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rat cunning

Steve Davidson joins the hunt for better ways to manage resourceful rat populations.

Rodents have accompanied we humans in our endeavours for millennia: mostly to their benefit and our detriment. Rats are serious agricultural pests, causing untold damage to crops and necessitating costly control measures. They also can carry deadly infectious diseases and, when introduced to island environments, can be a real threat to the survival of wildlife.

Dr Grant Singleton and his colleagues at CSIRO Wildlife and Ecology, and dedicated rodent researchers in many countries, are looking for better, ecologically-based ways to manage rodent pests.

'Simply killing rats with poisonous baits is not always the best or most long-lasting solution,' Singleton says. 'An understanding of the biology and ecology of the rodent pest can lead to more effective, sustainable and environmentally friendly management strategies. It's a case of know thine enemy.'

Life in rat society

The Norway rat or brown rat (*Rattus norvegicus*) is a case in point. This is probably the most studied mammal in laboratories throughout the world. But it is investigations into wild populations of the species that are revealing useful and fascinating insights into rat behaviour and ecology.

In the United Kingdom, Dr David Macdonald and his colleagues at the University of Oxford have found that this miscreant species – originating in South East Asia, but spreading right around the globe in company with humans – is adaptable, opportunistic and capable of explosive population growth.

They suggest food supply and social structure are central to the species' ecology, and hence to the effectiveness of control measures. Socially dominant rats gain feeding priority and greater reproductive access and success. Social pressures force subordinate male rats to migrate into less favourable areas, resulting in a strongly unbalanced sex ratio (more females) in breeding areas.

The Oxford scientists found that larger male rats tend to win dominance contests with smaller rats, but strangely, retain their status long after passing their prime. This means that dominance tends to be age-related, with the dominant alpha male often being smaller than many of his subordinates. Rats, it seems, respect their elders.

Why do younger, larger rats tend to accept the status quo rather than challenging?

'We suspect that the costs of aggression are too great relative to the value of the contested resource,' Macdonald says. 'Even the lowest-ranking male rats gain access to feeding sites by adapting their feeding patterns. Moreover, dominant males can't strictly control access to

Photos: CSIRO Wildlife and Ecology

Right: Dr Grant Singleton examines a day's rat captures from a trap-barrier system in Asian rice fields.

Left: One day's worth of rat captures from a trap-barrier system in West Java.

Far left: Earth banks around rice paddies are good burrow sites for rats.

receptive oestrus females. Sometimes, lower-ranking males actually achieve more matings.'

This is because of the rats somewhat scrambling mating system. In naturalistic enclosures, a string of up to seven males pursued a receptive female whenever she left the burrow. 'Males had little time to react with one another, and as a consequence, even the most dominant male could not monopolise the female,' Macdonald says.

To test whether female rats actually selected mates in this mad scramble or mated promiscuously by choice, the researchers devised a cunning device that allowed the female to choose mates if she wished. They called it the 'inverta-brothel'.

A female rat was placed in a central arena surrounded by cubicles in which males were housed. A circular passage gave the female access to the males, but was too narrow for the males to pass. Observations showed that females formed enduring bonds with a single male, but also mated promiscuously.

Feeding and neophobia

Rat control operations often fail due to poor bait uptake. We tend to blame this on the 'intelligence' of rats, but can science unravel other causes?

A foraging rat must make decisions about when, where, and how to feed, and what to eat, all against a background of dominance hierarchies, competition for mates, and the dangers of predation. One population of normally nocturnal wild rats switched to day-time feeding to avoid foxes that were hunting them at night!

One characteristic that has special relevance to control is the neophobic nature of rats: they tend to fear the novel or unknown, such as new foods or new human odours on a familiar food container. Disease can dramatically alter this trait (see story opposite).

When Macdonald and his colleagues compared neophobia in wild and enclosure rats, they found that overall the wild farm rats were more food neophobic. Other work has shown that neophobia was absent amongst rats on uninhabited islands off New Zealand. The phobia probably has adaptive significance and most likely increases with intensity of poisoning pressure. It also means that pre-baiting (initial familiarisation feeding without poison) needs to be a standard procedure in most baiting programs.

