Chapter 5

Animal Pests of Date Palm

5 Animal Pests of Date Palm

5.1. Rodents (Rats and Mice)

Rodents are some of the most serious pests, which have devastating effects on several agricultural crops. They are also held as the most serious pest on stored foodstuff. Their damages are not restricted to the direct damages they inflict while feeding or the havoc and destruction they leave behind in the field crops or stored stuff, but on the equally significant indirect damages, they cause to man. The most obvious indirect damages are attributable to their capacity to carry and transmit various disease-causing pathogens, whether bacteria, virus or others, as well as some parasites, to man mainly because rodents are commensally sharing human beings in their habitat.

Economic Damage on Date Palm

Rodents cause many economic damages to various agricultural crops worldwide. Commensal rodents, especially the climbing black rat, cause great losses on different agricultural crops. Rats attack wheat, corn, vegetables and fruit trees like the date palms, coconut palms and citrus trees. They also invade the warehouses to prey on the stored grains, fresh or dried dates and dried lemons. No doubt, when rodents are present in great numbers or in epidemic proportions in a certain area, they will wreak great losses to the agricultural sector there, unless extensive control programmes are implemented. The annual loss in the yield of crops may reach up to 50 % due to the epidemic attacks of rodents.

As for the date palms, rodents can climb the date palms to build their colonies. They feed on the date fruits in their different stages of ripening; Kimri, Khalal, Rutab or Tamar and nibble the spikelets, so all what is left of a fruit bunch might be the fruit stalks and spikelet bases. Sometimes, the fall of some stalks with their fruits on the ground around the palms is a sign of a rodent attack. It is observed as well that rodents have the capacity to move from one palm tree to another by jumping when the palm crowns are close enough. The rodents also feed on the barks of the citrus trees growing between the palms leading to the death of their branches.

In addition to the above mentioned direct damages caused by rodents on the different agricultural crops including date palm fruits and spikelets or stored dates, there are some other economic losses specifically attributed to rodent attacks on the date palms. These damages can be summarised as follows:

- When the rodents burrow their tunnels under the palm trees, they may feed on the roots of the offshoots leading to their weakness or complete destruction and death.

- The rodents may feed on the roots of the mother palm as well. When the feeding is from one side only, this may cause the fall of the palm tree itself with any strong gust of wind.

- The rodents decrease the market value of the stored dates whenever they attack them to feed on, making them unsuitable for human consumption or from aesthetic aspects or for hygienic reasons. Rodents contaminate the dates with their faeces, urine excretions and their hair, which may transmit many diseases to human through food poisoning or intestinal parasites.

It is important to note that, the aggregations of palm trees in the canyons between the mountains in many countries, e.g. in the Sultanate of Oman, United Arab Emirates and Yemen, provide suitable and convenient places for the rodents to colonise and reproduce in these wadis. These rodents build their holes there and become active at night, attack the date palms and return to their safe hiding places at the versants of the mountains in the morning.

From the already mentioned facts, it is clear that many rodents share man in his food and shelter. These rodents are called commensal rodents. The term "commensal" means living with or in close association to humans. Although many species of rodents occasionally may be found around humans, the term commensal rodents refer specifically to mice and rats. In Oman, the most common commensal rodent species, rats and mice, are listed in Table 5.1. Most of the commensal rodents living in Oman are from family Muridae and order Rodentia.

Table 5.1. The most important Rodents in Oman.

Common name	Scientific name
Black, Roof, Ship or Climbing Rat	*Rattus rattus* (Linnaeus)
House Mouse	*Mus musculus* (Linnaeus)
Lesser Bandicoot Rat	*Bandicota bengalensis* (Gray)
Large Bandicoot Rat	*Bandicota* (*Nesokia*) *indica*
Norway Rat	*Rattus norvegicus* (Berkenhout)
Spiny Mouse	*Acomys dimidiatus* Thomas

Signs and Proofs of the Presence of Rodents

The presence of rodents in a certain area should be confirmed first to investigate the preventive and control measures against them. There are many indications and signs, which confirm the presence of rodents in the locality. The main signs of rodent presence are:

- Positive visual identification of the rats wandering in the night particularly after sunset near their habitats. If the population is dense, rats can even be seen during the day.

- The presence of the rat holes, they live in. There are two types of rat holes; abandoned holes where rats no longer live in and the inhabited holes in which rats are still living. They can be differentiated by the presence of fresh, soft, moist and shiny faecal droppings, new dust at the entrances with the foot tracks and traces of observable food.

- The presence of signs of damages caused by the rats on the plant stems as they bite the maize kernels and feed on citrus and other fruit tree barks. They nibble the bark in a circular way eating the cambium, phloem and parts of the xylem, the conducting vessels, leading to the dryness and wilt of the leaves. In addition, rats feed on the fruit pulp and destroying the fruit or just eating a chunk and leave the rest of it to spoil.

- Inspection of the date fruit spikelets and the signs of rat feeding activity, as they bite them leaving nothing but their bases and the spikes.

- Confirm presence of rats and mice by using different kinds of traps, also to identify the species as well. There are many kinds of such traps like wire traps, snap traps, killer traps, glue traps etc.

Rats and Mice Behaviour

Rats and mice conduct a social life and work on storing food in their holes to feed on when needed. They are fast runners, able jumpers, capable of climbing and swimming, albeit in different degrees among their species. The climbing rat is very clever in climbing and moving on wires, walls, roofs and trees while the Norway rat is cleverest swimmer and diver of all, as it is called sometimes wharf rat, followed by the ordinary house mouse. In addition, all rats and mice can dig and burrow, but the Norway rat has a reputation as a digging rat and is considered the best in this usually excavating extensive burrow systems. The black or climbing rat rarely resorts to digging.

The most important behavioural trait of rats and mice is their ability to vanish by moving fast. Typically, rats begin their activity after sunset and most of them prefer to move under obstacles or alongside walls avoiding the open fields, where they can be easily spotted. The field of movement in rats differ according to their types. For example, the range of movement of the Norway rat is within an area of 15 square metres whereas the house mouse lives and moves in an area of 5 square metres. Contrary to these types, the climbing rat has a much wider field of movement and is considered a migratory species going for great lengths in search for food and shelter. Generally, rats and mice are extremely cunning, are very cautious and cannot be caught easily by mousetraps and if they see another rat caught in a trap, no rat would approach it unless it is thoroughly cleaned.

Cannibalism phenomenon has been observed among the rats and mice as they may eat their young or weak members if their numbers rise and they are aggressive and ferocious when they fight over food and shelter. The domineering males expel the weaker males from the female-inhabited holes. It is reported that some species of rats and mice are extremely hostile when their primary food is scarce, may attack farm animals and chicken barns biting their flesh, eating their young, and may steal the eggs of chicken or birds.

Reproduction

Rats and mice breed in an abnormally high rate if the conditions are suitable, which mainly are the availability of food and the lack of control measures to eradicated them from where they breed. Usually, rats litter their young after a short gestation period of 19 to 24 days, 21 days in average. Each female rat litters from 6 to 9 young according to the species. However, the littering number can be up to twenty, depending on the amount of food the female had during gestation and the favourable environmental conditions. Each female conceives and gives birth from three to eight times each year according to the species. The young rats are born hairless with closed eyes and ears, and helpless, i.e. altrical. They feed by suckling from their mother's nipples, where the number of nipples varies according to each species. The young rats keep on feeding on the mother's milk for 3-4 weeks then start eating easily digestible food after weaning. They reach reproductive maturity at three months of age, sometimes as early as two months.

Diseases Transmitted by Rodents to Humans

Since ancient times, man knew the evil role played by rodents in transmitting diseases to humans. Illustrations by ancient civilisations depict the rat as a source of sickness and death. To the contrary, cats are usually revered as food keepers because they predate on these malicious animals, rats and mice. The mechanisms involved in transmitting the diseases to humans or other animals may vary but most infections are gastrointestinal, from the mouth to the intestine. This usually occurs by consuming food or drinks contaminated by faeces or urine of rodents, which contain the disease-causing pathogens. Another mode of transmission, albeit rarely, is through inhalation. Man or animal may inhale the air carrying dust particles of the dry rodent faeces with the pathogens as in the case of Tularaemia (Rat-Bit Fever), Leptospirosis and other diseases.

