Rodent Management – Session 1

Reducing rodent damage to rice in Cambodia through ecologically-based rodent management approaches tailored to local conditions

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Throughout Cambodia, rodents are an important pre-harvest pest of rice. The degree of rodent damage varies depending on the season and location, but in Takeo province, average rodent damage estimates of 16-22% per season were recently recorded across several villages. In such areas, rice farmers indiscriminately apply acute rodenticides and electric fencing despite their awareness of the hazardous risks to people and other animals. To help smallholder farmers minimize yield losses from rodent pests, adaptive research experiments were established in two villages in Takeo province. In each village, three replicate 5-hectare sites were selected for treatment and three for control. In each treatment site, groups of farmers implemented ecologically-based rodent management (EBRM) methods over two rice cropping seasons. The management methods were adapted based on the local conditions and preferred practices of farmers. These included maintaining weed-free field margins, synchronous planting, community rat hunts, no electric fencing and either a Linear Trap Barrier System (LTBS) with limited and targeted bromadiolone application (Kandaul village) or a Community Trap Barrier System (CTBS) with no rodenticides along with a LTBS near refuge habitats (Ro Vieng village). Over 100 rats were trapped at each treatment site per season and rodent damage levels were reduced from 20-35% on average per site and season in the non-treatment sites to less than 6% in the treatment sites. Rice yields were 20-32% higher in the treatment sites than in the non-treatment sites, giving at least a 50% increase in farmers' net income. These findings provide strong evidence of the benefits of EBRM for rice farmers in areas where rodent damage is high. These results are now being disseminated to farmers across Cambodia through a cross-learning platform and an integrated package of recommendations that can be specifically tailored to particular conditions is currently being developed.

Rodent Management – Session 1

Identification and potential uses of spatial patterns for predicting pest species outbreaks

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Rodent crop pests pose significant risks to food security not least because of complications regarding control actions, largely due to difficulties in predicting when an outbreak will occur. While it is possible, in some instances, to anticipate outbreaks given specific environmental conditions, warning signs may not appear sufficiently early to allow farmers to implement timely pre-emptive control actions given the constraints of agricultural practices. Spatial lags in the spread of outbreaks may allow the detection of the beginnings of an outbreak in a location, and provide an early warning before the rodent abundance pattern reaches a subsequent location. Research carried out on spatial patterns, such as travelling waves, is limited due to the need for extensive and exhaustive monitoring over a large area, and as a consequence the use of spatial patterns in applied ecology is limited. An extensive monitoring programme from 2011 to 2017 of *Microtus arvalis* (common vole) in northern Spain (100,000 km^2) provides an ideal dataset, comprising 85,855 indices of abundance, for exploring both how a spatial pattern may inform control, but also advise on where monitoring efforts may be most effective. With this in mind, the aim of the research was (i) to determine the speed of the spatial pattern in common voles and how this varies with direction; (ii) to determine which environmental features are associated with the location of epicentres. Here we characterise the spatial pattern of common voles in a recently colonised part of their range, determine what landscape features lead to areas becoming sources of patterns, and suggest how this may provide valuable implications for the control of the pest species. In doing so we hope to be able to provide farmers with a predictive ability to prepare for an upcoming outbreak with the potential of reducing pest impacts.

Rodent Management – Session 1

Basic urban services as modifiers of rodent abundance in Brazilian urban slums

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There are more than one million *leptospirosis* cases reported annually worldwide, the majority of which are from tropical urban slums. In urban slums, inadequate infrastructure and lack of basic sanitation promote populations of synanthropic rats (*Rattus norvegicus* Berkenhout 1769), a major reservoir of *Leptospira* – the aetiological agent of *leptospirosis*. Slums are not homogeneous, and within slums there are socioeconomic and environmental gradients which influence access to basic urban services (BUS), which potentially affect rodent abundance and, ultimately, human infection risk. The aim of this study was to assess the effect of BUS, specifically rodent chemical control and urban refuse collection, on the abundance/activity of *Rattus norvegicus* populations in four urban slums in Salvador, Brazil, accounting for environmental and socioeconomic variation. Our main hypothesis is that rats will be less abundant/active in parts of the slums with rodent control and regular refuse collection. We have collected data to estimate rodent abundance and activity, by trapping-removal and track plates methods, in spatially randomized points within the four different slums. In addition to rodent sampling, we surveyed environmental variables and interviewed residents to evaluate their access to BUS within each area. Through mixed effects generalized linear models, we will assess whether rodent abundance/activity is lower where there is rodent control and urban refuse collection, after controlling for environmental and socioeconomic confounders. Further, this study will inform spatial models to identify rodent hotspots and relate those spots to human infection risk, both likely to be mediated by the access to BUS. Quantifying the effects of current offered BUS on the abundance/activity of urban *Rattus norvegicus* is key to evaluate current strategies for *leptospirosis* prevention, which will be the first step to the proposal of new, locally feasible and economic effective interventions.

