The Rat Ectoparasites, their Role as Vector of Human Diseases and their Control*

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INTRODUCTION

RATS have followed man to almost all inhabited parts of the world and carried with them several diseases of considerable public health importance. They are implicated in the spread of Murine typhus fever, Bubonic plague, Salmonellosis, Trichinosis, Haemorrhagic jaundice and Rat-bite fever. A considerable doubt also exists of the rat's role in the transmission of a score of other diseases affecting man. Doubtless the loathsome nature of the rat makes it a convenient repository for blame.

Apparently the rat ectoparasites play an important role in maintaining the infection in the rat reservoir and occasionally transmitting some of the diseases to man. The mode of transmission of some diseases to man, however, has not so far been well defined. With respect to rat-borne diseases, prevention and control, a knowledge of rat ectoparasites is, therefore, of paramount importance to the health officers, sanitarians and other health organization personnel.

ARTHROPOD ENEMIES OF RATS

The domestic rats are known to harbour four groups of arthropod ectoparasites, viz., fleas (Siphonaptera), lice (Phthiraptera), mites and ticks (Acarina). The fleas and lice are true insects (HEXAPODA), while mites and ticks belong to the class ARACHNIDA and can be conveniently separated by the following characters: —

Key to Rat-Infesting Arthropods

1. (4) With one pair of antennae, which may sometimes be concealed in antennal grooves or furrows; always with six legs in adult... Insecta (Hexapoda).

2. (3) Body strongly compressed; antennae short, reposed in antennal furrows; mouth-parts well-developed, modified into long piercing and sucking organs; legs adopted for jumping; Fleas Siphonoptera.

3. (2) Body dorso-ventrally pressed (depressed); antennae exposed, distinctly visible, mouth-parts embedded in the head; legs short, modified for clinging; lice Anoplura (Phthiraptera).

4. (1) Antennae wanting, adults with four pairs of legs. Abdomen lacks distinct segmentation, though annulation suggesting segmentation present; deep constriction between cephalothorax and abdomen wanting, rather typically fused to give sac-like appearance... Acarina.

5. (6) Trachae either absent or not opening upon lateral stigmal plates... Prostigmata, Heterostigmata, Astigmata.

6. (5) With distinct spiracular stigmal plates, one on each side of the body, little behind or just above the III or IV coxae... Mesostigmata.

7. (8) Hypostome small, without recurved teeth below; ventrum without furrows, body with conspicuous shields, no posterior marginal festoons... Parasitoidea.

8. (7) Hypostome large, furnished below with a number of recurved teeth, ventrum with furrows, skin leathery. Ticks Ixodoidea.

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The Fleas

The fleas are highly sclerotised, small, brownish, wingless insects, with laterally compressed bodies and long, jumping legs. The body covering is hard and shiny, furnished with numerous, backwardly directed hairs and short, stout spines often arranged to form combs. Antennae small, partially concealed in antennal grooves, situated behind the eyes. Mouth-parts are located at ventrofrontal margin of head, and consist of three stylets lying between the maxillary lobes, and are practically concealed by the labial palp. The stylets are piercing organs, modified for outflow of saliva and sucking of vital fluids of the host. Maxillary palpis present, 4 segmented.

All adult fleas—both males and females—are external parasites of warm-blooded animals and feed upon blood. They are usually specific, but not absolutely so. Adult fleas may live up to 38-127 days without food and up to about 100-513 days when fed on the host.

During early summer, the fleas deposit large number of eggs on their host (448 eggs over a period of 196 days), which later on drop off to the ground or into the nest or bedding or into debris of various kinds. They hatch in 2-12 days depending upon moisture and temperature conditions prevailing.

