

MITES OF PUBLIC HEALTH IMPORTANCE AND THEIR CONTROL

TRAINING GUIDE - INSECT CONTROL SERIES

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Public Health Service Publication No.772
Insect Control Series: Part IX
May 1963

UNITED STATES GOVERNMENT PRINTING OFFICE, WASHINGTON: 1963

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D.C. Price 25 cents

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Although mites belong to the Class Arachnida, and are not true insects, they are important vectors of some of the most significant arthropod-borne diseases and have been studied intensively by entomologists and public health workers. For this reason this Training Guide on mites has been included in the Insect Control Series.

INTRODUCTION

Most species of mites are so small that they are barely visible to the naked eye. The adults and nymphs usually have four pairs of legs, but the first stage, or larva, has only three pairs. Many species lay eggs, but some others retain the eggs within the abdomen and give birth either to six-legged larvae or eight-legged nymphs or adults. The life cycle is often short, two to three weeks, so the mites increase in numbers very quickly under favorable conditions. In dwellings they often infest foods, stuffed furniture, and mattresses, occurring literally by the thousands or millions. Some of the largest infestations in buildings result from the invasions of clover mites, or of bird or rodent mites, from out-of-doors. A number of mites discussed in this chapter are potential carriers of diseases affecting man or his domestic animals, while others may cause dermatitis and allergic reactions in men. Mites are important to man because they are associated with:

Scabies or mange-like conditions, produced primarily by mange or itch mites in the families Sarcoptidae, Psoroptidae, and Demodicidae.

Transmission of disease-causing organisms, primarily of four groups: (1) *viral diseases*,

such as encephalitis by certain bird mites; (2) *rickettsial diseases*, such as scrub typhus by chiggers in the Pacific area of the Old World, rickettsialpox by the house mouse mite and possibly murine typhus by the tropical rat mite; (3) *bacterial diseases*, such as tularemia by the tropical rat mite in the laboratory or epidemic hemorrhagic septicemia by the snake mite, and (4) *filarial disease* of the cotton rat by the tropical rat mite.

Dermatitis, caused primarily by direct attack of chiggers in the family Trombiculidae, bird and rat mites in the family Dermanyssidae, straw itch mites in the family Pyemotidae, and by contact with cheese mites in the families Acaridae and Glycyphagidae.

Annoyance and invasion of buildings, without causing dermatitis or transmitting any disease-causing agent, by the clover mite.

Infestation of the lungs, intestine, or urinary passages, as the lung mites or certain cheese mites.

Tapeworm infestations of domestic animals, as some beetle mites serve as intermediate hosts for certain tapeworms.

PUBLIC HEALTH IMPORTANCE OF MITES

SCABIES AND RELATED MANGE-LIKE DISEASES

Scabies is one of the most important disease conditions caused by mites. Scabies, which is also known as mange, itch, Norwegian itch, and craw-craw, occurs throughout the world. Sometimes the mites cause only mild infection, but often scabies causes serious skin irritations with secondary infections leading to impetigo-like conditions, or severe allergic reactions that prevent people from sleeping at night. During World War I, the U. S.

Army officially reported 32,871 cases in a total strength of about 3,700,000 men in Europe and United States between April 1, 1917 and December 31, 1919 – almost 1 percent of the total military strength with attack rates varying between 3 and 35 per 1000 per month during 1918 and 1919, highest during the first half of 1919 (Ireland, 1928). Outbreaks of scabies also occurred in World War II particularly in England and Germany, where they were associated with the extensive bombing of large cities, the destruction of homes, and the crowding together of people, particularly when two or more individuals

were forced to sleep in the same bed. For example, during the German bombing of London during 1940, when thousands of children were evacuated from London, if one of five children sleeping in the same bed had scabies, before long all became infected by simple contact. It is therefore often thought of as a family disease, such as could be contracted by children sharing the same bed.

