

Keeping Rats at Bay



A practical guide for premises owners and managers to prevent, control and monitor rat infestations

CONTENTS

1.	INTRODUCTION	3
1.1.	OVERVIEW	3
1.2.	COMMON URBAN RAT SPECIES AND THEIR HABITS	4
1.3.	UNDERSTANDING THE IMPACT OF URBAN RATS	6
1.4.	RECOGNISING EARLY SIGNS OF RAT INFESTATION	10
2.	PREVENTION AS A KEY STRATEGY	11
2.1	OVERVIEW	11
2.2	MAINTAIN GOOD HOUSEKEEPING	12
2.3	PROPER REFUSE MANAGEMENT	13
2.4	REMOVING ACCESS OR ENTRY POINTS (RAT PROOFING)	14
3.	SURVEILLANCE AND MONITORING	15
3.1	OVERVIEW	15
3.2	CONVENTIONAL METHODS AND TOOLS	16
3.3	EMERGING TECHNOLOGY-BASED SOLUTIONS	16
4.	CONTROL MEASURES TO REDUCE RAT POPULATION	24
4.1	OVERVIEW	24
4.2	TRAPPING	25
4.3	RODENTICIDES	27
4.4	BURROW TREATMENT	29
4.5	CULLING EXERCISE	30
5.	CONCLUSION	31
6.	OTHER USEFUL INFORMATION	32
6.1	LIST OF VCOS AND CODE OF PRACTICE FOR VCO, VCT AND VCW	32
6.2	CONTRACTING GUIDELINES	32
6.3	LAWS & REGULATIONS	32
7.	ANNEX	34
7.1	GUIDELINES FOR THE USE OF GLUE TRAPS	34
7.2	CHECKLIST FOR PREMISES OWNERS AND MANAGERS (PREVENTION)	36
7.3	CHECKLIST FOR PREMISES OWNERS AND MANAGERS (CONTROL)	37

1. INTRODUCTION

1.1. OVERVIEW

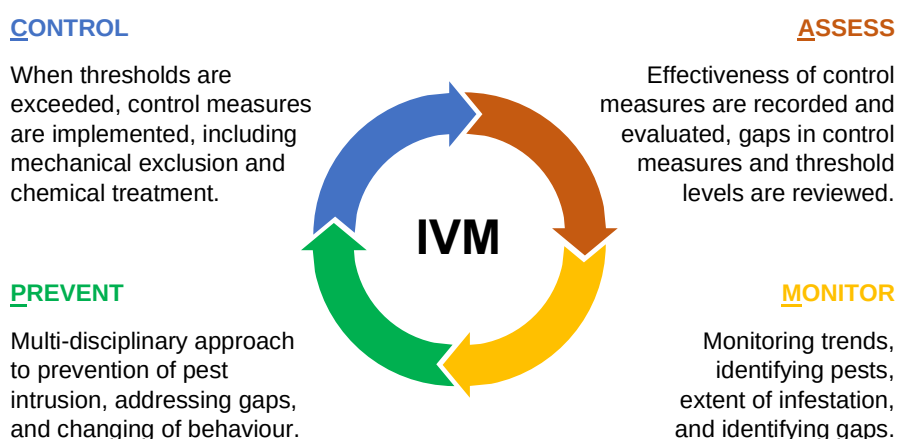
Urban or synanthropic (*i.e. those that are ecologically associated with humans*) rats have adapted well to our urban environment, rapidly multiplying in poorly managed and aged premises. They can cause significant damage to buildings and their infrastructure, which poses public and veterinary health risks by transmitting diseases to us and even our companion animals.

The **key strategy in managing rat infestation is to address issues upstream**, such as to remove and deny entry to food sources and remove potential areas of harbourage, so as to make nesting difficult and not encourage breeding. Hence, premises owners and managers, including landowners, building management, food establishment operators, play an important role in maintaining good cleanliness, hygiene, and housekeeping within their premises, and also keep infrastructure in good repair.

As rats reproduce very fast, it is important to sustain rat control measures, whether upstream or downstream. Technology allows for better surveillance and collection of data, which can then be used to guide intervention. The effectiveness of interventions can also be deduced from data collected.

To sustain efforts to reduce rat population and mitigate potential spread of diseases within the premises, a multi-pronged approach, based on the principles of **Integrated Vector Management (IVM)** and **Integrated Pest Management (IPM)** can be adapted for this context. In the context of this guideline, we will call it IVM. Below is a simplified overview of how the various tools and strategies can work together holistically:

Diagram 1: Main components of an IVM approach



IVM is a practical and sustainable approach to controlling diseases spread by vectors like rats, mosquitoes and ticks. The main aim is to reduce these diseases while being mindful of the environment and other living things.

IVM encourages different stakeholders, like health authorities, environmental agencies, and organizations, to work together to coordinate efforts to control vectors effectively.

IVM relies on evidence and data to make decisions. This means keeping an eye on where these vectors are (surveillance and monitoring), how and where rats are spreading, and what methods work best to control them (upstream and downstream measures). These usually include managing the environment, using safe and approved chemicals, and making sure

people understand the factors that attract rats to nest and breed, which may require training and resources to increase awareness.

Lastly, IVM keeps an eye on how well our efforts are working and makes changes if needed. This helps us make sure that our methods are effective and that we are always improving how we control rats, and also helps us use our resources wisely and make the biggest impact.

To help premises further improve the management of rat infestations, this set of guidelines provides useful information and practical advice for premises owners and managers on measures to **prevent**, detect, and manage rat infestations with their stakeholders.

1.2. COMMON URBAN RAT SPECIES AND THEIR HABITS

Urban rats are one of the five main vectors in Singapore that are capable of transmitting diseases, posing significant health risks to communities. Understanding the biological needs and behaviour of the different urban rat species in Singapore allows for the calibration of diverse preventative and/or control measures tailored to our local context. Below are the three common urban rat or similar rodent species in Singapore:

***Rattus norvegicus* (Norway rat, Brown rat or Sewer rat)**



Key features:

- Coarse, grey-greyish brown fur
- Dark (above) and pale (below), often scaly tail
- Tail length shorter than combined length of head and body
- Ears small, would not cover eyes when folded forwards and down



Behaviour:

- Often found living in large groups
- Active mostly at night
- Prefer to live in burrows, often making their nests in buildings and other man-made structures

Generally wary of new objects so traps have to be installed for some time for rats to familiarise themselves with it before being effective.

Rattus rattus (Black rats or Roof rats)



Key features:

- Fine, brown-dark brown fur
- Pointed muzzle head
- Uniformly dark tail with fine scales
- Tail length longer than combined length of head and body
- Ears large, can reach eyes when folded forwards and down

Behaviour:

- Often found living in large groups
- Active mostly at night
- Prefer to live in elevated areas, such as roofs, attics and trees

Generally wary of new objects so traps have to be installed for some time for rats to familiarise themselves with it before being effective.

Mus musculus castaneus (House Mouse)



Key features:

- Greyish brown-brown fur
- Pointed snout with large-rounded ears
- Uniformly dark tail

Behaviour:

- Often found living in large groups
- Active mostly at night
- Prefer living in warm dry areas, including homes and buildings

Generally exhibits exploratory behaviour, leading to perceived effectiveness in trapping mice.

Did you know?

Asian House Shrews are **not** rats nor rodents but often mistaken as them. Although shrews have not been implicated as vectors (transmitting diseases to humans) in Singapore, there have been reports of shrews found harbouring pathogens capable of causing diseases. Hence, it is advisable to treat the Asian House Shrew as with all wildlife and not handle them. If they need to be handled, care must be taken in handling, including donning of personal protective equipment to protect the handler.