It is important to notice that blood-sucking arthropoda species play a major role in transmitting many diseases

from rodents to man and animals. Such arthropods are considered as vectors of the disease and include many blood-sucking insects like fleas, ticks, lice, mosquitoes and others. These ecto-parasitic insects suck the blood from the infected rodents and then attack man or animals to feed on their blood, transmitting the pathogens while sucking. Some of the diseases transmitted this way are Tularaemia, Plague, Hemorrhagic fever, Leishmaniasis, and other diseases. In fact, the list of the diseases transmitted to man by or through rats and mice is long and exhaustive, so here reference will be made only on the most common diseases.

• Murine Typhus

This disease affects both man and rodents and is widely spread all over the world. The causal pathogen is a Rickettsia species, *Rickettsia typhi*, which lives naturally in the intestinal walls of the oriental rat flea, *Xenopsylla cheopis* (Rothschild) - (Siphonaptera: Pulicidae), and comes out with its faeces throughout its life. However, *R. typhis* does not live in the salivary glands of the flea and the disease is not transmitted to man directly when the flea bites. The truth is that the flea may have had defecated, earlier or while biting, on the skin of its victim and the bacteria enters the blood through the wound caused by biting or by scratching. The disease may be transmitted orally by consuming food contaminated by the flea faeces or rat urine, but rarely by inhaling air contaminated with flea faeces.

The Murine typhus disease outbreak epidemically in the former Soviet Union in 1939 and in the United States of America in 1940, where there are still around 5,000 cases reported annually. It is imperative that conducting successful control programmes against the natural reservoirs of *R. typhi*; the rodents (rats and mice) and the vector insects (the fleas), can greatly limit the spread of the Murine Typhus disease where it endemics.

• Rat-Bite Fever

Rodent bites, especially the black rat, can cause two diseases to human:

I. Rat-Bite Fever or Sodoku Fever: as it is called in Japan. Sodoku is a word coined from two Japanese words; rat and poison. Gram-negative spirochete bacteria cause the disease, *Spirillum minus* Sodoku. Sporadic cases have been recorded worldwide, but the disease is common in Africa and Asia, particularly in Japan and India. The center of disease control and most references on the Rat-Bite disease restrict spirillosis to Africa and Asia; particularly Japan and consider it a very rare disease in USA where the other form streptobacillosis is common.

II. Haverhill Fever: caused by the gram-negative bacteria *Streptobacillus moniliformis*. It is also called Streptobacillosis. Haverhill Fever is named after the epidemic outbreak of the disease in Haverhill Massachusetts, USA in 1926 due to milk contaminated with rat faeces and urine.

In both forms of the disease, the pathogenic bacteria are carried in the teeth or gums of the black rats. Studies indicate that the number of cases of Rat-Bite Fever in the United States of America reaches annually to 14,000 cases while in India there are 20,000-recorded cases each year.

• Bubonic Plague

Plague is the most dangerous epidemic disease ever known by humankind. The first historical record of the Bubonic Plague pandemic was in the 6th century when it led to the death of nearly 100 million human beings in many countries around the world, nearly half the world population at that time. The second pandemic of Bubonic Plague occurred in the middle of the fourteenth century and caused the death of 25 million people in Europe alone, one third of its population and more than 43 million worldwide in the span of 5 years from 1345-1350. It was not strange that it was called “Black Death”. The tragic fate of millions of people was accompanied by the death of huge numbers of rodents but the role of the rodents in transmitting and spreading the disease was not suspected. The Plague became endemic in Europe and caused catastrophes in many countries. In London alone; during

the three years between 1664-1666, nearly 70,000 died out of the 450,000 inhabitants of London at that time, while during two years 1665-1666 the quarantine of the houses where first imposed in London. The Plague ended by the fire in a baker's shop, which nearly destroyed London and killed the disease carrying rats.

In Moscow, in 1700, the Plague caused the death of 10,000 people each week and in Marseille, France in 1720, it killed 68,000 people. In 1803, around 150,000 persons died in Istanbul, Turkey, while the third pandemic of the Bubonic Plague was began in 1892 in the Yunnan Province of China and from there spread to India and then the rest of the world. It is said to have killed more than 6,000,000 people in India alone. And reached the San Francisco in 1899 till 1902 and the San Francisco earthquake destroyed the city and a bounty was placed on killing rats

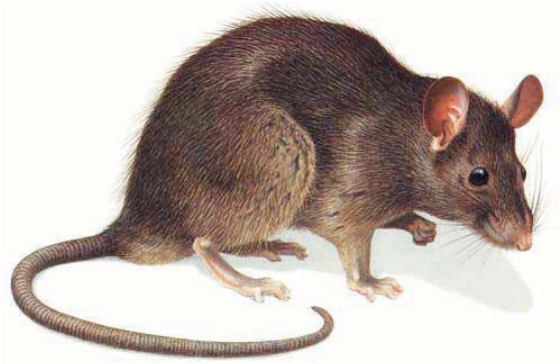
The relation between the sickness and death of the rodents and the spread of the Plague in humans was first established in 1894. The French scientist Alexandre Yersin and Shibasaburo Kitasato of Japan, each separately, identified the cause of the disease; a bacteria species first called *Pasteurella pestis* (in honour of Luis Pasteur). It was then named after its discoverer and was changed to *Yersinia pestis* in 1970. This bacteria species was found in the blood and faeces of sick rodents. The second important discovery came in 1898 with the confirmation of the role of the flea species, *Xenopsylla cheopis* (Rothschild) as the disease vector, which transmits and spreads the disease among the rodents, from the sick to the healthy, and from rodents to humans. Of the various rodent species, the black rat and the Norway rat are regarded as the most dangerous species to humans. In fact, the black rat was the perpetrator behind the Black Death pandemic in the middle ages.

The mode of disease spread starts when the fleas parasite on the infected rats to feed on their blood. With the blood come the pathogenic bacteria, as it was found that a single flea in single bite to a Plague-infected rat can suck large numbers of bacteria, up to 500 bacterial cells. Next, the bacteria actively multiply inside the flea, specifically in the area of the junction between the oesophagus and the stomach. The bacterial multiplication is so intense that it may physically obstruct the alimentary canal and hinder the passage of food. This keeps the fleas continuously hungry attacking more and more rodents and/or human to satisfy their hunger, transmitting the bacteria and the disease to more victims. The entry of *Yersinia pestis* into man's blood causes septicaemia, which leads to quick death. Infected persons develop skin haemorrhages appearing as black patches on the skin, the petechial, which were behind the name "Black Death".

The following are the main species of commensal rodents found in the Sultanate of Oman that are attacking the date palms and stored dates and leading to substantial damages and losses to both.

5.1.1. Black Rat

***Rattus rattus* (Linnaeus)**
(Rodentia: Muridae)



Distribution

The black rat, *Rattus rattus*, is known by different names; roof rat, ship rat, house rat, European house rat, bush rat, blue rat or climbing rat but it is most commonly called the black rat. It is widely distributed around the world and is common in the Middle East. It is spread in Jordan, Palestine, Syria, Lebanon, Iraq, Egypt, Sudan, Yemen and all Arabian Gulf countries, as it is found in Saudi Arabia, Bahrain and the United Arab Emirates. In the Sultanate of Oman, Harrison (1972, 1975) recorded this species in wilayats Muscat, Izki, and Sohar. However, today it is found in all regions in Oman and comprises more than 80% of all the commensal rodents of the country. Black rats can be widespread, utilising most habitat types, but they show a preference for drier habitats. They generally avoid swimming.

General Description

The colour of the black rat differs slightly from area to area, ranging between black and brown. Usually, either the back is black coloured with black or grey shine under the light and whitish grey abdomen, or the back is brown or dark brown (greyish black) with brown abdomen. The overall shape of the rat is cylindrical with pointed snout and protruding, wide eyes. The ears are slender, big and nearly hairless. However, the most characteristic feature of the black rat is its slightly hairy tail, which is always longer than the head and body length (HBL) combined and uniformly coloured. It was found that the tail length might reach up to 250 mm with a body length of 144-200 mm. The legs and feet are relatively strong with long hind legs and each foot having six pads that help it in climbing. The adult rat weighs from 120 to 160 grams but it can exceed 200 grams. Female of black rat has five pairs of nipples, two pairs on the thorax and three on the abdomen.