The mites burrow under the skin leaving open sores as sources for secondary infections. The first symptoms of scabies is itching, especially at night and frequently over much of the body. Victims of attacks may become pale and haggard from loss of sleep. British workers have noted that many people suffering from scabies often itch severely over large portions of the body which contain no mites at all. Apparently the tissues in these people become sensitized to certain proteins liberated by the scabies mites of the initial infestation. When a later infestation occurs, an allergic reaction develops with intense itching, redness or rash, over much of the body, even though the actual number of mites may be only a dozen or two in small areas between the fingers. The symptoms are often obscured by scratching, secondary infections, or impetigo. Mellanby (1943) noted from a study of about a thousand cases in England that sixty percent of the mites occurred in lesions on the hands or wrists, particularly in the webbing between the fingers or the folds of the wrists. Apparently touching or shaking the hand of infected people is the primary method of transmission of the mites. Mellanby noted that the remaining forty percent of the mites occurred in lesions scattered over the body with approximately ten percent on the elbows, ten percent on the feet or ankles, and ten percent on the buttock and genital area. Lesions were rarely found on the neck or head.

Itch mites on domestic animals are almost indistinguishable from human *Sarcoptes* although Hirst (1922) has described and figured minute differences for specimens occurring on dogs, cats, horses, and camels. Cases of mange in humans which probably originated from animal infections are usually short-lived. All the forms of *Sarcoptes* occurring on man are usually considered biological races of one species *Sarcoptes scabiei*, e.g., *Sarcoptes scabiei equi* of horses occasionally found on grooms and veterinarians.

The itch and mange mites which burrow in the skin belong in the genera *Sarcoptes* and *Notoedres*,

N. cati causing a severe, sometimes fatal, infection in cats. *Demodex*, the hair follicle or face mite (family Demodicidae), is a cigar-shaped mite living in the hair follicles beneath the surface of the skin. Although this species is usually harmless in man, in dogs and other domestic animals demodectic mange may be very severe and even cause death. Another mite, *Dermatophagoides scheremetewskyi* (family Epidermoptidae), causes mange-like symptoms. According to Traver (1951), it differs from *Sarcoptes* in burrowing under skin on the head as well as other parts of the body.

Most of the other genera of itch mites in the family Psoroptidae may be lumped together as "scab mites". These do not burrow into the skin, but remain on the surface, often causing such irritation that a many-layered scab is produced, with tremendous numbers of the mites living between the scab and the tissue. *Psoroptes* causes sheep scab, Texas itch of cattle, and mange in horses and dogs. One type *Psoroptes cuniculi*, causes extensive scab formation in the ears of laboratory rabbits. *Chorioptes* and *Otodectes* produce similar diseases in horses, sheep, and cattle.

CHIGGERS, SCRUB TYPHUS, AND HEMORRHAGIC FEVER

From the viewpoint of disease transmission, chiggers are probably the most important group of mites because they transmit the rickettsiae causing scrub typhus, also known as tsutsugamushi disease, Japanese river bottom fever, or Mossman fever. Fortunately this disease is not found in the United States. However, it has been a disease of importance to Americans because beginning in World War II members of the U. S. Armed Forces have been stationed in the Orient where the disease occurs from India, through Southeastern Asia to Japan and Korea. Scrub typhus is a rickettsial disease causing a definite rash, transmitted by several species of chiggers, particularly *Trombicula akamushi* and the same or a closely related species listed in the literature as *T. deliensis*. Philip (1948) has written that in World War II there were more cases of scrub typhus (almost 18,000 cases in Allied Forces) than there were of epidemic typhus (sixty-four cases in U. S. Army). In the Pacific area scrub typhus caused more trouble than any other arthropod-borne disease except malaria.

Human infections were most frequently contracted in particular "scrub typhus areas" such as the tall kunai grass fields in New Guinea; neglected coconut plantations and native village sites in New Guinea; abandoned fields and clearings in the Philippines, Burma, and India; food and ammunition dumps along the Stilwell Road in Assam; or localized areas along river bottoms in Japan and Korea — all areas where various species of rats (*Rattus*) and field mice (*Microtus*) were abundant, leading to high populations of infected chiggers. Maximum risk was usually encountered during the first week or two of a beach landing, or an occupation of a particular site, with progressive decline thereafter due to the "civilizing" factors on the camp site which decreased the number of rodents and rendered local conditions unfavorable for activity and survival of vector mites. The rickettsiae causing the disease are transmitted transovarially from infected parents through the egg to the larva or "chigger" stage which feeds on rodents and man. The mortality in humans varied from three to fifty percent — pronounced differences in the virulence of strains of the rickettsiae being observed in areas only a few miles apart.

