, Meghsar and Chandsar of district Bikaner, Kawas and Bidasar of district Barmar and Gokulpura and Chanpura of district Sikar. In total, more than 100 farmers benefited from these trainings.

Under Tribal Sub Plan of AINP on VPM Two field training on "Rodent Pest Management" was conducted in the villages of Chandela and Girwar, District Sirohi in Panchyat Bhawan on 23th& 24th August, 2023, respectively. More than thirty farmers attended the training at each village. At village Chandela the meeting was chaired by Ex-Sarpanch, Shri Ganesh Ram. At village Girwar the training was chaired by Dr. Jagdish Prasad Barwad, Joint Director, Animal Husbandry Department, Sirohi. Before the training, a questionnaire-based survey was conducted among participating farmers to understand their knowledge, attitude, and practices (KAP) for rodent management (Fig. 4.1). Later, interactive training was provided through lectures and demonstrations on techniques for preparing poison bait, bait placement, and the correct use of traps, was also provided.

Exhibitions on Vertebrate Pest Management were put up during Kisan Pashu Mela at Barmer and Kisan Sangosthi at the Institute. In addition, 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 various trainings.

Fig. 4.1. Field training on "Rodent Pest Management under TSP

4.2. Telangana (PJTSAU, Hyderabad)

Rodents being migratory crop pests, community approach is required in managing them. Social engineering was practiced to achieve technology adoption by motivating the farmer's participation. During the period Mamidipally, Palle Nizambad and Angalv were selected for implementation of KAP analysis. The KAP analysis revealed that the knowledge and practice levels are moderate in nature and attitude levels are mostly secondary adopters. Based on the analysis village-1 (Mamidipally)-knowledge was provided, campaigns were organized on community basis with complete technical support, Village-2

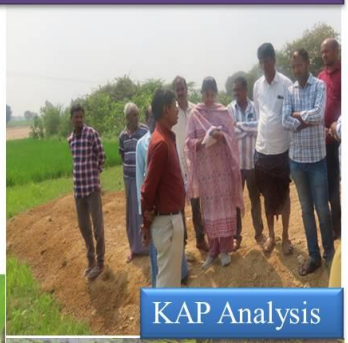
(Palle Nizamabad)- only knowledge was shared, and village-3 (Angal) considered as control. The per cent rodent control success of 70.5 percent in terms of live burrows and 64.0 percent in terms of tiller damage was achieved in Mamidipally village. In the village Palle Nizamabad where only knowledge was provided per cent rodent control success of 43.6 percent in respect of LBC/ha and 39.8 percent in terms of tiller damage (Table 4.1).

Table 4.1. KAP analysis and social engineering of wild boar

Social Engineering on Rodents

Particulars	Mamidipally	Palle Nizamabad	Angal
Score K	66.8	58.6	54.1
Score A	77.6	50.4	39.8
Score P	65.4	53.2	48.3
Motivational media	Demonstrations & interactions	Demonstrations & interactions	Demonstrations & interactions
Techniques adopted	Knowledge and campaign organized	Knowledge	Control

Name of the Village	Mamidipally	Palle Nizamabad	Angal
Area in hectares	40	30	30
Treated area in ha	40	30	30
Mean no. of live burrows /ha			
a) Pre treatment	26.8	29.1	30.4
a) Post treatment	7.9	16.4	24.7
Percent rodent control success	70.5	43.6	
Percent tiller damage/ ha			
a) Pre treatment	25.9	29.4	34.6
a) Post treatment	9.3	17.7	29.8
Percent rodent control success	64.0	39.8	



KAP Analysis

Live burrow count

A KAP analysis conducted by PJTSAU centre in three villages Rampur, Mujahidpur, and Ippayipally with respect to managing wild boar damage to crops. The analysis also provides recommendations for motivational media and techniques that need to be adopted to enhance the effectiveness of wild boar control. Each aspect is evaluated based on questionnaire across the three villages to provide insights into their strengths and areas that require intervention. The farmers in Rampur have a moderate knowledge but a positive attitude toward wild boar control. To enhance their knowledge and practice, it is recommended that the region utilizes demonstrations and interactions. Demonstrations of successful wild boar control methods can engage the farmers and motivate them to adopt improved practices in their fields. Farmers in Mujahidpur have a low knowledge score and a moderate attitude. In the backdrop of the relatively weaker knowledge base, demonstrations and interactions would be the most effective approach to educate them on new techniques and demonstrate the benefits of effective wild boar control. More interactive sessions, where farmers can ask questions and observe practical solutions, will help improve both their knowledge and attitude. Ippayipally's farmers already have a positive attitude and are implementing some control practices. However, their knowledge could still be enhanced to improve their methods. Demonstrations and interactions will further strengthen their existing efforts by introducing more advanced techniques and improving their knowledge base for more efficient wild boar control. Based on the KAP analysis Rampur village was selected to give inputs and knowledge, in Mujahidpur only Knowledge provided and Ippaipally taken as control (Table 4.2).

Table 4.2. KAP analysis and social engineering of wild boar

Particulars	Rampur	Mujahidpur	Ippayipally
Knowledge	68	65.3	61
Attitude	75.7	69	73
Practice	75.1	63	75
Motivational media need to be proposed	Demonstrations and interactions	Demonstrations and interactions	Demonstrations and interactions
Techniques need to be adopted	Knowledge and demonstrations	Knowledge and demonstrations	Knowledge and demonstrations

The survey results on knowledge of vertebrate pest management (VPM) techniques show varying levels of understanding among participants. A strong awareness of damage symptoms was evident, with 145 respondents demonstrating good knowledge, while only 16 reported no knowledge. However, there were gaps in understanding the causes of pest attacks, with 64 having no knowledge and only 81 showing good knowledge. In terms of the effects on crop yields, most respondents (143) had a good understanding. Awareness of management techniques was moderate, with 121 having fair knowledge, while 35 reported no knowledge. Regarding preventive measures, 58 had no knowledge, but 85 showed good knowledge. Overall, while many respondents were knowledgeable about symptoms and effects, further education is needed on causes and management strategies (Table 4.3).

Table 4.3. Result of KAP analysis on VPM techniques

SN	Questions regarding the knowledge on VPM Techniques	No knowledge	Fair knowledge	Good knowledge
1	What are the symptoms of damage of Vertebrate Pest attack	16^{a} (6.40)	89^{a} (35.6)	145^{b} (58.0)
2	What are causes of vertebrate pest attack	64^{c} (25.6)	105^{ab}(42.0)	81^{a} (32.4)
3	What is the effect of vertebrate pest attack on yield of crops	12^{a} (4.8)	95^{a} (38.8)	143^{b} (57.2)
4	What are the vertebrate pest management techniques	35^{b} (14)	121^{c} (48.4)	94^{ab} (37.6)
5	How vertebrate pest damage can be prevented using the techniques	58^{bc} (23.2)	107^{ab} (42.8)	85^{a} (34.0)

The survey on the adoption of vertebrate pest management (VPM) techniques revealed various practices among respondents (Table 4.4). The most commonly adopted method was the application of repellents, with 48 percent of participants using this technique. Nylon net or shade net fencing followed at 14.4 percent, while fencing with colored sarees was adopted by 12.4 percent of respondents. Fencing with wooden poles was used by 11.2 percent of participants. Installation of solar-electric fencing was less common, with only 6 percent adopting this practice, and just 1.6 percent installed bio-acoustic devices. Notably, 6.4 percent of respondents reported not adopting any pest management practices. This data highlights the varying levels of adoption among different VPM techniques.

Table 4.4. Adoption of VPM techniques by respondents

S. No	Practices of respondents	Adoption of VPM techniques
1	Fencing with wooden poles	11.2^{c}
2	Fencing with coloured sarees	12.4^{c}
3	Nylon net/shade net fencing	14.4^{c}
4	Application of repellents	48^{d}
5	Installation of bio-acoustic device	1.6^{a}
6	Installation of solar–electric fencing	6^{b}
7	No practices adopted	6.4^{b}

Monkeys are becoming a significant problem in agricultural areas, causing crop damage and significant economic losses. Social engineering is practiced to achieve technology adoption by motivating the farmer's participation. During the period Mujahidpur, Rampur and Salveed in the state of Telangana were selected for implementation and conducted KAP analysis by the scientists of PJTSAU Centre. The KAP analysis revealed that the knowledge and practice levels are moderate in nature and attitude levels are mostly secondary adopters. Based on the analysis village-1 (Mujahidpur) -knowledge was shared and inputs were provided, demonstration of technologies were conducted with complete technical support. Village-2 (Rampur) - only knowledge was shared. In village-3 (Salveed) considered as control where no information and inputs were given (Table 4.5).

In the adopted village of Telangana *viz.*, Mujahidpur, Agrisolar, Agri-cannon and HDPE net were demonstrated in Redgram and Rice crops in the farmer fields. Regular interactions were done with farmers and achieved cent percent control with Agri solar (Table 4.6).

Table 4.5. Social engineering on monkeys

Particulars	Mujahidpur	Rampur	Salveed
Score K	72.3	64	54.6
Score A	72.5	58.1	48.8
Score P	78.1	62.7	42.2
Motivational media	Demonstrations & interactions	Demonstrations & interactions	Demonstrations & interactions
Techniques adopted	Knowledge and training organized	Knowledge	Control

Table 4.6. Efficacy of Agri solar, Agri-cannon and HDPE net to minimize monkey menace

Technology	Name of the Crop	Total no of Acres	Percent Damage before	Percent Damage After
Agri solar	Rice	5	32.4 percent	Nil
Agri cannon	Rice	12	26.1 percent	8 percent
HDPE Net	Red gram	10	29 percent	9.1 percent

4.3. Punjab (PAU (RC), Ludhiana)

Farmers were interviewed in their crop fields, during *Kisan melas* and in their village-level societies. All questions were designed with multiple-choice answers. The questions included were about the farmer's socio-economic status, general behaviour of blue bull, preferred crops in different seasons, distribution and activity pattern, crop damages, breeding period, mitigation measures being adopted by them and knowledge about the Wildlife Protection Act (1972).

Majority of the farmer responders were marginal and small landholders and their occupation was agriculture only. According to farmers, the home range of blue bull is 1-2 km, raiding crops at night, shy and their raids in fields are predicted from faecal pallets and pug marks. They prefer wheat and oat crops; their non-preferred crops are mustard and berseem. Their damage predominantly ranged from 6-10 percent and they raid crops daily/weekly basis. Their preferred resting places include agricultural land, poplar fields and canals. Their group size ranges from 6-9, breed once in a year, the calving period ranges from September to October and can predominantly give birth to a single calf. Farmers were using traditional methods for blue bull management. They did not have much knowledge about the Wildlife Protection Act 1972 and were not getting any help from the Wildlife Department. Farmers also reported that animals have started entering villages after the degradation of their natural habitat or due to less availability of food in forests. There is a need to disseminate knowledge among farmers regarding upcoming technologies and critical timings for managing blue bull.

4.4. Kerala (KAU, Thrissur)

4.4.1. Evaluation of the efficacy of different crop protection measures against wild pig in the cassava agro-ecosystem of Kerala

Wild boars have emerged as a significant vertebrate pest in agricultural settings, particularly in the cassava ecosystems of Kerala, where their population has surged dramatically in recent years. This increase has led to substantial crop damage, raising concerns among farmers and researchers alike. To address this issue, an experiment was conducted by the scientists of KAU centre from 2023 to 2024 in the farmer field at Chelakkara. The study aimed to evaluate the effectiveness of various physical barriers and an olfactory repellent, BoRep, in mitigating wild boar damage to cassava (*Manihot esculenta* Crantz). The results of this research will provide valuable insights into practical pest management strategies for protecting crops from the growing threat posed by wild boars. Comparison of various fencing and repellent methods (Fig. 4.2 and Table 4.7) for crop protection reveals significant differences in efficacy in managing the wild pig incidence in cassava. The Agri Solar Electric Fencing (T1) stands out as the most effective option, with the lowest plant damage of 1.45 percent and the highest average yield of 291.35 kg/plot, though it comes with a relatively higher cost. In terms of value, the Shade Net Fencing (T5) and the olfactory repellent BoRep (T6) demonstrate impressive efficacy with a yield of 260.86 kg/plot and 271.88 kg/plot, respectively, while maintaining lower costs. Conversely, the Nylon Rope (T2) emerges as the least effective method, with an average yield of only 165.76 kg/plot; despite its higher cost relative to some more effective options. Overall, the data suggests that investing in electric fencing or utilizing shade nets and olfactory repellents could provide better protection for crops, balancing efficacy and cost-effectiveness.

Table 4.7. Evaluation of efficacy of different wild pig management technique in cassava

Sl No	Treatment	Plant damage (percent)	Average yield (Kg/plot)	Yield increase over control
1	Agri solar Fencing (Physical barrier) - T_1	1.45^{a} (2.31)	291.35^{a}	45.6
2	Nylon rope around crop field (Physical barrier) -T_2	14.13^{d} (26.66)	165.76^{d}	5.33
3	Nylon net around the crop field (Physical barrier) -T_3	6.89^{b} (12.91)	240.33^{b}	34.71
4	GI wire around the crop field (Physical barrier) -T_4	10.99^{c} (21.76)	190.30^{c}	17.50
5	Shade net fencing around the crop fields (Physical barrier) -T_5	4.19^{b} (8.91)	260.86^{a}	39.83
6	BoRep (@2Kg/Acre) (Olfactory repellent) - T_6	5.97^{b} (9.11)	271.88^{a}	42.28
7	Control -T_7	16.27^{d} (28.39)	156.81^{d}	--
	CD@ 5percent	**5.15**		
	CV	**16.55**		

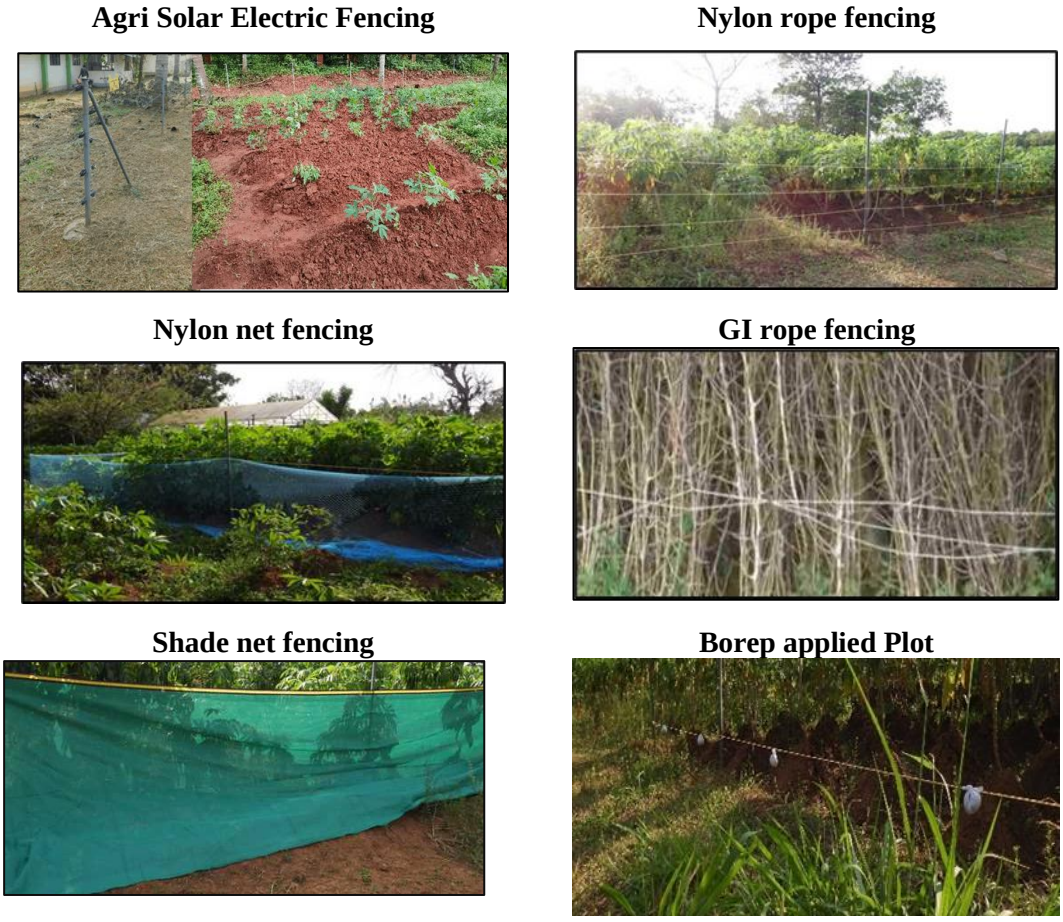


Fig. 4.2. Different treatments evaluated against wild pig in cassava

In the study across three selected villages of Kerala, the scientists gathered data on farmer participation in managing wildlife impacts on crops. In Mothorakkanni, farmer Raghavan cultivated 03 acres of cassava and used 15 Kumbham traps per acre, successfully trapping 15 *B. bengalensis*. In Chelakkara, farmer Santhosh grew cassava on 04 acres and applied BoRep at 02 kg per acre, resulting in a 42.28 percent reduction in wild boar incidence compared to the previous year. Similarly, in Kambolachira, farmer Babu planted snake gourd on 01 acre, using BoRep at 02 kg per acre, leading to a 45 percent decrease in wild boar activity. These findings demonstrate the effectiveness of the management techniques in mitigating wildlife-related challenges for local farmers (Fig. 4.3).

Placing *Kumbham* trap | BoRep- banana | BoRep- Snake gourd

Fig. 4.3. Farmers assisted in conducting adaptive research in villages

The

scientists of Kerala centre have conducted participatory research with farmers in selected villages; the scientists have chosen three locations: Mothirakanni, Chelakkara, and Kambolachira (Table 4.8). In these villages, we have implemented various management techniques for addressing issues related to wild boars and rodents, all with the active support and cooperation of the local farmers. This collaborative approach allows us to test and evaluate different strategies directly in the farmers' fields, ensuring that the solutions are practical and relevant to their specific challenges.

The details regarding the specific problems faced, the treatments applied, and the observations made during this research are summarized in Table 4.8. This data highlights the effectiveness of the interventions and fosters a deeper understanding of the issues at hand, facilitating further improvements in wildlife management practices. By involving farmers in the research process, the centre aims to create sustainable solutions that benefit both agriculture and the local ecosystem.

Table 4.8. Farmer's participatory adaptive research in three selected villages of Kerala

S N	Location with GPS points	Name of farmer	Crop and variety	Area	Date of sowing	Treatment imposed	Observation and remarks
1	Mothorakkanni (10.32106, 76.41987)	Raghavan	Cassava	03 acre	11-08-2023	Kumbham trap @15/acre	Trapped 15 *B. bengalensis*
2	Chelakkara (10.69797, 76.35305)	Santhosh	Cassava	04 acre	17-10-2023	BoRep @ 2kg/acre	Reduced the incidence of wild boar @ 42.28 percent
3	Kambolachira (10.55633, 76.25073)	Babu	Snake gourd	01 acre	23-12-2023	BoRep @ 2 kg/acre	Reduced the incidence of wild boar @ 45 percent

4.6. Karnataka (UAS, Bengaluru)

Two villages in Chikkaballapur and Bidaluru, of Bengaluru rural District were adopted to carryout rodent, bird and wild boar management campaign on a large scale. Initially, the general information on population, landholding, major crops present, and allied activities (Table 4.9) taken up in the villages was collected from the village to plan for management. Out of three villages, Bidaluru was treated as a control village where no extension intervention activities were taken up. In one treatment village (Kenkere) all extension activities like training programme and demonstrations were taken up, besides the farmers were provided with all required inputs necessary for the management of rodents (baiting materials and traps), birds and wild boar (Bio acoustics, reflective tapes, jute ropes and nets) it was taken up in entire village both in houses and fields crops areas. Whereas, in second treatment village (Tippenahalli) only extension activities like training programme and demonstrations were taken up. The result indicated that there was a reduction of rodent, bird, and wild boar damage by 81.56, 75.62 and 68.42 per cent at harvest, respectively in Kenkere (first village) whereas, input as well as knowledge was given. Whereas, in Tippenahalli (2nd village) where only knowledge was given and input was arranged by farmers themselves, reduction in rodent, bird and wild boar damage was only 46.52, 42.85, and 37.14 per cent at harvest, respectively, (Figure 4.4) indicating that farmers are reluctant to practice the management, though they were well aware of the things to do with the knowledge on vertebrate pest management. Hence only providing knowledge/information is a failure in villages. In the third village (control) either extension intervention or any materials were supplied, the rodent, bird and wild boar damage was increase by 20.54, 19.54 and 23.45 per cent at the harvesting, respectively (Figure 4.4). The entire process covered on area of 656 ha and 1346 farmers. The KAP (Knowledge, adoption and practice) analysis indicate that in first village (Kenkere) due to our interventions w.r.t. extension activities and resource supply, the knowledge (94 percent) adoption (91 percent) and practices (92 percent) were maximum when compared with initial data with lesser incidence to birds, wild boars and rodents on various crops. Where as in second village (Tippenahalli) where only extension interventions were made without supply of resources/inputs, the knowledge gained was maximum (88 percent), with medium adoption (76 percent) and practices (72 percent). The incidence due to birds, rodents and wild boar were

medium. However, in case of control village (Bidalur), the knowledge, adoption and practices were remained same and the incidence due to birds, wild boar and rodents increased compared to initial data indicating that extension intervention w.r.t., management of vertebrates is essential (Fig. 4.5, 4.6).