Economic Importance and Life History

Black rats are omnivorous and capable of eating a wide range of plant and animal foods. These include native snails, beetles, spiders, moths, stick insects and cicadas and the fruit of many different plants (Innes 1990). They also prey on the eggs and young of forest birds and inhabit farms, gardens, granaries and cattle barns (Innes *et al*. 1999). They climb the date palms and the coconut palms to build their nests on the palm crowns. They may

also dwell in the double roofs of the country houses in the villages. In the towns and cities, they can be found living in the sewer pipes, stored food warehouses where they can find plenty to feed on, or the deserted areas inside the residential, industrial or commercial buildings. This rat species is omnivorous and feeds on a wide range of food like, date fruits on their palms, various fruits, seeds, field crops and vegetables as well as some insects and snails. When the black rat feeds on the fruits including the date fruits, it nibbles a piece from one fruit only to move to another fruit to take another bite. Thus, the damages multiply by spoiling as many fruits as possible.

Black rats nest for shelter. Their nests are relatively big on the date palms and are made of palm fibres, leaflets, rachis, tree leaves, twigs and weeds. It is extremely difficult to track the black or climbing rat in its routes to and from its nest. It tends to move quickly on wires, cables, ropes and trees using its skill and agility in climbing. However, its routes can be identified or traced by observing carved marks left on the trunks of palms or trees, which are made during climbing.

The black rats breed all the yearlong and breed so fast that a male and a female couple can reach several hundred in number in just few months. The number of conceptions per year ranges from 6 to 8 times with each gestation period lasting 3 weeks. On average, each litter has seven young rats, which are born hairless with their eyes and ears closed. They depend on their mother for nursing and wean in three to four weeks. Within three months, they become fully-grown, sexually mature adult rats capable of breeding on their own. The total life of black rats may not exceed two years.

5.1.2. House Mouse

***Mus musculus* Linnaeus**
(Rodentia: Muridae)

Distribution

House mouse, *Mus musculus*, is also known as field mouse. It is distributed in most countries of the world or rather in all the countries of the world. It is the most populous mammalian species, preceded only by man and it holds the second rank in causing economic losses globally. In the Sultanate of Oman, Harrison (1972, 1975) reported that the house mice are common in Oman and was recorded in many regions and wilayats like, A-Rustaq, Ibri, Izki, Muscat, Nizwa, Sohar, Sur and Suwaiq.

General Description

House or field mouse, *M. musculus*, is a small, scaly-tailed mouse with a distinct notch in the cutting surface of upper incisors (seen best in side view); hair short; ears moderately large and naked; averaging 169 mm in total length. The tail is equal to or slightly shorter than the head and body length (HBL), ranging from 70 to 95 mm with an average of 85 mm. The fur or hair lining the back surface is light brown and the belly is buffy white, or buffy, usually without speckling and with slaty under fur; yellowish flank line usually present.

Fig. 5.1. Front view of *M. musculus.*

The tail has pointed tip, scale rings and is lined with thin hair. It has a pair of big eyes and the ears are big relative to its size; about 14 mm long. Each hind foot is 18 mm long. The mouse is light in weight, weighing from 15 to 30 grams and can jump from as high as 2.5 metres and lands unscathed. The female mouse has five pairs of mammary nipples (three pairs on the thorax and two pairs on the abdomen).

House mice walk, run and stand on all fours. They can stand only on the hind legs, as well, and are supported by the tail, which also provides balance while in motion. The house mouse has a sharp sense of hearing and communicates with other house mice through squeaks. Some of these squeaks are audible to humans, while others extend into the ultrasonic range.

Economic Importance and Life History

House mice inhabit houses preferring unused things in neglected places like cardboard cartons, old boxes or abandoned electric appliances. They also dwell in animal barns, stores, warehouses, agricultural fields and uncultivated wastelands. They also have been found even in hot deserts, semi-deserts and even completely secluded mountainous areas.

The house mice are omnivorous and feed on various kinds of food. They consume plant foodstuff especially fruits, vegetables, grains, fleshy roots, leaves and stems. They predate on the larvae of insects of the order Lepidoptera and on grubs of the members of the order Coleoptera as well as cockroaches and animal meat, if found. Contrary to the common belief, the house mouse consumes little food. It is estimated that it consumes 3 grams of food each day and drinks small amount of water as well. However, despite the little amounts of food consumed daily, the house mouse is notorious for its capacity to contaminate and nibble on large quantities of foodstuff rendering them unsuitable to consume or market. House mice are found in date storage facilities feeding and spoiling the stored dates there, tolerating extreme temperatures of 4°C in the cold storage rooms or as high as 80°C in the steam chambers used in sterilising the date fruits.

House mice are nocturnal and build nests in sheltered locations. Males may be aggressive, while females tend to remain in the nest, protecting their young. The house mouse has a high breeding capacity and may breed all year, if conditions permit. Each female, mouse gives birth 5-10 times per year, even reaching to 13 times. The gestation period is usually 19 days. Each litter has from 3 to as many as 21 young mice, 6 in average. The young are born altricial; hairless, blind and deaf and have to depend on their mother in nursing. They wean after three weeks and become sexually mature after 5-7 weeks of birth. The normal lifespan of a house mouse in nature is from 12 to 18 months.

5.1.3. Norway Rat

***Rattus norvegicus* (Berkenhout)**
(Rodentia: Muridae)

Distribution

The Norway rat, *Rattus norvegicus*, is one of the best known and most common rats. It is also known as brown rat, common rat, sewer rat, Hanover rat, Brown Norway rat, Norwegian rat or wharf rat. It is distributed almost worldwide but has not been proven to live in hot, arid desert areas or in the extremely cold Polar Regions. It resembles the climbing rat but is bigger, more stout and characterised by its ferocity with aggressive and offensive nature. Norway rats are originally native to northern China. Following a series of introductions, the species had found its way to Eastern Europe by the early eighteenth century. By the year 1800, they occurred in every European country. Today, Norway rats can be found on every continent of the world except Antarctica.

The Norway rat was first recorded in the Sultanate of Oman in the year 1995 in Masirah Island. It is probable that it came to Masirah on one of the ships or in some equipment's of the company constructing the port there. Since then, Norway rat spread on fishing boats to some other areas in Oman and they can be found in Matrah area and Sur Wilayat.

General Description

The Norway rat is a rather large member of the mouse family and is stoutly built. On average, these rats reach nearly 400 mm nose-to-tail, and the adult rat weighs from 400 to 500 grams. Males are usually larger than females. The dominant colours of its fur or hair are brown on the back and grey on the belly. The ears and tail are bald. The claws are complete and well developed especially those of the hind feet, which it uses in digging.

The tail is thick, has little hair, dark coloured on the upper side and light coloured on the lower side. In fact, the main characteristic feature of the Norway rat is its short tail, which is shorter than the head and body length (HLB). The tail is usually 205 mm long for a HLB of 260 mm. The snout is not as pointed as the snout of the black rat and the ears are relatively shorter, 20 mm long and sunken in fur.

The ears of Norway rats are typically shorter than those of related species, and do not cover up the eyes when pulled down. Norway rats can be easily mistaken for black rats; however, the temporal ridges of the Norway rat are

straight, whereas those of the black rat are curved. The Norway rat is also characterized by the strong hind feet, about 46 mm long, which are used in digging. The female Norway rats have six pairs of nursing nipples, three pairs on the thorax and three pairs on the abdomen.

Fig. 5.2. Side view of *R. norvegicus.*

Economic Importance and Life History

The Norway rat lives in self-made tunnels in muddy or sandy lands but it also dwells in the cities in the sewage tunnels and canals. It is found in the cities, seaports, stores, warehouses and animal or poultry barns. It seldom climbs the trees and is usually present on land and in the low levels of buildings.

It is considered as one of the serious agricultural pests and it feeds on both plant and animal foodstuffs. It attacks the stored food materials, poultry eggs and chicks, transmits several diseases to man and farm animals and destroys irrigation canals. It tears the packages of dates to feed on the stored dates as well as contaminating the dates and their packages by leaving its fur and faecal droppings on them leading to their spoilage and decreasing their market value.

The Norway rat, *R. norvegicus*, becomes sexually active after 3 months of birth and is such a prolific breeder with high fecundity that the female rat conceives seven times per year. The gestational period is 21 days and each litter has 5-18 young rats, 7 to 8 in average. Its lifespan in the wild is from 2 to 3 years.

Control of Rodents

Rats and mice can be control by several methods, most of which depend on using poisoned baits. They are specific toxic substances mixed with rat food, placed at the rat holes entrances or in areas frequented by rats or mice. On the other hand, as rodents are mammals, expected that such rat poisons have toxic effects on human beings and farm animals, hence, extreme care and precautionary measures should be exerted when using rodent poisons in the control programmes.