Chiggers are also suspected on epidemiological grounds of transmitting epidemic hemorrhagic fever (Traub *et al.*, 1954). This is a disease, probably caused by a virus, that American troops encountered in Korea which also occurs in Siberia and Manchuria. It causes fever, kidney damage, etc. and is fatal in about five percent of the cases. Although laboratory and field work were not able to demonstrate the etiological agent, a better correlation could be shown between the two peaks in incidence of the disease and the bimodal curve in population of chiggers than any other arthropods in the Korean area.

THE HOUSE MOUSE MITE AND RICKETTSIALPOX

In 1946 an outbreak of "atypical chicken pox" in adults in New York City led to the discovery of a previously unknown rickettsial disease which was named rickettsialpox. Investigations by Huebner, Jellison, and Pomerantz (1946) showed that the causative agent (*Rickettsia akari*) was transmitted to man by the house mouse mite (*Dermanyssus sanguineus*) from house mice which acted as the reservoir of the disease. Basically, the out-

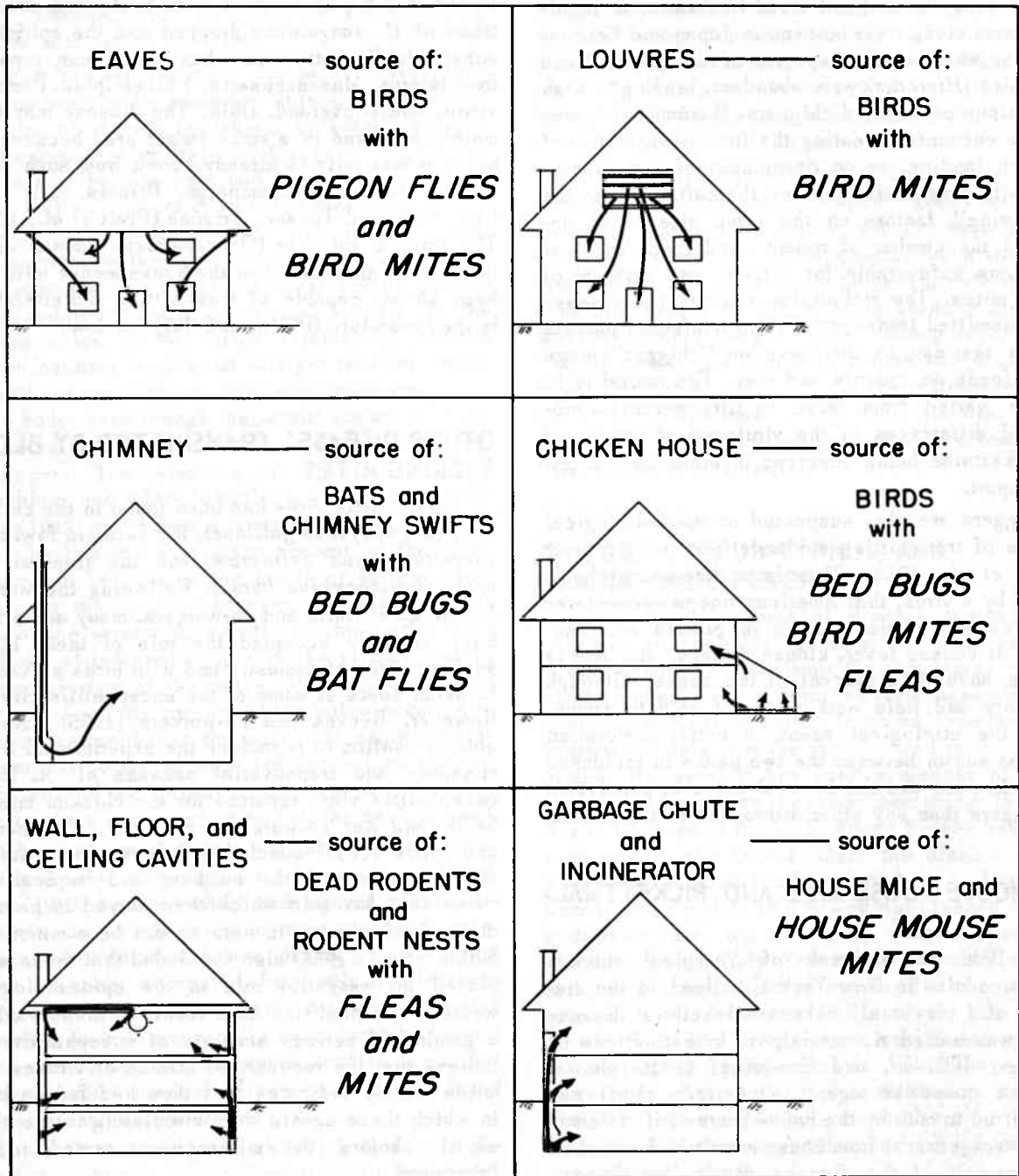
breaks of rickettsialpox in New York and West Hartford, Connecticut reported by Nichols, *et al.*, (1953) were the result of incomplete burning of garbage in basement incinerators and an overabundance of house mice feeding on unburned food scraps. (Plate 9.1). When proper methods of garbage disposal were enforced, and the house mice were controlled, infestations of *D. sanguineus* dropped and the epidemics subsided. Rickettsialpox has also been reported from Boston, Massachusetts, Philadelphia, Pennsylvania, and Cleveland, Ohio. The disease may ultimately be found in a much larger area because the house mouse mite is already known from such western localities as Champaign, Illinois, Salt Lake City, Utah, and Tucson, Arizona (Pratt *et al.*, 1949). The tropical rat mite (*Ornithonyssus bacoti*) which is far more abundant than the house mouse mite has been shown capable of transmitting rickettsialpox in the laboratory (Philip and Hughes, 1948).