Table 4.9. General information of selected villages for adaptive research

Sl. No.	General information	Kenkere, Gowribidanooru Tq. Chikkaballapur District	Tippenahalli, Sidlaghatta Tq. Chikkaballapur District	Bidaluru, Devanahalli Tq. Bangalore rural District
1.	Total population	1123	1026	982
2.	Total house holders	146	118	106
3.	Total area under cultivation (ha)	803	751	698
4.	Total area under irrigation (ha)	281	237	206
5.	Total No. of land holders	146	126	113
6.	Major crop grown during the year	Ragi, Groundnut, Tur, Paddy, Pulses, Fodder, Sorghum, Cucumber, Jasmine etc.,	Ragi, coconut, paddy, vegetable, cowpea, Field bean, Sorghum cowpea, etc.,	Paddy, Ragi, Sorghum, Beans, Fodder, Mango, Banana, Chrysanthemum Tomato etc.,
7.	Allied Agricultural activities	Dairy, Poultry, Sheep rearing	Dairy, Poultry, Sheep rearing	Dairy, Poultry, Sheep rearing

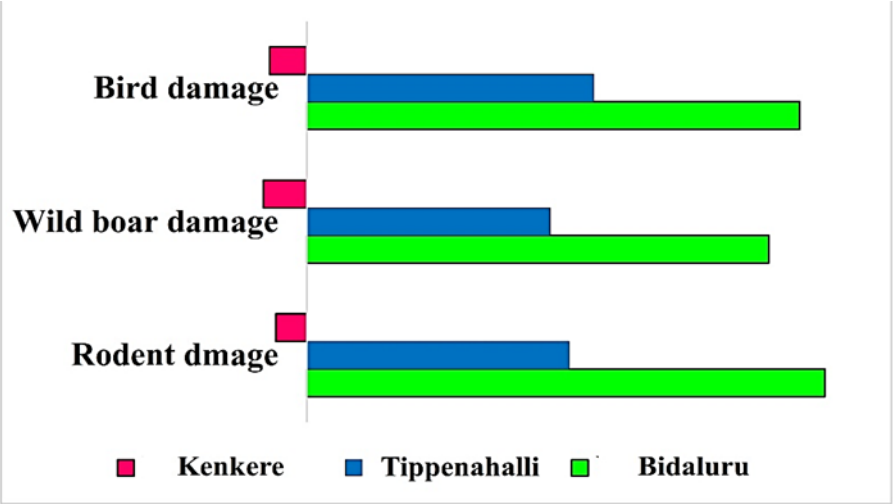


Fig 4.4. Influence of adaptive research on rodent, birds, wild boar menace in selected villages of Doddaballapura Taluk of Bengaluru district

Fig 4.5. Extension activities in selected villages of Doddaballapura Taluk of Bengaluru district

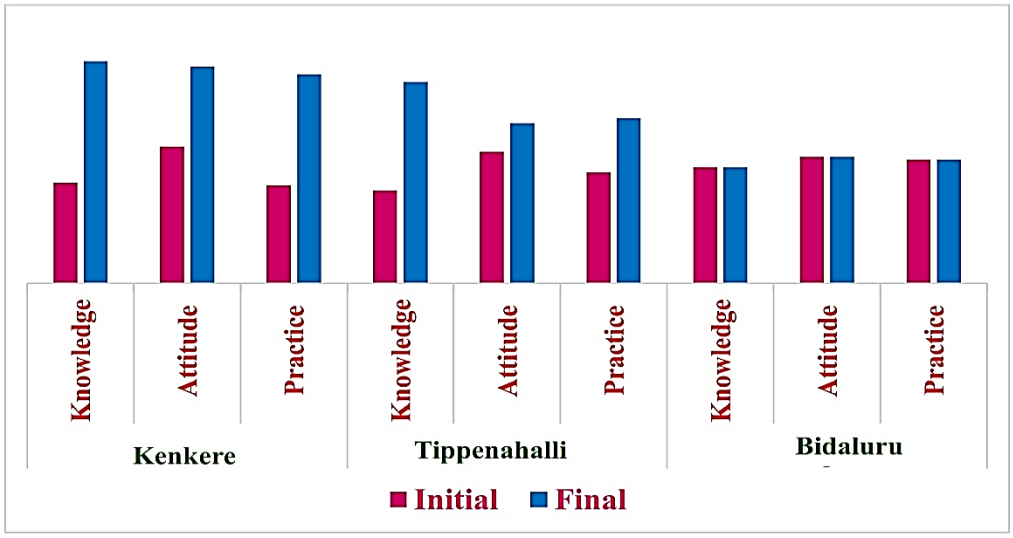


Fig 4.6. KAP Analysis of adaptive research on vertebrate Pest management in selected villages of Doddaballapura Taluk of Bengaluru district

4.7. Andra Pradesh (ANGRAU, RARS, Maruteru)

Participatory adoptive research, were taken up in three villages 1) Chinnamallam 2) Nadipudi and 3) Alamuur during the year 2023-24. In village 01, rodent management technologies developed by AINP on VPM, Maruteru centre like TBS and Mass Rodent control campaign on community basis were organized along with awareness creation and adoption. In village 02, only awareness was provided with nil input and village 03 was considered as control village with nil interventions and input. Before taking up the activity, KAP survey was conducted in all the three villages to identify the level of knowledge, attitude and practice on rodent control by the farming community in all the three villages. During the year 2023-24 in the adopted village Chinnamallam (01), demonstration on Trap barrier system was conducted after transplanting of rice. Further, rodent control campaign was organized on community basis at active tillering stage of the crop as per the protocol with complete technical and input support from the project. Pre and post campaign data was recorded on tiller damage and live burrow counts. Officials from DOA were also involved to achieve maximum participation in the village. The per cent rodent control success of 77.65 percent in terms of live burrows and 73.30 percent in terms of tiller damage was achieved. In another village Nadipudi (02), where only knowledge was provided rodent control success of 49.49 percent was achieved in respect of LBC/ha and 44.78 percent in terms of tiller damage. Similar activities were conducted during *rabi* season also. During *rabi*, the per cent control success of 79.76 in terms of live burrows and 77.97 in terms of tiller damage in was achieved Chinnamallam (01) village. In village Nadipudi (02), where only knowledge was provided percent rodent control success of 55.62 was achieved as LBC/ha reduction & 51.02 as tiller damage protection (Table 4.11 & 4.12). Installation of Trap Barrier System (TBS) was also done in adopted village Chinamallam in *Kharif* 2023. A total of 8 animals were trapped in the TBS and gave full protection to the paddy crop. TBS erected fields recorded only 1.85 percent tiller damage whereas it was 7.32 percent in non-TBS fields, thereby TBS has offered a mean protection of 74.65 percent to tiller damage (Table 4.10).

Table 4.10. Impact of TBS in adopted village against rodents in rice

Name of the farmer	Area	No. of rodents trapped	percent tiller damage protection	percent yield increase
Devarapu Maheshwararao	1 ac	9	78.32	3.66
Idhara Abhiram	1 ac	6	72.27	4.23
Gudara Paaparao	1 ac	8	73.36	6.66
	Total	23	--	
	Mean	7.6	74.65	

Table 4.11. KAP analysis in the project area (2023-24)

Particulars	Chinnamallam	Nadipudi	Alamuru
Score – K	46.5	53.8	67.0
Score – A	71.6	80.9	74.5
Score – P	62.3	78.3	72.7
Motivational Media	Demonstrations and Interactions	Demonstrations and Interactions	Demonstrations and Interactions
Techniques adopted	Knowledge & campaign organized on community basis	Only knowledge provided	Control

Table 4.12. Social Engineering on Rodent Control through Participatory Adoptive Research (PAR) in paddy (2023-24)

Particulars	***Kharif, 2023-24***			***Rabi, 2023-24***		
Name of the village	**Chinnamallam**	**Nadipudi**	**Alamuru**	**Chinnamallam**	**Nadipudi**	**Alamuru**
Mean no. of live burrows / ha						
a) Pre treatment	25.14	20.63	23.41	23.81	18.59	20.84
b) Post treatment	5.62	10.42	-	4.82	8.25	-
Per cent Rodent control success	**77.65**	**49.49**	**-**	**79.76**	**55.62**	-
Percent tiller damage/ha						
a) Pre treatment	20.26	24.12	23.94	15.48	14.72	13.13
b) Post treatment	5.41	13.32	-	3.41	7.21	-
Per cent Rodent control success	**73.30**	**44.78**	**-**	**77.97**	**51.02**	-

4.8. Assam (AAU, North Lakhimpur)

The proven technologies and technology under pipeline for vertebrate pest management recommended by different centres were demonstrated in 6.0 ha area with active participation of farmers in nine different locations spread over 02 districts and results and impact are presented (Table 4.13 & 4.14, Fig. 4.7a to 4.7d, 4.8). Damage caused by vertebrate pests and ITK used by the farmers were also recorded (Table 4.15). Bird damage has been repeatedly reported to cause economic loss in the agricultural field. Many methods have been employed to deter birds using various visual, auditory, tactile and olfactory deterrents. More novel approaches have been evaluated to cause effective management practices to control bird nuisance. Such an indigenous inexpensive farmer's friendly visual scaring device has been evaluated in the paddy fields of *Boro* rice in North Lakhimpur, Assam in the form of artificial *Drive Away* a big mechanical dummy bird with the concept of alarm in birds against predator. The test model (1x2m) is light weight, transportable and made with thin tin sheets that simply reflects the sunlight and incorporated with rattlers that produce sound. The model is suspended in the air through an elastic string attached to a bamboo pole for easy rotary, to and fro movement that gives flexibility to move through wind direction. The results showed a decreased activity of birds in the treated plots compared to the untreated plots. Using drive away ITK artificial bird cause reduced grain damage by birds in treated (46.14 percent) as compared to the untreated plots (60.73 percent). The array of visual and auditory deterrents are expansive or labour intensive and provide effective results, but as it is subjected to quick habituation by birds, the refinement of management technologies may provide to quicker and effective solutions to the pest problems.

Table 4.13. Farmers participatory adaptive Research – Large scale Demonstrations

Farmer	Location	Area covered (ha)	Technologies
Sunil Neog	Dikhowmukh, Sivasagar	0.25	Agri- solar fencing for Monkey management HDPE NET for Monkey management Rodent management in Deep water Paddy Reflective Ribbon & *Drive away bird* Repeller for depredatory bird management T- Perch and Barn owl nest box as a component of IPM in paddy field.
NityaNeog	Nakatani, Sivasagar	0.25	
Kamal Bora	Fesuchapori Lakhimpur	2.0	
KushalThegal Moheswar Mahanta BhabenGogoi, Kanak Sipahi	Kuchiamari, Lakhimpur Naharani Karipukhuri GabharuTunujan Uriampora	1.0 0.5 0.5 1.5	

Fig. 4.7a. Demonstration on HDPE Net for Protecting crops from monkey

Fig. 4.7b. Demonstration on used of Barn owl for rodent management & T perch for IPM

Fig. 4.7c. Demonstration on Rodent Management in Deep water rice field

4.7d. Demonstration on Bird repeller "DRIVE AWAY"

Table 4.14. Extent of damage (percent) caused by *Rhesus macaque* in *Rabi* crops in adaptive trials

Crops grown	Crops covered with Agri solar fencing (percent damage)	Crops covered with HDPE net of 8 feet height (percent damage)	Control plot (percent damage)
Knolkhol	0	0	60
Brinjal	0	0	0
Bottle gourd	0	0	90
Green bean	0	0	90
Pumpkin	0	0	0
Spinach, coriander	0	0	10
Mustard	0	0	0
Chilli	0	0	2
Coriander 0	0	10	

Fig. 4.8. Damage assessment *Rhesus* Macaque in Technology adopted villages

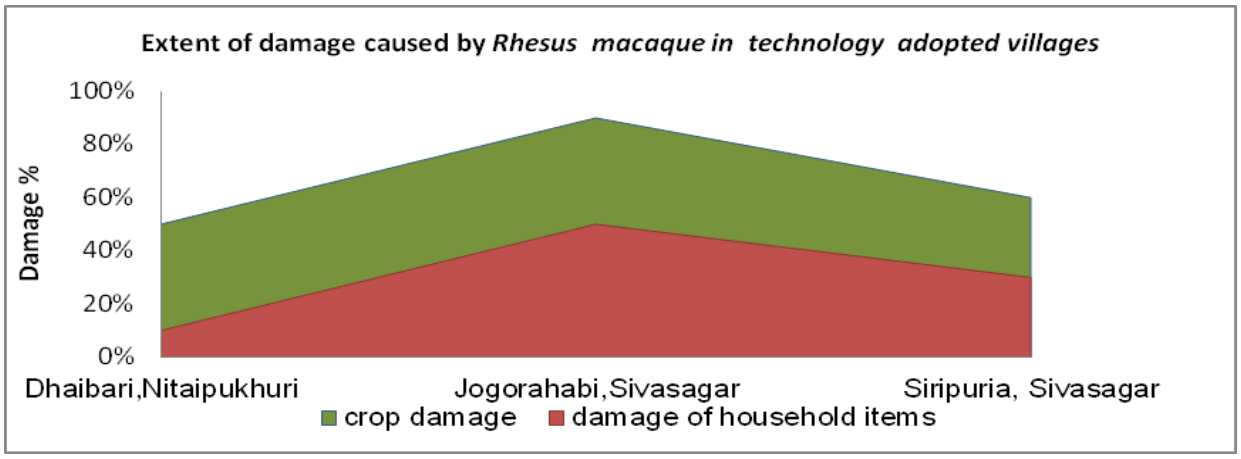


Table 4.15. Management strategies adopted by farmers against major vertebrate pests in experimental locations.

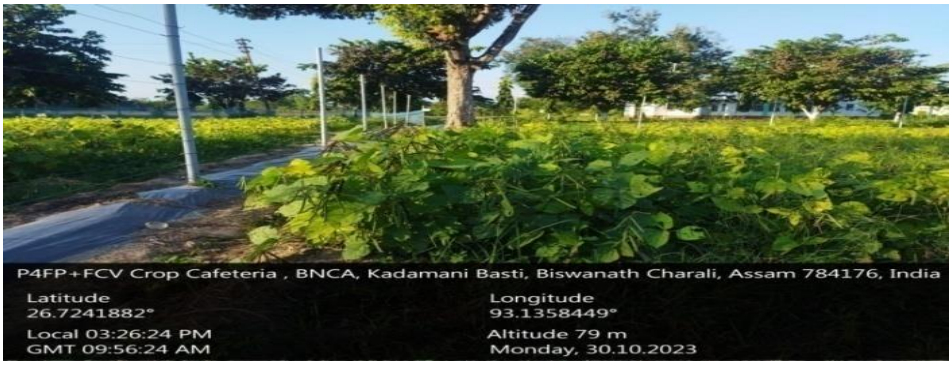
Sl. No.	Agro climatic Region	Name of Vertebrates pest	Management Strategies
1.	North Bank Plan Zone	Wild boar	Fencing, torch lightning, use of different sounds
		Parrot	Beating of drums, use of catapult
		Rodents	Digging of rat holes, rodenticides
2.	Central Brahmaputra valley Zone	Wild boar	Fencing, torch lightning, use of different sounds
		Parrot	Beating of drums, use of catapult
		Rodents	Digging of rat holes, rodenticides, use of traps
3.	Upper Brahmaputra valley Zone	Wild boar	Fencing, torch lightning, use of different sounds
		Monkey	Use of guilty, use of sounds
		Squirrel	Use of trap
		Rodents	Rodenticides, use of traps

Technology adoption & impact

- Crops grown inside the solar fencing *(AGRI- SOLAR*); a potential method to reduce the problem of intrusion by higher vertebrates (Monkey) into the agricultural landscape gave significantly higher yield as compared to crop yields recorded in the same plot without solar fencing in the previous year.
- HDPE net of 5 cm mesh and 1.5 mm thickness using bamboo poles of 8 feet in height found to protect *Rab*i and *Kharif* vegetables and effective in preventing monkey's entry in to the crop fields to the extent of 80-100 per cent and also a cost effective one.
- Use of ECO-Gun and wrapping of maize cobs in outer 3 rows significantly reduced the cob damage by parakeets.

Technology modification for adoption and acceptance

Solar fence with mulch paper enhances the efficacy and life of the wire by controlling the weeds, a major problem in Assam Using low-cost plastic fish networks same as nylon HDPE to protect crops from Monkey



4.8. Assam (AAU, Jorhat)

The villages selected for social engineering activity were 'RajabahorTup' and 'Deughoria' as adopted and partially adopted villages, respectively and 'Gayangaon' as control village. In adopted village (RajabahorTup) training, method demonstrations as well as inputs were supplied but in case of partially adopted village only training was provided. The major cropping system of the adopted villages was rice-vegetables.

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 percent) as cake at PI stage + local bamboo traps (*maatchitap*) @ 50 traps/ha. Emphasis has been given in clean cultivation including weeding on bunds and surroundings the roads, field etc. The rodent damage and population were recorded at the beginning of the crop season followed by tuber formation stage, maturity and harvesting stage of the crop (Table 4.16).

The data indicated that rodent infestation increased gradually from vegetative stage and reached a peak during the tuber formation stage of the crop. In the adopted village however, rodent infestation decreased from tuber formation stage of the crop. The LBC in the control plot was 12.66 during vegetative stage of the crop which increased up to 46.11 at harvesting stage, while in the adopted village LBC was 11.98 in vegetative stage and increased up to 14.66 at tuber formation stage and then decreased again to 11.11 at harvesting due to intervention in terms of application of rodenticides + trapping (Table 4.16). Similar trends were also observed in case of Trap Index and Cut tillers damage

Table 4.16: Live burrow count (LBC), Trap Index in different crop stages of potato at Social Engineering site during 2023-24

Stage of the crop	LBC (No/ha)		Trap Index (percent)	
	V_1	V_2	V_1	V_2
Vegetative stage	11.98	12.66	2.71	2.89
Tuber formation stage	14.66	28.01	2.22	4.46
Maturity stage	11.11	46.11	2.01	8.87

V_1-Adopted Village V_2-Control Village

Impact Assessment of Farmers Participating Adaptive Research under Social Engineering: A

Fig. 4.9. On Field Demonstration of *Kheti Rakshak* (Gamyam KR-18) at Paddy Research station, Dabhoi (Vadodara District, Gujrat)

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. 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, 88.61percent farmers started practicing rodent control with zinc phosphide. (Table 4.17). 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 76.61 percent farmers used bamboo traps after training and demonstration and 64.44 percent 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 etc.

Table 4.17. Impact assessment of farmers participating adaptive research under social engineering activities

Sl No	Rodent control practices	percent adoption	
		Before	After
1	Doing regular rodent control in field crop	0	76.11
2	Doing regular rodent control other than crop field	0.00	67.26
3	Use anticoagulant	14.44	77.18
4	Poison baiting in the crop field	0	61.04
5	Poison baiting in the lean period	0	00.00
6	Doing pre-baiting in case of acute rodenticides	0	88.61
7	Use bait station	0	86.66
8	Use local bamboo traps	0	76.61
9	Use of mechanical traps	18.66	64.44
10	Doing weeding	56.31	86.66
11	Treatment in surrounding area/vacant lands	0	09.91
12	Collection of remaining poisons bait	0	86.15
13	Washing of traps before reuse	0	81.11
14	Collection of dead rodents	0	76.66

4.10. Gujarat (AAU, Anand)

The Field demonstration of *Kheti Rakshak* (Model: KR-18) was organized in a paddy field at Paddy Research Station, Dabhoi, Vadodara district to generate awareness for *Kheti Rakshak* and its effectiveness in scaring the wild boar in maize crop during maturity stage. The dissemination of VPM technologies to two ***Khedutshibir*** on vertebrate pest management for tribal farmers was organized at KVK, Dahod district. A total of 100 (50-50 male and female farmers) participated from four villages. The farmers were briefed and made aware of the VPM (Fig. 4.9).

4a. EXTENSION ACTIVITIES

Centers	Exhibitions (Nos)		Farmers Trainings (Nos)		TV/Radio/ extension lectures (Nos)	Kisan mela/field days (Nos)		TSP activities (Nos)		Others (Nos)	
	Organized	*Beneficiaries*	*Off/on campus*	*Beneficiaries*		*Organized*	*Beneficiaries*	*Organized*	*Beneficiaries*	*Organized*	*Beneficiaries*
CAZRI, Jodhpur	04	5760	06	140	-	-	-	02	60	-	-
PJTSAU, Hyderabad	-	-	30	897	10	-	-	4	160	-	-
PAU Ludhiana (RC)	03	Farmers and State Agriculture Development Officers of Punjab	On Campus: 2 Off-campus field demonstrations: 12	12 farmers + 8 health officials 215 farmers	03 TV talks + 08 extension lectures	Kisan Melas: 02 Field Days: 07	Thousands of farmers from Punjab and adjoining states 156 farmers	--	--	i.-Individual-level guidance to Farmers and application of management methods to prevent rodent and blue bull damage ii.-Issued 03 Advisories to farmers at specific crop timings for rodent control ii.- Presentation as a resource person at 03 Research & Extension Specialists' Workshops iv.-Individual Technical guidance through telephone/personal visit	i.15 farmers ii.Farmers of the whole Punjab state iii.Punjab State Extension personnel iv.+40 farmers, scientists, staff, residents and officials
PAU Ludhiana (AO)	05	>550	02	65	02	04	>1 lakh	-	-	03	>150
KAU, Thrissur	01	109	04	284	--	--	---	06	1096	02	110
UAS, Banga	02	1103 (Public	50	3182	02	02	05 lakhs	03	175 (Inp	Problematic field visits -	71

lore		and Students)					(Students, Farmers, and public Government stakeholders)		ut distribution) 1372 (Extension activities)	71	
RARS, ANGRAU, Maruteru	04	3500	08	350	03	04	2000	04	183		
AAU, Jorhat	-	-	10	255	-	-	-	08	320	01	50
AAU, Lakhimpur	01	500+	09	230	09	01	526	06	794	01	
AAU, Anand	00	00	02	100		02	3000 approx.	00	00	Farmers meeting: 20	250 approx.