Rodent Management – Session 1

Bait attraction may not be the same as bait consumption

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Foraging rodents cause extensive damage in agricultural and silviculture, therefore posing a threat to food security and forest restoration. Adaption to rodenticides and public ban of many pesticides in forestry requires new methods of control to be developed. One possible solution is to use synthetic odors mimicking food to manipulate rodents' behaviors as many of them rely to a big extent on their olfactory system to forage. The use of different foods to trap rodents is common knowledge, but little is known about which parts of the food and their volatile signals. Therefore we studied forest rodents attraction to two parts of acorns (*Quercus robur*) – the shell and the nut - and analyzed their volatile emissions. We assessed the odor attraction by baiting snap traps with visually masked shells and nuts. To identify the volatile emissions from the shell and nut, we sampled the acorn parts using solid-phase microextraction and dynamic headspace and then analyzed the samples with gas chromatography coupled to mass spectrometry (GC-MS). We trapped mainly yellow-necked mice (*Apodemus flavicollis*), wood mice (*Apodemus sylvaticus*) and bank voles (*Myodes glareolus*). Acorn shell and nut were equally attractive to them indicating that some volatile compounds were shared between the acorn parts. Analysis with GC-MS revealed that 16 volatile compounds were emitted both by the shell and the nut. The result from our study indicate that rodents may not only be attracted by odors from the edible parts of their food, but also by in-edible parts such as the acorn shell. This have implications when evaluating baits as bait consumption and bait attraction may not be correlated. Future work will test forest rodents' attraction to the 16 identified compounds in order to develop an odor analog of acorns which will be used to camouflage seeded trees.

Rodent Management – Session 1

Deter to protect: use of predator's odor smell to deter granivorous rodents from consuming acorns

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Seed consumption by granivorous rodents such as *Myodes glareolus* and *Apodemus sylvaticus* are one major drawback for the implementation of low-cost direct seeding in forest restoration programs around Europe. As a main prey for several mammal predators, rodents have evolved a complex olfactory system triggering anti-predation behaviors. Although fear-induced behavior in rodents has been studied intensively in recent years, its applicability has not yet been implemented successfully in the field of forest protection. Therefore, we aim to identify how rodents could be deterred by volatile odorant molecules from their predators and how these predator smell could be used as repellents to deter them from acorn consumption when direct seeding is applied. Our focus is on the identification of relevant odor volatiles from feces, urine, and fur of different mammal predators such as mink (*Neovision vision*), stoat (*Mustela erminea*), least weasel (*Mustela nivalis*), ferret (*Mustela putorios furo*) and the red fox (*Vulpes vulpes*). After identifying relevant odor volatiles, behavioral experiments with bank voles (*Myodes glareolus*) were implemented using synthetic generated predator volatiles in a y-maze set up. Finally, field experiments will be carried out optimizing our most relevant volatiles into the base matrix formulation SPLAT (Specialized Pheromone & Lure Application Technology) to investigate rodent deterrence by selected odor compounds during field conditions and possible side effects on seed germination. Our preliminary results show high rodent repellency of mink excrement, and no significant negative effects on acorn germination. Here we present our preliminary volatile compounds from fur and feces of the selected predators and their effects on rodent behavior. The present project could increase our understanding of prey-predator interaction dynamics and how its appliance could enhance seed-based forest restoration.

