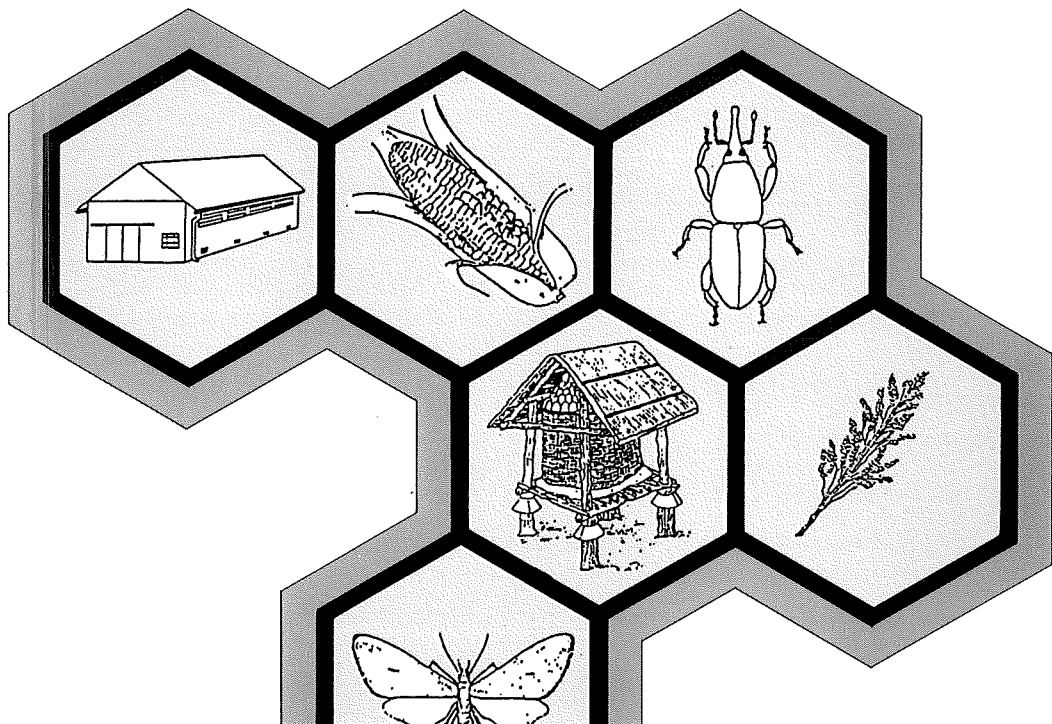




MANUAL ON THE PREVENTION OF POST-HARVEST GRAIN LOSSES

J. GWINNER R. HARNISCH O. MÜCK



10.5 Literature

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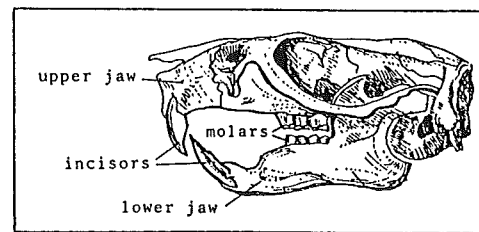
11 Rodent Pests

Rodents belong to the most important pests of stored produce. In a number of countries they cause as much if not more damage than insect pests.

Rodents have an exceptional ability to adapt themselves to different environmental conditions and an incredible potential for reproduction. One pair of rats can theoretically have 350 million offspring within the space of three years. Estimates state that over 3.5 million rats are being born daily.

11.1 Characteristic Features of Rodents

Rodents are characterised by their teeth. They have a pair of incisor teeth in the upper and lower jaws, separated from the molars by a large gap (diastema).



The incisors are curved inwards and have an extremely hard anterior coating. The softer inside layer is worn down much more rapidly than the hard, outer layer. This means that the teeth are continually kept sharp, enabling them to damage even materials such as masonry and electric cables. The incisors do not stop growing. This means that the animals are forced to gnaw steadily in order to wear them down.

11.2 Rodents as Storage Pests

Rats and mice (Muridae) are mainly causing damage to stored produce. Additionally some squirrels (Sciuridae) can also cause losses.

The three most important rodent species are to be found all over the world:

- Black rat or house rat (Rattus rattus)
- Norway rat or common rat (Rattus norvegicus)
- House mouse (Mus musculus)

There are also a number of species which are of great importance in specific regions:

- the multi-mammate rat (Mastomys natalensis) in Africa and the Middle East;
- the bandicoot rat (Bandicota bengalensis) in Southern and South East Asia;
- the Pacific rat (Rattus exulans) in South East Asia, also occurring in Southern Asia.

11.3 Damage and Losses

Rats and mice cause losses in a number of ways:

- By feeding on stored produce
Rats eat an amount of food equivalent to 7 % of their body weight daily, i.e. a rat with a body weight of 250 g will eat around 25 g daily, amounting to 6.5 kg of grain a year.

Mice eat a daily amount equivalent to around 15 % of their body weight, e.g. a mouse weighing 25 g will eat between 3 and 4 g a day, amounting to around 1.4 kg of grain a year.