'A good understanding of the feeding biology of rats will always assist in control,' Singleton says. 'For years, rodenticides in Hawaiian macadamia orchards were broadcast onto the ground to control marauding black rats (Rattus rattus). Then an ecological study found that the rats damaging the nuts actually foraged only in the trees. When bait stations were set up in trees, rat and damage control proved far more effective.'

Rats in South East Asia

In many parts of the developing world, rats directly compete with humans for food.

'Take Indonesia, where rice provides 50–60% of daily energy requirements for people,' Singleton says. 'There, rats consume about 15% of the crop before harvest each year, enough to feed more than 20 million Indonesians for a year. Throughout rice-growing regions of South East Asia we estimate that rats typically cause annual losses of between 5 and 17%.'

Rats (mostly the rice-field rat, *Rattus argentiventer*) are a chronic problem in South East Asia and long-suffering farmers are almost resigned to their depredations. Rats weigh 165–200 grams and consume about 1.5 kg of rice a month. Farmers explain that 'for every eight rows of rice we sow for our family, we sow two for the rats'. In bad years, individual farmers or even whole villages can lose more than 50% of their crop.

Local people have ingenious ways of controlling rats. These include rat drives by villagers, bamboo snares and live traps that garrotte the rat or break its back, fumigation, digging up burrows, physical barriers and flooding. Farmers in a few places resort to low wires in crops connected to mains electricity, a method sometimes causing human fatalities!

Rat bounty schemes are politically popular and produce many dead rats: in 1997, 55 million rats were killed in 22 participating provinces. But bounties may

Above right: Villagers laboriously replace rat-damaged rice plants in Indonesia.

Right: Delicious! Rats for sale in a Mekong Delta market-place.

Kamikaze rats spread disease

ONE of the many diseases harboured by rats is toxoplasmosis. This causes huge loss of life in livestock and is a serious problem in humans. In the United States, for example, it causes more congenital abnormalities than rubella, syphilis and herpes combined. The disease causes remarkable changes in the behaviour of rats, changes that help to spread the *Toxoplasma gondii* organism.

The parasite (a protozoan) passes from rats to cats to humans. It has long been known that the infection causes changes in the behaviour of rats that make them more susceptible to predation by domestic cats, which are the parasite's definitive host.

Dr David Macdonald's team from the Wildlife Conservation Research Unit at Oxford investigated how the parasite manipulates rat behaviour. Compared with healthy rats, infected ones were more active (and hence more prone to cat predation), more curious (even approaching humans), and more likely to overcome their innate fear of cat odour. Some infected rats even preferred areas scented with predator odours!

Such, almost suicidal, rat behaviour allows cats to catch and consume more diseased rats and so cunningly helps the *Toxoplasma* organism infect its cat host. Ironically, curiosity kills the rat.

In most other respects, these rats behaved normally. They were not totally deranged and their social status was unchanged. However, infected rats were less phobic of novel foods and more easily trapped. So, in addition to tempting fate with respect to predation, these unfortunate rats are more susceptible to control measures.

Before and after: rat traps can be made up from recycled materials.

not be the most effective way to expend all that time, effort and money.

With funding from the Australian Centre for International Agricultural Research, and in cooperation with scientists in several South East Asian countries, Singleton and his CSIRO colleagues – Peter Brown, Alison Mills and Luke Leung – have been evaluating traditional and modern rat control measures. They have examined rat ecology in rice crops, and developed cost-effective pre-harvest control strategies that are ecologically sound and dovetail into normal farming operations (see story below).

Trapping rice-field rats

In the 1980s, Malaysian scientists suggested adding live traps to the more conventional plastic-sheet fences often used to deflect rodents from crops in developing countries. CSIRO scientists and their colleagues in Indonesia have taken this a step further by adding a lure or trap crop within the fence. This consists of a rice crop planted several weeks earlier than the main crop. The traps, placed along the fence-line can hold many rats, which are later destroyed.