Rodent Management – Session 1

Rodents on pig farms: infestation levels related to environmental factors and management practices

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Domestic pig meat consumption is globally rising, increasing its production in development countries. Rodents produce economic and sanitary problems on pig farms. Characteristics of pig housing and management may affect rodent infestation. To analyze the relationship between wild small mammal infestation with pig farms' environmental characteristics and farmers' management practices, seasonal live-trapping in five habitats within 18 pig farms (seven under intensive and eleven under extensive management systems) were performed in central Argentina simultaneously with an environmental and management practices survey. The last was done interviewing the farmers with a semi-structured questionnaire. A total of 472 wild small mammal individuals were captured (with 2,360 cage live trap-nights and 2,463 Sherman trap-nights): the three introduced murids, *Rattus norvegicus*, *Rattus rattus* and *Mus musculus*, three native sigmodontines, *Akodon azarae*, *Oligoryzomys flavescens* and *Oxymycterus rufus* and also two native marsupials, *Didelphis albiventris* and *Lutreolina crassicaudata*. The information of the environmental characteristics and management practices registered were synthesized in eleven variables. Based on a Redundancy Analysis, 56% of the variance of small mammal abundances in the farms was associated with the type of management system, the frequency of rodent control activities, the type of disposal of domestic waste and the existence and location of waste deposits. Generalized Linear Mixer Models showed that *Rattus norvegicus*, *Mus musculus* and *Akodon azarae* abundances depended on season and habitat. Moreover, *Rattus norvegicus* was more abundant in farms where rodent control activities were absent or were not frequent, while *Mus musculus* where rodent control activities were frequent. For *Akodon azarae*, a relationship between the density of pigs and the habitat distribution was found. *Rattus rattus* abundances increased with the increase of dog abundances in farms. Management actions influenced infestation levels of rodents but little attention is lent to pest rodent control or prevention.

Rodent Management – Session 1

The occupancy of barn owl in artificial nest boxes to control rice field rats in Yogyakarta Indonesia

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To overcome rat problem in Indonesia, we implement an integrated pest management. One of the components implemented was a biological control using barn owls by constructing barn owl nest box in rice crop. The goal of the study was to evaluate occupancy of barn owl in an artificial nest box, rat population and rat damage. The research was conducted in three locations by allocating 10 nest boxes randomly in Yogyakarta in 2016. A separate location was selected as a control without barn owl nest boxes with 5 km distance. The assessment of their occupancy was monitored by the presence of the barn owl in their nest box (egg, chick and adult), used nest and their feces. An active burrow method was performed to monitor the rat population along 100 m of irrigation channel bank with three replicates. Rat damage intensity was estimated by sampling 150 tillers randomly (Aplin et al., 2003) then counting the total tiller number and cut tillers. The result indicated that 20% of nest boxes were occupied by the barn owl, 40% of them were ever occupied, and the rest 40% were never occupied. About 44% of active burrows was found with an average of one rat per 2 m length of the irrigation channel bank. The rat damage area was accounted for 44% with 6.5% for their intensity and was no significantly different to the control site. Constructing of barn owl nest boxes in rice fields did not affect the population of the rice field rat or their damage.

Rodent Management – Session 1

Biological control of urban rats in the World Heritage town of Luang Prabang, northern Laos

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Here we present results of a campaign of biological rodent control in the World Heritage town of Luang Prabang in Northern Laos that was implemented in 30 sub-districts ('villages') or 3,706 households, which constituted a large part protected under UNESCO (about 197 ha). Rat bait containing lethal quantities of the parasitic protist *Sarcocystis singaporensis* was applied by residents during the dry season (February to June) in the so-called 'wetlands' and 'heritage zone', both of which are part of peninsular Luang Prabang (at the confluence of the Mekong and Khan rivers). Levels of rodent infestation before and after treatment were monitored by the percentage of footprint-positive tracking patches, live-trapping, and interviews with residents. The only rodent species observed in the town were the Asian house rat (*Rattus rattus*; *Rattus tanezumi*) and the Pacific rat (*Rattus exulans*). The campaign significantly reduced rodent activity in the protected area: By 44.5% - 91.3% in the heritage zone (average reduction: 69.8%), and 27.3% - 95.5% in the wetlands (average: 67.1%) according to the post-campaign data in June/July (wet season). Rodents activity increased or remained at pre-campaign level in three untreated villages. Interviews with residents revealed similar results: They observed significantly fewer rodents on their properties after the campaign. We detected significant correlation between villagers' observations and rodent activity, lending credibility to the former. Almost all villages, except two, observed dead rats after application of rat bait. Interestingly, we trapped higher proportions of Pacific rats and juvenile House rats after the campaign, suggesting that a considerable part of the adult House rat population had been removed. Based on the spatial distribution of the Pacific rat in the town, we speculate about the possible origin of this species in Northern Laos. Results are discussed in view of the development of a sustainable, urban rodent management concept for Luang Prabang.