It should, however, be borne in mind that the actual losses are much higher than the amount of produce eaten by the animals, as they contaminate the stored produce with urine, faeces, hair and pathogenic agents.

There are around 50 illnesses which can be transferred to man by rodents, including typhoid, paratyphoid, trichinosis, scabies and plague. The problems and costs resulting from these illnesses are not normally taken into account when assessing infestation by rodents.

As it is difficult or even impossible to remove this soilage from the stored produce, infested batches often have to be declared unfit for human consumption or written off as total losses.

As rodents prefer food rich in proteins and vitamins, they cause particular damage to the nutritional value and germination ability of seeds.

- Damage to material and equipment (e.g. tarpaulins, bags, pallets, sprayers) and to the store itself (cables, doors).

These often lead to subsequent damage:

- Produce leaking out of damaged bags or storage containers.
- Bags stacks collapsing due to damage to the lower layers.

- Short circuits leading to sparks or fire from cables being chewed.
- Storage silos and store buildings may subside or even collapse as a result of being undermined.
- Drainage canals around a store may be damaged.

11.4 Biology of Rodents

11.4.1 Distinguishing Features

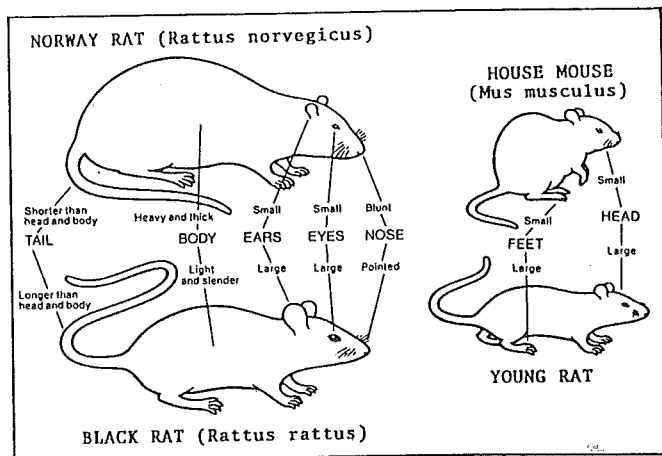
Correct identification of rodents in the store is of great importance for the success of control measures as differences in the behaviour of the individual species must be taken into account when selecting the correct strategy for treatment.

Distinguishing features of species are the size and shape of the body, the colour of the fur, the length of the head and body in relation to the tail, the size of the rear feet, the relative size of ears and eyes and the shape of the snout. The size and colour of the animals can vary greatly and does not alone provide an adequate means of identification. It is of practical use to catch a number of animals, using traps, for example, in order to be able to identify them clearly. In many countries, plant protection services or institutes have departments specialized in rodents which can be consulted if necessary.

The characteristic distinguishing features of the most important species of rodents are listed in the following table and illustration.

Characteristics of rodents harmful to stored products

	Black rat <u>Rattus rattus</u>	Norway rat <u>Rattus norvegicus</u>	House mouse <u>Mus musculus</u>
Adult weight	120 - 350 g (mean 200 g)	150 - 500 g (mean 300 g)	10 - 25 g (mean 15 g)
Length (excl. tail)	150 - 220 mm	200 - 250 mm	60 - 90 mm
Tail	180 - 250 mm Longer than head and body. Relatively thin, sparsely haired	150 - 200 mm Shorter than head and body. Thick. Frequently dark on top, light underneath	80 - 100 mm Usually longer than head and body. Uniformly dark
Colour	Usually black or grey	Brown with black on top. Grey or off-white underneath	Brownish grey. Lighter shades occur
Ears	Thin, translucent and hairless	Thick, opaque, short with fine hairs	Large, some hairs
Eyes	Relatively large	Relatively small	Relatively small
Snout	Pointed	Blunt	Pointed
Fur	Smooth, soft	Harsh and shaggy	



11.4.2 Reproduction

Rodents have an important reproduction ability. They reach full sexual maturity very soon after birth, have a number of litters a year and a large number of offspring per litter.

	<u>Rattus rattus</u>	<u>Rattus norvegicus</u>	<u>Mus musculus</u>
Number of litters/year	6 - 8	3 - 7	7
Number of offspring/litter	4 - 12	6 - 10	4 - 8
Gestation Period (days)	21 - 23	20 - 24	20 - 22

	<u>Mastomys natalensis</u>	<u>Bandicota bengalensis</u>	<u>Rattus exulans</u>
Number of litters/year	up to 12	up to 11	2 - 6
Number of offspring/litter	9 - 13	6 - 8	2 - 5
Gestation Period (days)	23	22 - 26	20 - 21

Mastomys natalensis has by far the highest reproduction rate of the six species listed here.

11.4.3 Senses

Rats and mice are animals which are most active at night or at dusk. Their vision is thus quite poor. They are very sensitive to light, but they cannot see clearly and are colour-blind.

Their poor vision is compensated for by their excellent senses of hearing, feeling, smell and taste.

Rodents are able to sense ultrasound. Their sense of smell enables them to find food, identify other beings and recognize runs and territorial limits.