4a.1. Rajasthan (CAZRI, Jodhpur)

4a.1.1. Off-campus training programme on Rodent Pest Management

SN	Title of Training	Date	Village	No. of Participants
1.	Rodent pest management	12.07.23	Ramgarh, District Jaisalmer	25 farmers
2.	Rodent pest management	13.07.23	Mohangarh, District Jaisalmer	20 Farmers
3.	Role of rodents in Agriculture and their Management	09.08.23	Gokulpura village District Sikar	15 farmers
4.	Vertebrate Pest Management	10.08.23	Chanpura village District Sikar	20 farmers
5.	Role of Rodents in cold arid Agriculture and their Management	23.08.23	Village Chandela, District Sirohi	30 farmers
6.	Role of Vertebrates in Agriculture and their Management	24.08.23	Village Girwar, District Sirohi	30 farmers

4a.1.2. Exhibitions on Rodent Pest Management

S.No.	Exhibition arranged	Date	Venue	Farmers visited/ benefitted (Nos)
1.	Exhibition on Vertebrate Pest Management during Kisan and Pashu Mela	1-3 April, 2023	Tilwara, Barmer	5000
2.	Chandela, District Sirohi (TSP)	23 August, 2023	Mudrla and Vasda,	30
3.	Girwar, District Sirohi (TSP)	24 August, 2023	Stakna	30
4.	Agriculture Innovation Visit Kharif-2023	29 August, 2023	CAZRI, Jodhpur	700

4a.2. Telangana (PJTSAU, Hyderabad)

Date	Title of the programme	Location	No. of participants
11.07.2023	VPM technologies	VPM office, R. Nagar	40
15.07.2023	VPM technologies	Mahbubnagar	40
02.09.2023	Exhibition	PJTSAU Auditorium	220
27.09.2023	Vertebrate Pest Management	Nagarkurnool	40
10.11.2023	Kisan mela	Nidigonda, Jangaon	650
10.01.2024	Rythusadassu (Sesame)	RARS, Jagtial	1150
07.02.2024	Apiculture	Patancheru	70
20.03.2024	Vertebrate Pest Management	Kundurg, Rangareddy	30
27.03.2024	VPM technologies	VPM office	50
30.03.2024	Rythusadassu	Motakondur, YadadriBhongir	85
17.05.2024	convergence meeting with line departments and awareness session on solar fencing	Gollagudem, YadadriBhongir	40
20.05.2024	wild animal management	Chinnakodur, Siddipet	80
23.05.2024	VPM technologies	VPM office	40
25.06.2024	VPM technologies	VPM office	65
12.08.2024	Vertebrate Pest Management	Rampur, Vikarabad	45
17.08.2024	VPM technologies	VPM office	40
21.08.2024	VPM technologies	VPM office	40
30.09.2024	Vertebrate Pest Management	Mujahidpur	52

4a.3. Punjab (PAU (RC), Ludhiana)

4a.3.1. Off camps training

S. No.	Name of the programme and the place	Date (s)	No. of farmers
1.	Training camp on different methods of managing rodent pests and blue bull in field crops	29.11.2023 (Dr BK Babar)	12 Farmers of village Noorpurbet, district Ludhiana
2.	Training camp on different methods of managing rodent pests and blue bull in field crops	12.12.2023 (Dr BK Babar)	20 Farmers of village Chandiala. Amlala, district Mohali
3.	Training camp on different methods of managing rodent pests in field crops and residential areas	04.06.2024 (Dr N Singla)	30 Farmers of village Minian of district Moga
4.	Training camp on different methods of managing rodent pests and blue bull in field crops	11.06.2024 (Dr BK Babar)	12 Farmers of Village Guhawar, district Jalandhar
5.	Training camp on different methods of managing rodent pests in field crops and residential areas	24.06.2024 (Dr N Singla)	20 Farmers of village Purane Wala of district Moga
6.	Training camp on different methods of managing rodent pests and blue bull in field crops	05.07.2024 (Dr BK Babar)	20 Farmers of village Chandiala. Amlala, district Mohali
7.	Training camp on different methods of managing rodent pests and blue bull in field crops	August 2024 (Dr BK Babar)	42 Farmers of village Mallah, District Ludhiana

4a.3.2. Training organized

S.No.	Name of training	Participants	Date (s)
1.	One-day training program on 'Rodent Pest Management in commensal areas' was organized for the staff of Civil Hospital Ludhiana at PAU campus.	8 staff members including staff nurse, sanitary inspectors, and others	09.05.2024 Wide coverage in newspapers and the PAU website (Dr N Singla and Dr BK Babar)
2.	One day Farmer's Training on 'Vertebrate Pest Management' was organized for farmers at PAU campus	Farmers of villages Noorpur Bet, Garah (Block Mangat) and village Mallah, (Block Jagraon), district Ludhiana	11.07.2024 (Dr BK Babar)

4a.4. Punjab (PAU (AO), Ludhiana)

Sr. No.	Date	Title	Location	No of participant
Training				
1	11.07.2024	First One-day Vertebrate Pest Management Training Course for Farmers	AINP-VPM, Department of Zoology, PAU, Ludhiana	30
2	02.08.2024	Training on Wildlife cameras for field photography was organized in collaboration with Nikon, India.	AINP-VPM, Department of Zoology, PAU, Ludhiana	35
Large scale Demonstration				
1	08.08.2024	Block-Village level Field Day was organized at village Mallah of district Ludhiana in collaboration with the Co-operative Society and the farmers of neighbouring villages also participated.	Mallah, district Ludhiana	>60
2	26.07.2024	Demonstration of VPM technologies at village Rajjapur of district Ludhiana in collaboration with the agricultural department.	Rajjapur, Ludhiana	>40
3	23.08.2024	Demonstration of VPM technologies at village Kathgarh of district Patiala in collaboration with the KVK, Rauni.	Kathgarh, Patiala	>50
Dedicated village level demonstration				
	07.12.2023	Demonstration of VPM technologies and interactions with the farmers.	Gocher, Mohali	>10
	31.01.2024	Demonstration of VPM technologies and interactions with the farmers.	Fazilka, Shri Mukutsar Sahib	>15
	12.07.2024	Demonstration of VPM technologies and interactions with the farmers.	Burana, Mohali	>15
	18.07.2024	Demonstration of VPM technologies and interactions with the farmers.	Chakdehra, Ropar	>10
	08.08.2024	Demonstration of VPM technologies and interactions with the farmers.	Shekha Kalan, Moga	>20
	23.08.2024	Demonstration of VPM technologies and interactions with the farmers.	Mirjapur, Mohali	>10
	18.09.2024	Demonstration of VPM technologies and interactions with the farmers.	Ladhowal, Ludhiana	>15
Exhibitions				
1	22-23.02.2024	The Research and Extension Specialist' Workshop for *Kharif* Crops	PAU, Ludhiana.	>200
2	10-11.08.2023	The Research and Extension Specialist' Workshop for *Rabi* Crops	PAU, Ludhiana	>200



4a.5. Kerala Agricultural University, Thrissur

Date	Title	Location	Number of participants
17-01-24	Session on Rodent management – DAESI Programme at ARS Anakkayam, Malappuram Dist.	Anakkayam, Malappuram	50
17-02-224	**Demonstration** of Agri-Solar at Konnalloor Padasekharam, Melarcode, Nenmara Block, Palakkad Dist. under FPBPP programme	Melarcode, Palakkad	60
10-05-24	Session on Ornithology and Vertebrate Pest Management – DAESI Programme at KVK Thrissur Dist.	KVK, Thrissur	50
16-06-24 to 26-06-24	**Rodent control campaign** in coconut fields at Manaloor, Thrissur Dist.	Manaloor, Thrissur	50
24-07-24	Training on VPM techniques & Distribution of Agri-inputs to tribal farmers of Aralam, Kannur Dist.	Aralam, Kannur District	109
17-08-24	Session on the management of wild animal intrusion in crop fields- Karshakadinam, at Chelakkara Krishi Bhavan , Thrissur Dist.	Chelakkara, Thrissur Dist	75

4a.6. Karnataka (UAS, Bengaluru)

4a.6.1. Extension activities under adaptive research

Village	Activity	Date	Beneficiaries
Kenkere, Gowribidanooru Tq. Chikkaballapur District	Training programme	• 21/8/2023 • 19/10/2023	• 143 farmers • 127 farmers
	Field demonstration	• 13/9/2023 • 24/9/2023	• 75 farmers • 75 farmers
	Exhibition	• 19/10/2023	378 (includes school children)
	Input distribution	21/10/2023	50 families
Tippenahalli, Sidlaghatta Tq. Chikkaballapur District	Training programme	• 23/8/2023 • 17/10/2023	• 127 farmers • 113 farmers
	Field demonstration	• 10/9/2023 • 22/9/2023	• 68 farmers • 68 farmers
	Exhibition	17/10/2023	327 (includes school children)

4a.6.2. Extension achievements

Extension activity	Numbers	No. Participants	Description
Training programme	26	1899	Vertebrate /Rodent pest management
Demonstration	24	1283	Baiting techniques, Use of different types of rodent traps and rodent management in horticultural crops, warehouses and poultry units, Bio-acoustic device, Wild boar, and bird management techniques.
Resource person	5	153	Rodent pest management / Vertebrate pest management
Problematic field visits	71	-	Rodents, wild boar, monkeys.
Radio & TV	2	-	DD Chandna, AIR.
Exhibition	4	-	Attended Krishi mela conducted by UAS, GKVK, Bangalore / ARS, Kunigal. National College, Basavanagudi

4a.7. Andhra Pradesh (RARS, ANGRAU, Maruteru)

4a.7.1. Trainings

S. No	Date	Title	Location	No of participants
1.	23.06.2023	Training on Vertebrate pest problems and mitigation measures	Rampachodavaram	Farmers (52)
2.	26-06-2023	Capacity building on the management of vertebrate pests in crop fields	Addateegala	Farmers (58)
3.	29.09.2023	vertebrate pest problems and their management	Virtual Mode	Crop protection officers (36)
4	16-12-2023	Management of vertebrate pests in crop fields	Rajavommangi	Farmers (23)
5	07-02-2024	Community rodent management	Vudumudi	Farmers (50)
6	24-02-2024	Capacity building on Vertebrate Pest Management to B.sc (Agri) students	Maruteru	Students (60)
	30-03-2024	Capacity building on Vertebrate Pest Management to (Agri. Diploma) students	Maruteru	Students (45)
7	27-06-2024	Integrated vertebrate Pest Management	Buttayagudem	Farmers (50)
8	24-10-2024	Training on Integrated vertebrate Pest Management to AOs, AEOs, and VAAs (partnering with central integrated pest management centers, GOI)	Maruteru	37

4a.7.2. Demonstrations

S. No	Season	Programme	Venue
1	*Rabi* 2024	Demonstrations of Trap Barrier System Rice Nurseries	Nellore
2	*Rabi* 2024	Demonstrations of Trap barrier system at farmer fields	Manchili
3	*Kharif*, 2023 and Rabi, 2023-24	Community rodent control campaign	Chinnamallam

Training programme on community rodent management at Vudumudi (2024)

FLD on Solar fencing against macaques in maize at Buttayagudem (rabi 2023-24)

Demonstrations of Trap barrier system at farmer fields at manchili

Capacity building on Vertebrate Pest Management to B.Sc. (Agri) students

4a.8. Assam (AAU, North Lakhimpur)

Sl No	Date	Title	Location
1	8/23/2023	Hands on Training on use of Bio-acoustic for the management of Vertebrate Pest in Agriculture	Nagaon, Boginadi, North Lakhimpur
2	9/29/2023	Hands on Training for Vertebrate Pest Management in Agriculture	DAO Office, Lakhimpur
3	10/13/2023	Training on Vertebrate Pest Management in Homestead Garden	Dekhowmukh, Sivsagar
4	11/9/2023	Awareness Meeting and Input Distribution (Rabi Veg. seed & Rat traps)	Dubi Village, Lakhimpur
5	2/12/2024	Training on Vertebrate Pest Management (Bird)	Fesu Chapori, Lakhimpur
6	3/20/2024	Awareness -Training & Workshop (World Sparrow Day)	NICRA, Borbali , Chamua
7	3/22/2024	Training on Vertebrate Pest Management	Rupohimukh, Sivsagar
8	3/27/2024	Training on Vertebrate Pest Management	Narayanpur, Lakhimpur
9	3/20/2024	Awareness Training on Bird Conservation in Agricultural Landscape	Dikhowmukh, Sivsagar




Training conducted under AINP on VPM, AAU-ZRS, NL centre during 2023-2024

4a.9. Assam AAU, Jorhat)

	Title	Date	Location	No. of participants
	Interactions with farmers regarding traditional grain storage structures and measures to be adopted for reducing vertebrate pests	12-05-23	Dikhowmukh, Sivsagar	30
	Training cum demonstrations on Vertebrates pest management in kharif vegetables	30-05-23	Balijan, Titabor	25
	Field demonstrations of rodent pest management in transplanted rice	07-07-23	Sankor Chuk, Bahphala	40
	Training and method demonstrations of different rodent pest management techniques in *sali* rice	15-07-23	Dighalipam, Badulipar	80
	Field training cum method demonstrations were conducted to aware the farmers about the application of different rodent pest management techniques in sali rice	05-08-23	Kolbari, Bekajan	30
	Field training cum method demonstrations on rodent pest management were conducted to aware the farmers	31-08-23	Dighalipam	25

	about the application of different rodent pest management techniques in rabi vegetables			
	Field training cum method demonstrations on rodent pest management were conducted to aware the farmers about the application of different rodent pest management techniques in rabi vegetables	08-09-23	Dighalipam	30
	Agri-cannon demonstrations were conducted to scare monkey from agro ecosystem	15-09-23	Titabor	25
	Field training cum method demonstrations on rodent pest management were conducted to aware the farmers about the application of different rodent pest management techniques in Kharif rice	04-10-23	Upor Temara	40
	Field training cum method demonstrations on vertebrate pest management were conducted to aware and demonstrate to the farmers the application of different pest management techniques in crop ecosystem	07-11-23	Balijan	35
	Participated in the Farmers Fair with exhibits at ARRI, Titabor	10-11-23	Titabor	>2000
	Method demonstrations and interactions with farmers on integrated rodent pest management techniques in rice crops	18-11-23	Kolbari, Borhulla	30
	Participated in the Farmers Fair with exhibits at Sugarcane Research Station with Exhibits	04-12-23	Buralikson	>1500
	Method demonstrations and interactions with farmers on monkey management techniques in crop ecosystem	08-12-23	Balijan, Golaghat	30
	Field training cum method demonstrations on rodent pest management was conducted to aware and demonstrate the farmers about the application of different rodent pest management techniques and methods in vegetables	30-12-23	Dikhowmukh	60
	Field training cum method demonstrations on rodent pest management was conducted to aware the farmers about the application of different rodent pest management techniques and methods in potato	30-01-24	Dikhowmukh	30
	Method demonstrations and interactions with farmers on monkey management techniques in crop ecosystem	12-02-24	Balijan, Golaghat	40
	Farmers training cum method demonstrations on vertebrate pest management technologies	23-03-24	Kolbari, Borhulla	25

LOCATION SPECIFIC PROGRAM

1. BIO ECOLOGY AND MANAGEMENT OF PURPLE MOORHEN IN RICE

Wetlands in the districts of Vadodara, Padra, Savli, Karjan, and Dabhoi block were observed for the presence of moorhens and their effects on the surrounding agricultural land (Fig. 1). Total 261 moorhens were found (11.86 moorhens on average per wetland). Out of these, 30 and 70 percent were found in marshlands and pond, respectively. Whereas, based on vegetation preference 40, 32, 12, 10 and 6 percent preferred *Eichhornia crassipes*, *Phragmites* sp, *Nali* weed, *Typha angustifolia* and *Nelumbo nucifera,* respectively (Fig. 2 & 3). During the survey farmers were also opined that moorhen causes little damage to paddy crop in the initial stage after transplanting.

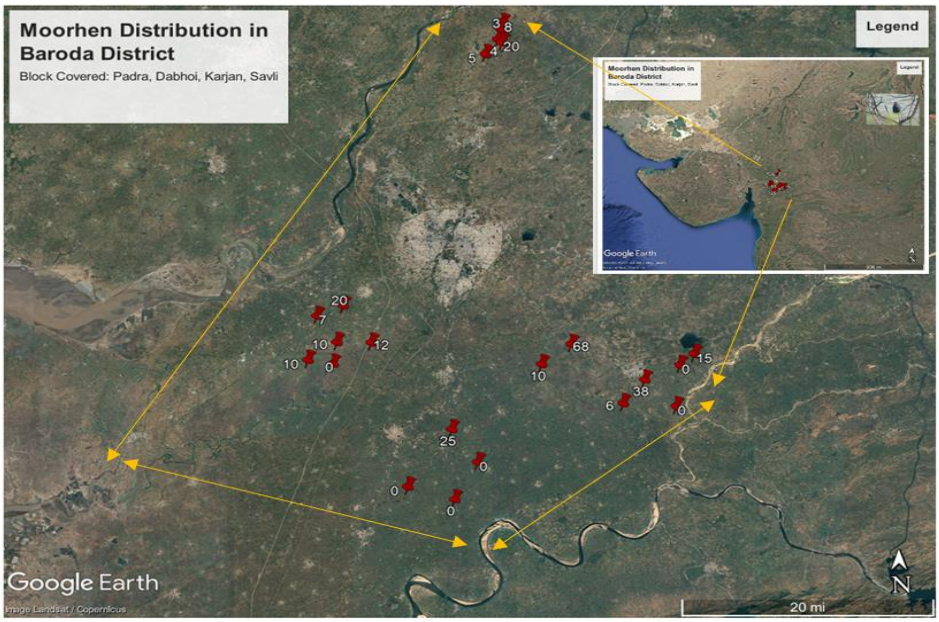


Fig. 1.1 Moorhen distrib ution in Baroda district

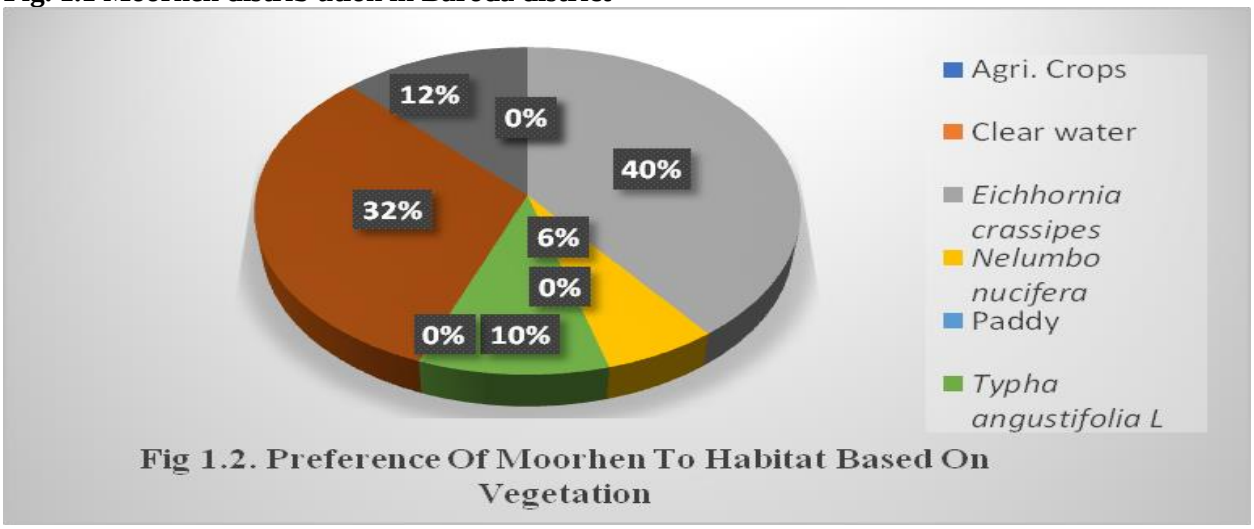


Fig 1.2. Preference Of Moorhen To Habitat Based On Vegetation

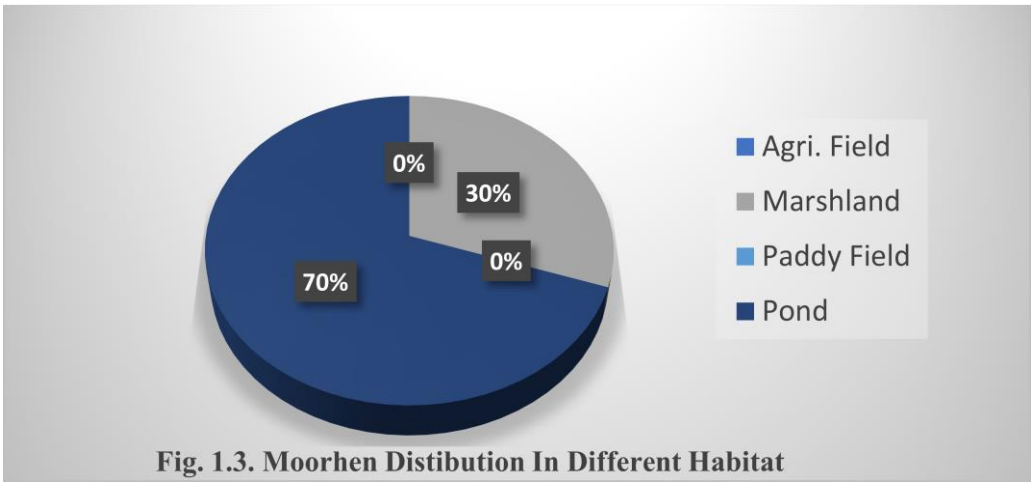


Fig. 1.3. Moorhen Distibution In Different Habitat

The village ponds adjacent to the agricultural fields at selected twenty villages of five districts i.e. Ludhiana, Barnala, Tarantaran, Rupnagar and Fatehgarh Sahib were surveyed for activity of purple moorhen. Purple Moorhen was found to cause damage in paddy fields at location specific fields near ponds (Fig. 4). Estimation of damage in the study area revealed that damage by the moorhen ranged from 2.40 –14.70 percent in germinating/transplanting rice crop and it was variable at all the locations depending upon the area under ponds and surrounding habitat structure (Fig. 4). For the management of Purple Moorhen, one side of the crop field facing the pond was fenced by poly net and supplemented by reflective ribbons, the combination treatment proved more effective than single method. Besides, habitat management, which includes removal of weeds and conservation of vegetation at the pond edges, proved effective, as then villages where habitat management was carried out, damage by purple moorhen was negligible and in unmanaged ponds the damage was moderate to high.