This improved system came to be known as the trap-barrier system plus trap crop or TBS+TC (see diagram opposite). The efficacy of these traps is being evaluated in Indonesia and Vietnam.

Results indicate that the TBS+TC system generally provides a halo of protection to surrounding crops up to 200 metres from the fence. That is, rats are attracted from some distance, although crop protection drops off with distance from the system. Trials show that the optimum size of the fenced area in a TBS+TC is in the range of 20 to 50 square metres. The halo effect varies with season, but yield increases in surrounding crops are usually about 0.3 to 1.0 tonne per hectare.

'Our experiments indicate that the technique is likely to be effective across a broad range of agro-climatic conditions,' Singleton says.

'In a 1995–96 study in West Java, the benefit-cost ratio of the system was 20:1, but where rat numbers are low there may be a net economic loss. In some countries, growers sell the trapped rats for meat, which offsets the high initial cost of traps.'

'The success of the method really depends on coordinated actions at a village or district level. It should be part of an integrated approach to rat management,' the researchers say. 'Otherwise, resourceful rat populations will quickly recover from trapping by immigration, better survival or improved breeding performance.'

The team's ultimate goal is to modify a computerised decision-support system for rodent control, that is being developed for Australian farmers, so that it can be applied in South East Asia.

More about rats

Singleton G Hinds L Leirs H and Zhang Z, eds, (1999) *Ecologically-based Management of Rodent Pests.* Australian Centre for International Agricultural Research, Canberra.

More information about rodent research is available on the World Wide Web at www.dwe.csiro.au/research/progv/rodents.

Abstract: Rodent researchers are seeking ecologically-based ways to manage rodent pests, which can threaten agriculture, human health and wildlife survival. An understanding of rat behaviour can assist in their control. For example, their neophobic nature may explain their reluctance to take baits. Also, different rat species have particular feeding preferences. Rats are a chronic problem in South East Asia where a new trap-barrier system plus trap crop is being evaluated. In Indonesia, limiting food and nest-site availability are key factors in rat control. The researchers' ultimate goal is to modify for use in South East Asia an Australian decision-support system for rodent control.

Keywords: rats; rodents; animal pests; pest control; Research; animal behaviour.

Tuning management to ecology in Indonesia

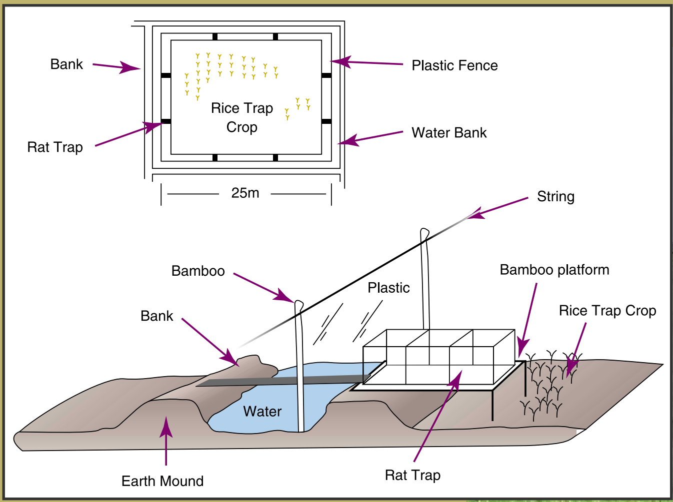
THE rice-field rat is the main pest in Indonesian irrigated lowland rice crops. To counter it, Indonesian and CSIRO researchers have been doing their homework on its ecology. They have come up with ways to improve rat control and so minimise chronic crop damage in West Java, the nation's 'rice bowl'.