Suncus murinus (Asian House Shrew)



Key features:

- Glossy mid-grey to brownish grey
- Long pointy snout, with rows of pointed sharp teeth in long jaws
- Hairy tail that is thick at the base

Behaviour:

- Insectivore but may feed on plant materials or discarded food
- Active mostly at night
- Produces high-pitched squeaks
- Prefer to live in urban areas

1.3. UNDERSTANDING THE IMPACT OF URBAN RATS

Rats can propagate rapidly if left unchecked, making it difficult to control their population once they are established within the premises. Upon reaching reproductive maturity at the age of 3 months, female rats can have up to 7 litters per year of 6 to 12 pups each, and they can become pregnant again just hours after giving birth. Without proper management, a pair of rats can quickly become a serious infestation within a year under ideal conditions (Diagram 3).

Diagram 2: Reproduction cycle of commensal rats

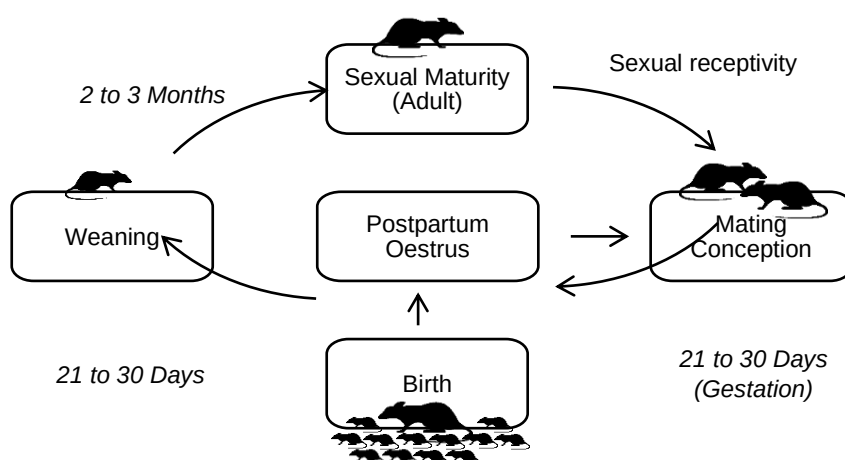
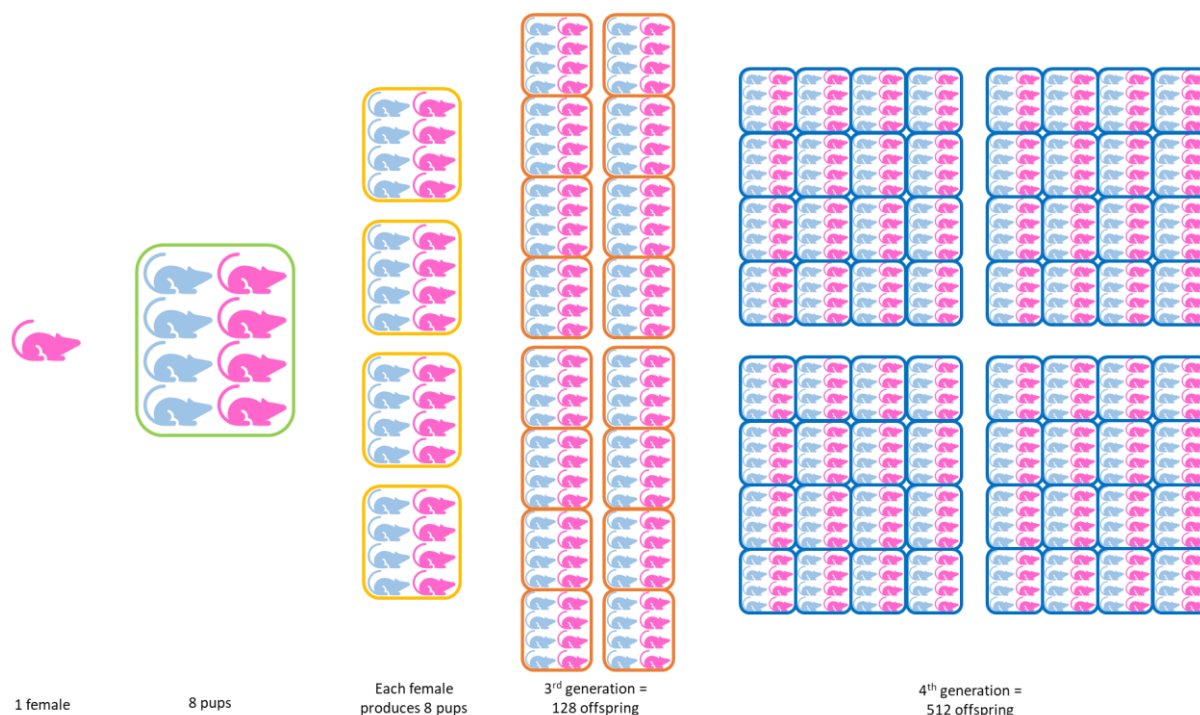


Diagram 3: Potential number of offspring from one pregnant female in less than a year, assuming 50% males and females, and all offspring survive and breed, and all females only give birth once.



Uncontrolled rat infestation within a premises can impact us negatively in many ways, including:

- **Public health risks:** Rats can carry and spread dangerous diseases such as *Leptospirosis*, *Murine Typhus* and *Hantavirus infection* (refer to **Table 1** for more details) directly or indirectly by contaminating our environment, food and water sources.
- **Property damage:** Rats can gnaw on and damage goods, wires, insulation and other building materials, which can lead to costly repairs and even pose a fire hazard in some cases.
- **Reputation:** Rat sightings and the public attention it receives can give rise to negative perception and affect the reputation of the premises. This may result in business disruption, enforcement and potential loss of customers, income and business opportunities.
- **Other legal and financial consequences:** In addition to costs required to clean up and sanitise the contaminated areas, premises owners and managers may also be liable to compensate stakeholders for any damages, injuries or health-related issues caused by rat infestations.

DID YOU KNOW?

In 2022, the two commonly found rats, *Rattus norvegicus* and *Rattus rattus*, have been found infected with pathogens such as *Leptospira spp.*, *Seoul hantavirus*, and *Rickettsia typhi* across different unique landscape in Singapore, with the most common areas being public residential areas, commercial sites and food establishments.

Source: Griffiths J, Yeo HL, Yap G, Mailepessov D, Johansson P, Low HT, Siew CC, Lam P, Ng LC. (2022). Survey of rodent-borne pathogens in Singapore reveals the circulation of *Leptospira spp.*, *Seoul hantavirus*, and *Rickettsia typhi*. *Scientific Report*, 12, 2692

Table 1: Most common rat-borne diseases detected in Singapore

Known disease	Murine Typhus	Leptospirosis	Hantavirus infection
Pathogen Type	Bacteria	Bacteria	Virus
Primary Vector	Rat flea	Rat	Rat
How it transmits to humans	<i>Diagram 3: Transmission pathway</i>		
	Bitten by infected flea or when infected flea faeces are rubbed into cuts or scrapes in the skin	Direct contact with the urine of infected rats or with a urine-contaminated environment	By air, oral and direct contact with saliva and excreta of infected rats
Incubation Period	6 to 14 days	2 to 30 days	1 to 4 weeks
Signs and symptoms may include	• Fever • Chills • Loss of appetite • Nausea • Vomiting • Abdominal pain • Cough • Rash	• High fever • Headache • Chills • Muscle Ache • Vomiting • Jaundice • Red eyes • Abdominal pain • Diarrhoea • Rash	• Fever • Fatigue • Muscle Ache • Nausea • Vomiting • Diarrhoea • Abdominal pain • Cough • Shortness of breath
If left untreated, may lead to	Damage one or more organs, including the liver, kidneys, heart, lungs, and brain.	Kidney damage, meningitis, liver failure, respiratory distress, and even death	Cardiopulmonary syndrome, renal syndrome, and even death
Source: https://www.cdc.gov/leptospirosis/index.html https://www.cdc.gov/typhus/murine/index.html https://www.cdc.gov/hantavirus/index.html			

Studies on Costs of Infestations

There have been various studies on the costs of rodent infestations, conducted mainly in western countries ranging from primary industries to cityscapes similar to Singapore.