OTHER DISEASES TRANSMITTED BY BLOOD-SUCKING MITES

Encephalitis virus has been found in the chicken mite (*Dermanyssus gallinae*), the northern fowl mites (*Nornithonyssus sylviarum*) and the tropical fowl mite (*Ornithonyssus bursa*). Following the work of Dr. Margaret Smith and co-workers, many authorities have virtually accepted the role of these blood-sucking mites of domestic and wild birds as vectors to avian hosts of some of the encephalitis viruses. However, Reeves and co-workers (1955) were unable to confirm or reproduce the experimental transmissions and transovarial passage of St. Louis encephalitis virus reported for the chicken mite by Smith and her co-workers. Similarly, Chamberlain and Sikes (1955) concluded from studies with the chicken mite and the northern and tropical fowl mites that any role which they played in perpetuating these viruses in nature must be a minor one. Sulkin *et al.*, (1955) also concluded that these mites played no essential role in the epidemiology of western encephalitis. As a result of these studies, a number of serious students of encephalitis now believe that the recovery of strains of viruses from mites merely indicates that they had fed on birds in which these agents were circulating in the blood shortly before the mites were tested in the laboratory.

PLATE 9.1

COMMON SOURCES OF BIRD, BAT, AND
RODENT ECTOPARASITES ANNOYING TO MAN



The tropical rat mite (*Ornithonyssus bacoti*) has not yet been demonstrated to be an important vector of human pathogens in nature. Schwab *et al.*, (1952) studied this species as a possible experimental vector of Coxsackie virus, but obtained no conclusive evidence that it played an important role in transmitting this agent. In the early 1930's Dove and Shelmire reported that the tropical rat mite transmitted the rickettsiae causing murine typhus. Later experimental work has not confirmed this or shown that these mites are important transmitters of the disease to man. Hopla (1951) was able to show transmission of tularemia bacteria under experimental conditions by this mite. The tropical rat mite has also been reared by the millions in the laboratory as an intermediate host of the cotton rat filarial worm (*Litomosoides*) on which new drugs for treatment of human filariasis could be tested initially.