Rodent Management – Session 1

The impact of rodent management on rice yield in lowland irrigated areas in Indonesia

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Rodent damage in rice crops leads to reduced yields and poor food security for farmers throughout Indonesia. The goal of this study, conducted between 2014 and 2016, was to assess the impact of rodent management methods on rice yields in 4 different regions. The study sites, all in lowland irrigated areas, were in Aceh Province, Cirebon and Indramayu Regency in northern west Java, and Purbalingga Regency in southwestern central Java. Different rat management methods ranging from full protection using plastic fences and bubu traps, fumigation, sanitation and synchronization of planting date were implemented depending on the severity of rat damage in the previous cropping season. In all regions farmers enclosed their crops using plastic fences equipped with bubu traps along the fence within a crop season. The number of rat captured during the crop cycle (planting to harvest) varied among locations: 1,331 rats from 44 traps for Aceh; 7,000 rats from 80 traps for Cirebon; 4,916 rats from 70 traps for Indramayu and 130 rats from 70 traps for Purbalingga. The rice yields before and after implementing the rodent management were different, with all regions showing increased yields: from 1.03 to 5.89 ton/ha in Aceh; 3.32 to 7.56 ton/ha in Cirebon; 4.76 to 8.93 ton/ha in Indramayu and 7.32 to 10.86 ton/ha in Purbalingga. In summary rat management, particularly surrounding the crop with the plastic fence plus bubu traps increased rice yield by 1.5-5 times compared to the previous season where these methods were not implemented. Farmers have indicated they will continue to use plastic fence and bubu traps.

Rodent Management – Session 1

Reducing impacts of rodents on the post-harvest value chain in rice-based cropping system in Myanmar

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Pre-harvest losses of rodents in Myanmar range from 8-25%, however, post-harvest loss (during harvesting and in storage) has not been well documented. Quantity and quality losses of rice grain and seed were monitored for two years in the lower Ayeyarwady delta. We measured (i) the amount of grain stored in burrows under non-threshed rice piles 4 weeks after harvest, (ii) losses of grain and effects on grain quality in grain stores, and (iii) seed quantity and quality losses from different storage bags (IRRI hermetic bags, local hermetic bags and polyethylene bags) were compared. The rice grain is stored for family consumption and for sale to markets. The rice seed is stored for the next crop. In year three of our study, a community village-level rodent management system was conducted in three villages. Actions included trapping, sanitation around storage houses, and promotion of rodent-proofing of grain stores. There were four species of rodents causing losses. The most common species in the field was *Bandicota bengalensis* and in grain stores was *Rattus rattus*. The mean amount of grain collected from rat burrows under a pile was 8.67 ±5.69 kg and the total grain loss was equivalent to 3% of total rice yield. Stored grain loss was 10.63 ±1.16% in 2013 and 1.22 ±0.42% in 2014. The mean seed loss was 4.49 ±2.07% and germination loss was 43.07%. Rodent damage to seeds was highest in bags that were not hermetic. Community level management of rodents reduced losses from 1 to 4%; farmers benefited by about USD 81/family. Storage structures need to be improved, and better sanitation is required in and around storage houses. Hermetic storage of seed is recommended to reduce losses and for maintaining seed quality. Regular trapping should be conducted as a community activity at the village level.