In 2000, [a study estimating annual environmental and economic costs](#) of introduced pests in the US specifically highlighted rats for causing approximately US\$19 billion in damages annually.

In 2015, [a report published by the Centre for Economics and Business Research \(CEBR\)](#) estimated an increase of US\$7.4 billion in operating costs due to disruptions caused by pests, and declines in revenues by about US\$15 billion.

More recently in 2022, [a study on global economic costs of invasive rodents](#) showed damages by undefined *Rattus* spp. to be about US\$ 327.8 million, followed by *Rattus norvegicus* causing US\$156.6 million in damages between 1930 and 2022, and were significantly increasing through time.

In early 2024, the US Department of Justice [fined a chain store US\\$42 million](#) for violation of the Federal Food, Drug and Cosmetic Act (FDCA) when the US Food and Drug Administration (FDA) found a serious infestation of rats at one of their warehouses.

These examples all show the serious economic impact of rodent infestation. Specifically for the chain store case, public health risks, property damage, reputation, and legal consequences were all affected as well.

On the contrary, a study in 2018 conducted for [New Zealand's primary industries in the Hawkes Bay Region](#) on a 10-year cost-benefit analysis indicated savings of up to US\$8 million with upstream rodent management measures in place.

Despite having no studies done in Singapore, proactively managing rat infestations early yields significant cost benefits and mitigates potential risks to public health and infrastructure. Recognizing the signs of early infestations allows for swift and targeted intervention, reducing the need for extensive and costly control measures. This proactive approach not only safeguards communities but also minimizes long-term economic impact, making it a prudent and responsible investment in sustainable urban environments.

1.4. RECOGNISING EARLY SIGNS OF RAT INFESTATION

Before embarking on any rat management plan, it is important to identify the extent and severity of an infestation, harbourage areas and other contributing factors. If you suspect that there is a rat infestation within your premises, you should take immediate actions to prevent the situation from getting worse.

Here are some common signs of possible rat infestations within and around the premises:



Live rat sightings

May indicate presence of a larger infestation as rats are social animals that live in groups.



Rat burrows

Round openings about 2-4 inches in diameter and may be surrounded by disturbed soil.



Rat droppings

Usually found near food sources or runways leading to nesting areas such as burrows or harbourage that are often hidden from sight.



Gnaw marks

Rats chew on surfaces and create rough-edged openings on materials such as wood, plastic or cables, causing damage to infrastructure.



Rub marks

Their fur picks up dirt and leaves marks as they frequently run along surfaces, walls and pipes.



Footprints

Left by rats when they travel in dusty, areas within indoor premises.

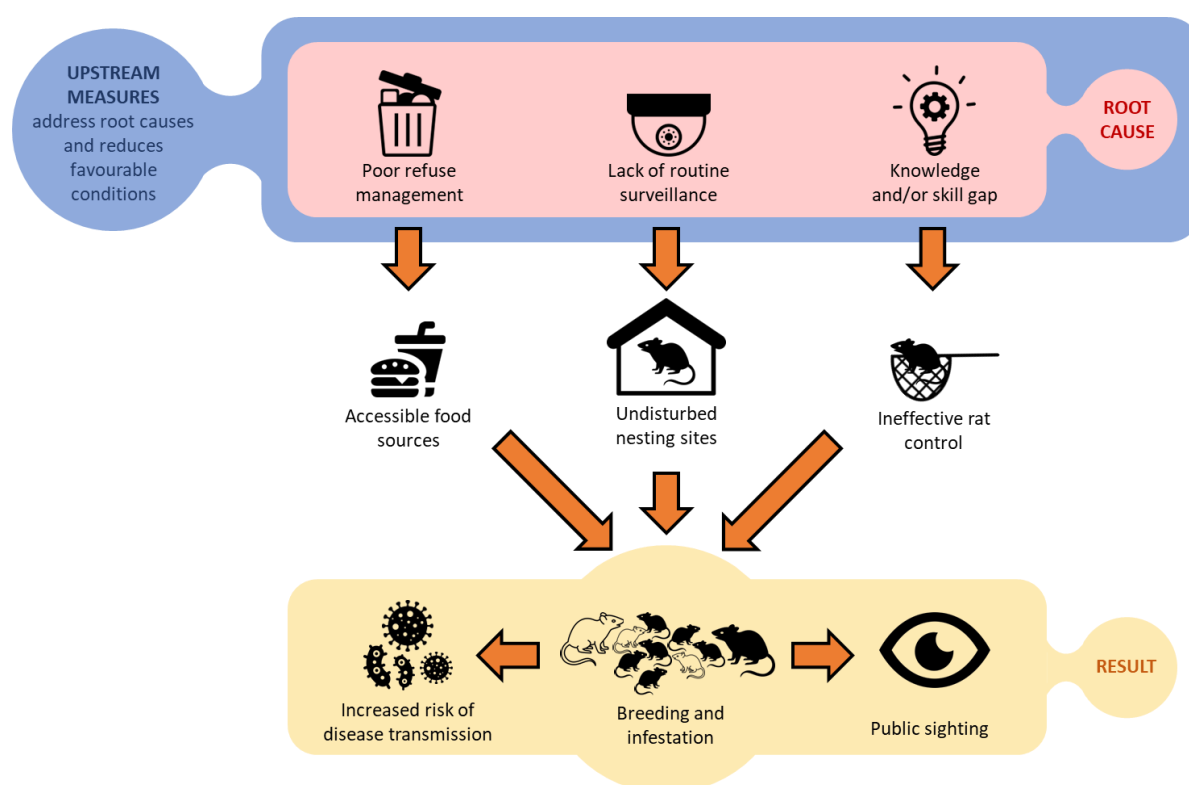
2. PREVENTION AS A KEY STRATEGY

2.1 OVERVIEW

Taking a proactive approach to prevent rats from entering or harbouring within the premises is often more sustainable and cost-effective, rather than reacting to growing infestations after they have already occurred. Implementing upstream measures, such as **maintaining good housekeeping, proper refuse management and removing access or entry points (rat proofing)**, can help to create an environment that is less attractive and accessible to rats, so that premises can reduce the risk of infestations and associated problems in the long term. **Routine rat surveillance, along with proper treatment** minimizes the risks of rat-borne diseases and prevent property damage.

The diagram below provides an example of how rat infestation and its associated problems could occur within the premises:

Diagram 4: Possible root causes of rat infestation and rat-borne disease outbreaks



2.2 MAINTAIN GOOD HOUSEKEEPING

Rats thrive in spaces that are cluttered with undisturbed items. Therefore, it is always important to ensure good housekeeping by neatly storing items and promptly removing bulky items that may serve as potential nesting sites.

Below are some examples of good and poor housekeeping:



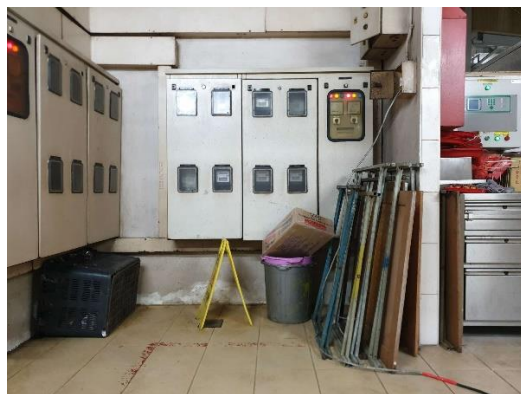
✓ Bulky items are neatly stored and routinely cleared within premises such as bin centres.



✗ Unattended bulky items such as old furniture, appliances can attract rats as they provide shelter and hiding places.