Their excellent sense of taste makes them fastidious. This is an important fact to be borne in mind when selecting bait.

Their whiskers serve as feelers.

11.4.4 Behaviour

Rats are exceptionally cautious and intelligent creatures. Changes in their environment, such as newly laid bait, are initially regarded with suspicion and only accepted hesitatingly after several days of becoming accustomed to their presence. This is known as their "new object reaction". It has important consequences for control measures.

11.4.4.1 The Black Rat (*Rattus rattus*)

The black rat lives in loose colonies and usually in the roof area of stores, where it generally builds its nest. Therefore it is often called "Roof rat". It is an excellent climber, can jump heights of up to 1 m and squeeze through an opening of only 12 mm in diameter.

Black rats rarely use established runs as Norway rats do.

11.4.4.2 The Norway Rat (*Rattus norvegicus*)

The Norway rat lives in colonies or groups outdoors, only entering stores for food. It lives in burrows which it digs near stores or beneath foundations.

They are good runners and swimmers, but cannot climb as well as black rats. They can jump about 60 cm and squeeze through openings only 12 mm wide. They tend to use established runs and normally return to a food source once they have accepted it.

11.4.4.3 The House Mouse (*Mus musculus*)

The house mouse lives in fixed families, primarily in buildings or stores, and its preferred source of food is grain. It can survive for long periods without water, being able to make use of the grain moisture and water produced by its own metabolism.

Its radius of activity is very small, not exceeding a space of 10 x 10 m. It is capable of spending its entire life within the confines of a single pile of stacks. This makes its detection particularly difficult.

House mice are good runners and climbers, and can jump heights of up to 30 cm. Their small size enables them to squeeze through openings only 6 mm wide.

House mice are very curious animals; the paths they follow are irregular, nibbling here and there, and they do not regularly return to specific food sources.

11.4.4.4 The Multi-Mammate Rat (*Mastomys natalensis*)

These animals live in colonies in burrows outdoors, but enter stores to obtain food. They live largely from plant substances, but do also eat insects and meat. They are excellent climbers, jumpers and swimmers.

Due to the small size of these animals, they are referred to in many countries as mice.

11.4.4.5 The Bandicot Rat (*Bandicota bengalensis*)

The Bandicot rats often live on their own outdoors where they dig elaborate burrows. The entrances are marked by noticeable piles of earth. The burrows comprise a number of chambers, where the rats store up to 10 kg of grain. They use established runs, which may well be sprinkled with odd grains they have dropped in transporting food.

They are excellent swimmers.

11.4.4.6 The Pacific Rat (*Rattus exulans*)

These animals live outdoors, building their nests above ground in branches, bushes or niches in rocks. They feed largely on plant substances. They are very active and are good runners, jumpers and climbers.

11.5 Signs of Rodent Infestation

When signs of rodent infestation are seen, it is absolutely necessary to conduct a thorough investigation of the store, its immediate surrounding area and possibly even neighbouring land.

In order to be able to perform measures to effectively control rodents, it is necessary to know what rodent species you are dealing with, where the nests are, how they enter the store and which runs they take.

There are a large number of clear signs of rodent infestation:

- Live animals

Rodents are mainly active at night. If animals are nonetheless seen during the daytime, this is a sign of an already advanced stage of infestation.

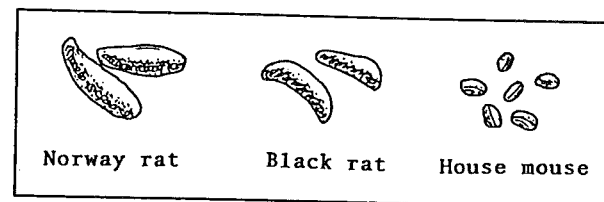
- Droppings

The shape, size and appearance of droppings can provide information as to the species of rodent and the degree of infestation.

The droppings of Norway rats are around 20 mm in length and are found along their runs.

The droppings of black rats are around 15 mm long and are shaped like a banana.

Mouse droppings are between 3 and 8 mm in length and irregular in shape.



Droppings are soft and shiny when fresh, becoming crumbly and matt black or grey in colour after 2 - 3 days.

- Runs and tracks

Runs, such as those of Norway rats, are to be found along the foot of walls, fences or across rubble. They virtually never cross open areas of land, but always pass through overgrown territory, often being concealed by long grass.

Runs inside buildings can be recognized by the fact that they are free of dust. The animal's fur coming into contact with the wall leaves dark, greasy stains. Even black rats, which do not have any fixed runs, can leave similar greasy stains at points which they pass regularly, e.g. when climbing over roof beams.

- Footprints and tail marks

Rats and mice leave footprints and tail marks in the dust. If you suspect there might be rodent infestation, scatter some sort of powder (talcum powder, flour) on the floor at several places in the store and later check for traces. The size of the back feet serves as an indication of the species of rodent:

- Back feet larger than 30 mm: black rat, Norway rat, bandicoot rat.

- Back feet smaller than 30 mm: house mouse, multi-mammate rat, Pacific rat.

- Tell-tale damage

Rats leave relatively large fragments of grain they have nibbled at (gnaw marks). They generally only eat the embryo of maize.

