Rodent Research

Rodent Research is a bi-annual newsletter produced by the Community Ecology Group of CSIRO Sustainable Ecosystems. The Community Ecology Group aims to foster international links between scientists, managers and communicators involved in pest management, rodent conservation and basic research.

International Reports

Australia

Changes at CSIRO

The CSIRO Rodent Research Group has been disbanded following a major restructuring at the Division of Sustainable Ecosystems at CSIRO in Canberra, Australia. Grant Singleton, the leader of the group, has since left CSIRO to take up a 4-year position at the International Rice Research Institute (IRRI) in the Philippines as Coordinator of the Irrigated Rice Research Consortium. Lyn Hinds has moved to the CSIRO Division of Entomology in Canberra. Roger Pech has taken a position with LandCare Research in Christchurch, NZ. Ken Aplin is now working with the Australian National Wildlife Collection based at CSIRO Sustainable Ecosystems in Canberra.

Peter Brown is with the Tropical Landscapes Program of CSIRO Sustainable Ecosystems and will continue work on rodents. Peter is currently leading rodent projects in Myanmar and Laos funded by the Australian Centre for International Agricultural Research (ACIAR).

CSIRO has been involved in rodent research since 1976. Since 1989 the research has been led by Grant Singleton with an emphasis on understanding the biology behind rodent population dynamics, new methods of control and promoting ecologically-based management of rodent pests. In 2001 the group joined with the Predator-Prey team led by Roger Pech to form the Community Ecology Group, a productive and dynamic group of more than 20 researchers.

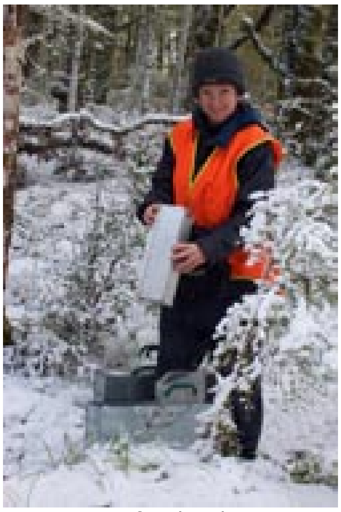
There has been much progress in rodent research over the past few decades and still much work to be done. Although the members of the Rodent Research Group at CSIRO are now dispersed, the enthusiasm and dedication to rodent research will continue through collaborations and new projects.

Rodent Research in New Zealand

Over 70% of New Zealand indigenous forest is either dominated by or otherwise contains beech trees (*Nothofagus* sp.). As such, these forests constitute a considerable proportion of New Zealand's indigenous landscape, which is a key asset for promoting conservation and protecting native biodiversity. The primary threats to biodiversity in New Zealand are introduced pests, among them, the common house mouse (*Mus musculus*).

House mice were accidentally introduced to New Zealand in the 1800's and have become extremely wide-spread in the native forests. Much work has been done on the cascade effect of beech 'mast' seedfall events and population increases in mice, ship rats (*Rattus rattus*) and their predators, stoats (*Mustela erminea*), and the resultant decline in native avifauna.

In a recent study, we asked whether introduced house mice could pose a threat to beech forests themselves by consuming seeds and thereby limiting the recruitment of young trees. Beech forests may be particularly susceptible to seed consumption by mice because they produce seed sporadically, so-called seed masting events, that occur on an irregular 2-4 year cycle. While many believe that seed masting is used by some plant taxa to swamp the capacity of seed predators to consume all seeds before germination can occur, New Zealand beech trees evolved in the absence of seed-eating mammals. Because mice have very high potential rates of increase and high energetic requirements, the amount of seed produced by New Zealand beech trees during mast years may be insufficient to swamp the capacity of mice to consume all available seed before it germinates. To determine whether or not mice could regularly consume all beech seed produced during a masting year, we measured the rate at which mice could consume seed (functional response), and the rate at which mouse abundance increased as seed availability increased (numerical response). This information was combined into a set of mathematical models which tracked simultaneous changes in mouse abundance and beech seed availability over the course of a mast event.