✓ Loose items such as wires, cardboards are neatly stored in confined spaces such as riser room.



✗ Rats may frequent or harbour in such spaces as they can make use of loose materials to build their nests.



✓ Food items that are covered and securely stored in containers or storage that prevents access reduces likelihood of attracting rats.



✗ Exposed food items attract rats and encourage them to frequent or harbour near the premises.

2.3 PROPER REFUSE MANAGEMENT

Proper refuse management is an important aspect in minimising risk of rat infestation. Bin centres, bin chutes, Central Refuse Chutes (CRCs) and overflowing refuse serve as one of the most common food sources for foraging rats and may provide shelter for the rat populations. Hence, they must be kept clean and in good condition to deter rats from harbouring in these areas.

Below are some examples of good and poor refuse management.



✓ Refuse are properly bagged and placed within designated bins or waste disposal points.



✗ Inconsistent or insufficient frequency of waste collection often results in overflowing bins and spillages.



✓ Timely waste collection helps ensure that bins and bin centres are kept clean and tidy.



✗ Indiscriminate dumping at open areas instead of using designated covered bins or waste disposal points.



✓ Any spillages are cleaned up promptly to minimise attracting rats to bin centres.



✗ Refuse spillage around bins and within bin centres emits smell that signal to rats a potential food source.

2.4 REMOVING ACCESS OR ENTRY POINTS (RAT PROOFING)

Addressing potential access and entry points within the premises is often more effective to mitigate rat infestations as compared to using reactive or short-term methods. In cases where prevention through infrastructural design is not feasible, you should diligently conduct routine checks to identify and promptly address any potential issues.

Below are some examples of good and poor practices to prevent rats from accessing your premises.



✓ Sealing possible entry points to prevent rats from entering or moving easily within the premises.

✗ Failing to seal gaps and holes within buildings, such as the walls, flooring and ceilings.

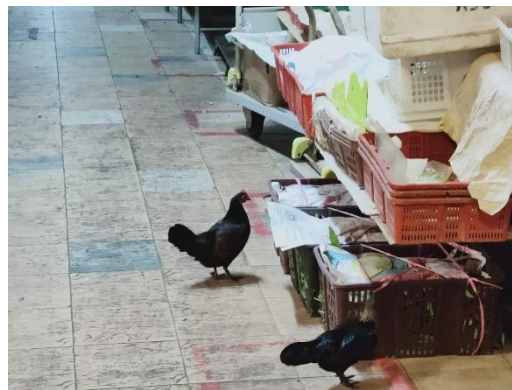


✓ Routine maintenance to repair or replace damaged infrastructures such as floor traps, covers and doors.

✗ Poorly maintained infrastructure such as damaged doors, broken vents and structural defects provide entry points.



✓ Securing food items above the ground makes it harder for rats to reach them.



✗ Leaving food items on the ground can attract rats due to the ease of locating and accessing them.

3. SURVEILLANCE AND MONITORING

3.1 OVERVIEW

The key to achieve sustainable, long term, and cost-effective management of rats is to focus on upstream measures, eradicating conditions favourable to the propagation of rats to prevent recurring infestations. Incorporating routine **surveillance methods and tools** (including **technology-based solutions**) as an integral part of a comprehensive rat management programme can help premises monitor rat activities, guide targeted early interventions, and also evaluate the effectiveness of the VCO's work.

Selecting the most appropriate method or tools depends on various factors, such as the structural limitation of the premises, extent of rat infestation, availability of resources and manpower. When in doubt, you can seek further advice from your appointed VCO.

3.2 CONVENTIONAL METHODS AND TOOLS

Below are some conventional methods and tools used by professional VCOs to detect signs of rat activities within a premises:

Type	Feedback	Visual inspection	Non-toxic Bait Station
Photo			
How it works	Stakeholders such as the public, tenants can provide early warnings and help to pinpoint the locations of rat sightings and suspected areas of rat infestations.	Involves physical inspection of common areas such as false ceilings, storage and refuse facilities for any tell-tale signs of rat activities.	Placed within the premises to serve as monitoring stations to assess extent of rat infestation by measuring the non-toxic bait consumption.
Pros	Encourages shared responsibility among stakeholders	Can be more targeted based on signs and feedback	- Easy to deploy - Scalable to cover large areas
Cons	- May not be reliable - Unable to pinpoint exact source of rat infestation - May require follow up with feedback provider	- Manpower intensive - Effectiveness is limited by the experience of the individual - Require tools to search difficult areas - May disrupt daily businesses and activities	- Require additional effort to plan, monitor and replace baits - Require expertise to analyse data

3.3 EMERGING TECHNOLOGY-BASED SOLUTIONS

Conventional surveillance and monitoring methods have limitations in their coverage and effectiveness in detecting signs of rat infestations. With the emergence of new technologies, VCOs have started to adopt technology-based solutions to overcome such challenges and take advantage of the **benefits** (not limited to the following) they can offer:

- Better coverage:** Data collected through conventional methods such as visual searches and traps are not able to provide a comprehensive assessment of the extent of rat infestation within the premises. Surveillance systems and their sensors can be easily deployed across a larger area over a longer period to provide consistent and continuous monitoring of a larger area and can complement conventional methods.
- Better accuracy:** Visual searches rely on human effort and are prone to errors and subjectivity. Rats are generally wary creatures who would hide whenever they detect unusual activities such as when a person conducts visual searches manually. Using technology helps to reduce inconsistencies and subjectivity in the surveillance data

collected, which can provide more valuable insights to identify the source of rat infestation for targeted interventions.

- **Long term cost-savings:** While initial costs may be higher than conventional methods, technology-based solutions, when used correctly, can support efforts to eradicate rat-related issues at the source and remove the need for reactive responses to manage recurring infestations. Furthermore, continuous monitoring enabled by technology can pick up early signs of rat activities, allowing for prompt, cost-effective interventions before the infestation escalates.

Some of the more commonly used technology include the use of **Sensors, Internet of Things (IOT), and Smart tools**.

COMMON MISCONCEPTIONS ABOUT LEVERAGING TECHNOLOGY

#1 Technology is able to solve all rat-related problems.

No, this is not true as technology is not an one-size-fits-all solution. It requires trained professionals to thoroughly assess the situation within the premises before it can be applied correctly. Technology is just a tool which should be selected according to the situation requirements and be used along with other tools and efforts to resolve rat infestations.

#2 Technology is always expensive.

Not all technology-based solutions are expensive. If the root cause of rat infestations can be accurately identified, premises owners and managers would be able to implement the most appropriate measures to get the best outcome and prevent further losses. Furthermore, economies of scale can be achieved over time with higher adoption of technology.

#3 Technology can replace all human effort.

This is false. Technology serves as a tool to complement existing rat surveillance and control measures. While technology can automate certain tasks, it still requires human effort for calibration and interpretation of the data collected for meaningful insights. Human intervention is also required to investigate and follow up with appropriate control measures.

3.3.1 SENSORS AND CAMERAS

Borescope/Videoscope

A flexible optical device equipped with a camera and light source. It is used to visually inspect and capture digital footages of difficult-to-reach or inaccessible areas such as burrows, enclosed spaces within buildings, where direct visual search is not feasible.

Best used for: Confirming presence of rats or nesting in suspected burrows or crevices, inspect gully traps and false ceilings, particularly in cases where the false ceilings are obstructed.

Limitation: Limited field of view; not suitable for large open areas or spaces.



Example of a commercially available borescope kit with extension tube.



A NEA officer inserting the extension of a borescope into a suspected rat burrow.



Borescope can also be used for infrastructural defects such as broken drain covers.

Motion or Passive Infrared (PIR) Sensors

An electronic device that detects movement by measuring infrared light radiating from objects within its field of range and alerts the user upon a trigger. While originally designed to detect human presence, these sensors are repurposed to detect possible rat movement.