The larvae are blind, legless, minute whitish, slender and cylindrical worm-like creatures. The head is well developed. They are frequently found in the crevices of the floor, under the carpet or matting, also in stables, coops, kennels, nests of rodents, etc. They feed on organic matter available in dust and dirt around the nest. The newly hatched larvae may subsist wholly on the bodies of the adult fleas. The larval periods depending upon favourable conditions of food, temperature and humidity, varies from 7-200 days. When full growth has been achieved, the larva spins tiny, loosely woven whitish cocoon and transforms into a quiescent pupa. The pupal stage lasts for about 7 days to nearly a year. Usually about the middle of the summer season, large number of the second generation appears.

Under optimum conditions, the life cycle is completed in 18 days to many months. The duration of egg, larval and pupal stages in 2-12, 7-34, 7-50 days respectively. A newly hatched larva provided the conditions are not otherwise unfavourable, is able to live for several days to more than a month without food.

ECONOMIC IMPORTANCE

The fleas affect human welfare in three ways: (1) during the act of biting, they inject salivary secretion and cause considerable annoyance, irritation and incessant itching; (2) they are intermediate hosts of certain tape-worms, viz., dog tape-worm *Dipylidium caninum*, rodent tape-worm *Hymenolepis diminuta* and transmit these to man; and (3) they are important vectors of fatal diseases, viz., bubonic plague and Murine typhus fever.

FLEAS OF RATS

The domestic rats serve hosts to several species of fleas, the vast majority of which belong to the family Pulicidae. The following species are of common occurrence but not of great preponderance: Oriental Rat Flea *Xenopsylla cheopis* (Roth.), *X. brasiliensis* (Baker), *X. astia* Roth., Cat Flea—*Ctenocephalides felis* (Bouche), Dog Flea—*C. canis* (Curt.), Human Flea—*Pulex irritans* (Linn.), Strickland Flea *Echinophaga gallinacea* Olliff. *Ceratophyllus* sp., *Leptopsylla* sp. Some of these species are easily infected with murine typhus and bubonic plague and, therefore, are of public health importance.

CONTROL OF FLEAS

Fleas in houses originate in sleeping places of animals, hunting and breeding places of rats. Spraying the infected areas with D.D.T. or creosote oil give good results. D.D.T. may be applied as a 5-per cent solution in kerosene or fuel oil, as a 5-per cent emulsion in water, or as a 2-5 per cent suspension in water. A 10-per cent D.D.T. dust on the floor, cracks and crevices, the rat-run-ways and other places where female rats are suspected to breed, will give good results.

The Lice

Lice are small, flattened, wingless insects with soft, pliable bodies. The
rat-lice are about 1.5 or less cm. long, the legs are short, with apically broad tibia and single claw. Mouth-parts are normally retracted into the head and adopted for piercing and sucking blood.

The nits are attached to the hairs of the host. In a few days they hatch into small, parent-like, active nymphs. The nymphs moult three times before reaching maturity. The life cycle may be completed in 14–21 days.

ECONOMIC IMPORTANCE

The lice are permanent parasites and depend upon the host during the entire life-cycle. The rat lice are most likely natural vectors of typhus from rat to rat. Infection occurs through the bite of infective lice or through such lice crushed upon excoriated skin. Since these lice do not feed upon man, their importance in transmission of the diseases from rat to man is as yet doubtful.

The following species have so far been described from rats. These are of very common occurrence. As many as 2,452 adults and nymphs of one species are known to have been once collected from one rat. Most familiar species are: Hoplopleura acanthopus (ex Mus musculus), H. hesperomydis (ex M. musculus), H. oenonymis (ex Ceylon rat), H. pecifica (ex Rottus ratus), Polyplax asiatica (ex Bandicota malabarica). P. spinulosa (ex R. rattus) and P. stephensi (Nesokia indica).

CONTROL OF LICE

A 10-per cent D.D.T. dust on the rat-run-ways will effectively control these pests.

The Mites

The mites are small and often of microscopic size. The large mite-Trombidiidae sp. (birbhoi) commonly seen in the fields are exceptions and are well above average size for mites.