Live trapping for abundance estimates.

Beech forest study area.

Field trials were used to measure how many beech seeds mice could find and eat in a 24hr period. 1m x 1m enclosures were established in beech forest and individual mice were provided with differing amounts of seed (10 – 2000 seeds). After 24 hours, the remaining seed and husks were counted and the number of

Seed trap to measure quantity of beech seeds available to mice.

Collecting the remaining beech seeds from an enclosure.

seeds eaten per mouse estimated. Approximately 40 mice were used and this generated a functional response curve (see Ruscoe *et al*. 2005). Regardless of whether alternative food was available to mice, they continued to search for and consume beech seeds until local availability reached zero. This means that theoretically mice are able to entirely eliminate seed reserves in beech forest, whether or not alternative food is available to them. The effect of providing an alternative food source (lepidopteran larvae) was also tested (Ruscoe *et al*. 2005).

Further field studies provided data on the influence beech seed availability had on mouse population growth rates (numerical response). Rates of change in mouse abundance are closely related to the amount of seed available in beech forests. However, the tendency for mouse abundance to increase rapidly when beech seed is abundant was substantially reduced when mouse density was already high. The reason that mice at high densities cannot respond as dramatically to high levels of seed availability remains unknown, but may be related to territorial behaviour or the effects of disease.

Combining the functional and numerical responses of mice to beech seed availability, we were able to quantify the impact of mice on the beech seed bank. Simple accounting models tracked simultaneous changes in mouse abundance and beech seed availability over a year in which different levels of seed fall occurred. Results indicated that mice would rarely be able to consume all beech seeds produced during moderate to heavy masting years. As such, the capacity for mice to significantly alter beech forests by limiting the recruitment of young trees appears limited.

These findings lend support to the important role that seed availability plays in the dynamics of mouse populations in New Zealand beech forests. While the capacity of mice to affect the dynamics of beech trees themselves appears limited, the regular eruption in mouse abundance that occurs in high seed fall years has important flow on effects for predators of mice (notably stoats), and the prey these predators subsequently consume (notably forest birds). By providing a more reliable basis for predicting when mouse abundance is likely to erupt, the simulation models produced in this study will allow us to refine our ideas about how to target control of these predators. In addition to the predators that consume mice, eruptive increases in mouse abundance may have important consequences for the other native species they consume. Mice are known to consume a wide range of insect species, and other native plants and fungi. By consuming these species as secondary food items, mice may be having a more insidious effect on forest biodiversity than their consumption of beech seeds alone may suggest. This will be particularly true where species consumed as secondary prey items play key roles in critical pathways for nutrient or energy transfer within the forest.

While this research reassures us that the presence of mice does not appear to be a threat to the continued presence of beech trees in beech forests, it highlights our lack of understanding of the roles other species that are consumed by mice play in these ecosystems. Given the pervasive nature of mice in beech forests and difficulties associated with their control, work aimed at understanding and managing these effects will be ongoing.

Further reading

Ruscoe, W. A., Elkinton, J.S., Choquenot, D. & Allen, R.B. 2005. Predation of beech seed by mice: effects of numerical and functional responses. *Journal of Animal Ecology*. In press.

Ruscoe W.A., Choquenot, D., Heyward, R., Yockney, I., Young, N. & Drew, K. 2003. Seed production, predators and house mouse population eruptions in New Zealand beech forests. pp 334-337 In: *Rats, Mice and People: Rodent Biology and Management*. (Eds. Singleton, G.R., L.A. Hinds, C.J. Krebs and D.M. Spratt). ACIAR Monograph No. 96. Canberra, Australia. 564 pp.