Best used for: Detecting possible rat movement within an enclosed area.

Limitation: Sensors sensitive to environmental factors, which may lead to false triggers.



Example of a PIR sensor used by VCOs.



Sensor placed high above ground to minimise tampering or interferences.



Sensor placed on the ground near potential rat runways and with lesser human traffic.



Vibration sensors can be placed in tamper-resistant housing to detect activation from snap traps, trapped and struggling rats on glue boards, or movement caused by gnawing of baits.

Trail or Hunting Cameras

These cameras are designed specifically for capturing movements of small animals such as rats. To effectively record footages of rats in the urban environment, they have features such as infrared or low-light capability, high trigger response, weatherproof and long battery life.

Best used for: Observing and recording rat activities in a target area

Limitation: Limited field of range; may be time consuming to review footages



Examples of commercially available trail cameras (left) and surveillance cameras (right).

Trail Cameras should be strategically positioned with unobstructed view of areas or pathways where rats are likely to travel.

Infrared capability is essential for capturing clear footage in dark and enclosed areas, where rats are more active.

3.3.2 INTERNET OF THINGS (IOT)

Remote Monitoring System or Network

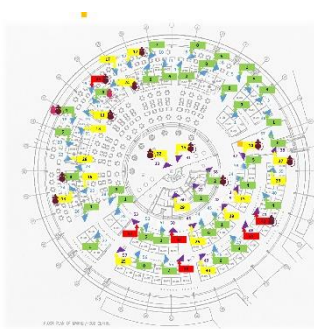
A network of sensors such as passive-infrared sensors and/or cameras working together to remotely detect and capture digital footages of rat activities within a targeted area continuously. These remote sensors are often linked together wirelessly, which enables real-time or periodic transmission and collection of surveillance data. Sensors can also be built into conventional traps to alert users upon a successful catch.

Best used for: Early detection and proactive control of rat infestation in built environments

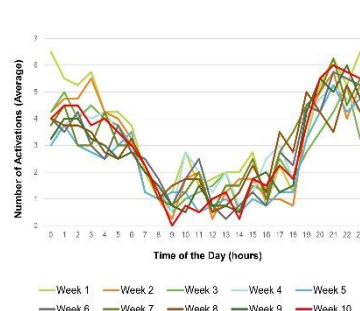
Limitation: Higher costs; require expertise to calibrate deployment and analyse data



VCOs may use a mix of PIR sensors and cameras to monitor targeted areas within the premises.



Data can help estimate the level of rat infestation or pinpoint areas of high rat activities (red).



Using data to identify peak level of rat activities, which help to guide and evaluate the effectiveness of the control measures.

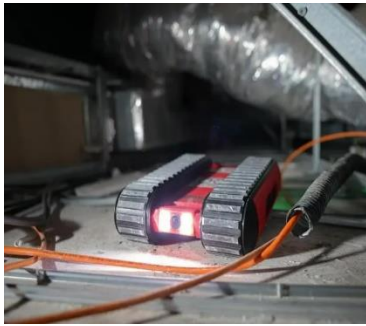
3.3.3 SMART TOOLS

Robots or automated devices

These specialised devices are designed to perform routine tasks such as visual search, trapping and bait deployment in place of humans. They are often equipped with sensors, cameras and mechanical parts to carry out surveillance and control measures in diverse environments that may not be suitable for humans to access or operate in.

Best used for: Reducing human effort for repetitive tasks, especially in difficult areas

Limitation: Higher costs; require expertise to operate and deploy effectively



False Ceiling Robot developed by SUTD, which can traverse false ceilings of buildings and look for signs of rat infestation.



Smart traps are designed to automatically reset after capturing and/or killing the rat, hence reducing the need for frequent human maintenance.



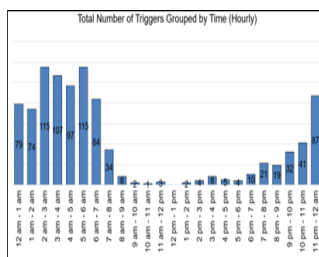
Automated rodent traps kill rats by blunt force trauma to the skull or spine and primes itself automatically, reducing the frequency of maintenance.

Artificial Intelligence (AI)

AI may be used by VCOs to substitute human effort in analysing large amount of data collected from conventional surveillance methods and/or cameras and sensors deployed within premises as part of a larger remote monitoring system. It can help to recognise rats through video analytics to reduce false positives, discern patterns in rat activities, identify infestation hotspots and provide valuable insights such as prediction of future areas of concerns, which further contributes to evaluating and improving the overall rat management strategies.

Best used for: Analysing large amount of data to derive insights to guide decision-making

Limitation: Requires diverse and high-quality data for accurate outcomes



Methodology or algorithms developed in-house by VCOs or technology solutions providers can efficiently process and analyse data collected by the sensors.

AI has the potential to assist in the development and training of advanced prediction models, which enables forecast of potential rat activities, infestation trends.

AI applied in video analytics can automate the identification of rats in footages by training the algorithm to recognised predefined shapes and movement.

3.3.4 CASE STUDIES

Rodent AI Camera Detection

Problem:

Rats were an issue in a fenced-up premises despite an ongoing rat management programme in place, including monitoring stations, bait stations, and regular inspections being conducted.

Conventional cameras capture all footages without detection triggers. This results in higher power consumption and labour to look through long hours of footages to find rat activity. Most currently available IoT cameras in the market only sends trigger and alert upon detection of movement and are not able to verify the presence of rats, i.e. an alert is triggered when a bird comes into the field of view of the camera as well.

Solution:

Rodent AI camera was placed such that it was able to detect rat activities such as entering traps, consuming baits, points of ingress and egress, movement tracking, and potential source of food and harbourage. Unlike conventional cameras, the Rodent AI camera provides footage that allows monitoring of the state of housekeeping, number of rodents, and their individual movement and behaviour.



With this information, users can better understand the reasons behind the frequent or repeated rat activity and can opt to switch trap placement if desired, switch to more attractive baits or bait locations if required, and conduct rat-proofing at points of entry. After extended deployment and collating footages and results, the rat management strategy can be optimised further.

AI Camera Detection in Confectionary Factory

Problem:

Rats were entering rooms in the factory where confectionary are kept, but sealing of visible entry points does not stop the intrusion and damage.

Solution:

AI camera was installed in a location overlooking the entire room to monitor the movement path of rats. From the footage and AI movement tracking, a potential entry point was found in the ceiling. The small hole was sealed and thereafter, the damage caused by rats ceased.

AI Camera Trace Image



AI Camera Detection Footage



4. CONTROL MEASURES TO REDUCE RAT POPULATION

4.1 OVERVIEW

Downstream measures remain an essential component in the management of rats. However, implementing only downstream control measures such as trapping and baiting within the premises are often insufficient and ineffective on their own. While they may help reduce the rat population within a specific area, the root causes are often overlooked, which leads to a perpetual cycle of reactive responses due to recurring infestations. Nevertheless, downstream measures remain an essential component in the management of rats.

Whenever there are signs of active rat infestations, control measures should be implemented promptly as part of a comprehensive strategy to manage or reduce existing rat populations and prevent any further proliferation of rats within the premises. It is important to conduct a thorough assessment of the situation to determine the extent of the rat infestation and identify the areas of high rat activities to determine the most effective control measures to adopt.

The commonly used control methods include **trapping**, **rodenticide baiting**, and **burrow treatment**.

TAMPER-RESISTANT HOUSING

Traps such as glue boards, snap traps, and toxic baits used in rat management poses a risk to non-target animals such as cats, dogs, birds, and many other wildlife species, and even young children. These traps should be deployed by qualified vector control workers or technicians in tamper-resistant housing and monitored closely for the duration of their deployment to minimise trapping of non-target animals. Entrance holes should also restrict larger animals from entering where possible.