Table 1.1. Bio ecology and management of purple moorhen in rice

Villages	**Presence of Purple Moorhen**			**Presence of water body nearby**		**Damage (percent) to nearby fields**	**Management methods**
	Information from farmers	***Field observation***	***Flock size (n)***	***Type of water body***	***Distance from field (m)***		
Rajjapur, Ludhiana	Yes	Yes	5-8	Ponds	5	10.0	P, RR, HM
Pabbian, Ludhiana	Yes	Yes	10-13	Pond	6	12.8	P, RR, HM
Sanghera, Barnala	Yes	Yes	7-10	Pond	12	9.5	RR, HM
Chambakalan, Tarntaran	Yes	Yes	6-9	Pond	8	5.8	RR, HM
Morinda, Rupnagar	Yes	Yes	5-7	Pond	3	2.4	P, HM

Chak dhera, Roopnagar	Yes	Yes	12-16	Pond	5	14.7	P, RR, HM
Khera, Fatehgarh Sahib	Yes	Yes	6-9	Pond	4	4.9	RR, HM

P- Polynet; RR- Reflective Ribbon; HM- Habitat Management

2. EFFECTIVENESS OF TREE COVER ON VERTEBRATE (ROSE-RINGED PARAKEET *Psittacula krameri* (Scopoli)) DAMAGE IN POMEGRANATE

The experiment on the effectiveness of tree cover to reduce the rose–ringed parakeet (*Psittacula krameri*)) depredation on pomegranate fruits was initiated at Anand (Gujarat) in year 2023-24. The treatments, nylon anti-bird net cover, fruit bagging, and control were applied at the time of damage initiation. A total of 40 trees were selected randomly from the orchard @ 10 trees for each treatment. The total number of fruits in each tree was counted before the application of the treatment. Observation of damage caused by the rose-ringed parakeet on pomegranate was recorded from March to July. The number of parakeets visiting to treatment plot was counted at ten ten-day intervals (Fig. 2.1).

Fig. 2.1. Treatments applied in field area

An average of 126 parakeets were recorded ranging between 121 during the morning and 131 birds in the evening hours in the control plot (Fig. 2.2). Difference in bird visitation period in all treatments (ranges between 24 to 36) was found significantly different from the control plot. Out of 40 sampled trees, 21-35 average number of total fruit were observed from which, 16.79 fruits were found damaged and 11.88 numbers were found healthy in the control plot. while in plots treated with paper bags and nylon net, damage was not recorded in which, 31.83 and 34.50 healthy fruits were recorded, respectively (Table 2.1 & 2.2).

Table 2.1. Parakeet depredation on pomegranate fruits in orchard

Particular	No. of fruits/tree					
	1st Picking		2nd Picking		Total	
	Damage	Healthy	Damage	Healthy	Damage	Healthy
T_1 **Paper bag**	0.71* (0.00)	2.24 (4.53)	0.71 (0.00)	1.31 (1.22)	0.71 (0.00)	5.69 (31.83)
T_2 **Nylon net**	0.71 (0.00)	2.46 (5.57)	0.71 (0.00)	1.47 (1.65)	0.71 (0.00)	5.92 (34.50)

T_3 **Grow cover**	1.19 (0.90)	2.00 (3.51)	0.93 (0.36)	1.11 (0.74)	2.84 (7.56)	4.73 (21.88)
T_4 Control	1.65 (2.23)	1.46 (1.63)	1.01 (0.52)	0.93 (0.36)	4.16 (16.79)	3.52 (11.88)
S. Em	**0.06**	**0.28**	**0.02**	**0.04**	**0.08**	**0.29**
CD	**0.16**	**NS**	**0.05**	**0.12**	**0.24**	**0.84**
CV percent	**16.50**	**43.72**	**6.15**	**11.07**	**12.57**	**18.70**

Note: *Figures in the parentheses are retransformed values, while outsides are square root transformed values

Table 2.2: Visitation of rose ring parakeet during morning and evening in experimental orchard

Variable	Average No. of parakeets visited/2 hrs at 10 min interval /tree in Each treatment			
	T_1	T_2	T_3	T_4
	Paper bag	Nylon net	Grow cover	Control
Morning	36	24	32	121
evening	32	33	36	131

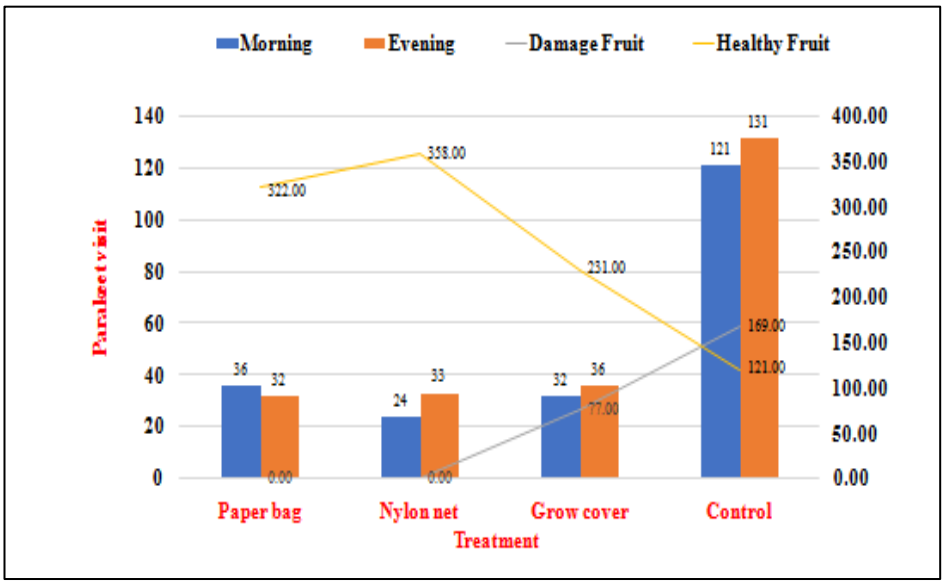


Fig. 2.2. Parakeet depredation on pomegranate fruits in the experimental site

3. GENOMIC STUDIES OF RODENTS AND BIRDS

The genomic studies of rodents and birds were conducted by AINP on VPM, PAU, Ludhiana and KAU, Kerala center. The genomic studies were given importance to phylogenetic studies and functional role of gut micro biota in pest rodents and birds.

In the phylogenetic studies conducted by AINP on VPM, PAU Ludhiana center the live rats were captured from both commensal and field areas. Upon capture, the rats were transferred to an animal facility where they were housed for subsequent morphological analysis. Genomic DNA was extracted from non-invasive fecal samples using the QIAamp Fast DNA Stool Mini Kit (Qiagen, Germany) following the manufacturer's protocol. The quality of the extracted DNA was assessed on a 01 percent agarose gel before further analysis. PCR amplification was conducted to target the mitochondrial DNA (mtDNA) regions encoding cytochrome oxidase I (COI) and cytochrome b (CytB) barcodes. Following amplification, the PCR products were analyzed on a 01 percent agarose gel, and the desired DNA bands were excised. The excised DNA was then purified using the Macherey-Nagel™ NucleoSpin™ Gel and PCR Clean-up Kit (Germany). The purified PCR products were subsequently outsourced for bidirectional Sanger sequencing on an automated sequencing platform. DNA was sequenced and cleaned before comparison to known NCBI sequences. Aligned sequences were used to construct a phylogenetic tree. The best-fit evolutionary model was determined and applied to create the tree. The tree's reliability was assessed using bootstrap analysis.

Based on the study, various rodent species were successfully identified. A total of 31 sequences were obtained, and the results revealed a diverse representation of species across different locations. The species *Golunda ellioti* was consistently identified in both Ludhiana and Jodhpur samples, while the house mouse species, *Mus musculus castaneus* was frequently identified in Ludhiana. Other *Mus musculus* variants were also found, with multiple sequences confirming their presence. *Millardia meltada* was detected in both the Ludhiana and Jodhpur samples. *Rattus rattus*, identified as *Rattus tanezumi* based on molecular evidence, was found in most of the samples, supported by both COI and sequences. Species such as *Bandicota bengalensis*, *Tatera indica*, and *Funambulus pennantii* were identified by CytB sequences. This study highlights the rich rodent diversity in the regions sampled and provides valuable genetic data that can be used for future research on rodent populations in these areas. A phylogenetic tree was constructed incorporating the sequences from the Punjab isolates alongside publicly available COI and CytB sequences from India and other countries (Figs. 3.1 and 3.2), with an outgroup species included for reference. The tree was generated using the Neighbor-Joining (NJ) and BioNJ algorithms, and distance estimation was performed using the maximum composite likelihood (MCL) method. This study also reports the first documented invasion of *Rattus tanezumi* in northwestern India, identified through mtDNA COI and CytB barcoding. Previously, records of *R. tanezumi* in northeastern India and the Andaman & Nicobar Islands relied on morphological identification, a method that is often unreliable for distinguishing *R. tanezumi* from its close look alike, *R. rattus*. Our findings indicate that *R. tanezumi* has expanded its range into new areas of northern and northwestern India, where it has likely been misidentified as *R. rattus* due to its morphological similarities. Phylogenetic analysis of the Punjab isolates revealed that these sequences clustered tightly with a known *R. tanezumi* isolate from China.

Fig. 3.1. Phylogenetic tree analysis using COI gene sequences from Punjab, India, and NCBI reference sequences: maximum likelihood and Bayesian methods

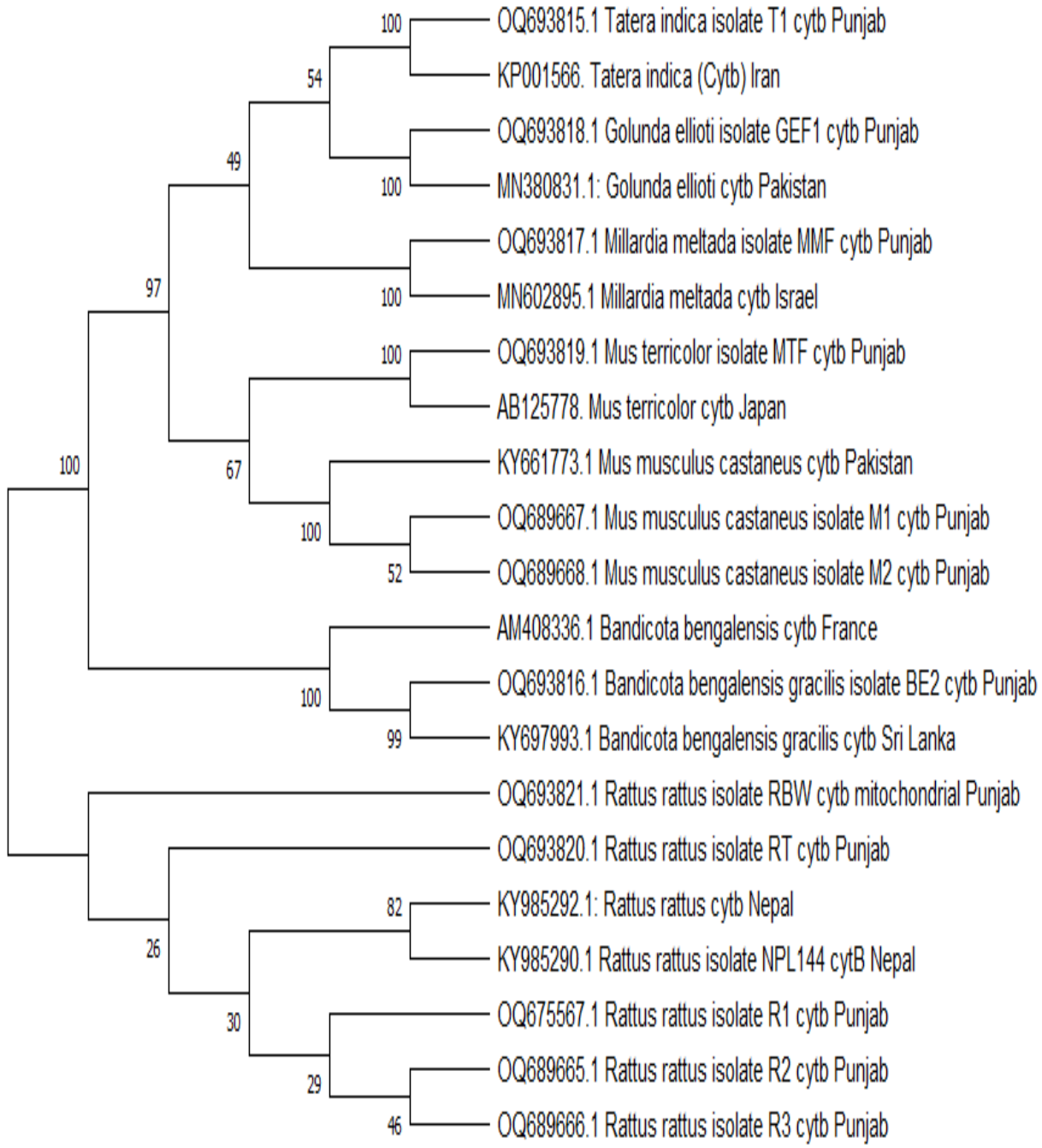
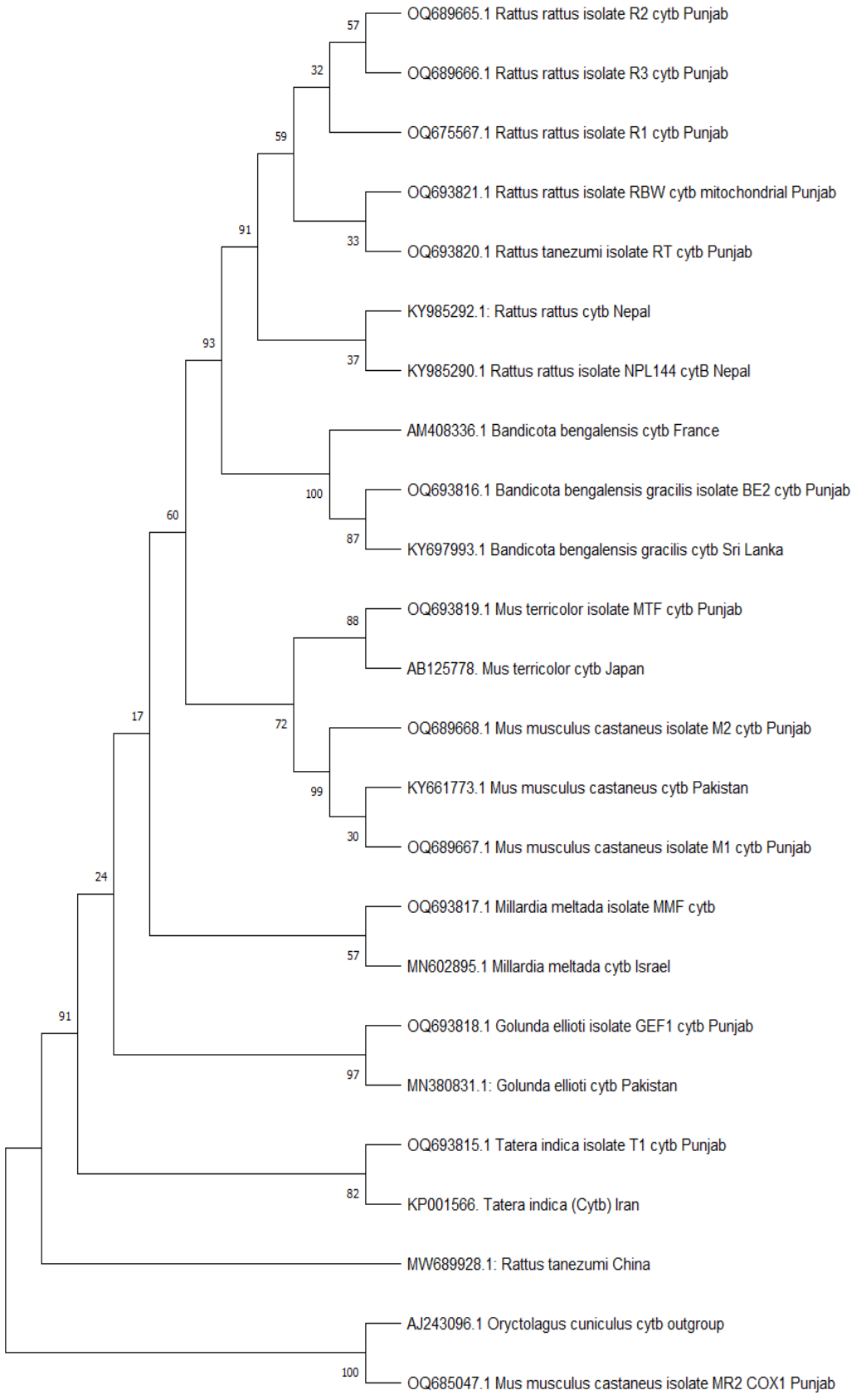


Fig. 3.2. Phylogenetic tree analysis using CytB gene sequences from Punjab, India, and NCBI reference sequences: maximum likelihood and Bayesian methods



At AINP on VPM, KAU, Thrissur, center during 2023-24 using 16S rDNA amplicon sequencing the gut microbes was identified. The metagenomic analysis gives valuable insights into the microbial communities that contribute to the fitness and health of individual organisms.

This direct approach not only uncovers the microbial composition present in the gut but also highlights the various functions of the associated microbial communities. The results from metagenomic analysis can be utilized to develop targeted strategies for manipulating microbial compositions to meet specific objectives, such as enhancing gut health or improving agricultural outcomes.

DNA from fecal pellets of little egret (2 samples), and peafowl (one sample) were analyzed. The dominant phyla of bacteria, the number of total bacterial species identified and the role of the most abundant bacterial species in the fitness of individual organisms are given in Table 3.1.

Table 3.1. Metagenomic analysis of birds and rodents

SN	Organism & Sample code	Dominant phyla	Number of species identified	Important functions
1	**Little Egret-EGE1 (Pullu)**	Proteobacteria	225	*Pseudomonas* spp. - vital in the control of multiple drug-resistant (MDR) bacteria.
		Firmicutes		*Escherichia* spp. - help us digest food, produce vitamins, and protect us from harmful germs.
		Bacteroidetes		*Candidatus moranella* -involved in essential amino acid production.
2	**Little Egret-EGE2 (Madakkathara)**	Proteobacteria	234	*Pseudomonas* spp. - vital in the control of multiple drug-resistant (MDR) bacteria.
		Firmicutes		*Escherichia* spp.- helps us digest food, produce vitamins, and protect us from harmful germs.
		Bacteroidetes		*Candidatus moranella* - involved in essential amino acid production.
3	**Peafowl-RSP1 (Vellanikkara)**	Firmicutes	320	*Prevotella* spp. - Digestion of plant material rich in carbohydrates and dietary fibre.
		Proteobacteria		*Bacillus pumilus* – Antifungal activity
		Bacteroidetes		*Bacillus subtilis*– immune modulation

4. POTENTIAL USE OF PHEROMONES IN THE MANAGEMENT OF RODENTS

The findings of previous study revealed that preputial gland extract of mature male house rats attracts mature female rats. Accordingly, preputial gland extract from mature male rats was analysis through Gas chromatography-mass spectrometry (GC-MS) and the predominant sex pheromone was found to be the acetophenone. The effective concentration of acetophenone was used in the present study as an attractant while formulating a 02 percent stable zinc phosphide bait to mitigate poison bait shyness in rats.

To determine the effective concentration of acetophenone as an attractant, five different concentrations (ranging from 0.1 percent to 0.5 percent) were tested for efficacy against both sexes of house rats (n = 3 rats per sex) over a 7-day treatment period under bi-choice conditions in laboratory cages. The acceptance of more than 50 percent was considered as attractive effect, and below 50 percent as repellent effect.