Choquenot, D. & Ruscoe, W.A. 2000. Mouse population eruptions in New Zealand forests: the role of population density and seedfall. *Journal of Animal Ecology* 69: 1058-1070.

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Radiation, good for you?

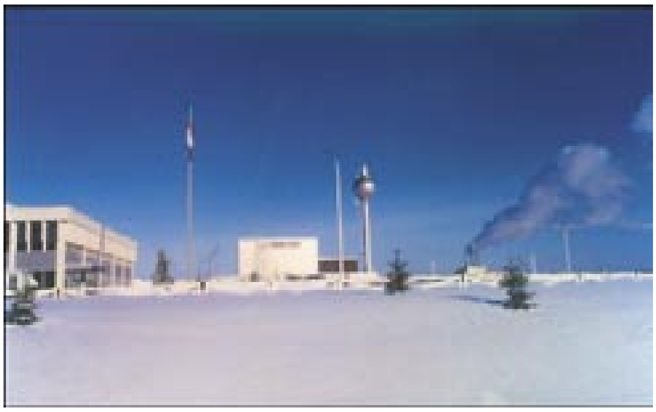
In a recent study at the Whiteshell Nuclear Research Establishment at Pinawa, Manitoba we found that low, chronic doses of radiation could have beneficial effects for health in meadow voles.

The findings, published in *Environmental Toxicology and Chemistry* (2005, vol 24: 334–343), show that low, chronic doses of gamma radiation at 50 to 200 times background levels had beneficial effects on the stress axis of natural populations of meadow voles (*Microtus pennsylvanicus*). The paper provides evidence of hormesis from the only large-scale, long-term experimental field test ever conducted on the chronic effects of gamma radiation on mammals.

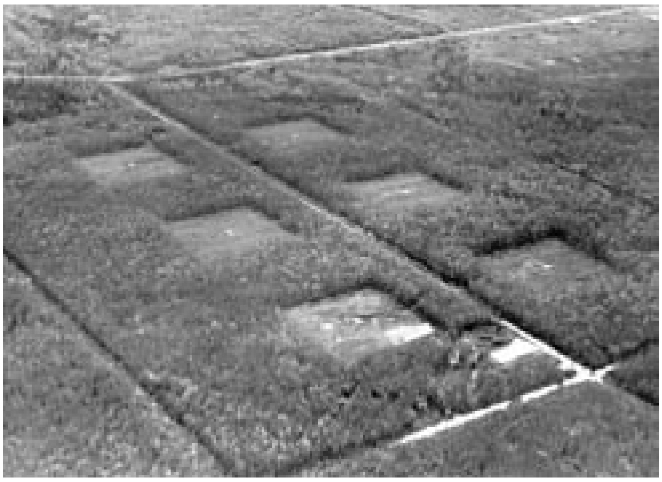
Hormesis is defined as a phenomenon where low doses of an otherwise harmful agent can result in stimulatory or beneficial effects. This phenomenon has been observed when organisms are exposed to a broad range of chemicals including alcohol and its metabolites, antibiotics, hydrocarbons, herbicides, insecticides, and fungicides, as well as physical processes such as radiation exposure and caloric restriction. The effects of hormesis have been observed in a wide range of organisms, from microbes and fungi to plants and animals. Hormetic responses are varied in form and include increased longevity; growth, reproductive, and physiological responses; and metabolic effects.

The experiment, entitled ZEUS (Zoological Environment Under Stress), was set up by the Atomic Energy of Canada to test the effects of chronic gamma radiation on natural populations. The experimental area was divided into six grids exposing vole populations successively to low, medium and high doses of radiation over a 4 year period. The voles were live-trapped biweekly to monitor their health. The voles exposed to a low dose had levels of corticosterone (the principal stress hormone in voles) that were significantly higher than those of controls and of high dosage populations.