4.2 TRAPPING

Trapping of rats can be carried out when rodenticides are not permitted or may pose a potential hazard (e.g. in food establishments or food handling areas). Each of these equipment serves a specific purpose in rat culling operations and should be used in accordance with established guidelines and best practices to ensure both effectiveness and removal of the targeted pests. When non-target species are present on the site and the traps are laid unattended, all glue traps and snap traps should be placed in tamper-resistant bait stations, and the stations should be firmly anchored by screws or cables/wires. After deploying traps at targeted locations, premises owners or managers should arrange for VCOs to monitor regularly for live captures and dispose any rat carcasses to prevent any public health risks. If a non-target animal (such as stray animal, pet, or wildlife) is caught in the trap, VCOs should be alerted immediately to release it, and send them to a veterinarian, or contact NParks' Animal Response Centre (helpline at [1800-476-1600](tel:1800-476-1600)) if necessary.

Table 3: Common types of rat traps

Type	Snap traps	Glue traps	Live traps (Cage)
Example			
How it works	When triggered, the spring mechanism snaps down and kills the rat by severing its spine.	Boards or trays covered with strong adhesive that will hold the rat in place when it passes.	After the rat is lured inside and tugs at the bait, the door shuts and traps it alive.
Pros	- Reusable hence more cost effective to use in long term - Able to kill rats quickly and humanely	- Easy and quick to deploy - Very cost effective	- Reusable hence more cost effective to use in long term - Allows capture and release without harming rat
Cons	Not effective for large scale infestations	- One-time use only - Indiscriminate use may cause non-target animals to be caught	Not effective for large scale infestations

WHERE AND HOW SHOULD TRAPS BE USED?

To achieve higher success of trapping, **traps should be strategically placed** along walls or pathways where rats frequently travel, which could be determined by observing the various signs of rat activities. Also, traps should be placed at areas which are remote and out of reach of the general public to minimise risk of tampering and/or contamination.

All traps deployed **must be retrieved, accounted for, and disposed of properly** (i.e. especially glue traps) after all vector control work has been completed by the VCO to prevent accidental trapping of non-target animals and/or decomposition of carcasses leading to contamination and public health issues.



Traps (cages) are often used together with lures or non-toxic baits to entice rats to enter.



A glue board (inside the box) should be used inside a tamper-resistant box to prevent non-target captures.

For more information on proper usage of traps, please refer to the NEA **Code of Practice for VCO, VCT and VCW**.

4.3 RODENTICIDES

Rodenticides are chemical substances designed for killing rodents, which includes rats. They are used by professional vector control operators (VCOs) as part of the comprehensive rat management programmes put in place for premises. Rodenticides comes in many forms, such as toxic and non-toxic baits that come in wax blocks, soft baits, dust, or water formulations (water formulations have yet to be registered in Singapore), and the mode of action of toxic baits are broadly categorized into anticoagulants and non-anticoagulants.

Table 2: Common types of rodenticides

Type	Anticoagulant rodenticide	Non-Anticoagulant rodenticide
Example	• Warfarin • Bromadiolone • Brodifacoum • Bifenacoum	• Bromethalin • Zinc phosphide • Cholecalciferol
How it works	Causes excessive internal bleeding due to the inability of their blood to clot properly, which leads to death.	Promote excessive clotting of blood, resulting in organ damage, eventually death.
Time to take effect	Usually several days to prevent bait shyness and ensure consumption of lethal dose.	May vary but usually more quickly than anti-coagulant rodenticides, e.g. lethal after single feed.



Examples of rodenticide (Top: Storm Secure, Bottom left: Final Blox, Bottom right: Contrac Blox)

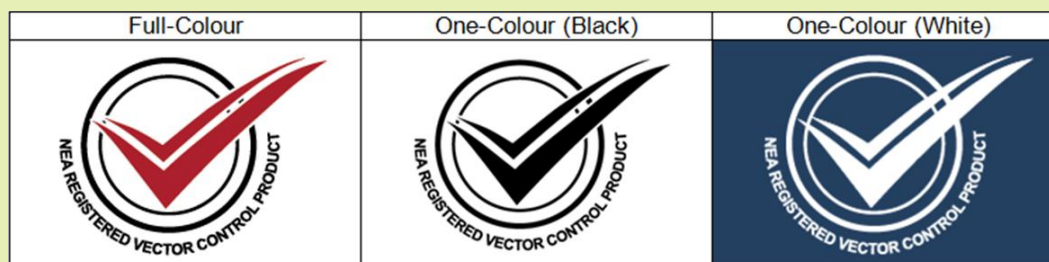


Rodenticide (blue wax block) placed inside a black tamper-resistant bait box

Rodenticides are used during a rodent infestation, or for the monitoring of rodent population and activity, and typically contained inside a tamper-resistant rodent bait box, as seen in the above illustration. These boxes should be anchored to or securely attached to an immovable surface or object. The boxes shall be securely locked/fastened and only licensed VCT and certified VCW should be allowed access. Tamper-resistant bait stations are to be properly labelled with the emergency contact number, VCO's business name and telephone number, a warning sign and the words "Rodent Bait Station, Do Not Remove" to deter curious members of public from disturbing the stations.

ARE ALL RODENTICIDES SAFE TO USE?

Any rodenticides used for rat control needs to be registered with NEA and bear the **NEA Registration Mark**, comprising a registration number and registration logo (below). All registered rodenticides are classified “For Restricted Use” and must only be applied by licensed VCOs. It is important to engage licensed VCOs, who can provide expertise and administer the safe and responsible use of rodenticides. Improper usage may cause unintended poisoning to people, domestic pets, and non-target wildlife. Toxic rat baits are often brightly coloured and may be attractive to young children. Tamper-resistant housings will prevent accidental consumption of baits by curious children and even dogs and cats.

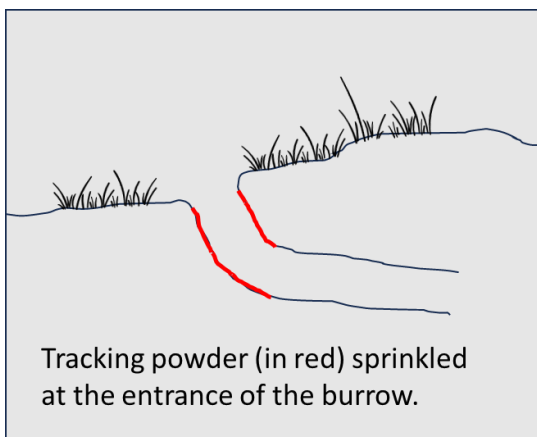


For more information on proper usage of rodenticides, please refer to the NEA **Code of Practice for VCO, VCT and VCW**.

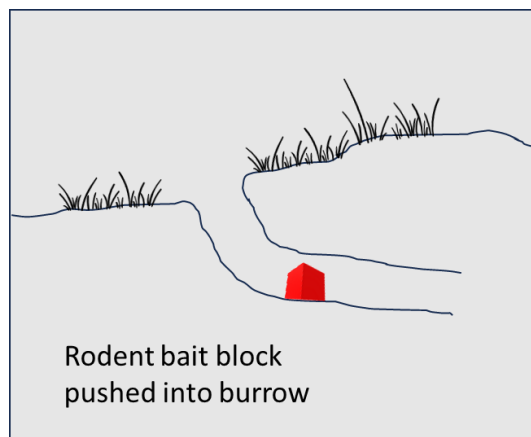
4.4 BURROW TREATMENT

Rat burrows indicate the presence of rats in outdoor environments, including the vicinity of buildings. Targeting rat burrows by applying rodenticides directly inside them can help reduce the rat population at its source and prevent further proliferation. Active rat burrows usually have entrances that appear compacted and smooth, or with freshly dug soil, as well as being clear of vegetation. Rodenticides must be placed deep into rat burrows where it is not visible from the outside.