As a rule, the presence of rats or mice in the area should be confirmed before starting a rodent control programme. This is done, as mentioned earlier, by proofs and signs of rodent presence like faecal droppings, biting marks on food, the presence of rat holes or nests, visual identification of live, wandering rodents especially at night or sometimes in the morning or the distinctive rat smell. In addition to these, one may observe some changes in animal behaviours especially dogs and cats which are extremely sensitive to the presence of rats in the area. Rodent control measures can be divided broadly into two main groups; preventive methods and remedial methods.

I. The Preventive Methods

The purpose of the preventive methods target is to prevent rodents from reaching suitable places to dwell and cause damages to the foodstuff stores like date storage facilities, trees or different crops. In other words, these methods are based on depriving the rats and mice from food sources and shelters like holes and nests.

The main methods and measures that should be followed in the agricultural areas to prevent damages caused by rats and or mice are:

1. Not leaving leftovers or neglected stuff around buildings in the agricultural areas.

2. Daily disposal of garbage and refuse of the agricultural processes and transferring them to remote places to be recycled or incinerated.

3. Tightly sealing the doors and vent windows in foodstuff stores like the granaries and dates storage rooms.

4. Avoiding gaps, whatever small, left in the doors of the dates stores from which rats or mice may enter. Galvanised metal sheets could be used in making the rims of doors and windows. Windows or vents should not be made at heights less than 75 centimetres as the rat can jump to the height of about 50 centimetres.

5. Covering the doors and windows with durable metal screens.

6. Rat holes or nests should be demolished once found and flooded with water to kill the young rats inside then sealed with cement and broken glass pieces.

7. Not leaving excess quantities of poultry or animal fodders around and continuously removing the remainders to prevent rats and mice from frequenting the barns and staples to colonise.

8. In Oman, Mekky and Osman (1991) reported that fixing a metal strap, 30 centimetres wide, around the palm trunk at a height of one metre, prevents rats and mice from climbing the palms and reaching the date fruits. They also recommended cutting the intertwined fronds especially those adjacent to building walls to prevent rats from reaching the palm crowns.

Generally, physical barriers can prevent mice and rats from gaining access to structures where food and shelter is available. Rodent proofing your dwelling is a permanent and effective means of control that can prevent much damage from occurring. Methods used to exclude mice and rats are similar, but mice can enter openings much smaller than rats can. Thus, in case of mice controlling seal all openings larger than ¼ inch must be concerning; and in case of only rats controlling it is necessary to seal all openings larger than ½ inch. To seal openings to structures, we should use heavy materials that will resist gnawing. These materials include concrete mortar, galvanized sheet metal, and hardware cloth.

In spite of there is a fact that mice and rats are wary animals and can be frightened by loud or unfamiliar sounds. However, they will quickly become accustomed to new sounds and thus tend to ignore them. Many devices that produce ultrasonic sound have been marketed as an effective and easy way to frighten mice and rats away from an area. Unfortunately, advertising claims made by companies that produce ultrasonic devices have not withstood scientific scrutiny. The studies that have been conducted proved that these devices might initially frighten mice and rats, but they usually return to the area and resume normal activities. Similarly, many devices, which produce electromagnetic fields, have been marketed as an effective rodent repellent. Again, however, scientific evidence clearly shows that these devices are not useful in repelling rats or mice. For these reasons, ultrasonic and electromagnetic devices are not recommended as a solution to rodent problems.

II. Remedial Methods

Remedial methods include the traditional mechanical measures in rats and mice control, like using the traps, and the chemical methods that involve using poisons or more precisely, the rodenticides.

1. Mechanical Control

Trapping is an effective and often used method of controlling mice and rats in human dwellings, in date's storage facilities, staples and poultry farms. Generally, there are two types of traps; killer traps and live traps. The shape and size of the trap must suit the size and the

species of the rodent targeted. In both types of traps, bait is laid inside the trap and can be made from any kind of food. Nevertheless, each species of rodents has a preferred kind of food which would be preferable to use it as bait. The bait for the house mouse, for example, is made of fruits like apple or coconut while the climbing rat baits of fish pieces or wheat bread. The Norway rat fancies fried fish and spoiled white cheese baits. Although cheese is often used for bait, it quickly become stale and losses its attractiveness. It is important not to leave the baits in the trap until dried but they should be replaced regularly with fresh ones. One of the universally attractive baits that are commonly used is bread fried in oil with onion. It has a smell that invites the rats and mice. Traps should be set close to walls with their openings to the inside, behind objects, in dark areas, or in locations where mouse or rat activity has been observed. The traps should be set so that the mouse or rat will pass directly over the trap during their normal travel. When removing rats or mice from traps, it is recommended to always wear protective gloves. There are numerous designs of traps, some with one door and some have two doors, and some have one cell while others may have several cells and passages.

Rodents caught alive must be handled with prudence to prevent the transmission of the Fleas and Acari they may carry to humans. They are disposed of by drowning in a barrel half-filled with water. Then, suffocated rats are either buried or burnt. The traps should be cleaned thoroughly, after each catch with soap and water and left in the direct sun for not less than two hours to remove any smell or odours that may repel the rats.

It is worth mentioning that the use of traps alone would not lead to a dramatic decrease in the number of rodents in a certain location, e.g. a date's storage facility. So, traps should be used as an element in an integrated pest control programme, IPM. An IPM programme is designed to limit the number of targeted rodents in certain locality and thus decreasing or preventing the economic losses expected.

2. Chemical Control

The most important method of chemical rodents control is the use of rodent-specific chemical compounds, collectively called rodenticides. These are divided into two main groups; the first group includes the single-dose rodenticides, which are fast-acting poisons and are termed acute rodenticides and the second group has under its umbrella the various multiple-dose poisons that are slowly-acting or chronic poisons like the anticoagulant rodenticides that work on the blood clotting mechanism. Below some of the major rodenticides of each group will be discussed.

a. Acute Rodenticides

Acute rodenticides form the group of rodenticides capable of killing immediately after ingestion of the poison and so they are called single-dose rodenticides. Because of their high toxicity not only to rodents but also to humans and many other farm animals, only qualified personnel trained to handle such poisons should use them. The acute rodenticides include both organic and inorganic chemical compounds that are highly toxic in relatively low concentrations, as they cause death within hours of the ingestion of the loaded bait. The single-dose, acute rodenticides were the first rodenticides to be used with considerable success in rodents control and some are still used up until now.

However, they have several disadvantages when used in open fields or farms because of their high toxicity to humans and domesticated farm animals leading to collateral, non-targeted deaths. It is important to note that after their prolonged and heavy use, they lead to the emergence of resistant strains necessitating the use of higher concentrations of the active ingredient in the baits, which imposing higher toxicity risks and exacerbating the costs of the control programmes. The main disadvantages of the acute rodenticides are:

1. When a rat or mouse ingests a sub-lethal amount of the

bait and survived, it would develop a defensive reaction by being very shy and wary of baits as a result of the pain and symptoms it suffered by the poison. Unlike many animals, rats are incapable of vomiting and are unable to remove the poison once ingested.

2. The need to apply what is known as pre-baiting, i.e. using the bait without any added rodenticides until the rodents get used to feed on the bait from this place without shyness. This practice, of course, entails extra costs and efforts to place the non-poisonous baits first and then the poisoned ones later.

Nevertheless, acute rodenticides are preferred such as an outbreak of rats and mice in very high numbers and their associated heavy damages in some indispensable cases. Here there is a need to decrease the number of the rodents as quickly as possible. In addition, acute rodenticides are used in the epidemics or outbreaks of diseases dependent on the presence of rodents in high numbers. The following are the most important acute rodenticides:

• Zinc Phosphide

A rodenticide used widely around the world in controlling the commensal rodents and many different field rodents. It is grey-black powder with a garlic-like odour. Zinc phosphide is highly toxic and its acute oral LD_{50} for rats is 45.7 mg/kg. Despite this high toxicity, it can be used as a relatively safe and specific rat poison because of its unattractive colour and repulsive odour, yet attractive to rodents.

The toxic effect of zinc phosphide occurs with liberation of phosphine (PH_3) gas from the reaction between the orally ingested zinc phosphide and the dilute hydrochloric acid in the gastric juices inside the stomach, according to the equation:

$$Zn_3P_2 + 6\ HCl \rightarrow 3\ Zn\ Cl_2 + 2PH_3$$

The liberated phosphine gas is rapidly absorbed into the blood stream causing metabolic changes that result in damage to the liver, kidneys and the blood vessels and erythrocyte membranes and eventual cardiovascular collapse. Phosphine also has some CNS effects. Zinc phosphide is used mixed with different baits in concentrations of 1 to 3%. Sometimes, date syrup (dibs) or some other sweet substances may be added to mask its bitter taste. It is preferable not to use zinc phosphide baits singly for long periods and to use them alternating with one of the anticoagulant rodenticides.