Rodent Management – Session 1

Adoption pathways of ecologically-based rodent management in Myanmar

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Rodents are one of the top three pests in both lowland and upland agro-ecosystem in Myanmar. A total of 25 rodent outbreak events were recorded from 2007 to 2017. Ecologically-based rodent management (EBRM) in lowland rice system has been introduced in Myanmar since 2005, yet it has not been adopted at a large scale. Developing and implementing EBRM in different agriculture systems is a complex issue that is affected by multiple factors. Household surveys and focus group discussions (FGD) were conducted in areas where chronic rodent problems occurred annually and where recent rodent outbreaks have occurred to identify the key challenges of farmers for EBRM adoption. In recent years, rodents have caused mean annual losses of 8.50 +1.31% in monsoon rice (n =76), 6.65 +1.3043 % (n=61) in summer rice, 13.32 +2.19% in green gram (n=14), 20.35 +4.11% in black gram (n=24) and 18 +7.80 % (n=17) in perennial crops including rubber, oil palm and betel nut. Mean losses caused during rodent outbreaks in upland rice was 76.67 +8.82%. Ninety percent of farmers only implemented control when rodents damaged plants and there were many rodent burrows visible. No proactive management actions were reported from either the household or FGDs. A subset of farmers used rodenticides (36%), and/or trapping (25%), whereas the rest did no control (killing of animals is not acceptable in their religion). In rodent outbreak areas, farmers control rodents by using rodenticides and kill-trapping. Neither approach discriminates between pest and non-pest rodent species. Farmers said control methods used are not efficient but are feasible and applicable. Our survey findings suggested that developing and implementing EBRM should be done through a farmer community participatory approach. Including policy makers early in development of EBRM is crucial for its promotion as a national policy.

Rodent Management – Session 1

Ecologically-based rodent management 20 years on - progress, challenges and where next

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Ecologically-based rodent management (EBRM) was first formulated in 1997, and has been a key approach to tackle important rodent impacts globally. Food security is a major concern in developing countries, where a 5% reduction of rodent losses on cereal staples could prevent 280 million people from being undernourished. In developed countries and oceanic islands, rodents are an important conservation issue. Alas, the conservation issue is not on the radar screen for most developing countries. Another major rodent issue in both developing and developed countries is that rodents are an important avenue for zoonoses in urban and rural environments. This paper will focus on progress and challenges in agricultural systems. Ecologically-based rodent management (EBRM) was developed based on adaptive research conducted to manage eruptions of mouse populations in Australian wheat fields, and chronic and acute annual losses by rats in Southeast Asian rice fields and in mixed cropping systems in eastern Africa where maize is the dominant crop. We will review progress of EBRM over the past 20 years with brief case studies from Africa, Asia, Australia and Europe and provide examples how EBRM helps to minimize rodent abundance, losses and the use of rodenticides. Although there has been strong progress, there is still much to be done. Further intensification of agriculture coupled with an increase in occurrence of extreme climatic events are likely to lead to more rodent outbreaks globally. Also minimum tillage agriculture and the re-designing of agricultural lands to include more corridors and increased heterogeneity at a landscape scale may lead to resurgence in chronic rodent problems both pre- and post-harvest. We also need to pay more attention to the extent and economic impacts of rodent borne diseases on smallholder communities.

Rodent Management – Session 1

Integration of the landscape of fear of rodents in EBRM methodologies

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Present pest management methods are mostly reactive and have huge disadvantages such as emerging genetic rodenticide resistance with serious threat for relay toxicity. Rodent control should be based on pest-species ecology and ethology to facilitate development of ecologically-based rodent management (EBRM). A main aspect of EBRM is the advanced knowledge of both the ecology and behaviour of the targeted rodent pest species. A tool to assist knowledge on the spatiotemporal behaviour of rodents, is the landscape of fear. The landscape of fear (LOF) indicates levels of anxiety that a prey species perceives at several sites within its territory and embodies the areal variation in scavenging cost as result of predation risk. In practice, the LOF enables to predict where traps or bait are most expected to come across and used by rodents by mapping habitat use as a result of perceived fear. A major opportunity for rodent control strategies would be to incorporate the LOF of pest species in EBRM methodologies. By focussing on those areas where rodents regard the smallest amount of predation risk, rodent pest management could become more effective.