The key assumption governing toxicology is a direct relationship between the dosage of the agent and its effect on the body. In the case of gamma radiation, this assumption is clearly incorrect. Corticosterone may protect against the excessive actions of the immune and inflammatory responses. The stimulation of the stress axis resulting in the increased secretion of corticosterone may indeed operate in other situations in which hormesis has been observed.



The nuclear reactor at the Whiteshell Nuclear Research Establishment at pinawa, Manitoba.



The six experimental grids. Each grid contained a lump of Cesium with heavy shielding to limit radiation and distribute it evenly.

The study was funded by the Natural Sciences and Engineering Research Council of Canada (NSERC).

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Aging and Death in Mammals: What takes its toll before the Grim Reaper Does?

A prerequisite in aging theory is that there is age-dependent decline in physiological function. Stress is a fundamental reality of existence and coping with it is crucial if we are to survive and get old. A declining ability to deal with stress, and thus in maintaining homeostasis, may play a major role in the physiological decline that accompanies aging. Laboratory rodents are central models in the research to understand how and why aging occurs, particularly as it applies to humans. A key finding, based heavily on the laboratory rodent model, is that aging animals show a marked deterioration in the ability to maintain homeostasis caused by an increasingly hyperresponsive and dysfunctional hypothalamic-pituitary-adrenal (HPA) axis. But does this occur in wild animals that have been selected to deal with a world that is infinitely more challenging and difficult than the benign conditions of the laboratory cage?

To test these ideas, we conducted two studies on wild microtines, the vole and lemming family. First, in the meadow vole (*Microtus pennslyvanicus*), a species that occurs throughout central and northern North America, we tested whether male meadow voles maintained in the lab showed any deterioration in their ability to handle stress over a 12 month period. Typically the summer breeding season lasts about 6 months in southern Ontario before winter sets in and all breeding animals die. Hence, to maximize fitness males should live about that long to maximize their reproductive opportunities. The HPA axis changed markedly over the study, but only after 6 months of age. After 6 months, baseline levels of corticosterone (the major stress hormone in voles) declined, response to a stress challenge (restraint) was reduced, and recovery from the challenge was attenuated. The changes we observed were virtually opposite that of what has been seen in relatively unstressed laboratory rats. Thus male meadow voles showed strong evidence of deterioration in the HPA axis, but only after 6 months of age, the maximal reproductive lifespan in nature.

Second, Quinn Fletcher (a masters student) and I examined whether free-ranging northern red-backed voles (*Clethrionomys rutilus*) from the Yukon, Canada, showed any evidence of deterioration of their stress axis over time. Their breeding season is typically only about 3-4 months at this latitude. We examined the ability of male voles to respond to, and to recover from, a stress challenge and we examined what changes occurred at the level of the brain (the hippocampus, hypothalamus, and pituitary). Over the breeding season, we found no change in either the ability to handle stress or in the brain.

We conclude that the HPA axis in the natural world is essential for survival given the extreme ecological pressures these animals face on a daily basis; any significant deterioration would rapidly be followed by death. Hence, none may occur until the fundamental purpose of life - reproduction - is complete.

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The meadow vole, Microtus pennslyvanicus *(left) and the red-backed vole,* Clethrionomys rutilus *(right).*

Shorter tails: A thermal adaptation of rats in cold stores

One of the objectives of the *All India Network Project on Rodent Control* is to monitor rodent populations in crops and storage. During regular trapping of house rats (*Rattus rattus*) in poultry farms at the Punjab Agricultural University, and in local cold stores in the Ludhiana district, an interesting observation was made regarding differences in the tail length of rats surviving in the different temperature environments (40°C in poultry farms; 4°C in cold stores).

Healthy adult rats were selected from each location for morphological comparisons (80 rats from poultry farms; 25 rats from cold stores). Young rats and rats with cut or injured tails were ignored. Each rat was weighed and mildly anaesthetized with diethyl ether. Measurements were taken of head length, head length + body length, tail length, ear length, forelimb length and hind limb length.