Sharp and small left-overs are typical for mice.

Rodent attack can further be detected by damaged sacks where grain is spilled and scattered. Small heaps of grain beneath bag stacks are a clear sign. These should be checked for using a torch on regular controls.

Attention should be paid to damaged doors, cables and other material.

- Burrows and nests

Depending on their habits, rodents either build nests inside the store in corners as well as in the roof area or in burrows outside the store. Rat holes have a diameter of between 6 and 8 cm, whereas mice holes are around 2 cm in diameter. These holes can be found particularly in overgrown areas or close to the foundations of a store.

- Urine

Urine traces are fluorescent in ultraviolet light. Where available, ultraviolet lamps can be used to look for traces of urine.

11.6 Preventive Measures

The most essential factors for the occurrence of rodents are:

- sufficient supplies of food
- protected places in which to build burrows and nests
- hiding places
- access to produce

Good store management and preventive measures taken as part of an integrated control programme can help to deal with these factors.

The information given in Chapters 5.2.3.2 (Activities to Prevent Losses in Storage), 5.2.4 (Storage Techniques) and 5.1.1 (Constructional Features of Stores) applies here.

11.6.1 Storage Hygiene and Technical Measures

- Keep the store absolutely clean! Remove any spilt grain immediately as it attracts rodents!
- Store bags in tidy stacks set up on pallets, ensuring that there is a space of 1 m all round the stack!
- Store any empty or old bags and fumigation sheets on pallets, and if possible in separate stores!
- Keep the store free of rubbish in order not to provide the animals with any places to hide or nest! Burn or bury it!
- Keep the area surrounding the store free of weeds so as not to give the animals any cover! They have an aversion to crossing open spaces.
- Keep the area in the vicinity of the store free of any stagnant water and ensure that rainwater is drained away, as it can be used as source of drinking water.

11.6.2 Keeping Rodents Out

The requirements of preventive rat control must be taken into account whenever new stores are being built. Particular attention should be paid to doors, ventilation openings, brickwork and the junctions between the roof and the walls.

Repair any damage to the store immediately! This applies especially to the doors.

11.7 Control Measures

Despite taking all possible preventive measures, it will not always be possible to avoid infestation with rodents. Control measures are a basic requirement in keeping damage down to a minimum. The sooner control of rodent pests is undertaken, the better are the chances of success. Before any control measures are taken it is necessary to make a situation analysis.

11.7.1 Situation Analysis

In order to achieve the greatest possible success with measures to combat rodents, the following questions must be answered:

- What species of rodent are causing damage to the produce?
- What is the approximate degree of infestation (loss estimation)?

- What is the extent of the infestation?
If necessary, work must be performed in conjunction with neighbours.

- Where exactly are the rodents particularly active?

- Where are the runs, burrows and nests?

- In what condition are the store and the surroundings?

Correct planning of control measures can only be performed once these questions have been answered.

Depending on the degree of infestation, the following control measures can be used:

- Low degree of infestation:

- Traps

- Cats

- Use of chronic poisons

- High degree of infestation:

- Use of acute poisons

11.7.2 Application of Non-Chemical Control Measures

11.7.2.1 Traps

The use of traps is only worthwhile if the degree of infestation is low.

There are different kinds of traps. Distinctions are made between killing traps and arresting traps.

When using traps, attention should be paid to the following:

- Place the traps along walls, on runs or in other places frequented by the rodents!

- Control the traps daily! Remove any dead animals and clean the trap!

11.7.2.2 Cats

Cats can make a contribution towards rodent control. It should be mentioned, however, that cats themselves may become a hygiene problem in stores if care is not taken (e.g. providing sand-boxes as cat cloak-room).

11.7.3 Use of Chemical Means of Rodent Control

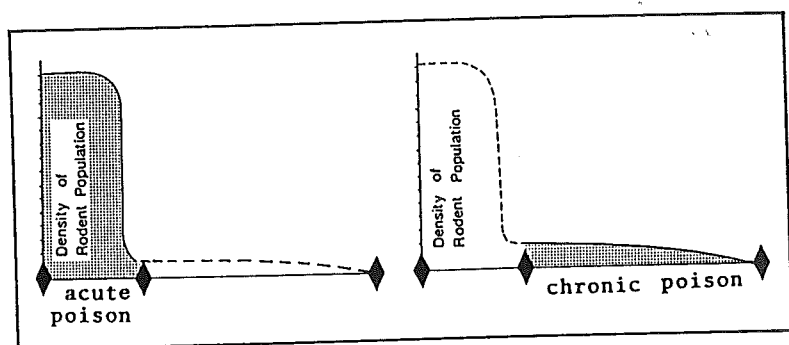
The use of rodenticides is only effective under good storage conditions and in particular good storage hygiene. Before the application of rodenticides, all preventive measures must be taken to ensure that no reinfestation takes place.

There are two groups of rodenticides:

- Acute poisons
- Chronic poisons

Acute poisons are used only in the case of high rodent population with the aim of reducing the degree of infestation to a low level within a short period.

Subsequently, chronic poisons or other methods must be used for further control.