• Red (Rat) Squill

A powder prepared from the dried bulbs red squill, Urginea maritima L., a native plant growing in the dry, sandy deserts in the Mediterranean Sea basin. It has been used since the Middle Ages as rat poison, and a medicinal drug in man, as a cardiac stimulant, diuretic, emetic and expectorant. The name scilliroside applies to a glycoside contained in the extract of the powdered bulbs of the red squill. Red squill powder has strong, penetrating odour and a bitter taste. Its most important feature as a rodenticide is that it is extremely toxic to rodents and quite harmless to man and farm animals, at the recommended concentrations. The fact that it induces emesis in all animals except rodents warrants its use as a safe, acute rodenticide. It is also moderate in its speed of action and rodents usually die within 24 hours of ingestion.

b. Anticoagulant Rodenticides

All the rodenticides in this group share one common feature, the mechanism of toxic action by preventing coagulation (blood clotting) through inhibiting the action of prothrombin. Disturbed coagulation causes continuous haemorrhage, which leads to death. In the same time, some of these compounds also cause damage to the blood vessel walls and increase their permeability thus decreasing their resistance to the pressure of the blood they carry. As a result, the blood vessels (especially the minute vessels) tear and rupture causing internal haemorrhage, which is fatal. This effect can be detected in the blood vessels around the heart, nose, anus and the female genital opening in the rats.

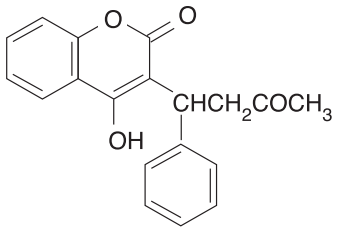
Anticoagulant rodenticides have great advantages over other rodenticides as follows:

1. The disappearance of the phenomenon of aversion or bait shyness in the rats, which is targeted by the bait. They keep on feeding on the anticoagulant rodenticide baits unsuspecting the toxic effects.
2. The anticoagulant rodenticides pose neither primary nor secondary toxicity risks to the non-targeted farm animals. Even in the case of accidental poisoning in man or any farm animal, treatment is available by using the specific antidote vitamin K, which can be given orally or by intramuscular or intravenous injections in different doses.
3. There is no need for pre-baiting before using the actual rodenticide, as is the case with the acute rodenticides. Rodents do not experience any symptoms or effects after ingestion of sub-lethal doses of the baits containing anticoagulant rodenticides.

Anticoagulant rodenticides are used as single dose or multi-dose baits. They are chemically are either of the hydroxycoumarin or indandion derivatives. In the following pages, the main features of the most commonly worldwide used rodenticides will be briefly discussed, with special emphasis on those used in the rodent control programmes on the agricultural corps in Oman.

• Warfarin

The chemical name and structural formula are 3-(α-acetonylbenzyl)-4-hydroxycoumarin



Warfarin is the first commercially produced anticoagulant rodenticide, as it was developed in 1950. Initially, it worked like magic and was very popular especially after the emergence of the disadvantages of the fast acting or acute poison baits. It had been very successful in controlling the black rats and the Norway rats. Like the case with most anticoagulant rodenticides, the rodents keep feeding on the baits containing them without shyness or aversion. General internal bleeding is induced by reduction of the prothrombin content of the blood and repeated ingestion is necessary to produce toxic symptoms.

Acute Oral LD_{50}:

Rats = 186 mg / kg

Mice = 374 mg / kg.

Oral LD_{50} daily for 5 days for:

Rats and pigs = 1 mg / kg

Cats and dogs = 3 mg / kg

Cattle = 200 mg / kg.

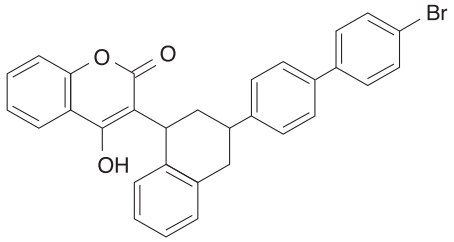
It is known that warfarin causes no harmful effects on man and farm animals because of the high doses needed to produce toxic effects, up to 60 mg/ kg body weight. It is even used as medicine for blood-thinning in stroke-stricken patients. Farm animals do not get poisoned by eating the poisoned rodents, as warfarin does not readily cause secondary poisoning. The solid poison baits are prepared in 0.05% concentration and the liquid baits at 0.05 mg/L (usually by the sodium salt of warfarin).

Warfarin enjoyed seven years of dramatic success as a rodenticide, from 1950 t0 1957 till reports of resistance to its toxic effect in the Norway rats discovered. Later, resistant strains were observed in the black rats, followed by recorded resistance cases in some groups of the house mice in the United Kingdom in 1965 and the USA in 1975. The mechanism of resistance in the house mouse and the Norway rat is linked to a single dominant autosomal gene, although on different chromosomes. Meanwhile, the resistance to warfarin in the black rat is supposed to be multi-factorial. The resistance is passed from a generation to the next as a result of ingesting small doses of the anticoagulant rodenticides and are recorded with all

of them, but almost none with the newer anticoagulant rodenticides, collectively known as the second generation including Brodifacoum, Bromadiolone and Difenacoum.

• Brodifacoum

The chemical name of this anticoagulant rodenticide is: 3-[3-(4'-bromobiphenyl 4-yl)-1,2,3,4-tetrahydro-1-naphtyl]-4-hydroxycoumarin.



Brodifacoum is an anticoagulant rodenticide of the second generation and is sometimes referred to as super warfarin. Chemically, it is related to difenacoum but it is more toxic. It is produced commercially under several brand names like Ratak® and Klerat®. It is used successfully in controlling the rodents that attack the date palms and coconut palms in Oman especially against the main commensal rodents; the Norway rat (*Rattus norvegicus*), the black rat (*Rattus rattus*) and the house mouse (*Mus musculus*).

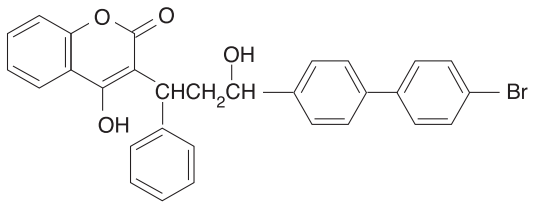
Brodifacoum is characterised by the very little amount of the active ingredient needed as a lethal dose for the above-mentioned rodents. In other words, the rodent only has to eat the least amount of the bait for the poison to produce its lethal effect. This is an extremely beneficial advantage over other poisons particularly with those rodent species with limited appetite for food, like the house mouse. It must be recognised that Brodifacoum can also be classified as a fast-acting, acute rodenticide because of the high probability that the rodent gets the toxic dose after ingesting the bait only once. However, it is conventionally classified as an anticoagulant rodenticide based upon its physiological mode of action. Brodifacoum is also available commercially as prepared baits in the form of waxy cubes of 0.005% concentration.

Acute Oral LD_{50}:

Male rats and mice = 0.4 mg / kg
Male rabbits = 0.2 mg / kg
Cats and Dogs= 0.25 mg / kg.

• Bromadiolone

Chemical name: 3-[3-[4'-bromo(1,1'-biphenyl)-4-yl]-3-hydroxy-1-phenylpropyl]-4-hydroxy-2-H-1-benzopyran-2-one.



The most important trade names of Bromadiolone are Lanirat®, Ratoban®, Lafar® and Maki®. Bromadiolone is one of the anticoagulant rodenticides and is used to control different species of rats and mice especially with warfarin-resistant strains. So, it is considered from the second generation of anticoagulant rodenticides. It is presented commercially in the form of ready-made baits based primarily on oats in 0.005% concentration of the active ingredient. It is characterised by being extremely palatable to the rodents and is lethal if they fed on it for only one day.

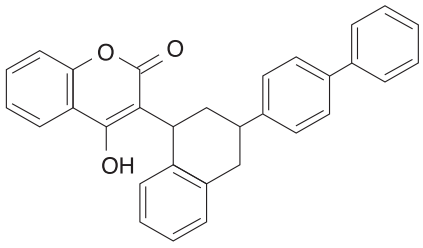
Acute Oral LD_{50}:

Rats = 1.25 mg / kg
Mice = 1.75 mg / kg.