Results showed significant differences in percent acceptance among groups and sexes, 0.2 and 0.4 percent concentrations was most effective as attractant for female and male rats, respectively. Interestingly, the 0.4 percent concentration exhibited repellent effects in female rats but optimal attractant effect was observed in male rats. However, 0.2 percent concentration, showed an attractant effect in both sexes of the rats. Behavioural observations revealed a preference for the treated side at 0.2 percent concentration by both male and female rats, which is also supported by the presence of faecal pellets in the treated area. Subsequently, the 0.2 percent concentration was identified as the effective concentration with an attractant effect against both sexes (Table 4.1).

The effective concentration (0.2 percent) of acetophenone was adsorbed on an organic polymer for its slow and consistent release. The polymer-acetophenone microcapsules so developed were analysed using Gas chromatography linked mass spectrometry analysis (GCMS), Thermogravimetric analyser (TGA), Differential Scanning Calorimetry (DSc), Field Emission Scanning Electron Microscope (FE-SEM), and UV-visible spectrophotometric analysis (UV-Vis), to confirm the stability and presence of pheromones after different durations of preparation (fresh, 30 days, 60 days & 90 days). The polymer-acetophenone microcapsules were added in stabilized 02 percent zinc phosphide to prepare bait 03 for further testing. Its efficacy was tested against house rats (n=3 rats) in comparison to bait 01 (02 percent zinc phosphide bait) and bait 02 (0 2 percent PEG-coated stabilized zinc phosphide bait) after different durations of their preparation in laboratory conditions.

Bait 03 exhibited higher acceptance and 100 percent mortality within a shorter duration (compared to baits 01 & 02) even after 90 days of preparation (Table 4.2). The level of toxic phosphine gas in stabilized zinc phosphide bait was also higher as compared to bait 01. The ready-to-use stable synthetic pheromone (acetophenone) based zinc phosphide bait proved highly effective as rodenticide even after extended storage periods.

Bait 03, formulated using stabilized zinc phosphide and a consistent concentration of acetophenone absorbed within the polymer matrix, appears to show significant promise as a practical, ready-to-use solution for addressing the persistent problem of rat infestations across various settings. This formulation, which integrates both the attractant properties of acetophenone and the lethal effect of zinc phosphide, may provide a highly efficient approach to controlling rat populations in diverse environments, ranging from agricultural areas to urban spaces, where traditional control methods often fall short. This is the first study reporting stable pheromone-based 02 percent zinc phosphide formulation to mitigate poison aversion in rats with a shelf life of 90 days at room temperature (18-20ºC). However, before widespread application, it is imperative to conduct field trials to assess the practical effectiveness of bait 03. These trials would involve deploying the bait in diverse environments where rat infestation is prevalent and monitoring its performance over time.

Table 4.2. Percent acceptance and time to death with different 2percent zinc phosphide baits

Baits (n=3 for each period)	Duration of preparation	Acceptance (percent)	Time to 100percent mortality (Minutes)
Bait 1	Day 0	70.02±15.26^{a}	820.00±401.49^{ab}
	Day 30	22.26±2.10^{b}	940.00±383.14^{ab}
	Day 60	55.30±8.27^{ab}	4080.00±1680.00^{ab}
	Day 90	52.92±6.67^{ab}	3020.00±2093.15^{ab}
	Overall	**50.13±1.39^{12}**	**2215.00±1139.53^{1}**
Bait 2	Day 0	57.39±11.28^{ab}	220.00±72.11^{b}
	Day 30	50.17±15.22^{ab}	3060.00±1443.74^{ab}
	Day 60	28.99±6.31^{b}	3020.00±2093.51^{ab}
	Day 90	50.69±9.12^{ab}	5360.00±922.65^{a}
	Overall	**46.81±10.19^{2}**	**2915.00±1132.99^{1}**
Bait 3	Day 0	63.46±23.58^{a}	370.00±104.40^{b}
	Day 30	62.43±4.46^{a}	193.00±8.81^{b}
	Day 60	76.06±6.92^{a}	156.67±39.29^{b}
	Day 90	68.57±5.79^{a}	180.00±69.28^{b}
	Overall	**67.63±9.71^{1}**	**225.00±55.54^{2}**

Mean±SE, Different superscripts indicate significant differences in overall percent acceptance and time to death along the column.

Table 4.1. Determination of the effective concentration of acetophenone as an attractant against both sexes of *Rattus rattus*

Group	Conc. (percent)	Sex	Body weight (g)	Pre-treatment consumption (g/100g bwt)	Treatment period consumption (g/100g bwt)		Acceptance (percent)
					UT	*T*	
I	0.1	M	172.66±10.47^{a}	10.12±0.68^{ab}	5.92±0.78^{bc}	3.29±0.36^{d}	36.56±8.56^{cd}
		F	154.00±2.84^{a}	12.17±0.03^{a}	5.95±0.91^{abc}	4.85±0.81^{cd}	40.36±9.25^{cd}
II	0.2	M	157.66±3.84^{a}	10.96±0.47^{a}	6.14±1.81^{bc}	6.74±1.68^{ab}	51.49±12.10^{bc}
		F	155.00±1.52^{a}	11.96±0.13^{a}	5.37±0.91^{bc}	7.99±1.02^{a}	60.03±6.95^{ab}
III	0.3	M	172.67±10.48^{a}	8.38±0.47^{b}	4.00±0.88^{cd}	3.26±0.42^{d}	43.99±10.38^{bcd}
		F	151.00±0.57^{a}	10.89±0.57^{a}	4.97±0.42^{c}	2.74±0.79^{d}	32.40±9.44^{d}
IV	0.4	M	163.66±3.37^{a}	9.05±0.64^{ab}	3.08±1.29^{d}	9.05±0.79^{a}	76.27±7.22^{a}
		F	156.66±0.66^{a}	10.49±0.23^{a}	7.89±1.06^{a}	4.79±0.63^{cd}	39.00±6.74^{cd}
V	0.5	M	173.00±10.48^{a}	9.44±0.30^{ab}	7.24±0.58^{ab}	5.87±0.72^{bc}	41.90±5.09^{cd}
		F	152.00±0.88^{a}	11.82±0.48^{a}	7.49±0.33^{ab}	5.97±1.15^{abc}	39.19±6.77^{cd}

Values are MEAN ± SE; Similar superscripts indicate a non-significant difference in body weight and consumption along the columns during the pre-treatment period; Different superscripts indicate a significant difference in consumption along the rows and columns during the treatment period; Different superscripts indicate significant difference in percent acceptance along the column during the treatment period.

5. TRAP BARRIER SYSTEM

The Trap Barrier System (TBS) has emerged as a promising method for managing rodent pests in rice fields, particularly in regions with soft alluvial soils that facilitate rodent burrowing. Despite its potential, the high costs associated with TBS implementation—mainly due to polythene barriers and multi-catch traps—hinder large-scale adoption by resource-limited farmers. This study aimed to enhance the economic viability of TBS by evaluating cost-reduction measures, including a reduced-height polythene barrier and the use of affordable iron mesh traps as alternatives to traditional multi-catch traps. Additionally, the efficacy of a galvanized iron (GI) mesh barrier was assessed against lesser bandicoots, with a focus on its ability to reduce tiller damage. These interventions were tested under field conditions to identify effective and economical rodent management solutions for rice cultivation

The study was conducted at the rice research farm of the Regional Agricultural Research Station (RARS), Maruteru, and Andhra Pradesh. The site is characterized by deltaic alluvial soils, which are soft and bulky, providing ideal conditions for burrowing by fossorial rodents. The region is irrigated by a canal system, ensuring a consistent water supply throughout the crop growth period.

To reduce the cost of implementing the Trap Barrier System (TBS), efforts were made to minimize expenses associated with polythene material by reducing the height of the barrier from the existing 2.5 ft to 1.75 ft, effectively lowering the height by 0.75 ft. The performance of these two TBS heights was

evaluated during the *kharif* season of 2023-24, focusing on trap catch efficiency and tiller damage protection.

Another significant cost component of the TBS is the multi-catch wonder trap, which is currently priced at ₹300–₹400 per unit in the market. The total cost of incorporating these traps into a TBS can range from ₹2,000 to ₹3,000, making it a major expense and a limiting factor for large-scale adoption by farmers. To address this issue, a cost-effective alternative was evaluated in the form of an iron mesh trap, priced at ₹150 per unit.

5.1. Efficacy of GI mesh barrier against lesser bandicoots

This experiment evaluated the efficacy of a galvanized iron (GI) mesh barrier in reducing tiller damage caused by lesser bandicoots. The GI mesh barrier's performance was compared to that of a polythene TBS and a control plot without barriers. The treatments were as follows:

- **T1**: GI mesh barrier
- **T2**: Polythene TBS
- **Control**: No barrier

Each treatment was implemented in separate plots of equal size. Tiller damage was recorded at different crop stages, including the tillering, PI, and flowering stages, to assess the effectiveness of each barrier system. Observations were made using the diagonal method, and data on tiller damage were used to compare the treatments statistically.

The results demonstrated that the 1.75 ft TBS effectively trapped 20 animals, slightly higher than the 18 animals captured using the 2.5 ft TBS. Similarly, tiller damage protection was found to be comparable between the two heights, with damage recorded at 3.8 percent for the 1.75 ft TBS and 3.2 percent for the 2.5 ft TBS. Statistical analysis indicated that the differences in trapping efficiency and tiller damage protection between the two TBS heights were not significant. These findings confirm that reducing the height of the polythene barrier to 1.75 ft does not negatively impact its effectiveness in controlling pests or protecting tillers. This height reduction can result in substantial cost savings without compromising performance (Table 5.1).

Comparative evaluations of the two trap types revealed that the iron mesh trap captured 12 animals, while the wonder trap captured 14 animals (Table 5.2). Despite this slight difference, statistical analysis indicated no significant difference in their trapping abilities. Thus, the iron mesh trap offers a viable, affordable alternative to the wonder trap, making the TBS more economically accessible for farmers without significantly compromising its trapping efficiency. In conclusion, reducing the polythene barrier height to 1.75 ft and substituting the expensive wonder trap with a lower-cost iron mesh trap can significantly lower the overall cost of the TBS. These adjustments maintain the system's effectiveness in pest management, enabling more widespread adoption among farmers.

Table 5.1. Impact of the height of TBS on its performance against lesser bandicoots in rice

Treatments	No. of Animals trapped		percent tiller damage	
	TBS (1.75ft)	TBS (2.5ft)	TBS (1.75ft)	TBS (2.5ft)
Tillering stage	12	10	1.2	1.0
Tillering to PI	06	07	2.2	1.8
PI to Flowering	02	01	0.4	0.4
Total	20	18	3.8	3.2
t-test	0.46 <2.7		0.64<2.6	
	NS		NS	

Table 5.2. Impact of locally made trap on performance of TBS in trapping bandicoots

Crop stage	No. of Animals trapped	
	Mesh trap multicatch (6)	*wonder trap (6)*
Tillering stage	6	8
Tillering to PI	5	4
PI to Flowering	1	2
Total	12	14
Mean	1.83	2.66
t-test	0.72<2.6 N.S	
cost of each trap	150/-	300/-

5.2. Efficacy of GI Mesh Barrier

The GI mesh barrier was compared with a polythene TBS and a control plot. At the tillering stage, tiller damage was highest in the control plot (3.46 percent), followed by the polythene TBS (1.33 percent), while the GI mesh barrier recorded no damage. From tillering to PI stage, damage in the control plot rose to 6.23 percent, compared to 1.66 percent for the polythene TBS and 0.0 percent for the GI mesh barrier. During the PI to the flowering stage, the damage was 1.33 percent in the control plot, while both barriers-maintained 0.0 percent damage (Table 5.3).

Cumulative tiller damage was 11.02 percent for the control plot, 2.99 percent for the polythene TBS, and 0.0 percent for the GI mesh barrier. Statistical analysis confirmed significant differences, with the GI mesh barrier showing superior efficacy by completely preventing tiller damage across all stages.

Table 5.3. Efficacy of GI mesh barrier against lesser bandicoot in rice

Crop stage	percent tiller damage		
	Polythene TBS	*GI Mesh Barrier*	*Control plot*
Tillering stage	1.33	0.0	3.46
Tillering to PI	1.66	0.0	6.23
PI to Flowering	0.0	0.0	1.33
Total	2.99	0.0	11.02
t-test	Significant		
Cost towards Rodent control	4000/-	6000/-	3000/-
Yield	25.45 qtl/acre	26.25 qtl/acre	23.35 qtl/acre
Earning	59,044/-	60,900/-	54,172/-
C:B ratio	1:1.22	1:1.21	-

TBS (1.75ft)

TBS (2.5ft)

Mesh trap multicatch

Wonder trap

Trap Barrier System

GI Mesh Barrier

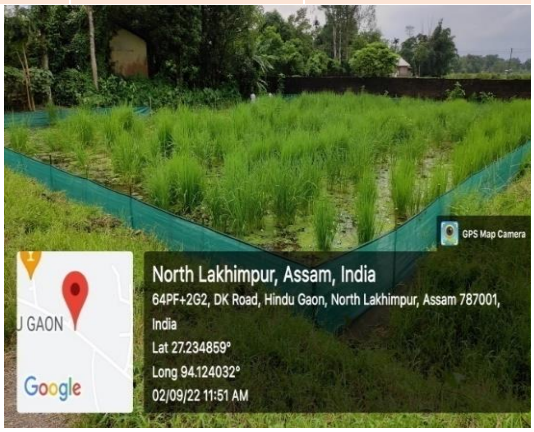
TBS was evaluated in *kharif* season at Phukon Doloni village and ZRS in Lakhimpur district having medium land and low land (deep water system). An area of 100m^2 for both situations were taken where one is treated with TBS and the other untreated control. Polythene sheets were used to construct the barrier system with bamboo stands in between to keep it erect. The stands were put 2m above the ground and the polythene sheets were rolled around and covered with mud below the ground so that no rodent could penetrate these sheets. Live multiple cage traps are placed every 2.5m (n=8 per TBS) from each side. These traps are installed along each side inside the fence held tightly against the fence with an opening hole. 2 kill traps are also placed inside the sheets. Observation on Trap Index (Number of Removal trap catches), live burrow count (LBC) and damage percent in both treated and untreated conditions were recorded.

It was observed that the live burrow count (LBC) was lower in both situations viz. medium land and deep-water rice situations. Damage assessment in medium land situations with TBS showed 8.91 percent damage of the crop while in the control plots the damage was 21.07 percent. In deep water land situations, the damage was observed to be 15.34 percent in the control plot and 2.19 percent in land with TBS. The trap index was observed to be 32.14 in medium land situation of rice and 3.57 in deep water land situation (Table 5.4).

Table 5.4. Rodent infestation and trap index in rice crop with different land situations

Particulars	Medium land with TBS	Medium land Control	Deep water land with TBS	Deep water land control
LBC	L (n=7)	M(n=28)	L(n=2)	L(n=7)
Damage assessment (percent)	8.91	21.07	2.19	15.34
Trap success	32.14	-	3.57	-

Medium land situation of rice crop



Deep water situation of rice crop


Live burrow in the TBS area


Damage assessment


Rat trapped in multiple catch trap rice field


Rat trapped in kill trap

6. BIOECOLOGY AND MANAGEMENT OF PORCUPINE

Porcupine damage to agricultural crops in Kerala has become a significant concern for farmers, especially those in hilly and forest-adjacent regions. These nocturnal animals feed on tubers, roots, and the bark of trees, causing substantial damage to crops like tapioca, vegetable crops, bananas, and even young coconut palms. Extensive surveys were conducted in the Thrissur district of Kerala to assess the damage caused by porcupines during the period from September 2023 to August 2024 (Table 6.1). Significantly a higher incidence (plant or fruit damaged/1 m^2 plot) was recorded in coconut (8.50 ± 4.04) followed by cassava (8.00 ±3.26), brinjal (3.50 ±2.87) and papaya (2.00 ± 0.86). The occurrence of porcupines was recorded by observing the indirect signs such as the presence of quills and faecal pellets and also by setting up the infrared night vision camera (Fig 6.1). The data reveals that 11 instances of porcupine presence were recorded in casava fields followed by coconut nursery (10), brinjal fields (6), and papaya plot (5) (Fig 6.2).

Table 6.1. Occurrence and damage caused by Porcupine

Sl No	Location	Crop	Occurrence		Plant /fruit damage per plot (1 m^2)
			2023(Sep-Dec)	2024 (Jan-Aug)	
1	Vellanikkara (10.549714, 76.282424)	Papaya	4	2	2.00 ± 0.86[a]
2	Madakkathara (10.561565, 76.263848)	Cassava	5	6	8.00 ±3.26[c]
3	Chirakkekode (10.558595, 76.290822)	Brinjal	0	2	3.50 ±2.87[ab]
4	Thaanikkudam (10.572103, 76.267536)	Coconut	3	1	8.50 ± 4.04[c]

Fig 6.1. Signs of porcupine occurrence in crop fields

Quills

Faecal pellet

IR camera photo

Fig 6.2. Porcupine damage in various crops

Further an experiment was laid out in farmers field at Madakkathara, Thrissur to evaluate the efficacy of various methods to manage the porcupine incidence in cassava. The treatment include application of BoRep @ 2kg/ acre (T_1), band application of Rogor @ 4ml per litre (T_2), spraying of natural repellent – Out get animal repellent (T_3), Nylon net fencing (T_4), fencing with iron sheet (T_5) and control (T_6) (Fig 6.3 and Table 6.2).

Table 6.2. Evaluation of management techniques against porcupine

Treatment	Plant damage/Plot ($1m^2$)	Yield loss (Kg)/plot	Yield loss (kg) /ha
T1 – BoRep @ 2kg/ acre	3.33 ± 2.08 ^{bcd}	8.09	202.25
T2 -Band application of Rogor	2.00 ± 2.16 ^{cd}	4.86	121.5
T3 - Spraying of natural repellent (Out Get Animal Repellent)	5.25 ± 3.86 ^{abc}	5.01	125.25
T4- Nylon net fencing	6.00 ± 2.16 ^{ab}	14.58	278.19
T5 – Fencing with iron sheet	0.50 ± 0.57 ^{d}	1.25	49.89
T6 – Control	8.00 ± 3.26 ^{a}	19.5	309.11

Among the treatments evaluated, the lowest damage (plant damage/ $m^{2)}$ was recorded in plot protected with iron sheet- T_5 (0.50 ± 0.57), followed by band application of Rogor- T_2 (2.00 ± 2.16), BoReP applied plot (3.33 ± 2.08), plot treated with natural repellent- T_3 (5.25 ± 3.86) and plot protected with nylon fencing (6.00 ± 2.16). However, the unprotected field recorded the highest plant damage (8.00 ± 3.26) due to porcupine incidence. Further, analysis of yield loss in cassava due to porcupine incidence revealed that a significant difference exists among the yield of cassava recorded in various treatment plots. The highest yield loss of 309.11 kg/ha was recorded in the cassava plot without any protection- T6, followed by the plot protected with nylon fencing -T_4 (278.19 kg/ha), BoReP applied plot- T_2 (202.25 kg/ha), plot treated with natural repellent- T_3 (125.25 kg/ha) and band application of Rogor- T_2(121.50 kg/ha). Whereas, the lowest yield loss was recorded in a plot protected with iron sheet- T_5 (49.89 kg/ha).

BoRep applied plot

Out get applied plot

Nylon net fencing

Iron sheet fencing

Fig. 6.3. Setting up of different porcupine management techniques

7. BIO-ECOLOGY AND MANAGEMENT OF SQUIRRELS

7.1. Bio-ecology and management of Flying squirrel, *Dremomys lokriah* in plantation crops

The surveillance of squirrels (*D. lokriah*) was carried out at different locations: Dikhowmukh, Bokakhat, Balijan, Merapani, Jamuguri, Borhulla, and Dergaon in Assam. The monitoring was done monthly by observing squirrels on coconut trees and damaged and fallen nuts on the ground below the tree. One person also climbed up to the top portion of the tree to count all the damaged nuts attached to the pedicel and calculated the percent damage. The activity of *D. lokriah* was also observed on different crops like jack fruit, guava, pomegranate, litchi, pineapple, pomelo, mango, coconut, and areca nut in different locations of Assam state throughout the year. They were active during the day time only and were observed to construct their nests above ground on different trees, bamboo plantations, and abandoned houses. They chose the nesting place which seemed safer and away from animal and human disturbances. In areca nut, squirrels attack tender nuts. In coconut, they make a hole in the centre of the nut. The observations indicated that *D. lokriah* is a major rodent pest species in coconut and other fruit crops. The squirrel infestations and damage ranged from 8.06-36.01`percent and 3.87-16.86 percent, respectively in different surveyed villages (Table 7.1).

An experiment was conducted to see the impact of the integration of different treatments on the incidence of squirrels in coconut trees. Before starting the trial, all the trees were numbered and the entire fallen nuts damaged by squirrels at the base of the trees were removed to record the number of freshly damaged nuts. Observations were made for fallen nuts/nuts damaged on trees after one month of the treatment. T_4 (Squirrel guard at the height of 8 ft at 45º angles from the ground+trapping), T_5 (Net guard at the height of 8 ft from the ground+trapping) and T_6 (Trunk banding at the height of 8 ft from the ground+trapping) treatments resulted in maximum control success (49.39-62.36 percent) and damage reduction (49.49-53.23 percent) in coconuts (Table 7.2).