Camín (1948) showed that the snake mite (*Ophionyssus natricis*) was probably an important mechanical vector of the bacteria (*Proteus hydrophilus*) which cause a severe and often fatal septicemia in snakes in zoos, circuses, and laboratories.

DERMATITIS

Skin irritations, or dermatitis, are caused by a number of types of mites, primarily chiggers, rodent and bird mites, straw itch mites, and grain or cheese mites. Probably no creature on earth can cause more torment for its size than the chigger or redbug. These are found throughout the tropics and subtropics. In the United States they are common in the southern half, in the Mississippi Valley, and in the Central Valley of California, but are rare in the Northeast. They are most abundant in wooded areas, swamps, roadsides, and particularly where food and shelter for wild rodents and birds are found such as patches of raspberries or blackberries. The chiggers attach especially in areas where the clothing fits tightly, such as the tops of the stockings, the waist area where belts or underwear are fastened or the armpit area. Chiggers do not feed on blood, although their red color when engorged gives that impression, hence the common name "redbug". Chiggers inject saliva into the host tissue, forming a stylostome, or feeding tube, from the reaction of the saliva and the insoluble flesh. This feeding tube is filled with semidigested tissue debris which the mite sucks up as food. In some specimens the stylostome may be twice the length of the engorged

chigger. Severe chigger attacks can itch and be as serious as acute cases of poison ivy or sumac.

Bird and rodent mites also cause irritation and annoyance. The chicken mites feed commonly on people who work in chicken houses and live poultry markets. They also may swarm from pigeon, starling, and English sparrow nests in the eaves or attics (sometimes accompanied by the northern and tropical fowl mites) along the outside of buildings and crawl through doors or windows, or through openings into the upper portions of the building, and bite people (Plate 9.1). The tropical rat mite (*Ornithonyssus bacoti*) may likewise bite humans and become a pest.

Typically, though not always, people are bitten when the normal host, the rat, is not available to the mites. Frequently such attacks are associated with (1) death of the rat as the result of trapping, poisoning, or disease; (2) the destruction of rat harborage; or (3) building rats out of premises by rat stoppage.

The straw itch mite, *Pyemotes* (formerly *Pediculoides*) *ventricosus*, is normally a parasite of the larvae of a number of borers, such as the Anguimoid grain moth and the wheat jointworm. Outbreaks are usually associated with infested straw and are most common in the midwestern United States. Two of the largest outbreaks occurred at the State fairs in Indianapolis, Indiana, among farmers, visitors, and attendants, particularly 4-H students with show animals bedded on infested straw. Over 1,100 people were treated in the dispensary for fever, irritation, and secondary bacterial infections. In three Indiana strawboard factories approximately 120 men were affected by grain itch mites migrating from infested straw to the more succulent human beings, (Booth and Jones, 1952), some of them with 200 to 300 bites per person.

The grain and cheese mites are frequently found in tremendous numbers in flour, grain, dried fruits, and cheese, particularly when humidity and temperatures are high. Some of them are comparatively unimportant except that they are liable to cause dermatitis to people handling the infested foods. These skin irritations have been given specific names in particular industries: "Vanillism" among vanilla workers who come in contact with heavy infestations of mites (*Acarus siro*) on vanilla pods and beans; "copra itch" among workers in copra mills due to attacks of *Tyrophagus castellani*; "Grocer's itch"

due to bites of *Glycyphagus domesticus* which is very common on dried fruits.