• Difenacoum

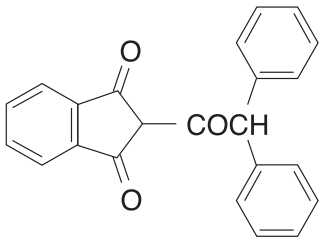
The chemical name: 3-(3-biphenyl-4-yl-1,2,3,4-tetrahydro-1-naphthyl)-4-hydroxycoumarin

Difenacoum is a second-generation anticoagulant rodenticide, which was discovered in the mid 1970's.



• Diphacinone

Chemical name: 2-(diphenylacetyl) indan – 1, 3 – dione



Diphacinone is an anticoagulant rodenticide of the indandione derivatives group and counters the role of vitamin K in blood clotting. Diphacinone requires multiple feedings by the rodent to exert its toxic effect. The time needed to be lethal for the rodent is much longer than the time with warfarin.

Diphacinone is produced commercially in 0.1% concentration of the active ingredient and its bait is prepared in the ratio of 1:19 to reach a final concentration of 0.005% of the active ingredient in the bait. Baits are usually sold as ready-made baits under several trade names like; Tomcat® or Ramick®.

Acute Oral LD_{50}:

Rats = 2.3 mg / kg

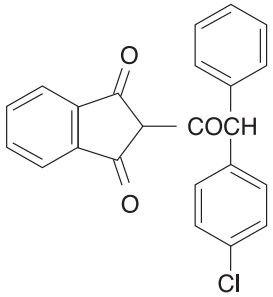
Rabbits = 35 mg / kg

Dogs = 3 – 7.5 mg / kg

Cats = 14.7 mg / kg.

• Chlorophacinone

Chemical name: 2-[(4-chlorophenyl) phenylacetyl] –1H – indene –1,3 (2H) – dione.



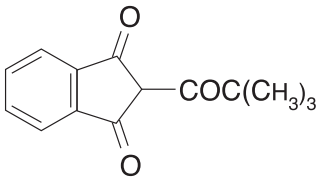
Chlorophacinone is a rodenticide of the indandione group and is highly effective anticoagulant against Norway rats and house mice. It is stronger than warfarin and is used instead when the rodents refuse its baits. Chlorophacinone was developed in France and is sold under the trade names of Rozol® or Raviac®. The most important feature of Chlorophacinone is its production of its toxic effect after the ingestion of a single dose. It is reported that the bait containing 0.005% of the rodenticide is enough to kill the Norway rat after a single dose from the fifth day of ingestion. Baits are usually prepared by mixing wheat grits or sunflower seeds with the active ingredient in the concentration of 50-250 mg for each kilogram of the bait and are sold as pre-mixed product.

Acute Oral LD_{50} :

Rat = 6.25 mg / kg.

• Pindone

Chemical name: 2-pivaloylindan-1, 3-dione



Pindone is a member of the indandione group of anticoagulant rodenticides and can substitute warfarin especially in cases of rodent aversion from the bait. Commercially, Pindone is sold under the trade name of Pival ®, a mixture of 0.5% active ingredient with starch. It was noticed that it had an added effect on the sucking insect parasites living on the rodents. These are killed when they suck the blood of the poisoned rodents. It is also observed that Pindone is more effective on black rats and house mice than on the Norway rats. It needs 6-10 days of continuous feeding on the bait to exert its toxic effect.

Acute oral LD_{50} :

Rats = 280 mg / kg.

5.2. Birds

Birds are considered agricultural pests because they feed on the same types of food consumed by humans. Some feed on grains, fruits and plant seedlings while some others feed on flowers or sometimes plant roots. Birds are also regarded as one of the most important means of spread of pests, plant diseases and weeds from the infected plants or farms to the healthy ones. The grain-eating birds are some of the most serious pests causing great losses in corn, millet, rice, wheat, barley and other crops. In desert areas, birds are considered as devastating as the desert locust swarms.

Historically, birds had been regarded as agricultural pests since man practiced organised farming. The ancient Egyptian Pharaohs recorded this fact on the walls of the tomb of Queen Hatshepsut, where they draw crane birds with their bills tied with ropes to prevent them from picking seeds and date fruits. Date fruits are considered favourable delicacies by many birds, which feed on them during the Rutab or Tamar stages while still on the palms, Fig. 5.3.

Fig. 5.3. Damage of birds on dates.

They also attack the collected date fruits left to dry in the open air. Some birds have the most devastating feeding behaviour on date fruits by pecking small pieces from one fruit then moving to another to do the same. Thus, the fruits are become unbefitting for consumption because of the bites or the secondary rottenness and spoilage. In other cases, they may gobble the whole fruit leaving a kernel and some flesh remains suspended from the spikelet by its calyx end.

However, it is important to mention that birds are not always agricultural pests. They can also predate on pest insects and worms, thus helping in decreasing the pest density. Because of this, the call to eradicate certain bird species from an area completely ignores several scientific facts and may disrupt the natural balance among the different organisms in the ecosystem. As happened in China, the complete eradication of passerines (sparrows) led to the emergence of new pests, which previously of no economic importance. Preventive methods from bird damages should have the priority as the primary measures to be taken against their damages.

In the Sultanate of Oman, (Gallagher and Woodcock 1980) and (Eriksen and Sargeant, 2000) recorded many bird species, whether permanent residents type (non-migratory) or as migratory birds. Below the most important birds known to attack and feed on the date palm fruits in the Sultanate of Oman.

5.2.1. House Sparrow

***Passer domesticus* (L.)**
(Passeriformes: Passeridae)

The house sparrow, *Passer domesticus*, is a species of passerine bird of the sparrow family Passeridae. It is also known by the alternative vernacular names English sparrow, Indian sparrow, and Spatzie or Spotsie.

This passerine bird is common in Europe and Asia as well as, India, Iran, Iraq, Egypt, Saudi Arabia, Bahrain, and Kuwait. It is considered a permanent resident bird in the north of Oman. The sparrow feeds on the date fruits in Rutab or Tamar stages whether still on the palms or after collection.

General Description

The house sparrow, *P. domesticus*, is a chunky little bird, with feathers mostly different shades of brown and grey. *P. domesticus* is a small sparrow of 14.5 centimetres long in average with non-striking colouration.

The male is relatively more colourful than the female having whitish cheek, black throat and a chestnut coloured dorsal area of the crown. The buttocks are grey and the under-parts are whitish grey. The female sparrow is brown and has neither grey back nor a black throat. The bills in both sexes are black or brownish grey with yellow bases.

The house sparrows, as the name implies, are mainly found near the houses and gardens especially in the date palm groves preferring to build their nests in the palms grown in house gardens. They breed from two to three times yearly. The female sparrow lays from 3-4 pale-coloured eggs in the nest built of straws and feathers on the trees, between houses or rocks.

5.2.2. Palm or Laughing Dove

***Streptopelia senegalensis* (L.)**
(Columbiformes: Columbidae)

The Palm Dove, *Stigmatopelia senegalensis*, is a small pigeon which is a resident breeding bird in the tropics in Africa south of the Sahara, the Middle East and southern Asia east to India. In India it is also known as the Little Brown Dove. The palm dove is called the Laughing Dove because its coo sounds like man laughing. It is also called the Senegalese dove. The Palm Dove is widespread in Iran, Iraq, Palestine, India and many countries in the Arabian Peninsula. It is the most common species of pigeons in the Sultanate of Oman.

General Description

This pigeon species is small, with a light body and is about 72 centimetres long. The body is overall brown inclined to rose-red colour. The female and juveniles are paler in colour, while the other doves may be bright or deep coloured. The neck and upper chest are pale violet with black spots. The outer wing edges are greyish blue and the flight feathers are darker in colour. The outer tail feathers are white tipped and are quite visible upon landing. The legs are rose coloured with black claws.

The palm doves are common in farms and are being monogamous birds. They are not particularly gregarious, and are usually alone, or in pairs. However, they may aggregate in flocks for feeding, drinking or travelling. It is characterised by its quick flight near to the ground and whistle-like voice. It is easily distinguished by its coo that ends in a kind of a human laugh. This species has a most peculiar behaviour during courtship by flying fast upwardly with sharp flicks of the wings, then diving spreading its wings and tail in a way similar to other pigeons. Palm Doves eat grass, seeds, grains, other vegetation and small insects. They are fairly terrestrial, foraging on the ground in grasslands and cultivation. The palm dove breeds in the spring and builds nests on the trees in the fruit or palm groves or on some buildings. It produces young chicks every several months.