11.7.3.1 Acute Poisons

- Properties

Acute poisons have a rapid effect due to their high toxicity, meaning that poisoned rodents die immediately. In control campaigns using these poisons the bodies of dead rodents can be found in and around the store. These must be collected and burned.

Acute poisons do not, however, work selectively. This involves a risk for other living beings. Therefore great care must be taken in applying acute poisons.

They must not be used in the same place again until at least six months have passed, as it will take this long for the rodents' bait aversion to be overcome (see section 11.7.3.6).

- Products

Zinc phosphide is the most common acute poison in use all over the world. It is comparatively cheap and has a good and fast effect if applied correctly. Zinc phosphide is mixed in bait in a concentration of 2.5 %.

There are a series of other acute poisons, all of which, however, have disadvantages compared to zinc phosphide and which are prohibited in many countries due to their side effects.

- Application of acute poisons

When applying zinc phosphide, follow all safety measures (see Section 11.8) and proceed as follows:

- Draw up a sketch of the area and of the store and mark the settings of the bait!
- Make sure you have an adequate amount of receptacles (bait boxes)!
- Make sufficient amounts of untainted bait for prebating (see sections 11.7.3.4 and 11.7.3.6)!

- Fill the receptacles or bait boxes with untainted bait and set them out at the planned points! Offer it until it is fully accepted.
- Control the bait daily and refill if necessary!
- If the bait has not been accepted after a number of days, change the food base or the bait positions!
- Replace all untainted baits with poisoned ones at the same time!

Mix zinc phosphide with freshly broken grain or meal at a ratio of 1:39, i.e. each kg of poisoned bait will consist of:

975 g best quality grain + 25 g zinc phosphide

Before mixing, add approximately 1 % edible oil in order to prevent dust developing! (Never mix water with zinc phosphide!). Mix the bait by shovelling from one side to the other!

- Attach warning signs to the doors of the store and at the entrance to the property drawing attention to the control campaign in progress, the poison used and the dangers involved, and lock the stores!
- Control the baits daily!
- Note on the control sheet how much bait has been eaten (see example in section 11.7.3.7)!
- Refill any bait which has been eaten!

- Stop the campaign after 5 days at the latest, as bait aversion will occur!
- Collect all receptacles (bait boxes)!
- Thoroughly clean all materials which have come into contact with the bait and store them in a safe place!
- Burn or bury any dead bodies of rodents found!

- Further measures

Continue the control campaign using chronic poisons or by putting out traps!

11.7.3.2 Chronic Poisons

- Properties

Chronic rodenticides have a delayed action. The rodents will die without feeling pain. They will thus not become suspicious of the poisoned bait and no bait aversion will ensue. Prebaiting is therefore not necessary.

Poisoned animals normally die in their nests or hiding places. The bodies of dead rodents are therefore not usually found during the course of treatment.

- Products

- Anticoagulants

Anticoagulants prevent any clotting of the blood. Animals that have been poisoned will die from internal

bleeding. There are two different groups of these poisons:

"First generation" anticoagulants

These are rodenticides which only lead to death after repeated ingestion (up to 7 times). They are referred to as "first generation" anticoagulants because they were the first to come on the market.

They include the following products:

Active ingredient	Most common brand names
Warfarin	Warfarin
Difacinon	Ramik, Difacin
Chlorfacinon	Caid, Raviac, Quick
Coumatetralyl	Racumin
Coumachlor	Tomarin
Coumafuryl	Fumarin
Pindane	Pival

"Second generation" anticoagulants

These are rodenticides which kill the animals after a single ingestion. These products are thus also categorized as "acute poisons with delayed effect".

They include the following products:

Active ingredient	Most common brand names
Brodifacoum	Talon, Klerat, Ratak Super
Difenacoum	Ratak
Bromadiolon	Rodine, Mak
Flocoumafen	Storm

Bromadiolon is particularly used against mice.

An antidote in the case of poisoning with anticoagulants is Vitamin K₁, contained in plants. As rodent pests often eat weeds, the effect of the poisons may be neutralized. This encourages the development of resistance.

Resistance is already present in a number of countries to Warfarin and other rodenticides. As all anticoagulants work in essentially the same fashion, cross-resistances have developed even between the first and second generation anticoagulants.

- Rodenticides with hypercalcaemic effect

Calciferol (= Vitamin D₂) works by triggering off a rapid calcification of the animals leading to quick death. One or two ingestions of the poison suffice for a lethal dose. Calciferol is very effective against mice and less so against rats. It can also be used in combination with other active ingredients, such as Warfarin.

There are rodenticides which have different mode of action. These include Bromethalin which incapacitates the animals' energy metabolism.

- Application of chronic poisons

When applying chronic poisons attention has to be paid to the safety measures in section 11.8.
Proceed as follows:

- Draw up a sketch of the store and its surrounding area and mark the settings of the bait!
- Make sure you have an adequate amount of bait stations (see section 11.7.3.5)!
- Make a sufficient amount of poisoned bait if there is no ready-to-use bait available!