The rats trapped from poultry farms were found to have relatively long tails (average tail length / head+body length = 1.2), a typical feature of house rats. Rats trapped in the cold stores had shorter tails (average tail length / head+body length = 0.93). The shorter tails on the rats from cold stores could be a thermal adaptation of rats living at a temperature less than 4°C. Morphological adaptations, along with other physiological and behavioural adaptations, contribute to the survival of animals in a particular environment.

Rats use their tails to balance themselves and to help them maintain their body temperature. Blood flowing into the furless skin of the tail carries heat, which is then radiated out of the body. Under ideal conditions rats can loose up to 20% of their metabolic heat in this way. In cold environments, shorter tails may help to reduce the heat loss. Studies reported in the literature reveal that animal size and the size of external organs frequently reflect habitat, so that species adapted to living in colder climates will have shorter ears and/or shorter tails than species adapted to living in a warmer climate.

The other morphological measurements of rats from poultry farms and cold stores showed no significant differences. Rat samples from both locations were sent to the Zoological Survey of India in Calcutta for identification to subspecies level. All the rats were identified as *Rattus rattus alexandrinus*. This showed the existence of the same subspecies living at extremely different thermal conditions.

This is a preliminary observation. Other aspects regarding morphological, physiological, behavioural and biochemical differences of house rats trapped from different thermal environments need to be explored so as to know the actual modifications required for adapting the same subspecies of house rats to two extremely different thermal environments.

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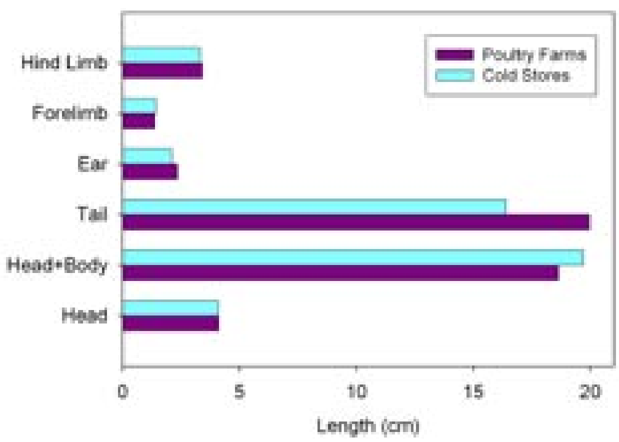

Comparison of morphological measurements of house rats from poultry farms and cold stores.

Conserving a rodent pest?

Most water voles are black in Scotland while they are generally brown in England and in the rest of Europe.

The ecological concepts and tools that govern the management of pest species and the conservation of endangered species are closely similar, yet it is exceptional that they should be applied to the same species in different parts of its geographical range. This however is the situation of the water vole *Arvicola terrestris*, a rodent with the status of agricultural pest in much of continental Europe but that of conservation icon in Great Britain.

Thorough their Palearctic distribution, water voles are highly variable in adult size ranging from 70-280 grams. Their life style may be wholly or seasonally fossorial, or wholly aquatic. They exist as large continuous populations with cyclic fluctuations, or as highly fragmented colonies functioning as metapopulations. This variability maps in part on to their different status.

Relatively small (ca 120 grams) water voles in continental Europe live up to their Latin name more than their much larger British counterparts. They live and forage year-round in extensive burrow systems, often in pastures. Fossorial water voles in SE France and Switzerland exhibit pronounced regular cycles in abundance, with a period of 7 years. The cycles spread in space like waves via the above ground dispersal of young voles. Farmers incur large losses of forage due to removal of the vegetation and extensive excavation of earth mounds. Large-scale control campaigns have long been implemented, relying on trapping or poisoning using anticoagulants. As is often the case, these have limited effectiveness and farmers now seek to promote generalist predators to at least dampen the peaks of abundance. Water voles are also perceived as pests in other parts of mainland Europe but the scale of damage to agriculture is more localised.