5.2.3. Turtle Dove

***Streptopelia turtur* (L.)**
(Columbiformes: Columbidae)

The Turtle Dove, *Streptopelia turtur*, also known as European Turtle Dove, is a member of the bird family Columbidae, which includes the doves and pigeons. The Turtle dove is common in Palestine, Jordan, Syria, Iraq, Iran, Arabian Peninsula, Egypt, Sudan, Libya, Morocco and some European countries.

In the Sultanate of Oman, flocks of turtle doves cross the Sultanate and it is considered a breeding migratory bird in Al-Batinah coast area especially between the months of March and November of each year.

General Description

The Turtle dove is bigger than the palm dove in size, as it can be 26-30 centimetres long, 28 cm in average. The upper parts of the dove are mottled with black or dark brown colour. The feathers on its wing and back have dull brown edges and black centres. On both sides of the neck, there are black and white striped patches of feather. Its tail is wedge-shaped with dark feathers at the centre and the rest black with white borders and tips.

The mature bird has the head, neck, flanks, and rump blue grey, and the wings cinnamon, mottled with black. The breast is vinaceous, the abdomen and under tail coverts are white. The bill is black, the legs and eye rims are red. The black and white patch on the side of the neck is absent in the browner and duller juvenile bird, which also has the legs brown. The Turtle dove resembles the palm dove in its flying pattern. It has a soft and enchanting voice. They begin to build their nests in Al-Batinah area from April of each year.

5.2.4. Indian Roller

***Coracias benghalensis* (L.)**
(Passeriformes: Coraciidae)

The Indian Roller, *Coracias benghalensis*, also called the Blue Jay in former times, is a member of the roller family of birds. The Indian Roller is a widespread bird in Iraq, Iran, India and all the countries on the Arabian Gulf as UAE, Qatar, Bahrain, Saudi Arabia and the Sultanate of Oman. In the Sultanate of Oman, they breed and live in great multitude near the coastline up to the town of Sur.

Generally, the Indian Roller, *C. benghalensis*, are found in southern Asia from Iraq to Thailand and are best known for the aerobatic displays of the male during the breeding season. They are very commonly seen perched along roadside trees and wires and are commonly seen in open grassland and scrub forest habitats. It is not migratory, but undertakes some seasonal movements. Several states in India have chosen it as their symbol.

General Description

The Indian Roller is a squared stocky bird and dark-coloured when approaching. It is 31 centimetres long. The upper chest is vinaceous red and the rest is chestnut-coloured. The central feathers of the tail are green while the outer feathers of the tail and the wings are blue. The leg bases are dark blue followed by a light blue area with darker edges, while the feet are yellow in colour and the bill is black. The Indian roller has a characteristic call; harsh, loud and low-pitched voice, almost crow-like.

The Indian Rollers inhabit the date palm groves and breed there building their nests on the palms. They start to breed in April and each female bird lays from three to four eggs. They feed on the dates but fortunately, causes limited economic damages. It also predates on insects, reptiles and even small fish.

5.2.5. Yellow-vented (White-eyes) Bulbul

***Pycnonotus xanthopygos* (Gould)**
(Passeriformes: Pycnonotidae)

The Yellow-vented bulbul, *Pycnonotus xanthopygos*, is also known as White-spectacled Bulbul or White-eyes Bulbul. A nightingale, which is distributed in many countries as it, is common in the coastline areas of the Arabian Peninsula as well as Turkey, Syria, Lebanon, Palestine, Jordan, Iraq, Saudi Arabia, Yemen, United Arab Emirates and South Sinai in Egypt. In the Sultanate of Oman, it is found in both the Northern and Southern regions except the island of Masirah. It is also called the black- headed bulbul and is considered of the tree (perching) birds, as it is not found in the desert areas.

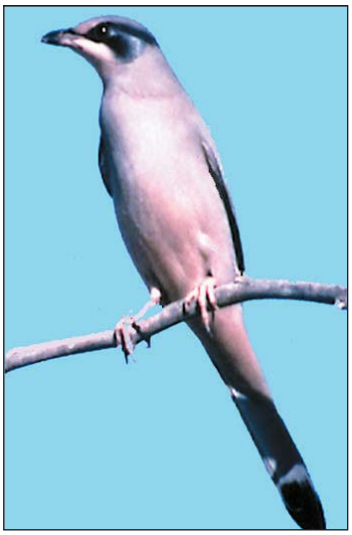
General Description

The Yellow-vented bulbul, *P. xanthopygos*, is a very familiar bird in parks, gardens and wadis. The head is black-coloured with white rings around the eyes; hence, it is sometimes called the white-spectacled bulbul. The body and the wings are copper-brown in colour and the abdomen is greyish brown. The most characteristic feature of this species is that the posterior under-tail area is lemon yellow. The bill, eyes and feet are black in colour. The bulbul is 19 centimetres long and characterised by its intermittent singing voice.

These bulbuls live gregariously in sociable, noisy flocks and feed on all types of fruits including the date fruits, grains and many types of fruits. They build their nests in early spring from plant stems, wool and hair and lay from 3 to 5 eggs each time. The eggshells are characteristically rose-coloured, glossy with black and violet spots.

5.2.6. Grey Hypocolius

***Hypocolius ampelinus* (Bonaparte)**
(Passeriformes: Bombycillidae)



The Grey Hypocolius, *Hypocolius ampelinus*, is common in the Middle East, breeding in Iraq, Iran, Afghanistan, Pakistan, Turkmenistan area and wintering mostly near the Red Sea and Persian Gulf coasts of Arabia, including Bahrain. The Grey Hypocolius is a vagrant to Turkey, Palestine, Egypt and Oman. They are regular winter visitors to the Kutch region of western India and vagrants have been noted as far south as Kihim near Bombay. It is found in woodland and scrub in arid and semiarid regions, especially river valleys near deserts, as well as in irrigated and cultivated areas with trees, such as palm groves and gardens.

General Description

The Hypocolius is a slim bird with a long tail, slight crest and thick, short hook-tipped bill. Its shape and soft, satiny plumage resembles that of the waxwing. Birds are mainly a uniform grey or brownish-grey colour, with males having a black triangular mask around the eyes. They have white-tipped black primary wing feathers and a black terminal band on the tail. The legs are black in the male and grey in the female. Adults are about 19–23 cm in length. The head feathers are raised when the bird is excited. They fly in a straight non-undulating style and when hopping in shrubbery, can appear like a babbler. The tarsus is short and sturdy with coarse scales. There are rectal bristles visible at the base of the bill and the nostrils are exposed, small and oval.

The breeding season is June or July in Arabia. The nest is cup shaped and deep lined with hair and fluff. The nest is often placed on the fronds of a date palm at a height of about 3 to 5 feet. The clutch is four eggs. The eggs are leaden white with blotches. The incubation period is about 14–15 days. The Hypocolius can be found between the trees and bushes and on the date palm groves where they feed on the dates in the Rutab and Tamar stages.

Protection of Dates from Birds Attacks

There are many methods and procedures must be considered to minimise the damages caused by the attacks of birds on date palm fruits. The following are the main control measures against birds:

1. Covering the date fruit bunches with bags during ripening: Paper bags, plastic nets or baskets plaited of palm leaflets can be used, to protect them from bird attacks during ripening.

2. Covering the fruit bunches with metal-wired cages: This method is used in Iraq, Iran and some other countries. The fruit bunches are enclosed inside cages made of metal wire during the fruit ripening season to prevent bird attacks. It has the advantage of using the same cage repeatedly for years.

3. Using balloons or scarecrows: Balloons, in the shape of predatory birds or having their shape painted on, are placed in the field to scare the birds from approaching the area.

4. Hanging metal stripes especially arranged to produce sounds with breeze or wind: The sounds scare away the birds and prevent them from approaching the fruit-bearing trees. This method can be used with short trees like apple or pear trees as well as the grapes but is not suitable for tall trees like the date palms.

5. Using devices that produces banging sounds: A special gas-operated device is used to produce frightening banging sounds resembling gun shots in a timely fashion to scare the birds away from the area having fruitful trees in need of protection, Fig. 5.4.

6. Using metal tins to frighten the birds: Banging metal tins to scare the birds and driving them away from the date palms and other fruit-bearing tree areas. Obviously, it is unpractical and expensive because of the labour cost involved.

7. Collecting the late ripen date fruits earlier: Farmers may resort to collecting the late-ripening date varieties prematurely along with other date fruits varieties in their due time. Then, they would be ripened artificially to prevent them from being left alone subject to intensified bird attacks in some areas.