INVASION OF BUILDINGS AND ANNOYANCE

Many species of mites invade houses and are annoying simply by their presence, without biting man or transmitting diseases. The clover mites (*Bryobia praetiosa*) frequently infest houses in great numbers and are of concern to householders, particularly in the northern half of United States. They do not bite man, transmit diseases, or damage household furnishings or foodstuffs, but their presence is disturbing. They commonly swarm by the thousands over outer walls of buildings, particularly those with a sunny exposure, and make their way indoors through cracks and crevices about doors, windows, foundations, and elsewhere. They apparently swarm into houses in the fall, seeking a place to hibernate like the box elder bugs or cluster flies, and become active again the following spring seeking a way out of the house back to growing plants on which they feed. Most of the complaints come from new residential areas with well-fertilized lawns, shrubbery next to the buildings, where the mites have opportunity to build up large populations which can migrate into homes as cold weather approaches. Usually householders report myriads of "tiny bugs" literally coating the walls as they attempt to swarm into or out of a home. In addition, when crushed on linens, curtains, walls, or woodwork, they produce a reddish stain.

MITE INFESTATIONS OF INTERNAL ORGANS

A number of mites are obligate parasites which live in the respiratory tract of common laboratory animals such as dogs, monkeys, and birds. *Pneumonyssoides caninum* has been found in the sinuses and nasal passages of dogs and *Pneumonyssus simicola*, in the lungs of a high percentage of rhesus monkeys used in laboratory research. The canary mite (*Sternostoma tracheacolum*) has been found in the trachea and air sacs of canaries. Other species of nasal mites in the family Rhinosyssidae are found in the sinuses of many species of wild and

domestic birds. Related species of these mites have been found in the lungs of snakes and seals.

There are a number of reports in the literature of mite infestations of the alimentary canal and urinary passages. Laboratory workers at the Communicable Disease Center have examined fecal and urine samples in which mites were found. Most of the mites in the fecal samples examined have been common grain and cheese mites in the families Acaridae, Glycyphagidae, and Tarsonemidae, which also infest vegetable products and could have been ingested with food. In some of the fecal samples, and in most of the urine samples examined, it seems likely that the mites observed were really contaminants from packing in the containers after they were unpacked. Chandler (1955) does mention one source of mites, however, a famous German cheese, Altenburger "milbenkäse" that owes its sharp flavor to the presence of myriads of acarid mites. The ingestion of this cheese with its thousands of mites and their excretions may cause gastrointestinal disturbances when the cheese is eaten for the first time. Under most conditions there is no good evidence that ordinary contamination of human food with mites leads to gastrointestinal disturbances, and there is little reason to believe that mites ever become established in the alimentary canal.

MITES AS INTERMEDIATE HOSTS OF TAPEWORMS

According to the review of Allred (1954), some forty species of beetle mites in the grouping Oribatei and *Glycyphagus domesticus* serve as intermediate hosts of at least thirteen species of tapeworms. One of these, *Bertiella studeri*, has been reported only eleven or twelve times from man. A well-known tapeworm of sheep, goats, and cattle, *Moniezia expansa*, has oribatid mites as an intermediate host. The eggs of the tapeworms are ingested by the mites in which the parasites develop to the infective cysticeroid stage in several months. Herbivorous animals feeding on vegetation on which infested mites are crawling easily acquire the infestation, and the tapeworms develop to the adult stage in a period of several weeks.

MITE CHARACTERISTICS AND SYSTEMATIC POSITION

Mites are members of the Class Arachnida which includes other important arthropods such as scorpions, whip scorpions, spiders, harvestman, and ticks. These differ from true insects in having four pairs of legs in typical adult specimens, and in lacking antennae.

The mites and ticks are classified in the order Acarina which differs from other arachnids in having the head, thorax and abdomen fused into one body region. Within the order Acarina the mites and ticks may be separated by many characters listed in the following table:

COMPARISON OF IMPORTANT CHARACTERS DIFFERENTIATING TICKS FROM MITES

Tick	Mite
Size usually larger (usually 1/8 inch (3 mm.) or more)	Size usually smaller (usually 1/8 inch (3 mm.) or less)
Few short body hairs	Many long body hairs in many species
Toothed hypostome in some stage of life history, usually in adults	Hypostome without teeth
Haller's organ (a large sensory pore) on first tarsus	Haller's organ absent
Body texture leathery	Body texture often membranous or heavily sclerotized