Example for the preparation of a bait:

- 18 parts (900 g) of broken grain (premium quality)
- 1 part (50 g) of poison
- 1 part (50 g) of salt or sugar

- Set out the bait stations at the predetermined points!
- Fill the bait stations with the required amount of bait (see section 11.7.3.5)!
- Attach warning signs to the doors of the store and at the entrance to the property drawing attention to the control campaign in progress, the poison used and the dangers involved!

- Control the bait stations every 2 - 3 days!
- Note on the control sheet how much bait has been eaten at each bait station at every inspection!
- Refill any bait which has been eaten!
- If the bait is not accepted change the food base or the bait positions!
- Stop the campaign if it is seen on 2 - 3 inspections in succession that the bait is no longer eaten!
- Collect all bait stations or prefabricated baits which have been set out!
- Thoroughly clean all materials which have come into contact with the bait and store them in a safe place!

Further measures

- Make daily inspections in and around the store in order to detect signs of new rodent infestation at time!
- Do continuous control with traps!
- Start the next control campaign immediately at the first sign of new rodent infestation using chronic poisons!

11.7.3.3 Formulations

There are various formulations of both acute and chronic poisons:

- Dust formulations

They are mixed according to the recommended application rate with a suitable feed such as cereal, to form a bait.

- Ready-to-use baits

Ready-to-use or prefabricated baits are available in various forms and compositions. They are used especially in the application of chronic poisons. The most common are:

- Grain poison: mixtures of grain or grain meal with poison.

- Wax blocks: pressed bait on a wax base with nutrients and poison.

- Tracking powder

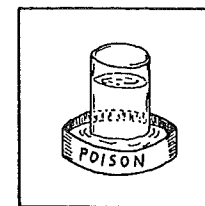
This formulation is scattered on runs, in rat or mouse holes or other places frequented by rodents. When the animals run through the powder, some of it will stick to their feet and fur. Rodents clean themselves several times a day by licking their fur whereby the poison is taken in.

Tracking powders can be used in combination with poisoned bait.

- Water-soluble powder

This poison is dissolved in water in the ratio of 1 part poison to 39 parts of water and offered to the animals

as watering place. It is only recommended for use in arid regions where rodents are dependent on any sources of water they can find.



11.7.3.4 Bait

There is naturally no lack of food for rodent pests in a grain store. Bait has to compete with the other food sources. Attention should therefore be paid to the following remarks:

- Only use premium quality grain for making bait! Poor quality bait, as processing left-overs or sweepings will not be accepted by the rodents and will make the success of treatment dubious.

- Take only feed to which the rodents are used (no maize in a rice growing area!)

- Bait made of freshly broken grain or meal is better than bait made with whole grains.

- Moist bait is preferred to dry. Bait must, however, never have a musty smell or be mouldy.

- Adding sugar or salt makes the bait considerably more attractive.
- Experiment with various kinds of grain in order to make the best possible bait! A number of types of grain have proved very successful, and so have mixtures. Rodents also accept fruit, tuberous and root plants. These, however, have the drawback of going mouldy more rapidly.
- Mice prefer small-sized seeds, such as millet.
- Do not make any more bait than can be used before it goes mouldy!
- Keep any bait made for stock locked away!

11.7.3.5 Setting Out Bait

When working with rodenticides, danger to people, pets and other non-target animals cannot be excluded. The following basic rule must always be observed:

Never set out bait in the open!

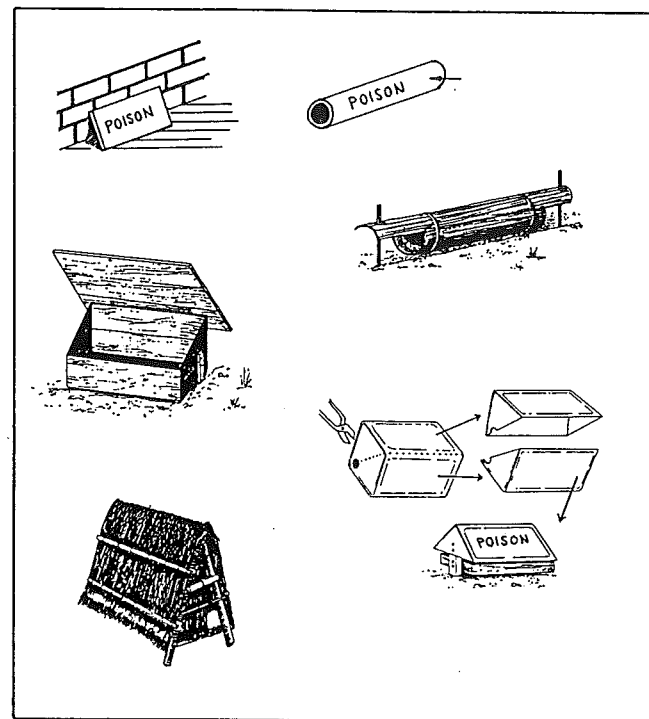
That means that bait must always be protected under some cover. This is in line with the rodents' preference for concealed places. Planks of wood, crates or bamboo tubes can be used. More suitable, however, are specially made bait boxes.