Fig. 5.4. A special gas-operated device that emits sounds to frighten the birds.

5.3. Bats

Bats are flying mammals in the order Chiroptera. Chiroptera comes from two Greek words, cheir "hand" and pteron "wing". The forelimbs of bats are webbed, developed as wings, making them the only mammals naturally capable of true and sustained flight. Bats do not flap their entire forelimbs, as birds do, but instead flap their spread out digits, which are very long and covered with a thin membrane or patagium. Bats are nocturnal mammals, which hide during the day in quite places and become active by night. They are characterised by hanging heads down when resting and in being capable of flying making fast manoeuvres to avoid hitting obstacles.

Some bats are beneficial as they predate on insects but some are deleterious and harmful like those bat species feeding on the fruits or those sucking animal blood. Generally, they are avaricious eaters and whatever the kind of food they eat, they excrete huge quantities of faeces, which have strong ammonia odour and can be utilised as fertilisers. Bats have peculiar mating behaviour as their females are polyandrous and they aggregate together after mating in places no male dares to enter. The most important bat species in the Sultanate of Oman is the bat known as 'the fruit bat' or 'the Egyptian fruit bat', which attacks the date palms and other fruit trees. In what follows this bat will be described and will define the damages it causes to the date palms.

5.3.1. Egyptian Fruit Bat

***Rousettus aegyptiacus* (Geophroy)**
(Chiroptera: Pteropodidae)

The Egyptian Fruit Bat, *Rousettus aegyptiacus*, lies under the suborder Megachiroptera and is the only member of this suborder that prefers inhabiting the mountain caves, grottos or safe dark places like deserted monuments or castles. Generally, bats prefer to live and settle to be away from human irritation or any other harassment. The fruit eating bat is distributed in many Middle Eastern countries and the island of Cyprus. It was recorded in the Sultanate of Oman in 1964 (Harrison 1964).

General Description

The Egyptian fruit bat, *Rousettus aegyptiacus*, has a wingspan that averages 60 cm, and a body length around 15 cm. The weight of Egyptian fruit bat is typically around 160g. Males are larger than the females and can be easily distinguished by their large scrotal sack. They are typically a light brown in colour, with darker brown wings. They have large pointed ears, dark eyes, and a long dog-like muzzle, which sometimes leads them to be referred to as

flying foxes. Their fur is very soft, and their wings feel not unlike pantyhose. Like many bats, Egyptian fruit bats are nocturnal. They spend their days roosting in trees or caves, often with large groups of other bats, sometimes numbering in the thousands. They emerge from the roost to forage for food in the late evening, and return just before dawn. They hang upside down, with their wings folded closely around their body, Fig. 5.5.

Behaviour

Egyptian fruit bats, along with other species in the genus *Rousettus*, are the only megachiropterid bats to use echolocation, which they accomplish by emitting a series of sharp clicks with their tongue. The clicks are normally slow and constant and speed up dramatically when the bat approaches an object. These clicks are sharp, high-pitched, and loud with wide wave length and a frequency range from 10-60 Kilohertz. They also make use of a range of vocalizations for communication, including grunts and screeches. As a result, a large roosting colony can be a deafening cacophony. The bat spends most of the day roosting in its dwelling and goes out after sunset to actively search for food for the whole night. It was observed that this bat species migrates and leaves its habitat to new places if they scarcity, or unavailability or difficulty in obtaining its food source from the surrounding plantations and when it feels threatened by the presence of man and moves to safer places.

One of the most peculiar observations about the Egyptian fruit bat behaviour is that the larger the number of the bats colony, the more they crowd and adhere together making bodily contacts. One can observe the bats continuously fighting among themselves for suitable spots, food or for female bats to fertilise. However, the truth is that in spite of the apparent aggressiveness, they rarely hurt one another. The fruit bat feed on many kinds of fruits and is known to fly relatively great distances in search of ripe fruits to eat.

Reproduction

The Egyptian fruit bat, *Rousettus aegyptiacus*, is reached maturity at about 9 months of age. Females typically give birth to only a single baby each year, but

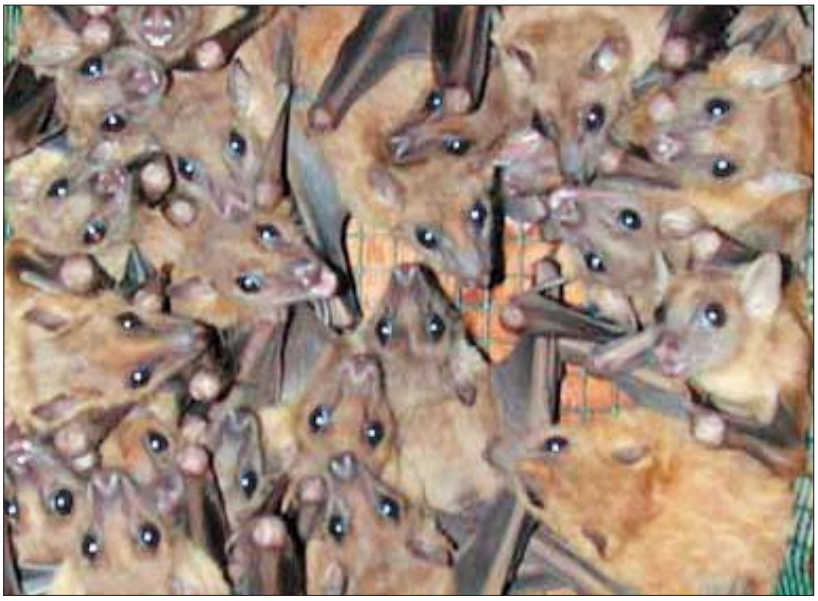


Fig. 5.5. A photo taken from the ground, showing aggregated fruit bats suspended from their feet inside a cave.

twins are occasionally born, after a gestation period of around 115-120 days. The young bat grasps its mother's nipples immediately after birth with its teeth and begins to suckle. The female carries the young until they are able to hang from the roost on their own, after about six weeks. Once the baby bat can fly, at about three months of age, it will leave the roost on its own to hunt for its own food. Offspring typically stay with the same colony as the parents for their entire lives. It was found that the mating season of the Egyptian fruit bats starts from December to March in most of the regions they inhabit.

Damages Caused by Egyptian Fruit Bats

Egyptian fruit bats are frugivorous, a fruit eater. They are consuming large amounts of fruit each night. Wild dates tend to be a favourite, but they will consume almost any soft, pulpy fruit. Most of their diet tends to consist of unripe and insect- and fungus-damaged fruit, which allows them to thrive in habitats where ripe fruit are not available year-round. Some of the most important direct and indirect damages caused by the Egyptian fruit bats to fruits growing near their dwellings are:

- Fruit bats feed on the dates by attacking the fruit bunches at night to feed on well- ripened fruits. They also cause the fall of many date fruits to the ground while feeding which causes great economic losses to the harvest.

- The bats also feed on the fruits grown under the date palms like citrus fruits. They can eat orange pulps, leaving the seeds and the outer rinds only.

- If available, bats feed on many other fruit species like grapes, figs, pomegranate, mango and other fruits as well as ripened vegetables like tomato, watermelon or melons.

- Bats spoil the walls of the stores and houses built near the trees they call upon for feeding in the farms. Reddish brown spots can be seen copiously on these walls, which are the faecal droppings of the bats. They have very strong distinctive odour of the released-ammonia. These spots cannot be removed easily off the walls.

- Bats are nuisance as they pester the tourists and visitors of ancient monuments in which they may be dwelling.

- Bats can transmit serious diseases such as rabies to humans when biting them.

Control Measures

The main control measures against the fruit-eating bats can be summarized as follows:

- Protecting the dates from bat attacks by covering the fruit bunches with narrow-meshed fishing nets to prevent the bats from reaching the date fruits.

- In order to control the bats on vegetable crops and fruits, poisonous baits can be used. The bait is made of date paste, zinc phosphide 3%, and kneaded into orange-sized balls to be suspended by a thread from the trees and bushes nearby. This method is suitable when the bats hide is unknown or unreachable; but it is not suitable for the tall date palm trees.

- If the caves or bat dwellings are known and can be reached, bats can be eradicated by burning a mixture of sublimed Sulfur 30 grams and Sudanese capsicum powder 1 gram for each cubic metre. The bat dwelling should be sealed off with the bats inside. Care must be exerted to avoid the poisonous gases released during fumigation by using the protective masks and goggles.