Table 7.1. Surveillance of Flying Squirrel *Dremomys lokriah* at different locations in Assam state

Village/Area (location)	Nesting site	Activity (peak activity)	Infestation (percent)	Damage (percent)
Dikhowmukh 94º47'71'' 27 º 00'3''	*Bamboo plant	Throughout the year (April-August)	36.01	16.66
Bokakhat 93 º 52'36'' 26 º 42'15''	*Crevices in buildings *Bamboo plant	Throughout the year (April-August)	14.11	6.11
Balijan 94 º 11'17'' 26 º 58'87''	*Bamboo plant *Abandoned houses	Throughout the year (March-August)	28.87	16.71
Merapani 94 º 53'0'' 26 º 19'26 ''	*On the tree *Crevices in buildings	Throughout the year (May-August)	26.04	14.46
Jamuguri 93 º 57'22'' 26 º 23'6''	*Bamboo plant *Abandoned houses	Throughout the year (May-September)	29.99	16.86
Borhulla 94 º 75'2'' 26 º 26'56''	*Treetop	Throughout the year (May-August)	8.06	3.87
Dergaon 94 º 12'29'' 26 º 43'36''	*Treetop *Bamboo plant *Abandoned houses	Throughout the year (April-August)	30.33	16.76

Table 7.2. Effect of integration of different treatments on squirrel infestation in coconut

Treatment	Infestation (percent)			Damage (percent)		
	Pre-treatment	Post-treatment	Control success (percent)	Pre-treatment	Post-treatment	Reduction (percent)
T_1	18.76	10.11	46.10	14.01	8.11	42.11
T_2	18.96	10.49	44.67	12.09	7.11	41.19
T_3	21.66	12.33	43.07	13.69	7.61	44.41
T_4	18.76	7.06	62.36	14.99	7.01	53.23
T_5	19.11	9.66	49.45	11.86	5.99	49.49
T_6	20.44	9.21	54.94	12.46	6.01	51.76
T_7	20.46	31.67	-	11.86	16.87	-
CD at 5percent	**NS**	**5.51**	**-**	**NS**	**4.77**	**-**

T_1: Squirrel guard at the height of 8 ft from the ground at 45° angle, T_2: Net guard at the height of 8 ft from the ground, T_3: Trunk banding at the height of 8 ft from the ground, T_4: Squirrel guard at the height of 8 ft at 45° angles from the ground + trapping, T_5: Net guard at the height of 8 ft from the ground + trapping, T_6: Trunk banding at the height of 8 ft from the ground + trapping, T_7: Untreated control

7.2. Management of southern squirrels (*Funambulus palmarum*)

7.2.1. Evaluation of various botanical extracts as potential repellents against southern squirrels (*Funambulus palmarum*) in cocoa plantations

Various botanical materials (50g each) were taken in a muslin cloth and tied near the pods in cocoa plantations. Pre- and post-treatment counts were taken on pod damage at regular intervals to evaluate the efficacy of treatments. All the treatments were effective 3 days after treatment (DAT) with no damage caused to pods. At 7 DAT, pod damage was observed in some of the treatments. The treatments T4 (Sulphur), T8 (RBF, PAU) followed by T3 (Garlic and dry chili mixture) are significantly at par with each other with mean pod damage of 0.90, 1.17, and 1.22 percent and control success of 96.46, 95.90 and 95.56 percent, respectively (Table 7.3). Sulphur and RBF-PAU exerted significant protection (up to 95 percent) against squirrel incidence in cocoa for up to 15 days.

Table 7.3. Efficacy of different treatments against squirrels in cocoa plantations

Treatments		Dose ml/g per tree	Mean pod damage (percent) n = 3 each						Control success (percent)
			Pre-treatment	3 DAT	7 DAT	10 DAT	15 DAT	Mean	
T1	Naphthalene balls	50	24.20 (28.44)^{a}	0.00 (0.00)^{b}	2.05 (6.80)^{bcd}	3.33 (6.34)^{b}	4.17 (9.27)^{bc}	2.39 (7.63)^{bc}	90.14
T2	Vinegar	50	24.93 (29.78)^{a}	0.00 (0.00)^{b}	2.78 (5.78)^{bcd}	8.20 (15.82)^{b}	13.36 (20.74)^{b}	6.08 (11.91)^{b}	75.60
T3	Garlic and dry chilli mixture	50	27.47 (31.21)^{a}	0.00 (0.00)^{b}	0.60 (2.75)^{cd}	0.60 (2.75)^{b}	3.69 (9.01)^{bc}	1.22 (4.98)^{c}	95.56
T4	Sulphur	50	25.42 (30.22)^{a}	0.00 (0.00)^{b}	0.00 (0.29)^{d}	1.45 (4.20)^{b}	2.13 (5.07)^{c}	0.90 (3.83)^{c}	96.46
T5	Agniastra	50	29.25 (32.40)^{a}	0.00 (0.00)^{b}	0.00 (0.29)^{d}	7.32 (12.81)^{b}	8.27 (13.81)^{bc}	3.90 (8.10)^{bc}	86.68
T6	Ecodon	50	31.24 (33.33)^{a}	0.00 (0.00)^{b}	6.66 (14.81)^{b}	6.73 (12.32)^{b}	8.17 (11.96)^{bc}	5.39 (11.64)^{b}	82.76
T7	Pig oil	50	27.88	0.00	6.47	7.66	10.18	6.09	75.05

			(31.13)[a]	(0.00)[b]	(12.07)[bc]	(15.49)[b]	(18.41)[b]	(12.35)[b]	
T8	RBF-PAU	50	25.16 (29.11)[a]	0.00 (0.00)[b]	0.00 (0.00)[d]	1.80 (4.67)[b]	2.86 (9.66)[bc]	1.17 (4.37)[c]	95.90
T9	Control	50	24.39 (29.35)[a]	28.73 (32.34)[a]	30.59 (33.30)[a]	31.46 (33.88)[a]	33.81 (35.55)[a]	31.56 (34.15)[a]	-
		SEM	**2.45**	**0.37**	**0.84**	**1.17**	**1.56**	**1.81**	-
		CD (0.05)	**NS**	**1.77**	**10.25**	**13.95**	**13.30**	**5.30**	-
		CV (percent)	**14.39**	**18.14**	**17.51**	**16.95**	**18.33**	**22.82**	-

Figures in parentheses are angular transformed values, NS- Non-Significant
In a column, means followed by common letters are not significantly different by DMRT (P=0.05)

7.2.2. Management of squirrels in a pomegranate orchard

Out of eight treatments evaluated against squirrels in pomegranate orchard at Vijayapura village of Devanahalli Taluka, results indicated that covering the entire plot with HDPE fish net of 1"x 1" mesh size was found significantly superior over other treatments with least (0.57percent) fruit damage and highest yield (17.85 t/ha). The next best treatment was fixing an inverted metal funnel, which resulted in 2.47 percent damage and 15.56 t/ha yield. In the control plot, the maximum damage (12.87 percent) and least yield (11.68 t/ha) were recorded (Table 7.4).

Table 7.4. Management of squirrels in a pomegranate garden

Treatment	Description of treatments	No. of squirrels visited/plant/day/ 8 hours	Fruit damage at ripening stage (percent)	Yield (t/ha)
T1	Fruit bag cover	6.26[ab]	3.56[def]	14.73[b]
T2	Egg + Hing (1 full egg + 10 g hing) 25 L of water	3.21[cd]	7.87[abc]	13.89[bc]
T3	Azadirachtin 10,000 ppm spray	2.56[de]	5.74[cde]	14.91[b]
T4	Netting with HDPE fishnet (1" x 1")	0.23[e]	0.57[f]	17.85[a]
T5	Metal inverted funnel	1.74[de]	2.47[ef]	15.56[b]
T6	Wonder traps @ 15 days interval (50/ha)	3.46[cd]	6.82[bcd]	14.02[bc]
T7	Strychnous 5percent bark solution	5.87[bc]	8.74[ab]	12.78[cd]
T8	Control	8.74[a]	12.87[a]	11.68[d]
	CD at 5percent	2.56	3.74	2.01
	CV (percent)	6.74	8.48	8.07

Values with different superscripts (a-f) along a column indicate significant differences at 5percent level of significance

7.3. Management of northern palm squirrel (*Funambulus pennantii*)

7.3.1. Pomegranate and Date Palm

The various treatments for the management of squirrel damage in pomegranate and date palm was laid during critical period of time and observation on the efficacy of various treatments were recorded at an interval of 20-25 days until the complete crop was harvested. Six sets of treatments, are, Netting around border, Botanical repellent, Burrow Baiting+Bagging, Trapping+bagging, Netting+Trapping+Bagging, Netting+Trapping+Bagging+Burrow Baiting and control. The best four treatments out of the six set of treatments evaluated during preceding years (2021-22 and 2022-23) were laid during critical period of damage by squirrels in pomegranate and date palm crops. The efficacy of various treatments was recorded at an interval on 20-25 days till the complete crop was harvested. The four set of treatment viz., T1: Netting around border, T2: Trapping + Bagging, T3: Netting +Trapping + Bagging, T4: Netting + Trapping + Bagging + Burrow Baiting along with control was employed. The control success in pomegranate crop was at par in treatments T3 (69.85 per cent) and T4 (72.29 per cent) and significantly superior than treatments T1 and T2 (Table 7.5). Whereas, in date palm crop control success in all the treatments (T1, T2, T3, T4) was at par with respective control success of 52.54, 54.39, 59.62 and 62.08 per cent (Table 7.6).

Table 7.5. Efficacy of different treatments against rodent pest in pomegranate

Treatment	Per cent Control success assessed on the basis of infestation/damage on			
	2.11.2023	1.12.2023	31.12.2023	Mean
Netting around border	55.54 (48.47)	59.86 (50.98)	57.82 (49.79)	57.74[b] (49.75)
Trapping+ bagging	59.89 (51.00)	61.70 (52.06)	45.27 (42.57)	55.62[b] (48.54)
Netting+Trapping+Bagging	71.59 (58.11)	69.89 (57.03)	68.08 (55.91)	69.85[a] (57.02)
Netting+Trapping+Bagging+Burrow Baiting	74.15 (59.77)	71.33 (57.94)	71.40 (57.99)	72.29[a] (58.57)
CD at 5%				**5.25**

Table 7.6. Efficacy of different treatments against rodent pest in date palm

Treatment	Per cent Control success assessed on the basis of infestation/damage on			
	April	May	June	Mean
Netting around border	40.87 (40.03)	56.87 (49.24)	59.87 (50.99)	52.54[a] (46.75)
Trapping+ bagging	40.26 (39.68)	56.37 (48.95)	66.54 (54.96)	54.39[a] (47.86)
Netting+Trapping+Bagging	55.68 (48.55)	57.89 (49.83)	65.29 (54.20)	59.62[a] (50.86)
Netting+Trapping+Bagging+Burrow Baiting	58.56 (50.22)	60.45 (51.33)	67.22 (55.38)	62.08[a] (52.31)
CD at 5%				**5.63**

Per cent control success = 100 (1-[(T_2 x C_1)/(T_1 x C_2)])

Where: T_1= Pre-treatment population of rodents in treatment plots & T_2= Post-treatment population of rodents in treatment plots.

C_1= Pre-treatment population of rodents in reference plots & C_2= Post-treatment population of rodents in reference plots.

7.3.2. Fruits and vegetables

Damage caused by five striped squirrels, *Funambulus pennantii* was recorded to peach, grapes, plum, and pomegranate fruits in a private kitchen garden where it caused 40-60 percent damage. Damage was also recorded in orchards and crop fields. The highest relative percentage damage was recorded to peach (33 percent) followed by loquat (26percent), raspberry (24 per cent), and ber (22 per cent) in orchards, and the highest damage to kakri (18 per cent) followed by sponge gourd (15 percent), tomato (13 percent) and brinjal (9 percent) in crop fields. The squirrels were found to show an interesting behaviour of first consuming fruits that were already eaten by them till they consumed the whole fruit. Installation of an aluminium cone guard on the trunk and reflective ribbon on the canopy of plum trees resulted in 90 percent protection of fruits from squirrels and parrots. The use of different methods such as reflective ribbon, reflective ribbon + nylon net, and reflective ribbon + nylon net + reflective CDs was found to achieve 40-70 percent control success. Finally, the squirrels had to be trapped and released at far-away places to protect the fruit crops in the kitchen garden.

The evaluation of different management strategies alone like reflective ribbon, alternate food, predatory sounds, and repellents (peppermint oil and phenyl) in the orchards on peach, loquat, raspberry, and ber resulted in 16-28 percent control success. While, the evaluation of different management strategies alone like reflective ribbon, predatory sounds, and peppermint oil as repellent in the crop fields in kakri, sponge gourd, tomato, and brinjal crops resulted in 3-14 percent control success indicating that no single method is effective in reducing squirrel damage. These have to be used in integration to effectively manage the squirrel population.

8. BOTANICALS FOR RODENT PEST MANAGEMENT

Various botanicals were evaluated deterrent properties against *Millardia meltada* and *Tatera indica* experimental rattery and Storage conditions. The studies were conducted in the experimental rattery of All India Network Project on Vertebrate Pest Management, University of Agricultural Sciences, Gandhi Krishi Vignana Kendra, Bengaluru. In the experimental rattery conditions 6 stacks containing three cloth bags containing ragi (5kg) were placed together and covered with a cloth cover and plastic bag. Each stack was tied with the plastic bowl containing the 25 g cereal bait mixture (Cereal bait mixture: 10 g ragi, 10 g rice, 2.5 g groundnut seed powder, 2.5 g groundnut seed oil). The plastic bag was removed and botanical extract of 4,6,8,10 percent was sprayed on the cloth cover separately on each stack and the control stacks were sprayed with plain water, later the cloth cover on the stack was covered with the plastic bag. The animals which were pre-occupied were left for exploring. The bait consumed in the bowl of each stack was recorded and antifeedent index was calculated. The evaluation of different botanicals revealed that botanicals at 8 and 10 % were found effective in repelling the rodents. In *Millardia meltada* the evaluation revealed that the highest antifeedant index (AFI %) was recorded in pepper extract with an AFI of 62.17-37.25 per cent and it was followed by chilli extract (61.27-36.27 %), garlic extract (60.19-40.17 %), neem leaves extract (59.23-39.23 %), gliricidia leaves extract (53.82-31.67 %) and vitex leaves extract (41.28-16.27 %). Whereas, in mixture form of the extracts 80.26 to 63.18 per cent AFI in *Millardia meltada* was recorded. In *Tatera Indica* the highest antifeedant index (AFI %) was recorded in pepper extract with an AFI of 67.28-62.17 per cent and it was followed by garlic extract (65.23-54.67 %), neem leaves extract (66.18-44.32 %), chilli extract (65.19-52.23 %), gliricidia leaves extract (56.24-42.17 %) and vitex leaves extract (44.28-19.23 %) whereas, in mixture form of the extracts 82.32-65.32 per cent AFI in was recorded. The extracts of the different botanicals were found effective for 6-9 days whereas, in mixture form of the botanicals the extracts were effective for 11-12 days (Table 8.1).

In antifeedant effect of different phyto contents (solvents) against *Bandicota bengalensis* under rattery conditions Six plants which have more antifeedant effects were selected (neem glyricidia, vitex, pepper, chilli and garlic) (Table 8.2) to know which phyto content was more effective in deterring rodents. Among the solvents/phyto contents evaluated (ethylene acetate, Hexane, Acetone and whole water), the extraction with hexane having the volatile oil content was found better with AFI of 58.68% to 86.93% after 5 days after application with 5 per cent concentration (Table 8.2)

Table 8.1. Antifeedant effects of different plant extracts against rodents in rattery conditions

Botanical	AFI (%)		Concentration (%)	Days effective
	Millardia meltada	*Tatera indica*		
Neem leaves	52.17-39.23	57.73-44.32	8	6-8
	59.23-48.23	66.18-58.17	10	
Gliricidia	49.13-31.67	48.13-33.17	8	7-9
	53.82-42.32	56.24-42.17	10	
Vitex	31.26-16.27	33.16-21.38	8	6-8
	41.28-37.13	44.28-19.23	10	
Pepper	59.72-37.25	62.23-49.28	8	8-9
	62.17-59.17	67.28-62.17	10	
Chilli	53.09-36.27	60.18-51.08	8	7-8
	61.27-49.32	65.19-52.23	10	
Garli	50.17-40.17	58.27-39.28	8	8-9
	60.19-51.80	65.23-54.67	10	
Botanical Mixture	76.12-63.18	78.56-65.32	8	11-12
	80.26-70.26	82.32-72.82	10	

Table 8.2. Antifeedant effect of different phyto content against *B. Bengalensis*

Botanical	Concentration (%)	Solvents (Phyto content)			
		Ethyl acetate (phenolic compounds)	Hexane (Volatile oils)	Acetone (Polar Components)	Whole Water extract
		AFI (%) (5 DAA)			
Neem	**5 %**	**37.67**	**73.87**	**31.03**	**56.14**
Gliricidia		**29.93**	**58.68**	**24.65**	**44.60**
Vitex		**33.14**	**64.98**	**27.29**	**49.38**
Pepper		**44.33**	**86.93**	**36.51**	**66.07**
Chilli		**42.10**	**82.54**	**34.67**	**62.73**
Garlic		**45.16**	**88.54**	**37.19**	**67.29**

9. STUDIES ON BEHAVIOUR OF RODENTS TOWARDS RICE VARIETIES

The study was conducted at the cage rattery of RARS, Maruteru, involving the evaluation of behaviour of rodents towards ten short-duration (120–140 days) rice varieties. The experiment was laid out in a randomized row planting system with three replications. Normal agronomic practices were followed throughout the cultivation period. To assess rodent damage, animals were acclimatized before their release into the setup. Two male and female lesser bandicoot rats were introduced at the panicle initiation (PI) stage. Tiller damage was recorded daily to monitor rodent activity.

For assessing grain preference, paddy grains from the ten rice varieties were subjected to multi-choice testing. Feed cups containing the grains were shuffled daily to minimize positional bias. The experiment was replicated thrice, and daily grain consumption was recorded to evaluate rodent feeding preferences.

This study was conducted to understand the rodent behaviour/ preference towards various rice varieties, among the 10 short duration test varieties, no significance difference was observed in per cent cumulative damage caused by bandicoots. The entire test rice lines were damaged to more than 80% by the 7th day of testing. Similarly, the grains of respective varieties were also screened to find out the relative preference by the rodents under choice condition and no significant effect was noticed among the varieties (Table 9.1& 9.2).

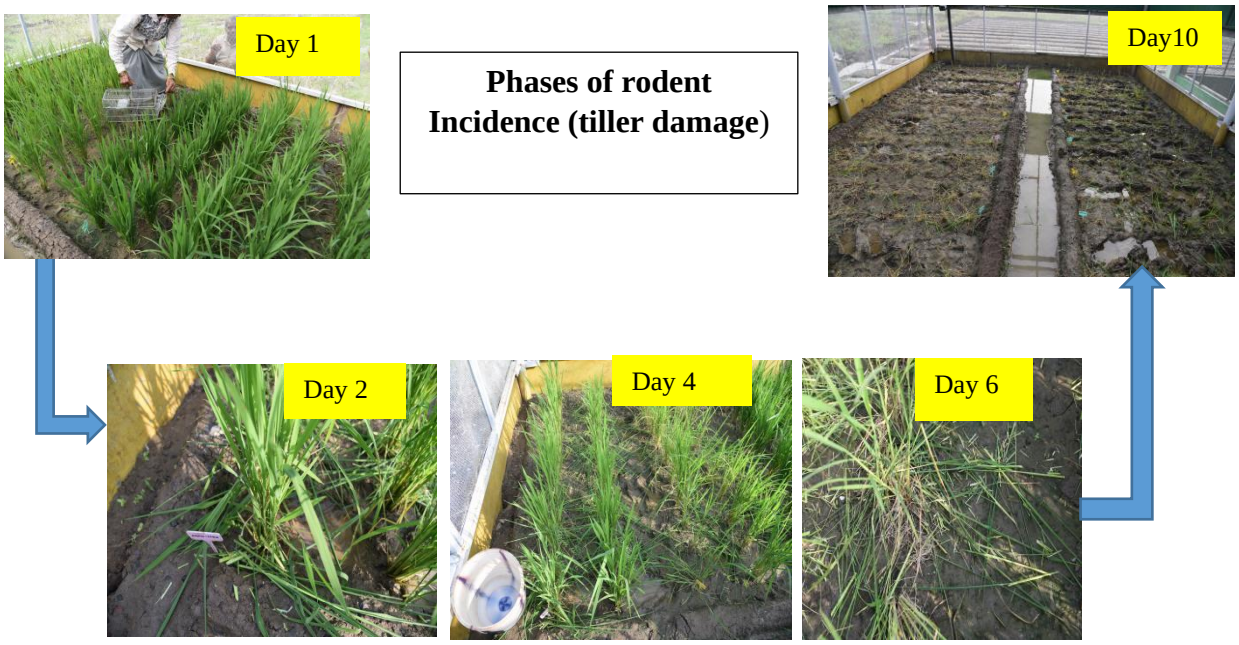


Table 9.1. Feeding behaviour of rodents towards rice varieties (*Kharif* 2023)

Variety	Percent cumulative tiller damage						
	Day 1	Day 2	Day 3	Day4	Day5	Day6	Day7
MTU-1121	3.4	5.2	6.3	23.4	71.3	79.0	81.8
MTU-1153	2.8	11.5	31.8	53.4	73.9	76.1	77.8
MTU-1210	2.4	11.9	35.1	47.8	71.8	75.0	76.4
MTU-1273	5.2	21.4	41.3	59.0	76.5	78.2	79.1
MTU-3626	1.7	9.5	25.0	50.7	72.9	75.3	76.7
MTU-1293	7.7	19.2	40.4	65.2	79.1	80.3	82.6
MTU-1001	7.1	23.5	43.4	60.1	77.9	79.4	81.1
MTU-1282	1.3	7.0	25.0	45.9	71.0	73.9	75.6
MTU-1006	16.0	30.9	41.2	60.3	86.7	89.6	91.1
MTU-1156	12.4	31.5	45.5	63.8	82.2	84.5	86.5
	NS		Sig.				N.Sig.
CV	54.7		22.18				5.86
CD (5%)	--		10.99				--

S. No	Variety	Food grain given	Grain Consumption (Grams)				
			R1	R2	R3	Total	Mean
1	1001	360	119	95	39	253	84.3
2	1121	360	108	63	48	219	73.0
3	3626	360	114	101	67	282	94.0
4	1273	360	115	96	59	270	90.0
5	1153	360	100	88	44	232	77.3
6	1210	360	102	74	34	210	70.0
7	1156	360	115	99	55	299	89.7
8	1006	360	116	100	52	268	89.3
9	1282	360	100	48	31	179	59.7
10	1293	360	114	88	39	241	80.3
							NS
CV							22.07

Table 9.2. Feeding behavior towards paddy grains

9.1. Feeding behaviour of lesser bandicoot towards rice varieties (*Kharif* 2024)

The study was conducted at the cage rattery of RARS, Maruteru, to evaluate the behaviour of rodents towards four varieties each of long, medium, and short-duration rice. The experiment followed a randomized row planting design with three replications, adhering to standard agronomic practices throughout the crop growth period. To assess rodent-induced damage, the animals were acclimatized before their release into the experimental setup. At the panicle initiation (PI) stage, two male and two female lesser bandicoot rats were introduced. Tiller damage was observed and recorded daily to monitor rodent activity and their impact on the rice varieties.