Bait boxes can be made from a variety of materials available locally. They should have an entrance and an exit on the opposite site as rodents do not like to enter

dark spots. The openings should be approximately 6 - 8 cm in diameter for rats; 2 - 3 cm suffice for mice.

Care should be taken that the bait does neither absorb any moisture nor dry out. Bait boxes for placing outdoors should have legs and a waterproof roof in order to protect them from ground moisture and rain.

A number of examples of bait boxes are shown in the following illustration:



When setting out bait, attention should be paid to the following points:

- Ensure that the bait is safe from children and pets!
 - Set out bait in places frequented by rodents, e.g. on runs!
 - Place bait boxes so that their entrance and exits are close to the wall or exactly on the run of the rodents, which will then pass straight through the bait box!
 - Note behaviour specific to different species:
 - With rodents living outside the store (e.g. norway rats, bandicoot rats) place bait close to the inside walls of the store near the door and on runs outside the store!
- One bait station every 200 m² will generally be adequate. Around 300 g of bait should be used for every place.
- With black rats, place additional bait in the area of the roof! 3 bait stations every 200 m² are recommended with an amount of 100 - 150 g bait at each point.
 - For mice, set out numerous baits around 2 m apart in the store! An amount of around 50 g for each point should suffice.
 - Leave the bait boxes in the same place for the entire duration of the control campaign! Any change in the location of feeding places would endanger the success of the campaign due to rats' new object reaction.

11.7.3.6 Prebaiting and Bait Shyness

Prebaiting is essential when using acute poison! Due to the rodents' new object reaction they do not accept bait immediately. First one animal of the community will taste the bait only eating a little. When this bait is already poisoned the ingestion will not be sufficient to kill this animal but to make it ill. Poisoning with acute poisons causes pain. The animals are well able to recognize the bait as having been the cause of their pain and will avoid it in future. They will also pass on this information to the community, so that poisoned bait will no longer be accepted by any rodents and the control campaign will be a failure and have to be stopped. Once rats connect their sickness with the poisoned bait they will develop bait shyness or bait aversion.

Therefore prebaiting is practised which means offering the unpoisoned (untainted) bait until it is fully accepted usually after a few days. This is the moment when the poison should be added to the bait.

11.7.3.7 Keeping Records

A record must be kept of every control activity in the store journal. The details should be listed on a separate control sheet.

Enter the date when baits are set out. The amount of the bait which has been eaten should be estimated during inspections. On the basis of these entries decisions on the following points can be made:

- must a control campaign be continued?
- should control methods be changed?
- is the bait accepted?
- must any bait location be changed?

An example of a control sheet is shown below:

Control Sheet for Rodent Control

Place:

Store No./area:

Bait Location

No./Ref.

Date of Control

Entries on the amount of bait eaten:

Nothing eaten: -

Much eaten: xx

Little eaten: x

All eaten: xxx

Person in charge of treatment:

Name:

Date:

Signature:

11.8 Safety Measures

All safety measures for insecticides (see Sections 8.4.1 and 8.4.2) also apply for rodenticides. Special attention should also be paid to the following:

- Ensure that children and pets cannot come into contact with any bait that has been set out!
- Warn all people working on and living around the treated area!
- Attach warning signs to the doors of the stores and at the entrance to the property in order to draw attention to the rodent control campaigns!
- Always wear rubber gloves when working with rodenticides!
- Clearly mark bait boxes and stations with the words:

"Danger" "Poison"

- Inform a doctor about the active ingredients used and provide him with a label or information sheet from the product to enable assistance in the case of poisoning!
- The following applies when using zinc phosphide:
 - Always wear a breathing mask with a P₃ particle filter!
 - Ensure that zinc phosphide does not come into contact with any moisture, as a poisonous gas (phosphine) will be produced!

11.9 First Aid Measures in Case of Poisoning

The first-aid measures listed for insecticides (see Section 8.4.3) also apply for rodenticides.

Attention should be paid to the following:

- Chronic rodenticides:

This group of poisons is regarded as having a relatively low toxicity. No symptoms or damage will normally result from a single ingestion. Nevertheless, always consult a doctor on suspicion of poisoning.

Anaemia and shock may occur with repeated ingestion of chronic poison within short time.

Vitamin K₁ (5 - 10 mg) can be administered as an antidote.

A blood transfusion is necessary in serious cases of poisoning.

- Zinc phosphide

Anyone suffering from zinc phosphide poisoning must be taken to the nearest hospital immediately!

Symptoms of poisoning are catarrh of the throat, bronchitis and possibly pneumoedema, and with serious poisoning sickness, vomiting (smell of carbide), diarrhoea, disturbance of consciousness and cramps.

The person affected should be made to vomit immediately by sticking your fingers deep into his mouth. Potassium

permanganate solution (0.1 %) as well as activated carbon should then be administered.