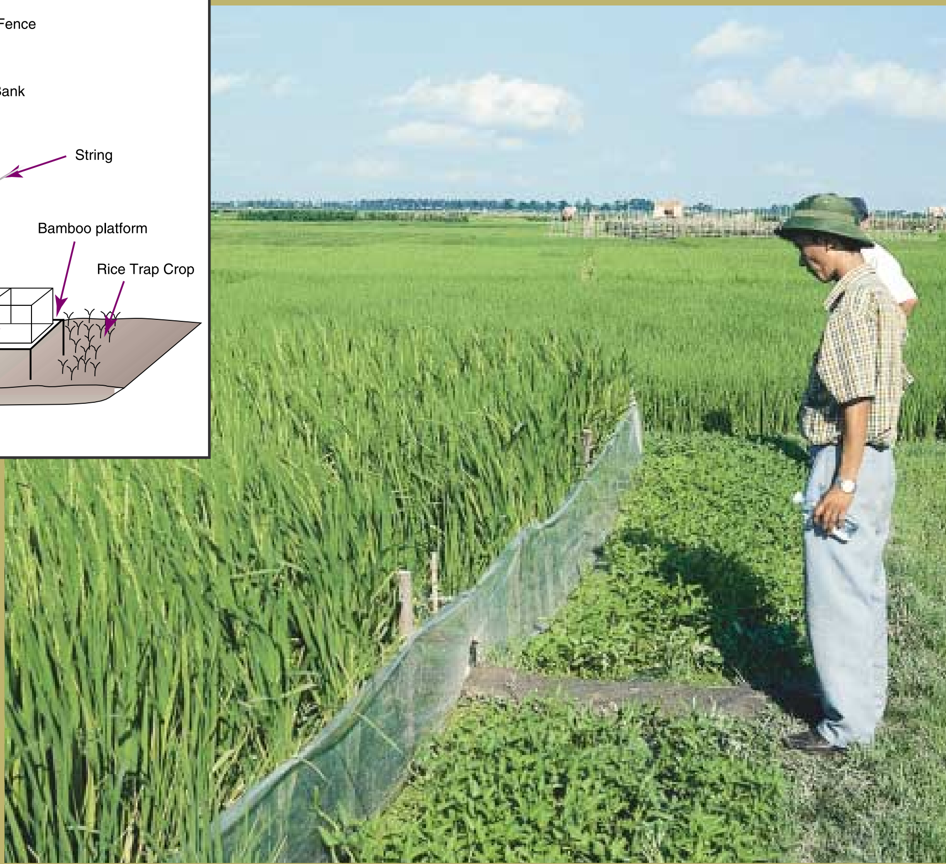
They found that the breeding cycle of the rice-field rat is closely synchronised with rice crops. This enables breeding rats to use the ripening rice crop to raise their young. Earth banks at the margins of flooded paddies are crucial habitat for the rats and this is where they mostly shelter, burrow and breed.

Three main factors limit rat population size: farm management practices, such as widespread cultivation of fields and reformation of earth banks; availability of nest sites, such as the banks of irrigation channels; and finally, food supply. For example, the number and size of rats decline dramatically during the dry season fallow due to the diminished food supply.

Based on this knowledge, the researchers recommend Indonesian rice growers should:

- minimise the number of banks in rice fields in order to limit the number of nest sites available;
- synchronise the planting and harvesting of crops over a large area so as to shorten the time that ripening rice is available to rats, thereby reducing their breeding season;
- maintain fallow during the dry season to reduce rat numbers; and
- conduct poisoning and other direct control measures after the dry season fallow when rats are weak and fewer in number. Control campaigns at other times – including the traditional pre- or post-harvest digging and fumigating drive – allow resilient rat populations to bounce back too soon.





Above: To set up a trap-barrier system plus trap crop, villagers fence-off a lure crop with plastic sheeting and place live rat traps along the barrier. Surrounding rice crops subsequently suffer less damage. (Source: Singleton *et al* (1999); Design: Arawang Communication Group)

Right: A trap-barrier system near rice crops in Vietnam, with a trap entrance visible.

Below: Villagers here in Laos use a range of ingenious, traditional snares to catch rats.