Burrow under treatment with rodenticide (tracking powder)



Burrow under treatment with rodenticide (wax block)



WHAT IS NEXT AFTER PLACING THE RODENTICIDE IN THE BURROW?

You should continue to check and treat burrows with rodenticide every 3-4 days to maintain its effectiveness (or even daily if it rains) until there is no sign of rat activities. The frequency of the checks depends on factors such as the level of infestation, type of rodenticide used and characteristic of the site. Thereafter, inactive burrows can be sealed, and structural defects repaired.

4.5 CULLING EXERCISE

Rat culling is a systematic reduction of the rat population through various methods such as trapping using mechanical traps and non-chemical tools. It is important to conduct thorough inspections to identify these areas by the presence of signs of rat activity.

Prior to the culling, it is advisable to note the following:

- i. Conduct a site survey during the day to identify runways, burrow locations, types of habitats, severity of infestation, number of rats etc. Alternatively, night observations, such as lookout posts can be used to identify rat harbourage before the start of culling operations.
- ii. Thoroughly assess the ground situation and understand the rats' behaviour, considering their exceptional muscle memory and tendency to surface at familiar locations.
- iii. Once information is gathered from the survey, plan the type and number of devices to be used and locations to be deployed (e.g. number of traps and amount of baits to be used. If glue boards are used, ensure that all glue boards deployed must be accounted for at the end of the exercise).
- iv. The traps should be strategically placed and not be shifted around throughout the culling exercise to ensure effectiveness. Additional traps may be added based on observations further into the culling exercise.



Strategic placement of snap traps along sides of drains.



Placement of glue boards along established runways



Use of rat cages within drains used as runways.

Note: Culling operations tend to be short in duration (3 to 4 hours) and intense in trap deployment where snap traps and glue boards are monitored closely throughout the period of the exercise. The timing of these operations and the constant monitoring minimizes capturing of non-target animals.

- v. Trapped rats must be killed humanely and disposed of properly. An animal can be deemed to have been killed humanely if the method used is quick, efficient, and as painless as possible, e.g. by a sharp and acute impact to the head or by cervical dislocation or decapitation by trained personnel. Where a cutting edge is used for decapitation, it should be sharp enough to achieve immediate severance of the head.
- vi. Rat carcasses should be securely fastened in plastic bags and ensured of no leakage of fluids, i.e. using sufficiently thick material to prevent easy puncture, closing off the bag opening securely to prevent leakage, double- or triple-bagging to reinforce containment, before disposal.

GOOD PRACTICES FOR SECURING BIOHAZARD WASTE

A good method would be to twist the opening of the bag to enclose its contents, continue twisting till a length is formed, forming a loop with this length, before taping or securing the loop with a cable tie.



1. Twist the opening of the bag to a sufficient length



2. Loop the length of twisted bag



3. Secure by tape or cable tie

5. CONCLUSION

Joint action by all stakeholders is important to detect early signs and prevent rat infestation to keep the threat of rat-borne diseases at bay. For effective rat management, it is crucial to adopt upstream measures such as the implementation of effective refuse management, maintaining good housekeeping practices, having a monitoring programme in place, and preventive measures such as sealing up gaps and having proper food storage to minimize rat intrusion. The appropriate use of rodenticides in burrow treatment and rat baiting also contributes to effective long-term management of rat populations.

The importance of adopting a pre-emptive and sustained approach cannot be over-emphasised. Rat surveillance and control measures must be complemented by good sanitation standards. Premises managers and owners are urged to reference the steps highlighted in the sections to put in place a holistic management programme: **Prevention as a key strategy, control measures to reduce rat population**, and routine **surveillance and monitoring**.

6. OTHER USEFUL INFORMATION

6.1 LIST OF VCOS AND CODE OF PRACTICE FOR VCO, VCT AND VCW

Licensed Vector Control Operators (VCOs) should be engaged to prevent or reduce rat infestations. For more information on the list of VCOs and the Code of Practice, please visit the NEA webpage: <https://www.nea.gov.sg/our-services/pest-control/vector-control-operator>

6.2 CONTRACTING GUIDELINES

You can refer to the latest sample rat management contract specifications at: <https://www.nea.gov.sg/our-services/pest-control/rat-control>

6.3 LAWS & REGULATIONS

NEA adopts a pre-emptive approach by conducting inspections at residential and commercial premises. During inspections, breeding habitats of these vectors are removed, preventing the transmission of diseases. When lapses are found, fines or other penalties are imposed.

Premises owners or managers who fail to practise proper refuse management or create conditions favourable to the harbouring or propagating of rats are subject to enforcement by NEA under the **Environmental Public Health Act 1987 (EPHA)** and the **Control of Vectors and Pesticides Act 1998 (CVPA)** respectively.

The maximum penalty under the CVPA is a **fine of up to \$20,000 or imprisonment for up to 3 months, or both**, for a first offence. For a first offence under the Environmental Public Health (Public Cleansing) Regulations, premises owners can be fined up to a maximum of \$1,000 and to a further fine not exceeding \$100 for every day or part thereof during which the offence continues after conviction.

References

Baker, N. and Lim, K.K.P., (2008). Wild animals of Singapore.

Modlinska, K., & Stryjek, R. (2016). Food Neophobia in Wild Rats (*Rattus norvegicus*) Inhabiting a Changeable Environment—A Field Study. *PloS One*, 11(6), e0156741. <https://doi.org/10.1371/journal.pone.0156741>

Akiti, K., Tsutsui-Kimura, I., Xie, Y., Mathis, A., Markowitz, J. E., Anyoha, R., Datta, S. R., Mathis, M. W., Uchida, N., & Watabe-Uchida, M. (2022). Striatal dopamine explains novelty-induced behavioral dynamics and individual variability in threat prediction. *Neuron*, 110(22), 3789-3804.e9. <https://doi.org/10.1016/j.neuron.2022.08.022>

Pimentel, D., Lach, L., Zuniga, R., & Morrison, D. (2000). Environmental and economic costs of nonindigenous species in the United States. *OUP Academic*. [https://doi.org/10.1641/0006-3568\(2000\)050](https://doi.org/10.1641/0006-3568(2000)050)

Centre for Economics and Business Research Ltd. (2015). The business and economic impacts of pest infestation. In *Rentokil.co.uk*. Retrieved May 28, 2024, from <https://www.rentokil.co.uk/assets/content/files/rentokil-business-impact-report-2015.pdf>

Diagne, C., Ballesteros-Mejia, L., Cuthbert, R. N., Bodey, T. W., Fantle-Lepczyk, J., Angulo, E., Bang, A., Dobigny, G., & Courchamp, F. (2023). Economic costs of invasive rodents worldwide: the tip of the iceberg. *PeerJ*, 11, e14935. <https://doi.org/10.7717/peerj.14935>

Salam, E. (2024, February 29). Family Dollar ordered to pay over \$40m for rodent-infested Arkansas warehouse. *The Guardian*. <https://www.theguardian.com/business/2024/feb/28/family-dollar-rodent-warehouse-fine>

Hutchison, M., Mitchell, M., Sullivan, J., Kramer, M., & McCaughan, H. (n.d.). Proposed regional pest management plan 2018 - 2038: Cost-benefit analysis and cost allocation report. In *Hawke's Bay Regional Council*. Lincoln University. Retrieved May 28, 2024, from <https://www.hbrc.govt.nz/assets/Document-Library/Plans/Regional-Pest-Management-Strategy/Proposed-Hawkes-Bay-Regional-Pest-Management-Plan-2018-2038-Cost-Benefit-Analysis-and-Cost-Allocation-Report.pdf>

Boey, K., Shiokawa, K. & Rajeev, (2019), S. *Leptospira* infection in rats: A literature review of global prevalence and distribution. Vol. 13, PLoS Neglected Tropical Diseases. Public Library of Science.