The feeding behaviour of the lesser bandicoot towards various rice varieties was studied during the *Kharif* season of 2024, focusing on cumulative tiller damage percentages on Day 3, Day 10, and Day 18. No significant difference in tiller damage was observed between short, medium, and long-

duration varieties on Day 3 and Day 18. However, 10 days after the release of the animals, a significant difference in tiller damage was observed among the varieties. Short-duration varieties exhibited the highest tiller damage compared to medium and long-duration varieties, except for one short-duration variety, **MTU-1121**. This particular short-duration variety showed damage levels similar to those of the medium and long-duration varieties, even though it reached the panicle initiation stage earlier than the others. Further studies need to be conducted to better understand these observations.

Statistical analysis revealed significant differences in cumulative tiller damage across varieties by Day 10, with critical differences at 0.01 and 0.05 levels observed as 30.04 and 22.17 percent, respectively. However, no significant differences were noted on Day 3 and Day 18 (Table 9.3).

Table 9.3. Feeding behaviour of lesser bandicoot towards rice varieties (*Kharif* 2024)

S. No	Duration type	Variety	Percent cumulative tiller damage		
			Day 3	Day 10	Day 18
1	Long	MTU -7029	1.06	51.73^{cde}	99.42
2		MTU-1262	2.58	40.71^{def}	97.24
3		MTU-1064	0.58	66.09^{abc}	100.00
4		MTU-1318	0.22	31.11^{ef}	98.78
5	Medium	MTU-3626	1.37	57.88^{bcd}	99.06
6		MTU-1001	1.70	42.40^{def}	98.56
7		MTU-1075	0.51	28.60^{f}	97.54
8		MTU-1210	0.30	40.30^{def}	98.75
9	Short	MTU-1121	0.26	52.82^{cde}	100.00
10		MTU-1153	3.59	80.70^{a}	97.56
11		MTU-1156	9.93	77.56^{ab}	98.55
12		MTU-1010	8.54	73.46^{abc}	98.42
			NS	Sig.	NS
CD(0.01)				30.04	
CD(0.05)				22.17	
CV			151.95	25.53	1.39

10. RODENT MANAGEMENT IN ORGANIC FARMING

The Studies were conducted in Tippagondanahalli ($12^0$36’54N $77^0$22’ 10.2”E) village of Magadi (Taluka) Ramanagaram District to manage rodents in organic farming system groundnut with non-chemical means, during *Kharif* 2023. The experiment consists of eight treatments (Table 10.1) including standard check (placement of snap trap @ 50/ha continuously for three nights during germination stage and 2% bromadiolone baiting during ear head formation stage) and control. There were three replications with RCBD design. The treatments were imposed during germination stage vegetative stage and peg formation stage of ground crop. The mean data on LBC/ha at three different stages indicated that (Table 10.1) at harvesting stage the least LBC/ha (10.49) was recorded. Treatment 04 deep ploughing before and (regular trimming of weeds) during germination stage, spraying with botanical product (500g neem leaves, 500g glyricidia leave, 250g garlic bulbs and 2g chilli powder were mixed and boiled in 10 liters of water for 30 min and filtered, to this add 2 ltr of cow urine and 500g pepper was added and kept for 3 days and above mixture was diluted to 20% and sprayed) during vegetative stage and installation of snap trap @ 50/ha continuously for 03 nights, recorded only 9.90 LBC/ha and 70.79 percent control success with C:B of 1:4.40, statistically on par with standard check having control success of 72.4 percent over control and yield of 979.83 kgs/ha with C:B of 1:4.95 (Table 10.2).

Table 10.1. Modules for management of rodents in organically cultivated groundnut.

Treatment	Germination stage	Vegetative stage	Peg formation stage
T1	Regular trimming of weeds, thinning of bunds, deep ploughing before sowing	Bird T perches and destroying the active burrows	Burrow smoking with chili powder
T2	Botanical mixture 1	Botanical mixture 2	Botanical mixture 3
T3	Snap trap @ 50/ha continuously for 3 nights	Snap trap @ 50/ha continuously for 3 nights	Snap trap @ 50/ha continuously for 3 nights
T4	Regular trimming of weeds, thinning of bunds, deep ploughing before sowing	Botanical 2 spraying and Burrow smoking with chili powder	Snap trap @ 50/ha continuously for 3 nights
T5	Snap trap @50/ha continuously for 3 nights	Bird T perches@ 20/ha, and destroying the active burrows	Botanical mixture 1
T6	Botanical mixture 3	Snap trap @ 50/ha continuously for 3 nights	Bird T perches @ 20/ha, destroying the active burrows and Burrow smoking with chili powder
T7	Placement of snap trap @ 50/ha continuously for 3 nights	-	2% Zn_3P_2 baiting*
T8	Control		

T7 Standard check as per UAS (B) POP recommendation.

a. **Botanical mixture 1:** Add cassava flour to fruit juice of tuba (*Croton tiglium*) in the ratio of 1:1; the above mixture is sun-dried and powdered. To these 2 cups of boiled rice was mixed and placed as a bait.

b. **Botanical mixture 2:** 500 gm of neem leaves, 500 gm of gliricidia leaves, 500gm of vitex leaves, 500 g of garlic bulbs, and chili fruits were boiled in 10 L of water for 30 min and filtered, to this add 2 L of cow urine and (500 g) of pepper powder was added and kept for 3 days and above mixture was diluted to 20 per cent and sprayed.

c. **Botanical mixture 3:** Gliricidia bark and leaves are boiled in 2 L of water for 20 min and filtered, the maize was soaked overnight in a filtered solution, and the maize was used as bait material.

Table 10.2. Management of rodents in organically cultivated Groundnut during *kharif* 2023

Treatments	Germination stage (LBC/ha)		Vegetative stage (LBC/ha)		Peg formation stage (LBC/ha)		Harvesting stage (LBC/ha)	Reduction over control (%)	Yield kg/ha
	DBT	10 DAT	DBT	10 DAT	DBT	10 DAT			
T_1	15.67 (3.92)	12.33 (3.53)	12.67 (3.58)	10.67 (3.28)	16.30 (4.07)	12.47 (3.59)	19.07 (4.38)	48.06	844.00
T_2	17.33 (4.20)	8.00 (2.84)	9.33 (3.08)	8.00 (2.84)	12.33 (3.55)	9.33 (3.09)	16.10 (3.98)	56.14	864.67
T_3	19.33 (4.40)	8.67 (2.98)	10.37 (3.26)	9.67 (3.13)	14.67 (3.89)	10.47 (3.28)	15.74 (4.00)	57.11	882.33
T_4	15.37 (3.97)	11.33 (3.43)	14.67 (3.88)	8.33 (2.96)	11.37 (3.40)	6.33 (2.57)	10.30 $(3.26)^{cd}$	71.93	953.33^{ab}
T_5	16.67 (4.08)	13.67 (3.66)	15.99 (4.00)	10.07 (3.25)	15.37 (3.93)	9.57 (3.13)	16.33 (4.07)	55.51	907.33
T_6	18.00 (4.24)	10.33 (3.25)	12.33 (3.53)	9.33 (3.06)	13.40 (3.66)	10.00 (3.11)	15.00 (3.83)	59.14	884.33

T_7	15.33 (3.91)	6.00 (2.52)	9.33 (3.10)	12.33 (3.56)	15.53 (3.99)	7.33 (2.68)	9.67 (3.15)^{d}	73.67	977.33^{a}
T_8	16.33 (4.08)	22.00 (4.72)	23.67 (4.91)	26.35 (5.18)	33.33 (5.81)	34.49 (5.91)	36.71 (6.10)	-	741.00
F test	NS	**	**	**	**	**	**		**
SEM±	-	0.37	0.22	0.28	0.29	0.38	0.19		6.55
CD(0.05)	-	1.13	0.68	0.85	0.88	1.19	0.59		19.8
CV%	-	18.98	10.71	14.25	12.54	19.87	8.36		10.28

** significant at p<0.05 and 0.01; the same alphabets in superscript did not differ significantly, but alphabets with different superscripts differed significantly.

Figures in the parentheses are square root transformed values √ (X + 0.5).

11. COLLECTION AND VALIDATION OF INDIGENOUS TRADITIONAL METHODS FOR VERTEBRATE PEST MANAGEMENT.

The ITKs available in different areas for vertebrate pest management was documented (Table 11.1 & 11.2, Fig. 11.1).

Table 11.1. Management strategies adopted by farmers (including ITKs) against major vertebrates in experimental locations of Lakhimpur

Sl. No.	Agro-climatic Region	Name of Vertebrates pest	Management Strategies
1.	North Bank Plan Zone	Wild boar	Fencing, torch lightning, use of different sounds
		Parrot	The beating of drums, use of a catapult
		Rodents	Digging of rat holes, rodenticides
2.	Central Brahmaputra Valley Zone	Wild boar	Fencing, torch lightning, use of different sounds
		Parrot	The beating of drums, use of a catapult
		Rodents	Digging of rat holes, rodenticides, use of traps
3.	Upper Brahmaputra Valley Zone	Wild boar	Fencing, torch lightning, use of different sounds
		Monkey	Use of guilty, use of sounds
		Squirrel	Use of trap
		Rodents	Rodenticides, use of traps

Fig. 11.1. Indigenous traps developed by farmers in Assam

Table 11.2. Mitigation measures (ITK'S) practiced by farmers in Chamarajanagar, Mandya and Tumkur district of Karnataka

S.N	Management measures practiced	Control measures practiced for crops	Targeted species
1	Use of snake skin as a repellent for rodents	Paddy and groundnut	Rodents
2	Lighting serial sets	Sweet potato, groundnut	Wild boar
3	Sounding through drums with fan	Ragi, sweet potato, pulses etc….	Elephant, wild boar, parrot, Monkey
4	F.M Radio as bioacoustics	Ragi, banana, pulses, groundnut	Wild boar
5	Use of Local dog (Painted as tiger)	Ragi, banana, pulses, groundnut	Wild boar, Monkey
6	Use of bright colored cloths / Bright colored polythene covers	Ragi, banana, pulses, groundnut	Wild boar
7	Artificial fires with tires	Ragi, banana, pulses, groundnut	Wild boar, Elephant, Sloth bear
8	Cultivating un preferred crops such as chili, sun hemp, around the main fields	Groundnut	Wild boar, Elephant, Monkey
9	Discorded cattle horn filled with kerosene and burnt	Ragi, gondnut and vegetable crops	Wild boar
10	Datura plants are planted outside the main field. As the Datura seeds start shattering rodents coming in the fields eat the Datura seeds.	Groundnut, Vegetable crops, Paddy	Rodents

TECHNOLOGY RECOMMENDED, COMMERCIALIZED, UNDER EVALUATION, PATIENTS FILED AND GRANTED, TECHNOLOGY INCLUDED IN EXTENSION BULLETINS AND OTHER PUBLICATIONS FOR FARMERS

1. Telangana (PJTSAU, Hyderabad)

1.1. Technology under evaluation: Solar Flair light for Agriculture

2. Punjab (PAU (RC), Ludhiana)

Name of Technology	Detail	Recognition	Output
2.1. Technologies Under Evaluation			
Repellent based formulation (RBF) developed	The RBF adsorbed on wood waste and packed in small pouches of muslin cloth need to be tied around the crop with the help of bamboo poles and ropes or directly on stems	This formulation was found effective in repelling rodents, blue bull and Wild boar	This formulation provided up to 90% prevention against their damage during the vulnerable stages of crops
Developed neem and andrographolide based bait with toxic and antifertility effects against both sexes of rats	Tested and found effective in crop fields and commensal situations. Testing its shelf life, stability and effective mode and duration of application	This formulation was found effective against rodents	Being tested further in crop fields and commensal situations
Developed neem-based bait with antifertility effects against both sexes of rats	Improved bait to increase the antifertility effect against rodent pests	This formulation was effective as antifertility agent against both sexes of rats but effect was reversible after short duration	Need to test improved bait both in laboratory and field conditions
Identified economically viable techniques for the management of blue bull in different crop fields	Physical barriers like nylon net, electric fencing at a height of 7 feet from ground, acoustic and visual deterrents and RBF were tested in villages of district Ludhiana and cost benefit ratio calculated for different crops	Effective against blue bull & wild boar	Technologies found effective are being tested in district Mohali at identified vulnerable stages of different crops
Developed sex pheromone based ready to use stable 2% zinc phosphide bait for mitigating bait shyness/poison aversion	Found effective and stable for 90 days in laboratory conditions. Need to test in fields	This formulation was found effective against rodents	Being tested further
Developed papaya seed extract based solid lipid nanoparticles	Found effective in causing antifertility in rats up to 105 days of treatment withdrawal	This formulation was found effective against rodents	Being tested further
Developed quinestrol based PLGA nanoparticles and ready to use bait	Found effective in causing antifertility in rats up to 90 days of treatment withdrawal	This formulation was found effective against rodents	Being tested further
2.2. Patent filed			
Stable ready to use zinc phosphide bait for rodent management	Developed and found effective against rodents for application in crop fields and outer area under commensal situations		Patent filed on 12.12.2019 in Indian Patent Office

3. Punjab (PAU (AO), Ludhiana)

3.1. Olfactory Repellent (OR): 500 ml of olfactory repellent (Ricinoleic acid 60%, Neelbo®) was mixed with 500 gm of wood shavings. 100 pouches / acre were tied with poles/rope at a height of 1 to 1.5 feet from the ground. Cost per acre = Approx. Rs 950.

3.2. Acoustic Deterrent (AD): Bioacoustics (1 unit/ acre) was installed in selected fields and were played at the rate of two hours each in the morning (4:00 to 6:00 am) and evening (7:30 to 9:30 pm).

3.3. Habitat Management: For management of Purple Moorhen Habitat management in integration with other bird pest management methods. It includes clearing of pond peripheries and removal of weeds from ponds and installation of reflective ribbon and polynet on the periphery.

3.4. Technology Commercialized: CD- Revised & updated of alarming calls for management of depredatory birds: Evaluation of revised CD of alarming calls for management of depredatory birds was carried out. It was under pipeline for mass production for farmers by Additional Director, Communication Centre, PAU, Ludhiana.

4. Assam (AAU, Jorhat)

4.1. Technology under Evaluation

- The treatment combination of Parachute nets + bhut jolokia baiting+ agri-cannon (at vulnerable stage) against Rhesus macaque has recorded 68.31% control success with a B:C ratio of 3.06:1.
- "Squirrel net guard" made of plastic net (mesh size: 3mm) fitted on wooden frames were erected at 45^0 angle around the coconut trees at 8 feet height above the aerial route + trapping with local trap. This product has resulted reduction of 52.85% infestation as well as 49.49% nut damage in coconut caused by *Dremomys lokriah.*

5. Assam (AAU, North Lakhimpur)

5.1. Technologies accepted for state pop on 23/10/2024

The Farmer - Rhesus Monkey conflict in agricultural crop fields can be minimized by installing the integrated Agri-solar power fencing system for crop protection. The Agri-solar energizer uses 12V input solar energy, generate electrical shocks to the higher vertebrates. The shock from an electric fence causes no physical damage to animals and humans beings and if they are forced to enter the fence, experience mild jerk and thus helps saving of the crop from being damaged

5.2. Technology under evaluation

- HDPE net of 5 cm mesh and 1.5 mm thickness using bamboo poles of 8 feet in height found to protect *Rab*i and *Kharif* vegetables and effective in preventing monkey's entry in to the crop fields to the extent of 80-100 per cent and also a cost effective one.
- Use of ECO-Gun and wrapping of maize cobs in outer 3 rows significantly reduced the cob damage by parakeets.

6. Andhra Pradesh (ANGRAU, RARS, Maruteru)

6.1. Technology Recommended for farmers and in state POP

6.1.1. Trap barrier system for rodent management in rice
6.1.2. Liquid baits for rodent management in storage godowns
6.1.3. Low-cost solar fence for monkeys and wild boar

7. Karnataka (UAS, Bengaluru)

7.1. Peafowl management

For the management of peafowl in crop lands arrange the reflective ribbons of 2 inch width in grid format with a spacing of 6 ft X 6 ft with a twist towards north to south direction around crop area and 1feet above the crop.

7.2. Rodent management in natural farming

For the management of rodents in organic cropping system take up the cultural practices such as deep ploughing before sowing and regular trimming of weeds. In the vegetative stage spray (40 DAG) the botanical product and in the peg formation stage/crop maturity place the snap traps @50 per hectare for 3 nights continuously.

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Research Publication

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37. Ranjit, M.T., Chellappan, M. Chaudhary, V. 2024. Evaluation of management techniques against wild pig (*Sus scrofa*) in cassava (*Manihot esculenta* Crantz) in Kerala. *In* book of abstract for conference on Achieving Sustainable Developmental Goals in Challenged Agro-ecosystems (ASDGCAE-24) (Eds Santra, P, Chaudhary, V., Kumar, M., Singh, D.V., Kumar, P., Solanki, R.K. and Choudhary, K.). Published by Arid Zone Research association of India, Pp 184 (Abs).
38. Rohini, Babbar, B. K. 2024. Behavioural responses in house rats exposed to acetophenone- a known sex pheromone. In the proceedings of Conference on Achieving sustainable development goals in challenged agro-ecosystem organized by ICAR-CAZRI, Jodhpur from March 3-5, 2024.
39. Saikia, P. 2023. Agricultural Ornithological Research at Assam Agricultural University. In *Proc ICBFSCC -2023* AAU, Jorhat, April 2023
40. Saikia, P. 2023. Bird diversity in agricultural landscape. In *Proc. International conference Next-Gen Preparedness for Food Security and Environmental Sustainability*. 22-24 November 2023 AAU-ARRI, Titabar, Assam
41. Saikia, P. 2023. Traditional knowledge for Pest Management. In the *Proc. National Conference on DHARA: Bharatiya Paramparik Krishi Mela Ministry of Education, GoI,* Tezpur University, 04-06 June 2023
42. Saikia, P. 2024. Bird Diversity in River Eco-system of Assam. In *Proc. National Seminar Socio-Economic valuation of Rivers of North East India.* 15 March 2024, Madhabdev University, Assam
43. Saikia, P., Phukon, B. 2024. Reproductive cycle of Barn Owl *Tyto alba* in artificial nest box and diet analysis in agro- ecosystem of Assam. In *Proc. National conference on Achieving sustainable goals in challenged Agro ecosystems* March 03-05, 2024, ICAR-CAZRI, Jodhpur
44. Sharma, A., Singla, N., Bansal, N. 2024. Toxicity of ready-to-use Brodifacoum bait against *Bandicota bengalensis*: mortality, coagulopathy and histology. In *Conference on achieving sustainable development goals in challenged agro-ecosystems* held at CAZRI, Jodhpur, India from 04-05 March, 2024. Pp. 94.
45. Singh, S. Chaudhary, V., Meena, R.C. 2024. Effectiveness of second-generation anticoagulant rodenticide for managing commensal rodents. *In* book of abstract for conference on Achieving Sustainable Developmental Goals in Challenged Agro-ecosystems (ASDGCAE-24) (Eds Santra, P, Chaudhary, V., Kumar, M., Singh, D.V., Kumar, P., Solanki, R.K. and Choudhary, K.). Published by Arid Zone Research association of India, Pp 302 (Abs).