11.10 Equipment

The following equipment is required for dealing with rodents:

- Receptacles (bait boxes), e.g. sardine tins, with warning signs
- Bait stations with warning signs and material and tools to prepare bait stations
- Quality grain, sugar or salt and edible oil for preparing bait
- Broom
- Shovel
- Rubbish bin
- Rubber gloves
- Breathing mask with P₃ particle filter (for zinc phosphide)
- Warning signs
- Rodent traps
- Troughs in case of the application of water-soluble preparations
- Rodenticides

11.11 Further Literature

Anonymous. 1983. Food Storage Manual, FAO, Rome, 263 pp.

Anonymous. 1980. Post-Harvest Problems, GTZ, Eschborn, 258 pp. + 33 pp. appendix

Anonymous, 1981. Problèmes de post-récolte, GTZ, Eschborn, 242 pp. + 31 pp. appendix

Posamentier, H. & A. van Elsen (ed.) 1984. Rodent Pests and their Biology and control in Bangladesh, Dhaka, 111 pp.

Weis, N. (ed.) Rodent Pests and their Control, GTZ, Eschborn

ANNEX 1

TABLE FOR THE CALCULATION OF THE AMOUNT OF DUST NEEDED TO TREAT 100 KG OF GRAIN

Concentration of the active ingredient in the dust	Recommended application rate of active ingredient ppm													
	0,1	0,2	0,3	0,4	0,5	1	2	3	4	5	6	8	10	12
	Required amount of dust (in g) for 100 kg stored product													
0,05 %	20	40	60	80	100	200	400	600	800	1000	1200	1600	2000	2400
0,1 %	10	20	30	40	50	100	200	300	400	500	600	800	1000	1200
0,2 %	5	10	15	20	25	50	100	150	200	250	300	400	500	600
0,3 %	3,3	7	10	13	17	33	67	100	133	167	200	267	333	400
0,4 %	2,5	5	7,5	10	12,5	25	50	75	100	125	150	200	250	300
0,5 %	2	4	6	8	10	20	40	60	80	100	120	160	200	240
1 %	1	2	3	4	5	10	20	30	40	50	60	80	100	120
1,5 %	0,7	1,3	2	2,7	3,3	7	13	20	27	33	40	53	67	80
2 %	0,5	1	1,5	2	2,5	5	10	15	20	25	30	40	50	60
2,5 %	0,4	0,8	1,2	1,6	2	4	8	12	16	20	24	32	40	48
3 %	0,3	0,7	1	1,3	1,7	3,3	7	10	13	17	20	27	33	40
4 %	0,25	0,5	0,8	1	1,3	2,5	5	7,5	10	12,5	15	20	25	30
5 %	0,2	0,4	0,6	0,8	1	2	4	6	8	10	12	16	20	24

Example: - You have to treat 2t of grain with a dust containing 2% a.i.
 - The recommended application rate is 10ppm.
 - How much dust is required for 100kg of grain?
 - For each 100kg of grain you need 200g of dust.
 - For each 100kg of grain you need 2kg of the 2% dust with the 10ppm-column!
 - It reads: 50g dust per 100kg stored product.
 - Calculate the amount of dust required for 2t- 2000kg:

$$\frac{50g}{100kg} \times 2000kg = 1000g = 1kg$$

- 1kg of a 2%-dust is required to treat two tons of grain at the application rate of 10ppm.

CALCULATION OF THE AMOUNT OF INSECTICIDE NEEDED FOR 1 LITER OF SPRAY MIXTURE

Recommended application rate (% a.i. in the spray mixture)												
Required amount of commercial product (ml EC or g WP) for 1l of spray mixture												
0.1 %	0.2 %	0.25 %	0.3 %	0.4 %	0.5 %	0.6 %	0.8 %	1.0 %	2.0 %			
100	200	250	300	400	500	600	800	1000	2000			
50	100	125	150	200	250	300	400	500	1000			
40	80	100	120	160	200	240	320	400	800			
33	67	83	100	133	167	200	267	333	667			
20	40	50	60	80	100	120	160	200	400			
14	28	36	43	57	71	86	114	143	286			
10	20	25	30	40	50	60	80	100	200			
5	10	12.5	15	20	25	30	40	50	100			
4	8	10	12	16	20	24	32	40	80			
2.8	5.6	6.9	8.3	11	14	17	22	28	56			
2.5	5	6.3	7.5	10	12.5	15	20	25	50			
2	4	5	6	8	10	12	16	20	40			
1.7	3.3	4.2	5	6.7	8.3	10	13	17	33			
1.3	2.7	3.3	4	5.3	6.7	8	11	13	27			
1.3	2.5	3.1	3.8	5	6.3	7.5	10	12.5	25			
1.1	2.2	2.8	3.3	4.4	5.6	6.7	9	11	22			
1	2	2.5	3	4	5	6	8	10	20			

Example:

- To make a stock treatment you need to apply 12l of spray mixture.
- The available insecticide is an EC-formulation containing 50% a.i.
- The required EC-formulation rate is 0.3%.
- How much of the EC-formulation is needed for the treatment?
- Find the intersection of the 50%-line with the 0.3%-column!
- It reads: 10ml EC for 1l of spray mixture.
- Calculate the amount of EC needed for 12l.

$$10\text{ml} \times 12 = 120 \text{ ml}$$

- 120ml of the EC-formulation is required to be mixed with 12l of water.