Francis, C., 2019. Field guide to the mammals of South-east Asia. Bloomsbury Publishing.

Griffiths J, Yeo HL, Yap G, Mailepessov D, Johansson P, Low HT, Siew CC, Lam P, Ng LC. (2022). Survey of rodent-borne pathogens in Singapore reveals the circulation of *Leptospira* spp., Seoul hantavirus, and *Rickettsia typhi*.

Suzuki, H. et al, (2013). Evolutionary and dispersal history of Eurasian house mice *Mus musculus* clarified by more extensive geographic sampling of mitochondrial DNA.

Centers for Disease Control and Prevention (CDC)

Acknowledgements

Environmental Health Institute (EHI)

Singapore Pest Management Association (SPMA)

All parties who have contributed content and photographs for this document.

Disclaimer

This guide contains information that may be useful and adopted by premises managers and owners to improve their rat management measures. This Guide may be updated from time to time. Please refer to NEA's website for the latest version of the Guide.

7. ANNEX

7.1 GUIDELINES FOR THE USE OF GLUE TRAPS

The National Parks Board (NParks), together with the National Environment Agency (NEA) and the Singapore Pest Management Association (SPMA), have revised the guidelines for the use of glue traps (previously issued in May 2012) to better ensure that non-target animals are not trapped, and that appropriate measures are taken to respond to trapped animals.

The revised guidelines for the use of glue traps are as follows:

1. Glue traps are to be used responsibly. Users should take the considerations listed in para two into account when using the traps.
2. Pest control operators should implement the following:
 - (a) Glue traps should not be used in open areas or semi-open areas where there is concern that a non-target animal might be trapped. If a glue trap is used in an open area or semi-open area, there must be strong reasons to do so, such as the need to bring down the rat population quickly due to rat infestation, and an appropriate cover must be used over the glue trap to prevent a non-target animal from being trapped. Site assessment must be conducted and documented clearly to justify the need for deployment of glue traps.
 - (b) The glue trap should not be larger than 35cm by 25cm in size and should not be deployed adjacent to each other in open/semi-open areas or where there is a concern that non-target animal might be trapped.
 - (c) The glue should be laid on a stiff backing to prevent the animal from being encased in the trap.
 - (d) Once a glue trap is set, the pest control operator is to give specific written instruction to the client to notify them if an animal is caught and advise the client to check the trap daily. Upon notification, the pest control operator must collect or rescue any animal caught on the trap, for both targeted and non-targeted, within **3 hours**.
 - (e) Trapped target animals must be killed humanely and disposed of properly by double bagging and sealing securely before disposal. An animal can be deemed to have been killed humanely if the method used is quick, efficient, and as painless as possible.
 - (f) Any non-target animal caught on the trap, such as cats, birds, and snakes, must be released from the trap unharmed and have the glue removed from its body. For assistance on domestic animals, operators may send the animal to a private veterinarian for necessary attention or call NParks' Animal Response Centre helpline at 1800-476-1600. For wildlife, such snakes, and birds, please hand them over to NParks' Animal and Plant Health Centre at 6 Perahu Road, Singapore 718827 in accordance with the handover SOP.
 - (g) All glue traps deployed must be retrieved and disposed of properly after all pest control work has been completed.
3. Please ensure that the above guidelines are closely observed. Failure to do so may result in enforcement actions against the company or staff for animal cruelty. Please call NParks'

Animal Response Centre at 1800-476-1600 if you need clarification. Alternatively, you may contact NEA at 6225-5632 or SPMA at 6565-8197.

However, given the diverse terrain and ground conditions, if there is a need to deviate from the guidelines, additional care should be taken to ensure that non-targeted species will not be trapped. In such cases, all glue traps should be monitored during trapping and collected by the end of the operation. These guidelines are essential for ensuring the responsible and humane use of glue traps in pest control operations.

7.2 CHECKLIST FOR PREMISES OWNERS AND MANAGERS (PREVENTION)

S/N	Item	Yes
Proper Housekeeping		
1	Conduct regular maintenance and inspection to ensure that storage areas, facilities, equipment and materials remain in good condition	☐
2	Keep common areas and walkways free of clutter at all times (e.g. cardboard boxes, wood piles, furniture, old appliances, etc.)	☐
3	Store food in airtight containers and above ground	☐
4	Regularly clean and remove unwanted items, especially food and spillages, within surfaces and floor of the storage areas	☐
Proper Refuse Management		
5	Provide sufficient bins, disposal points and facilities (e.g. bin chutes, bin centres, Central Refuse Chutes (CRCs)) to manage and prevent overflowing of refuse	☐
6	Remind stakeholders to properly bag and tie, and place refuse within the designated refuse facilities and bins, and ensure that all bins have lids to prevent rats from accessing refuse	☐
7	Increase frequency of refuse collection if required to prevent overflowing bins and refuse facilities, especially right after peak mealtime	☐
8	Clear up spillages around bins and refuse facilities regularly	☐
Removing access or entry points		
9	Ensure lids, covers, shutters and doors can fully close without leaving any gaps	☐
10	Seal up any remaining holes or gap inside bulk bins, entrances or walls with durable materials, such as steel wool, copper gauze or screen wire	☐
11	Repair or replace any infrastructural defects such as broken doors, floor traps, gully traps and grating covers	☐
12	Use stainless steel materials (where possible) to protect infrastructure or building materials from gnawing by rats, such as floor trap grating covers, door kick plates (at least 300mm in height)	☐

7.3 CHECKLIST FOR PREMISES OWNERS AND MANAGERS (CONTROL)

S/N	Item	Yes
Before treatment		
1	Engage VCO to develop and implement a comprehensive plan to manage rat infestation based on the assessment	☐
2	Carry out thorough checks to assess the risk and extent of the rat infestation within the premises.	☐
3	Ensure that all Vector Control Technician and Workers (VCTs and VCWs) appointed by your VCO are licensed by NEA	☐
4	Inform stakeholders such as tenants and patrons on any treatment plan, if necessary	☐
During treatment		
5	Ensure that VCO, VCTs and VCWs adhere to the treatment plan and relevant code of practices	☐
6	Ensure that only NEA-registered rodenticide(s) are used	☐
7	Do not place rodenticides in open and exposed surfaces to minimise accidents involving non-target animals/people	☐
8	Do not place rodenticides in drain and sanitary lines	☐
9	Use tamper-resistant/proof bait stations to house and secure the rodenticide, where necessary e.g. especially areas with active pets or near food premises	☐
10	Ensure that dead rat carcasses are removed as soon as possible	☐
11	Monitor and review detailed reports submitted by the VCO	☐
After treatment		
13	Ensure that remaining baits and traps are accounted for and removed after the treatment period	☐
14	Evaluate the effectiveness of the treatment plan in reducing or removing the rat infestation	☐
15	Follow up with stakeholders such as tenants and contractors to rectify any defects and/or address issues contributing to the rat infestation	☐
16	Put in place routine inspections or surveillance equipment to monitor for rat activities	☐

About the National Environment Agency

The National Environment Agency (NEA) is the leading public organisation responsible for ensuring a clean and sustainable environment for Singapore. Its key roles are to improve and sustain a clean environment, promote sustainability and resource efficiency, maintain high public health standards, provide timely and reliable meteorological information, and encourage a vibrant hawker culture. NEA works closely with its partners and the community to develop and spearhead environmental and public health initiatives and programmes. It is committed to motivating every individual to care for the environment as a way of life, in order to build a liveable and sustainable Singapore for present and future generations.

For more information, visit www.nea.gov.sg

Connect with us on [Facebook](#) | [Instagram](#) | [Telegram](#) | [Twitter](#) | [Youtube](#) | [LinkedIn](#) | [TikTok](#)