The mites are characterised by having eight legs in adult and post larval stages and six legs in larval stages. The body is depressed, unsegmented, without distinction between head, thorax and abdomen. The mouth-parts are borne on a false-head called capitulum and consist of a pair of needle-like piercing stylets called chelicerae and a pair of movable palpi.

Mites exhibit a wide range in feeding habits. Many are free living, feeding on plant juices, others are scavengers and living on dead and decayed matter of animal and vegetable origin; still others are predators and parasitic, attacking other mites, insects and higher animals. Of the many parasitic forms several are worst enemies of man. According to their habits in relation to man they can be conveniently divided into: Parasitic mites which remain on the host after feeding (Itch mite), Semiparasitic mites which are parasitic only during part of their life (chiggers), Occasionally parasitic: these are not true parasites of man but may infest occasionally persons handling dried fruits and other products (grocer’s itch).

Domestic rats have been recorded to be attacked by about twenty different species of mites. Most of the mites move freely from one host to another and readily attack man. Some of them are of interest, because they are vectors of human rickettsial diseases. The symptoms, severe itching and severe inflammation following an attack by mites, vary greatly. Some get considerable annoyance, irritation and incessant itching and intense prurience or unsatisfied desire for scratching and general lowering of morale. This is probably due to nervous condition of the victim and acute feeling towards the pest.

Liponyssus bacoti (Hirts), Trombicula deliensis (Walcher), Gahlrieia homunguis (Abdusalam), Laelaps nattali (Hirst), Echinolaelaps echidinus (Berlese), Hamogamas sp. and Alloendymyssus sp. are commonly collected from Rattus rattus Linn. The existence of suitable hiding and nesting places for the rats is a great contributing factor in mite annoyance.

CONTROL

A frequent use of fresh pyrethrum dust gives good relief. Spraying with nicotine sulphate, at the rate of 3 tablespoonful in one gallon of water to which one inch cube of soap is added, is old and well-established remedy. Application of
lime-sulphur wash to rat-run-ways and burrows is highly effective. Arachnids are especially sensitive to sulphur dioxide. Burning of sulphur, therefore, is universally suggested for heavily invaded houses. Sulphur dioxide has a corrosive action on metals, bleaching effect on fabric and also involves some hazard and should always be used with proper care. Dimethyle phthalate is one of the most satisfactory repellents for mites.

It may be pointed out here that in all cases, it is essential to get at the nesting places of rats as to secure satisfactory results.

The Ticks

Ticks are closely related to the mites and are distinguished from them by large size, leathery integument and in their possession of a stigmatic plate situated just behind the posterior pair of legs, on the abdomen. They are much less common on the domestic rats, but immature stages of various ticks may sometimes be found.

The mouth-parts of ticks consist of a beak and the palpi. The hypostome, chelicerae and the mandibular sheath constitute the piercing organs. Their food consists entirely of the blood and lymph taken from the host.

The life cycle of various species of ticks differ greatly. Some are one-host-tick, others are two or three-hosts-tick and still others are many-hosts-tick. Copulation takes place in nearly all cases on the host. Fertilized females drop from their host and deposit eggs in some protected places on the ground, in cracks and crevices. Each female lays 800-12000 eggs, in several masses, over a period of 15-30 days. The eggs, depending on temperature and other factors, hatch in 20-60 days and even in 200 days in certain species. The larva attach to some suitable hosts. Larvae of some species drop off after each meal for each molting while others remain on the host until they have reached the adult stage and mated. The immature stages last for 40-165 days. The larval ticks are capable of withstanding long periods of starvation. The young tick can survive for 5-15 months and the adults can live without food for over 2-3 years. The development from hatching to egg laying adult varies from one to nine months with an average of 5½ months.

ECONOMIC IMPORTANCE

There are possibly no species of ticks, which are primarily restricted to man. But a large number of species, however, use man intermittently as host. Tick-bites, at times, produce rather serious effects. In some instances, especially when the base of the skull or spine is attacked, an acute intoxication is accompanied by a rapid motor paralysis. Ticks are also vectors or intermediate hosts of pathogenic organisms. Relapsing fever of man, rocky mountain spotted fever, are distinctly known to be transmitted to man by ticks. The possibility that ticks might serve as a vector of murine typhus fever was suggested by Maxcy in 1929.