ORDER: ACARINA

Baker and Wharton (1952) divide the Order Acarina into five suborders, the first of which, the Suborder Onychopalpida, is rare in the United States. The other four suborders are briefly characterized as follows, with a few of the most important species listed for each:

SUBORDERS

Mesostigmata

Mites with a single pair of spiracles lateral to the legs, usually associated with an elongated tube or peritreme, or if absent, highly specialized parasites of the respiratory tract of vertebrates. Haller's

organ absent on first tarsus. Hypostome not developed for piercing. Representatives include such species as:

House mouse mite	<i>Dermanyssus sanguineus</i>
Chicken mite	<i>Dermanyssus gallinae</i>
Tropical rat mite	<i>Ornithonyssus bacoti</i>
Tropical fowl mite	<i>Ornithonyssus bursa</i>
Northern fowl mite	<i>Ornithonyssus sylviarum</i>

Ixodides

Hard and soft ticks in the families Ixodidae and Argasidae. With a pair of spiracles posterior or lateral to the third or fourth coxae, located in a stigmal or spiracular plate, without an elongated tube. Haller's organ present on the first tarsus. Hypostome modified as a piercing organ. For discussion of ticks, see Chapter X of this Insect Training Manual.

Trombidiformes

Mites with a pair of spiracles on or near the gnathosoma, or "head region". Palpi usually free and highly developed. Chelicerae usually modified for piercing. Haller's organ absent. Coxae seldom forming conspicuous internal projections beneath skin. Anal suckers never present. Representatives include the following:

Chiggers	<i>Trombicula</i> and allies in family Trombiculidae
Gall mites	Family Eriophyidae
Follicle mites	<i>Demodex</i> species
Straw itch mite	<i>Pyemotes ventricosus</i> (formerly <i>Pediculoides</i>)
Water mites	Hydracarina
Spider mites	<i>Tetranychus</i> and allies
Clover mite	<i>Bryobia praetiosa</i>
Fur mites	<i>Myobia</i> , <i>Radfordia</i> and allies <i>Cheyletus</i> and allies

Sarcoptiformes

Mites without spiracles or a few with a system of tracheae opening through stigmata and porose areas on various parts of the body. Haller's organ absent. Coxae forming conspicuous internal projections beneath skin on venter of body. Mouthparts usually for chewing, with strong chelae. Pal-

pi simple. Anal suckers often present. Representatives include the following:

Mange or itch mites	<i>Sarcoptes</i> , <i>Notoedres</i> , <i>Psoroptes</i> , etc.
Cheese mites	<i>Tyrophagus</i> , <i>Caloglyphus</i> , <i>Glycyphagus</i>
Feather mites	Analgesidae
Hair mites	Listrophoridae, <i>Myocoptes</i> of mice
Oribatid mites	Oribatei and various families