A hay pasture during a water vole outbreak in the French region of Franche Comte. The brown appearance of the grass field does not result from ploughing but from the presence of earth mounds.

In contrast to the continental European situation, British water voles have experienced a catastrophic and accelerating decline of no less than 96 % since 1950. Despite being protected under UK law and being amongst the top-priority species selected for conservation under Britain's Local Biodiversity Action Plans, there is now little doubt that, if the trend continues unchecked, the species will eventually become extinct from the whole of Britain. Substantial financial resources are spent through conservation projects aimed at staving off extinction. It is thus legitimate to ask what circumstances may be responsible for such contrasting fortunes? The answer is multi-stranded.

British water voles are substantially larger than in Western Europe, with adults commonly reaching 280, occasionally 300 grams. They also construct extensive burrow systems, but these rarely extend more than a few meters from watercourses. Despite being previously abundant and often seen feeding on the riverbanks, British water voles never interfered with human activities. On the contrary, the species always enjoyed certain popularity with the public, and "ratty" the central character of a well known children's tale "Wind in the willows" was a water vole.

Crucially, owing to the size of their inhabitants, the diameter of water vole burrows in Britain is such that a now widespread alien predator of water voles, the American mink *Mustela vison* is able to enter. The large British water vole is an ideal prey for this generalist predator that has become established in much of Europe following escape from fur farms. Furthermore, British water voles exclusively inhabit water margins, such that populations are linear and arrayed along rivers, canals and small ditches, in contrast to more diffuse two-dimensional mainland Europe populations. As a consequence, whenever a mink encounters a linear population of water voles, they are able to predate a very high proportion of the population and extinction inevitably ensues within a few weeks. Mink home ranges encompass several kilometres of river and each individual is capable of eradicating water voles from long stretches of waterways. This process has been repeated again and again such that water voles are now absent from most of lowland Britain where they used to be abundant.

The mink invasion of Britain is not yet complete, with northern Scotland so far unaffected. In addition, the advance of mink in mountainous areas of Scotland has been slower than in surrounding lowland areas. There, some of the valleys that cut into the hills have so far escaped permanent invasion by mink. Thus, in vast mountainous areas of Scotland, water voles still coexist at low density with sparse native predators. It is not known whether these low productivity refuges will remain free of the American mink's influence or whether the advance of this alien predator will merely be slower.

Although the hills of Scotland do offer a partial haven to water voles, living in such a harsh environment inevitably poses challenges. The grass-rich patches where voles establish their colonies are thinly scattered over the moors and most only accommodate a handful of voles. Neighbouring colonies are often more than one kilometre apart. Due to predation, disease or bad luck, nearly half of the colonies naturally die out each year. Normally, the population as a whole survives because new colonies are created each year by the arrival of dispersing young water voles who have left their families and travelled away from waterways, often though dense heather and soaking bogs in search of a new home. DNA technology has revealed the amazing dispersal ability of the water vole. It was found that no fewer than a third of the voles breeding in spring had travelled one to seven kilometres between the colony of their birth and the place where they found a mate. Thus, colonies scattered over vast areas are linked by dispersing water voles, enabling the species to persist at low density. The remarkable mobility of water voles, in size more akin to that of much larger rodents such as beavers or muskrats, also offers hope for their recovery in those areas where mink can be controlled through trapping.

Typical water vole habitat in upland areas of Scotland. These areas are managed by game keepers for the benefit of the red grouse, a prized gamebird.

Ongoing research attempts to understand the rules that govern the dispersal of both the prey and the predators. Indeed, the frequency of invasion by mink on the edge of conservation areas and the ability of water voles to recolonise areas that have lost water voles are key parameters that will determine whether conserving large, aquatic British water voles is feasible in the face of American mink invasion.