CONTROL

A spray containing one part of 40 p.c. nicotine sulphate in 200 parts of water will reduce tick menace. Dusting the premises with 10 p.c. D.D.T. powder or spraying with 5 p.c. D.D.T. solution will give good results. Under bush, weeds and grass should be cut close to the ground.

Interrelation of Rats, Ectoparasites and Diseases.

Observations in countries where murine typhus is endemic, have shown that 35-51 per cent of the domestic rats contain typhus compliment fixing antibodies. The difference in seasonal abundance of various ectoparasites are such that there is considerable overlapping and at no time does the number of ectoparasite reach the vanishing point. There is no consistent difference between the number of parasites found on immature and adult hosts. The experts are of the opinion that the maintenance of the disease obviously depends primarily on the frequency of contact among vermins and the ectoparasites. The frequency of the disease in the human cases is directly proportionate to the population of the rats and upon the parasite on each rat. The increase of the parasite is about two months.
before the maximum number of typhus cases in human beings are recorded. These observations are important in enzootic studies.

**General Control Programme**

The control of rat-ectoparasites is a temporary measure for the prevention and control of certain rat-borne-diseases. Essentially the eradication and control of the rat themselves is the only effective method in the abatement of the parasites and the diseases they transmit. However, it has been observed, that with the elimination of murine hosts, the ectoparasites become more annoying to man. Therefore, to speed up the control, to increase its effectiveness and to have real relief the control, both of the ectoparasites and the hosts is essential and suggested here.

**CONTROL OF HOST**

Rats and mice cause tremendous damage and distress to mankind. Rats are the most formidable and most widely distributed type of rodents which are destroyers of our food. They invade houses, stores, warehouses and markets and besides destroying fabrics and leather goods, they attack all kinds of food-cereals, animals, groceries, fruits, vegetables, etc. Its ruthless activities do great damage to the foundation of buildings. Everywhere it destroys ceaselessly and yet we tolerate its presence. Every means that human ingenuity can devise should be used to combat these adaptable, hardy and prolific pests.

(1) **Exclusion** is the proper solution to the rat problem and gives somewhat permanent relief. Concrete floors, foundation carried well down into the ground, screening of all ventilators, cementing in or sheathing with metal all pipes or electric conduits which enter buildings and provision of tight fitting of all doors and windows accomplish major step in the control of the vermin. Civic authorities should adopt and enforce sanitary conditions in towns and cities. Cleanliness and prevention of the accumulation of refuse and garbage are essential in eradication of rats. Immediate incineration of garbage prevents increase of rats. Household supplies of food should be kept in covered containers of metal, crockery and glass. The principle is to starve out, and afford no harbour and shelter for rats in the house.

(2) **Trapping** : Experience has shown that almost any trap will catch rats. But the efficiency of cage-traps is far below that of spring traps (guillotine type). Such traps may be baited with any human food. They should be placed in locations where droppings, tracks or gnawing or food indicate the presence of the animal. Traps should always be placed with the trigger end against the wall, on beams, on pipes or other places where they are accustomed to travel. A wary rat must be made accustomed to the presence of the trap by baiting several days on unset trap.

(3) **Fumigation** : With carbon bisulphide, with compressed hydrocyanic acid gas or disks impregnated with the gas gives excellent results. Calcium cyanide dust in burrows is also effective in controlling both ectoparasites and rats. Unfortunately these methods are dangerous and can only be used in small percentage of premises and conducted only by trained personnel.

(4) **Poison baits** : Poisoning, while second to fumigation in effectiveness, is more economical and practicable method to eliminate rats. A poison bait contains a rodenticide, food and emetic. Many different materials have been used to poison the rats. Some of these are very effective raticides. Some rats are wary of taking lethal dose of the poison bait. Some of these are highly poisonous to domestic animals and man himself. The more common poisons are given below.