46. Singla, N. 2024. Rodent pest management: Recent challenges and future trends. Proceedings of Asian Pest Management Forum 2024 held at Emerald Hotel, Bangkok from 10-11 July, 2024, pp 24. (Invited Talk)
47. Singla, N. 2024. Rodents and Arthropods: Key Vectors in the Spread of Zoonotic Parasitic Infections. *32nd National Conference of Parasitology* held at IISER, Pune from 03-05 October, 2024. (Invited talk)
48. Singla, N. 2024. Sustainable rodent pest management strategies for reducing crop losses in agro-ecosystems. *Conference on achieving sustainable development goals in challenged agro-ecosystems* held at CAZRI, Jodhpur, India from 04-05 March, 2024. Pp. 34.
49. Thukral, R., Singla, N., Arora, P., Choudhury, D. 2024. Nano formulated papaya seed extract and its influence on fertility of *Bandicota bengalensis*. *Conference on achieving sustainable development goals in challenged agro-ecosystems* held at CAZRI, Jodhpur, India from 04-05 March, 2024. Pp. 304.
50. Vashishat, N., Kler, T. K., Kumar, M, 2024. Assessment of the reproductive status of Wild boar from hormonal estimation of fecal samples. In the conference on "Achieving Sustainable Development Goals in Challenged Agro-Ecosystems (ASDGCAE-24)" (March 3-5, 2024) organized by ICAR-Central Arid Zone Research Institute, Jodhpur (Abs).

Research Publication (Nos) (2023-24)

Centres	Research			Popular/ Technical/ Extension articles	Technical bulletins	Chapters (Book and others)	Books	Folders, pamphlets & others*	Abs/papers in conference/ symposium/ seminar	Accession deposited in Gene Bank etc
	Less than 6	*6 -10*	*10 and more*							
CAZRI, Jodhpur	3	1	-	3	1	10	1	-	8	11
PJTSAU, Hyderabad	2	2	Nil	Nil	Nil	Nil	Nil	6	13	Nil
PAU Ludhiana (RC)	8	15	1	2	1	Nil	1	4	16 (2 as invited talks)	30
PAU Ludhiana (AO)	9	2	Nil	6	Nil	Nil	Nil	Nil	6	Nil
KAU, Thrissur	4	3 (submitted)	Nil		Nil	Nil	Nil	Nil	6	3 SRA submission
UAS, Bangalore	2	Nil	Nil	Nil	2	Nil	Nil	8	5	
RARS, ANGRAU, Maruteru	2	Nil	Nil	02	Nil	Nil	Nil	Nil	02	01
AAU, Jorhat	1	3	Nil	Nil	2	Nil	Nil	Nil	2	Nil
AAU, Lakhimpur	01	Nil	Nil	01	02	03	Nil	01	08	Nil
AAU, Anand	04	01	00	03	02	01	Nil	03	04	Nil

Details of all the above items in a separate list may be attached

Resource Generation (2023-24)

Centre	Source/Agency	Projects/consultancies/ products	Amount (Rs)
CAZRI, Jodhpur	NICHEM SOLUTIONS, Miraj Corporate Park, Plot No. A-223, Second Floor, Road No. 16, Behind Ashar IT Park, Wagle Industrial Estate, Thane (W) - 400604, Maharashtra-INDIA.	Evaluation of efficacy of different grades of non-toxic, eco-friendly Rodent Repellent Additive developed by M/S NICHEM SOLUTIONS, against rodent attack under choice and no-choice conditions.	Rs. 5,04,986.00
PJTSAU, Hyderabad	M/s. Gamyam Technologies Pvt Ltd, Hyderabad	Products- Royalty charges	Rs.1,11,672/-
PAU Ludhiana (RC)	Department of Wildlife and Forest Preservation, Punjab) Syngenta India Ltd. i) Institute of Research and Development, Montpellier, France	Project: Study on the Ecology, Behavior and Management of Nilgai & Wild boar at Mattewara Forest & Surrounding Villages and at Rail Coach Factory, Punjab: A Pilot Project) Testing the efficacy of ready to use brodifacoum in rice and sugarcane i) Atypical Human Trypanosomiasis due to *Trypanosoma* spp. in Punjab, India: A Pilot Study	The department will share five camera traps (worth Rs 1,25,000/-) and a drone (worth Rs 1.5 lakh) to study the behavior of blue bull) 11.80 lakhs s 5.98 lakh along with equipment and testing kits
KAU, Thrissur	Revolving Fund, Kerala Agricultural University	Products	
UAS, Bangalore	i. Syngenta i. Katidhan Tech Pvt Ltd i. Pestosys llp	i. Bio efficacy of Brodifacoum 0.005% BB against rodents in Sugarcane and paddy. i. Evaluation of parabraksh autonomous light deterrent system for mitigating the vertebrate pests in agriculture i. Evaluation of Rat-run green bait for deterrent effect	i. 8,00,000 i. 5,65,000 i. 3,00,000

Extension activities (2023-24)

Centres	Exhibitions (Nos)		Farmers Trainings (Nos)		TV/Radio/ extension lectures (Nos)	Kisam mela/field days (Nos)		TSP activities (Nos)		Others (Nos)	
	Organized	*Beneficiaries*	*Off/on campus*	*Beneficiaries*		*Organized*	*Beneficiaries*	*Organized*	*Beneficiaries*	*Organized*	*Beneficiaries*
CAZRI, Jodhpur											
PJTSAU, Hyderabad	-	-	30	897	10	-	-	4	160		
PAU Ludhiana (RC)	03	Farmers and State Agriculture Development Officers of Punjab	On Campus: 2 Off-campus field demonstrations: 12	12 farmers + 8 health officials 215 farmers	03 TV talks + 08 extension lectures	Kisan Melas: 02 Field Days: 07	Thousands of farmers from Punjab and adjoining states 156 farmers	--	--	v.-Individual-level guidance to Farmers and application of management methods to prevent rodent and blue bull damage vi.-Issued 03 Advisories to farmers at specific crop timings for rodent control ii.- Presentation as a resource person at 03 Research & Extension Specialists' Workshops ii.-Individual Technical guidance through telephone/personal visit	v.15 farmers vi.Farmers of the whole Punjab state vii. Punjab State Extension personnel iii.+40 farmers, scientists, staff, residents and officials
PAU Ludhiana (AO)	5	>550	2	65	2	4	>1 lakh	-	-	03	>150
KAU, Thrissur	1	109	4	284	--	--	---	6	1096	02	110
UAS, Bangalore	2	1103 (Public and Student	50	3182	2	2	5 lakhs (Students,	3	175 (Input distr	Problematic field visits - 71	71

		s)					Farmers, and public Government stakeholders)		ibution) 1372 (Extension activities)		
RARS, ANGRAU, Maruteru	04	3500	08	350	03	04	2000	04	183		
AAU, Jorhat	-	-	10	255	-	-	-	8	320	01	50
AAU, Lakhimpur	01	500+	09	230	09	01	526	06	794	01	
AAU, Anand	00	00	02	100		02	3000 approx.	00	00	Farmers meeting: 20	250 approx.

Human Resource Development (2023-24)

Centre	Student guided (Nos)		Training received (Nos)		Others (Nos)
	PhD	*M.Sc.*	*Kind of training with topic*	*Duration*	
CAZRI, Jodhpur					
PJTSAU, Hyderabad	--	2	Production protocol for biocontrol agents	21 days	--
PAU Ludhiana (RC)	6	2	i) Two days "Regional training for nominees of CCSEA (Committee for Control and Supervision of Experiments on Animals)" organized by the Institute of Microbial Technology (IMTECH), Chandigarh in collaboration with the **Ministry of Fisheries, Animal Husbandry and Dairying (MoFAH&D)** ii) Online two days "5th National Level Workshop on NIRF Indian Rankings 2024" organized by Institute for Academic Excellence, Hyderabad, Telangana ii) Online 3 days training on "Vertebrate Pest Management: Wild boars, Monkeys, and Birds" organized by National Institute of Plant Health Management (NIPHM), Hyderabad	20-21 June, 2024 (two days) (Dr Neena Singla) 13-14 December 2023 (two days) (Dr Neena Singla) 10-12 October, 2023 (Three days) (Dr Neena Singla)	**Dr Neena Singla-** -Taught 06 different courses to UG, and PG Students -Advisory Committee Member/co-advisor -07 students -Invited talks-06 -Peer recognition-03 **Dr BK Babbar-** -Taught 11 different courses to UG, and PG Students -Advisory Committee Member/co advisor-07 students - Organized a training event for PG students on the use of wildlife cameras on 02.08.2024
PAU Ludhiana (AO)	7	1	Nil	Nil	Nil

KAU, Thrissur	1	2	AI Tools and ChatGPT for research Training for AKC Nodal officers	1 day 3 days	Nil
UAS, Bangalore	-	2	-	-	-
RARS, ANGRAU, Maruteru	-	1	Field experimentation on rodent management	01 year	-
AAU, Jorhat	4	2	Nil	Nil	Nil
AAU, Lakhimpur	2	Nil	Nil	Nil	Nil
AAU, Anand	04	02	01	5 days	00

Awards and recognition

Centres	Fellowship*	Best paper		Editor of Journal	Others
		Oral	*Poster*		
CAZRI, Jodhpur	-	-	02	01	
PJTSAU, Hyderabad	Fellow of PPAI, Hyderabad	-	-	-	-
PAU Ludhiana (RC)	-	02	04	04	Best M.Sc. & Ph.D. Thesis Awards to students: 03
AAU, Lakhimpur	-	-	-	-	Conferred state-level award entitled ***Parivesh Mitra - 2023***(Friend of Environment) to PRABAL SAIKIA, PI, AINVPM& Chief Scientist, AAU-Zonal Research Station, North Lakhimpur, Assam by the Department of Science, Technology & Climate change, Govt. of Assam for the year 2023
AAU, Anand	-	-	-	-	01 (Dr. R. K. Thumar: Best Teacher award in agricultural higher education at university level 2020) 01 (Dr. Jalpa Dand, Best Research Award at University level 2023)

*Fellow of any national or international society

Collaborations and Linkages (2018-22)

Centres	Collaborative agency	Area of Collaboration and Linkage	Benefit to the Institution with such collaboration	Remarks
PJTSAU, Hyderabad	Dept. of Agri.	Demonstrations	Large-scale demonstration of VPM technologies	Dept. of Agri.
PAU Ludhiana (RC)	PAU, Ludhiana, CAZRI, Jodhpur, Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, Department of Wildlife and Forest Preservation CSIRO, Australia Institute of	v) Ecology, Behaviour & Management of blue bull & Wild boar) Testing neem seed extract-based bait alone or in combination with andrographolide for rodent pest species in the lab and field environments i) Testing rodent samples for the presence of to Trypanosoma spp. in Punjab, India for determining their zoonotic importance ii) In vivo testing of antihelminthic nanoparticle-based formulations in	i) Sharing of trap cameras, drones, guidance and technologies ii) Collaboration on using different research approaches and experimental designs iii) International recognition in the area of rodent-born zoonosis. The institute became a member of PREZODE (Association for the Prevention of Zoonotic Diseases). Dr. Neena Singla invited to attend the first meeting of PREZODE held at the French Institute of India on 28.11.24 as a	

	Research and Development, Montpellier, France ii) Thapar Institute of Engineering & Technology, Patiala iii) Departme nt of Veterinary Anatomy, GADVASU, Ludhiana i) vi) School of Public Health, GADVASU, Ludhiana	rodents viii) Histological analysis of female rat tissues in response to the effect of papaya seed-based nanoparticles Rodents as reservoirs of arthropod vectors for scrub typhus	specialist representative of PAU which was also attended by representatives of Govt. of India iv) Research & Development, publications v) Research & Development, publications vi) Research & Development, publications	
PAU Ludhiana (AO)	i. State Agricultural Department ii. KVKs of Punjab ii. Borlaug Institute for South Asia (BISA) v. AICRP on Honey Bees, Department of Entomology, COA, PAU v. GADVASU (Guru Angad Dev Veterinary and Animal Sciences University) vi. PAMETI, PAU ii. Wildlife Department of Punjab: ii. Skill Development Center x. Collaboration with FAAS Centres, Amritsar , Faridkot and Patiala x. Air Force Stations, Halwara and Air Force Stations, Adampur xi. Indian Army HQ, New Delhi ii. Defense Review	i. VPM Camps/field Days were organized in collaboration with the Chief Agricultural Officer of the State agriculture Department ii. Technical input and material, input and guidance were given regarding vertebrate pest management to the scientist of KVKs at Samrala, Ropar, Pathankot, Moga, Faridkot. ii. For management of wild boar problem, scientific knowledge was shared along with the material support v. Collaboration for the management of birds v. Collaboration with Department of Veterinary Parasitology vi. Regular lectures and training regarding vertebrate pest management was given to participant farmers. ii. Studies on the higher vertebrate's population in the areas adjoining the forest areas was undertaken. ii. Revision of course content of farmer training conducted for three-month programme x. Training regarding vertebrate pest management was given to participant farmers.	i. Benefitted from the information about the importance of bird and higher vertebrate and their management. ii. The material and guidance were provided to KVK Faridkot and Pathankot to manage the wild boar problem in field areas in proximity to the forest. ii. Benefitted from the information about vertebrate pest management. v. Benefitted from the information and guidance about bird pest management in apiaries. v. Information about the avian parasite was compiled. vi. The material and guidance were provided about the management of wild boar problem. ii. Benefitted from the information about the importance of wild life and vertebrate pest management. ii. Benefitted from the information about the importance of bird and higher vertebrate and their management. x. Participants from different walks of life benefitted by information provided about the importance of bird and higher vertebrate and their management. x. Bioacoustics system was	

	Committee, GOI visited the Halwara Air force	x. Studies on the higher vertebrate population as well as bird problem around the perimeter of Air force Station has been undertaken. xi. Initiative of green Delhi ii. Bird problem around the perimeter of Air force Station.	proved to be 100% successful in managing the problem. xi. Bird conservation strategies shared Appreciated the efforts and impact of the management methods used there.	
KAU, Thrissur	IIT Palakkad	Development of laser-based animal repellers and precision rodenticide applicators. Combines IIT Palakkad's expertise in engineering and technology with industry-driven agricultural innovation needs.	Strengthens research credentials, fosters industry partnerships, and drives innovation with real-world impact.	Nil
AAU, N Lakhimpur	ICAR-IARI, Assam, Gogamukh 23 KVK s & Dept of Agriculture, Assam & Arunachal Pradesh	Knowledge sharing, training	Capacity building on vertebrate pest management	
AAU, Jorhat	KVKs/ RARS/ Agriculture Dept. Govt. of Assam	Field training/method demonstration/ SE activities/ TSP program	To impart training and demonstration as well as input distribution to the targeted farmers	

Externally funded projects (2023-24)

Centres	Agency	Title of project	Duration	Amount (Rs)
CAZRI, Jodhpur				
PJTSAU, Hyderabad	National Bee board, New Delhi	Sustainable Intensification of Apiculture through Research & Technological Interventions for Doubling Farmers Income in Telangana State	1 year	196.27 Lakhs
PAU Ludhiana (RC)	) Syngenta i) Department of Wildlife and Forest Preservation ii) Institute of Research and Development, Montpellier, France	(i)Testing the efficacy of ready to use brodifacoum in rice and sugarcane (ii) Study on the Ecology, Behavior and Management of Nilgai & Wild boar at Mattewara Forest & Surrounding Villages and at Rail Coach Factory, Punjab: A Pilot Project (iii) Atypical Human Trypanosomiasis due to *Trypanosoma* spp. in Punjab, India: A Pilot Study	Two years) Three years iii) Two years	i) 11.80 lakh ii) The department will share five camera traps (worth Rs 1,25,000/-) and a drone (worth Rs 1.5 lakh) to study the behaviour of blue bull. iii) Rs 5.98 lakh along with equipment and testing kits
KAU, Thrissur	Syngenta India Pvt Ltd	Evaluation of the efficacy of Brodifacoum in managing the	6 months	4 lakhs

		rat incidence in deep water rice ecosystem of Kerala.		
UAS, Bangalore	Director of Research, UAS Bangalore	Depredatory Interactions of Parakeets and Peacock in Agroecosystem Human-Animal Interactions in Agrarian Ecosystem	2 years 1Year	4,00,000 2,00,000
RARS, ANGRAU, Maruteru	Nil	Nil	Nil	Nil
AAU, Lakhimpur	Nil (last year projects are contd.)	-	-	-

Technology Recommended, Commercialized, Under Evaluation, Patients Filed and Granted

Centres	Technology Recommended for farmers and in state POP (Nos)	Technology Commercialized (Nos)	Technology under evaluation (Nos)	Patents with detail (Nos) Filed	 Granted	Others (Nos
PJTSAU, Hyderabad	02	02	01	--	--	
PAU Ludhiana (RC)	Technology for rodent control in direct seeded rice crop in pipe line	Product on combination rodenticide (bromadiolone + Vit D3) formulation in pipe line for registration and commercialization	07	01	--	Technology for rodent control in rice nursery under evaluation
PAU Ludhiana (AO)	3 These technologies are included in the Extension Bulletin published by the Additional Director Communication, PAU for dissemination to farmers	01	LASER-based bird scare	-	-	-
KAU, Thrissur	-	03	02	05	-	Nil
UAS, Bangalore	02	-	-	-	-	-
RARS, ANGRAU, Maruteru	1) Trap barrier system for rodent management in rice 2) Liquid baits for rodent management in storage godowns Low-cost solar fence for monkeys and wild boar	-	1	-	-	-
AAU, Lakhimpur	01	-	02	-	-	-
AAU, Anand	01 (2023-2024)	-	02	-	-	-

List of AINP VPM staff

Sr. No.	Name		Designation	Date of Joining
1.	Dr Vipin Chaudhary	NC Unit, CAZRI Jodhpur 1977-78	Network Coordinator	16.10.1998
2.	Mr. Ramesh Chand Meena		ACTO	19.10.1998
3.	Mr. Surjeet Singh Bharath		ACTO	23.01.1999
4.	Dr. Kundan Mal Gawaria		ACTO	01.04.2012
5.	Mr. Zakir Hussain		Driver/TO	05.04.2011
6.	Dr. P Rajnikanth	PJTSAU, Hyderabad September 1982	PS & Head	04.09.2024
7.	Dr. V Sunitha		Scientist	26.02.2014
8.	Dr. I Aruna Sri		Scientist	27.06.2020
9.	Dr S Srinivas Rao		Scientist	04.09.2024
10.	Dr. P Venkateswarlu		Technical Assistant	27.10.2010
11.	Mr. AVLN Ramalingeswara Rao		Technical Assistant	27.10.2010
12.	Mr. Korani Naveen		Lab Boy	19.04.2010
13.	Dr. R. K. Thumar	AAU, Anand	Sr. Ornithologist	01.02.2023
14.	Dr. Jalpa J. Dand	29.11.1982	Jr. Ornithologist	01.02.2023
15.	Shri. A. H. Nayi		Technical Assistant	09.10.2017
16.	Dr. Tejdeep Kaur Kler	PAU, Ludhiana 20.01.1978 & 19.01.1983	Principal Ornithologist	25.05.1996
17.	Dr. Manoj Kumar		Ornithologist	04.03.2010
18.	Mr. Manjeet Singh		Fieldman	11.08.2020
19.	Dr. Neena Singla		Principal Zoologist (Rodents)	28.07.2000
20.	Dr. B. K. Babbar		Sr. Zoologist (Rodents)	28.12.2005
21.	Ms. Baljit Kaur		Technical Assistant	22.09.2012
22.	Mr. Sarbjit Singh		Agricultural Sub Inspector	01.03.2013
23.	Dr. R. K. Borah	AAU, Jorhat 23.03.2001	Scientist	13.12.1991
24.	Mr. Jintu Saikia		Technical Assistant	17.07.2024
25.	Mr. S. J. Bhuyan		Field Assistant	08.12.2017
26.	Dr. Prabal Saikia	ZRS, N Lakhimpur, AAU, Jorhat 23.11.2009	Chief Scientist	24.11.2009
27.	Dr. Mani Chellappan	KAU, Trissur 2015	Ornithologist	05.05.1999
28.	Dr. Ranjith M T		Jr. Ornithologist	18.06.2019
29.	Mr. Aswin T S		Technical Assistant	01.08.2022
30.	Dr. Mohan I Naik	UAS, Bangalore January 1978	Prof. & PI	01.10.2013
31.	Dr. Namala Srinivasa Rao	ANGRAU, Maruteru 1986	PS & PI	01.06.2015
32.	Dr. ADVSLP Anand Kumar		Scientist	01.08.2024
33.	Shri. P. Veeraiah		Technical Assistant	01.06.2022
34.	Dr. M Abas Shah	ICAR-CITH, Srinagar 02.02.2024	Scientist	02.02.2024
35.	Rohit Chaudhary	BUAT, Banda 02.02.2024	Scientist	04.11.2024
36.	Dr Rakesh Kumar	Dr YSPUH&F, Solan 25.07.2024	Scientist	25.07.2024
37.	Dr Navneet Rana	IGKV, Raipur 02.02.2024	Scientist	02.02.2024

Financial Progress (ICAR-Share only)

Year	Target (BE/ RE)	Remittance received from ICAR	Achievements (Rs in lakhs)				Achievement (%)
			Released to centers	Actual Expenditure by centers	Expenditure at PC Unit	Total	
2018-19	581.19	581.19	555.42	542.3	22.33	564.63	97.15
2019-20	558.84	558.84	530.59	489.41	26.50	515.91	92.32
2020-21	548.5	548.5	520.2	520.2	10.06	530.26	96.67
2021-22	577	577	546.5	527.4	29.3	556.7	96.48
2022-23	540	540	505.11	505.3	34.89	540	100.00
2023-24	788.34	788.41	725.24	694.63	56.56	751.19	95.28

Glimpses of Annual Review Meeting 2023








ALL INDIA NETWORK PROJECT ON VERTEBRATE PEST MANAGEMENT

ICAR-CENTRAL ARID ZONE RESEARCH INSTITUTE, JODHPUR