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3rd International Conference on Rodent Biology & Management August/September, 2006 Hanoi, Vietnam

The 3rd International Conference on Rodent Biology and Management (ICRBM) will be held at Thang Loi Hotel, Hanoi, Vietnam, from Monday 28 August to Friday 1 September 2006.

Please register your interest in attending the conference on line – this will ensure you will be on the mailing list for future announcements. Visit the conference website (see below) and click "on-line reply" in the top left corner to register.

Planning for the conference has commenced under the guidance of the following executive committees:

Local Organising: Prof Nguyen Van Tuat, Dr Nguyen Phu Tuan, Prof Zhibin Zhang, Mr Jian-Xu Zhang (Secretary General)

Scientific Program: Lyn Hinds, Herwig Leirs, Wendy Ruscoe, Hannu Ylonen

Plenary Speakers Program: Zhibin Zhang, Grant Singleton, Charles Krebs, Nils Chr. Stenseth

Sponsorship: Dale Nolte, Zhang Zhibin, Nguyen Van Tuat

Travel Grants & Allocation of Funds: Steve Belmain, Peter Brown, Nguyen Phu Tuan [Regional advisors: Rhodes Makundi and Nico Avenant (Africa), Mauricio Lima and Maria Busch (South America), Lyn Hinds and Sudarmaji (Asia and Pacific)]

Student & Other Prizes: Charles Krebs, Jens Jacob, Ken Aplin, Ara Monadjem

Plenary Speakers:

Jerry Wolff (USA) – Social biology of rodents - based on his new book

Nils Stenseth (Norway) - Ecological economics of rodent control

Mauricio Lima (Chile) - Biology of eruption of rodent populations in South America.

Jens Jacob (Germany) – Animal behaviour in small mammal management

Ken Aplin (Australia) - Systematics of rodents in Asia: a new appraisal

Stephen Belmain (UK) - Socio-economic aspects of rodent management in villages (Bangladesh and Southern Africa)

To be confirmed (Vietnam) – Ecologically based management

To be confirmed – Rodent diseases

Charles Krebs – Overview of conference and future directions (closing ceremony)

For more information visit the conference website: http://icrbm2006.ioz.ac.cn

Recent Publications of the CSIRO Rodent Research Group

Arthur, A.D., Pech R.P., and Dickman C.R. 2005. Effects of predation and habitat structure on the population dynamics of house mice in large outdoor enclosures. *Oikos* 108: 562-72.

Belmain, S., Aplin K.P., Azad A.K., Bachchu M.A.A., Baker A., Haque M.S., Harun M., Hasanuzzaman A.T.M., Hossain M., Hossein M.M., Hoque A., Islam A.M., Islam M.S., Kadri A.I., Kamal A.Q., Meyer A., Mian Y., Mohammad N., Roy R., Shafali R.B., and Singleton G.R. 2005. *Ecologically-Based Rodent Management for Diversified Rice-Based Cropping Systems in Bangladesh: Final Technical Report 1 April 2002 - 31 March 2005* to Department of International Development, UK, Project no. R 8184, Crop Protection Program. Chatham Maritime, Natural Resources Institute, University of Greenwich.

Farroway, L.N., Gorman, S, Lawson,M.A., Harvey, N.L., Jones, D.A., Shellam, G.R. and Singleton, G.R. 2005. Transmission of two Australian strains of murine cytomegalovirus (MCMV) in enclosure populations of house mice (*Mus domesticus*). *Epidemiology and Infection* 133, 701-710.

Jacob, J. and Wegner, R.E. 2005. Does continuous removal of individuals separate high- and low-quality ricefield rats. *Journal of Wildlife Management* 69: 821-826.

Sutherland, D.R., Spencer, P.B.S., Singleton, G.R and Taylor, A. 2005. Kin interactions and changing social structure during a population outbreak of feral house mice. *Molecular Ecology* 14, 2803-2814.

Abstracts of these papers are available on our web site: *http://www.cse.csiro.au/research/rodents/publications.htm.*

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