(i) **1080 or Sodium fluoroacetate** : It is, without exception, the most effective rodenticide, but it is among the most dangerous ones to all warm blooded animals. It is fast acting, producing symptoms of poison in about twenty minutes and killing in one-eight hours. It is only used in poisoning water at the rate of the 12 gms per gallon of water. (In every case of real or suspected poisoning—induce vomiting, put patient completely at rest and call the doctor).

(ii) **Antu or Alphanaphthylthioures** : It is safest with the exception of red squill
and most toxic excluding 1080. It is very toxic to dogs, cats and chicks. Death occurs within 48 hours. It can be used both in baits and in tracking dusts. It is safest tracking poison in dust (containing 20 parts antu, 72 parts inner powder and 8 parts D.D.T.). It is also effective in poisoned baits (2-3 per cent of antu by weight). (Antidote of this poison is not yet discovered. All precautions given under 1080 above, should be followed in every case of poisoning accident).

(iii) Zinc phosphide (Zn₃P₄) is a toxic and effective rat poison. It creates no fire hazard. A bait containing 4 parts of tartar emetic, 10 parts zinc phosphide and 986 parts of food, gives a reliable stuff to combat rats. Both its colour and odour are objectionable to man and pets and so make it safe to use. (In a case of poisoning, give one quarter gram of copper-sulphate dissolved in a glass of water, repeat after every ten minutes, until vomiting induced. A cathartic of magnesium sulphate should also be given).

(iv) Thallium sulphate (Tl₂SO₄) is highly effective and is used both in "poisoned water" and "food baits" against rats. It is a slow-acting cumulative poison and can be readily absorbed through broken skin. Its toxicity is twice that of zinc phosphide. A bait should contain 1% per cent of Thallium sulphate by weight and about half that amount of tartar emetic. It is odourless and tasteless substance and, therefore, dangerous for general purposes. (In all cases of poisoning induce vomiting, stomach lavage and cathartic administered).

(v) Red Squill powder can be used successfully with all food baits which can be ground finally and mixed thoroughly with it. About 10 per cent of squill by weight is effective. It is strongly emetic in action.

(vi) Arsenic trioxide (As₂O₃) is a finely ground or micronised substance. It can be mixed with any suitable bait in the proportion of 3 : 97 by weight. Three per cent solution of sodium arsenite is also very effective. (A freshly prepared solution of ferric-hydroxide and magnesium oxide should be given immediately after the poison has been taken and it is promptly followed by a stomach lavage and magnesium sulphate as a cathartic).

(vii) Barium carbonate is cheap, tasteless and odourless poison and is mixed with flour in the proportion of one part in 4 parts or with gram in 1 : 8.

(viii) Strychnine sulphate is a very rapid poison. Dissolve half an ounce of strychnine sulphate in a pint of boiling water, add to it one pint of thick gur syrup, stir well. Moisten flour with the syrup or soak gram overnight, place where other animals will not have access to it.

(ix) Sodium fluosilicate. Dusting the floors with silico-fluoride once a month is also efficacious in controlling the rats. This substance adheres to the rat's feet and is licked off during preening and poisons the vermin.

5. Natural Enemies of Rats. Several animals prey upon the rats and mice and hence are beneficial. These animals need protection and encouragement in every possible way. The most common enemies are cats and birds of prey.

CONTROL OF RAT-ECTOPARASITES

A mixture of 10 per cent D.D.T. and 90 per cent soap stone (Sel khari) or Pyrophyllite if applied to rat runs will be picked up on the feet, bellies and tails of the rats as they will move along the run ways, pass through holes, burrows, etc. The poison will be eventually transferred to the fur coat, as the rats habitually preen themselves, and cause death to the ectoparasites. Some of the dust will be carried to the nest and distributed over the breeding places of fleas.