Rodent Management – Session 1

Rodent trapping grids are sustainable for long-term landscape suppression of invasive rat (*Rattus rattus*), but not mouse (*Mus musculus*), populations in Hawaii

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Invasive rodents (rats, *Rattus* spp., and *house mice*, *Mus musculus*) are among the most damaging animals to agriculture and native species on many island ecosystems including those in Hawaii. Traps and toxic baits are widely used tools for rodent pest control or eradication. Rats and mice cause widespread environmental harm in Hawaii, including by feeding on insect pollinators and many native plants, and land managers require sustainable ways to control rodents across the landscape without using toxic baits. We experimentally tested whether snap-traps, placed in plastic boxes to limit non-target interference, were effective at suppressing invasive rodents in woodland and grassland sites on Hawaii Island where 20 threatened or endangered plant species reside; many of these species are harmed by rodents. Our design had a total of 12 plots, each 2.25 ha, that included three treatments (n = 4 per treatment): rodent removal (RR), rodents+ants+yellowjackets removal (AR), and control or reference plots (CO). In each RR and AR plot, a grid of 169 mouse traps (each 12.5 m apart) and 49 rat traps (each 25 m apart) was installed and armed continuously for 1.5 years, with bait refreshed each 1-2 weeks. We monitored rodent populations in all 12 plots using tracking tunnels, which are baited ink cards placed in tunnels so that foot prints of animal visitors can be identified. We determined that both rats and mice could be effectively suppressed (<20% detection in tracking tunnels) for ~4 months after trapping initiated; yet only rat, and not mouse, suppression was sustainable thereafter. Trail camera evidence revealed that mice became habituated to traps in some cases, leading to trap avoidance, and that some non-target animals interfered with mouse traps. In areas with high mouse populations, grids of snap-traps may not be a sustainable management technique for long-term house mouse control.

Rodent Management – Session 1

Ecology of rodent pests in lowland irrigated rice fields under alternate wetting and drying conditions

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With the introduction of the water-saving technology, Alternate Wetting and Drying (AWD), farmers are hesitant to adopt this measure for fear the practice will lead to increases in rodent pest activity, consequently exacerbating yield loss. Rodents are one of the most important pests in rice, causing both pre- and postharvest damage. It is, therefore, understandable that farmers will be hesitant to adopt a measure when they think this will lead to more rat damage to their rice. We investigated the effects of AWD on the population dynamics, habitat use and damage levels inflicted on growing rice crop by two most important vertebrate pests of rice in Indonesia and the Philippines, respectively: *Rattus argentiventer*, and *Rattus* t*anezumi*. The knowledge, attitudes and practices (KAP) of Indonesian and Philippine farmers were also surveyed. Analyses indicate that AWD has no effect on rodent pest population dynamics, habitat use and damage levels on rice. Indonesian and Philippine farmers employed similar rodent control methods: use of poisons and cleaning the rice fields. Philippine farmers prefer acute rodenticides whilst Indonesian farmers prefer anticoagulants. Farmers in both countries prefer to work alone when managing rodent pests. Damage levels in Indonesia and the Philippines seem to reflect that the interventions by farmers are inadequate and call for community-based action.

Rodent Management – Session 1

Status of rodent pests in rice eco-systems in Sri Lanka

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Sri Lankan farmers report rodents as an emerging problem in rice cultivations across the country. This is in addition to the incidences of leptospirosis among the farming communities since 1990s. Hence, both the agriculture and health sectors initiated programs to minimize pre-harvest crop losses and rodent-borne diseases. This study aims to develop ecologically-based rodent management system (EBRM) against this pest. The study areas covered three agro-ecological zones (wet, intermediate and dry with annual rainfall >2,500, 2,500 - 1,750 and <1,750 mm respetively) where farmer reported high rat populations and incidence of leptospirosis cases (7,099 recorded cases in the year 2008). Live capture traps were set up for two consecutive nights at three different crop stages in the field and during off season in and around houses. The percentage tiller damage was assessed in the sampling sites. Disease incidences of *Leptospirosis* were collected from the Ministry of Health. We observed *Rattus rattus* and *Bandicoa indica* as the dominant species present in the rice fields and *Rattus rattus* was the most common species found in and around houses. The peak populations of *Rattus rattus* was recorded during the booting stage of rice in all sampling sites and in the intermediate zone we recorded the highest rodent population. Highest rodent damage was observed in the intermediate zone during booting (18.4%) and at the booting stage in the wet zone (10.2%) and the dry zone (6.8%). The prevalence of leptospirosis was high in the wet zone compared to the other areas. Efforts will be made to study the breeding ecology of *Rattus rattus* and to determine the prevalence of leptospirosis through a serological test. Based on the results, a disease forecasting model and EBRM will be developed.