Punjab is about 61,989 square miles in area. At the rate of one rat to an acre, there are about 4 crores of rats in our province. Their extreme fecundity is emphasised by a published statement that "a single pair and their progeny in five seasons would amount to nearly one million individuals." At a most conservative estimate of about rupees two for the accumulative damage to human beings each rat does in a year, Punjab is losing some eight crores of rupees through the ravages of rats alone. To check their
onward progress there is a great necessity to organise united front. The actual cost of a complete campaign will be very small when compared with the annual losses incurred by them. Neglecting a small section unattended, or not thoroughly doing the operation or leaving one house is a wrong policy. It is the real loophole, where the treatment would fail. Each gravid female, which is allowed to survive, will produce a hundred thousand many of the destroyers. For effective and economical measures, therefore, a systematic destruction of rats, whenever and wherever possible, should be launched. The organisation of rat-clubs, rat destruction weeks, etc., for systematic warfare against rats is imperative.

PRECAUTIONS

1. Always wear rubber gloves, surgical mask while compounding and distributing the poison. During an operation, totally abstain eating, drinking, smoking, etc.

2. All containers and equipment used for poison or poison-products should be very conspicuously labelled "POISON."

3. Poison and poison baits should never be left carelessly in establishments or on premises.

4. Householders and occupants of buildings, should always be advised fully as to the nature of the poison. Their permission and active cooperation should always be obtained.

5. Always use recommended amount of poison in the bait, as the higher amount will decrease acceptance by rats and increase the danger both to man and his animals.

6. It is important not to use poisons without emetics, either outdoors, residential areas or on farm.

7. Poisoned water should not be used in residences, on farm, out of doors or in business buildings where proper safety precautions are impracticable.

8. It is recommended that baits be placed where other animals will not have an access to the poison. It is always advisable to keep pets in safe places and children are looked after until the poisoned baits and dead rats are all recovered and properly disposed of. The known quantity of the baits should always be placed on the floor and accounted for on the next day.

9. Do not rely on occupants to dispose of the poisoned bait or water. Operators should consider it their sacred duty to perform all operations themselves.

10. After every operation, wash everything contaminated with poison. The hands should be washed with soap, hot water and a brush.

11. In every case of poisoning:—

(i) Empty the stomach immediately by inducing vomiting.

(ii) Keep the patient quiet, do not disturb and shock the victim.

(iii) Arrange medical aid immediately.

(iv) If possible, administer antidote with stomach lavage.

12. Collect all poisoned papers, earthenware, etc., search out all the dead rodents and bury them deep or incinerate the carcass, used cups, etc.

SUMMARY

Besides the enormous destruction of our food supplies, the domestic rats are serious menace to public health. The rat-ectoparasites have been found to transmit most devastating human diseases viz., Bubonic plague, Murine typhus, etc. Sanitation, rat proofing or rat poisoning if confined to those who complain, or who request assistance or who act voluntarily, will be a wasteful contemplation leading far from eventual success. To control rats effectively and indirectly combat rat-borne diseases, a clean-up drive, a city-wide rat-poisoning campaign or community control of ectoparasites is emphasised. To get a permanent relief from these vermins and the diseases they transmit the following must be remembered:—

(1) Proper sanitation, consisting chiefly of adequate refuse storage, its collection and disposal, is most effective for control of rats.

(2) Rat-proofing of old and new buildings by blocking off or stopping up all
actual and potential passages, assures prevention and control of rat-borne diseases.

(3) Complete elimination of rats from within rat-proofed buildings by any means of killing methods (building fumigation, spot fumigation, poison baiting, trapping) and maintaining it rat-free thereafter is essential and economical.

(4) Spectacular and consistent control of rat ectoparasites could be expected by distribution of 5-10 per cent D.D.T. dust to rat-run-ways and blowing it into rat-burrows. Mite menace could, however, be stopped by lime sulphur wash. We need to enact legislation for the compulsory eradication of the rats.

REFERENCES

With best compliments,
for criticism and favour of exchange.

From
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