MITE ANATOMY

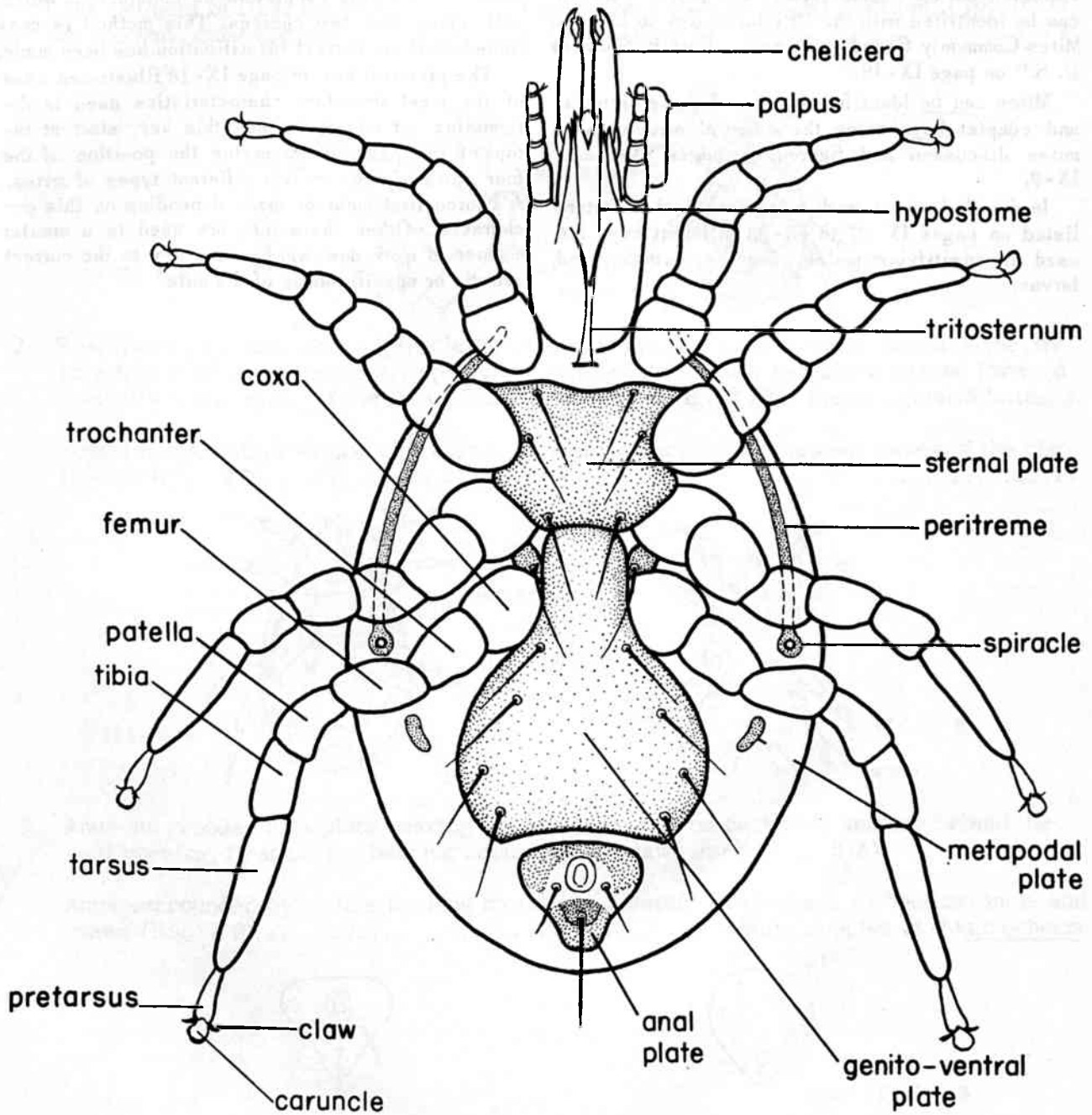
Mites differ so greatly from one another that it is impossible to write a short general description which would be generally applicable. The books by Baker and Wharton (1952) and Baker *et al.*, (1956) contain good descriptions of all types of mites, their life histories, and excellent figures. The mite life history is not strictly comparable to the basic types found in insects, i.e. insects with incomplete or complete metamorphosis. Typically, a blood-sucking mite of the mesostigmatid type (which includes parasites of vertebrates and potential or actual vectors of disease) lay eggs, which hatch into larvae that pass through two or more nymphal stages to the adult stage. The *larva* has only three pairs of legs and may be distinguished by this character from later stages with four pairs of legs. The first nymphal stage, or *protonymph*, has four pairs of legs, one or more plates on the dorsal side, and a single, short sternal plate with three pairs of setae. The second nymphal state, or *deutonymph*, has four pairs of legs, a single dorsal plate, a longer sternal plate extending at least to the fourth coxae, and four pairs of setae along the sternal plate. Most *females* of the mesostigmatid type have one or more plates on the dorsal side, and three plates of various sizes and shapes on the ventral side, known as the sternal, genito-ventral, and anal plates. *Males* of the mesostigmatid type have these three ventral plates fused into one plate known as the holo-ventral plate with the male genital opening at the anterior end, often more or less between the second pair of legs. There are many modifications and variations from this basic type, the chigger larva being highly modified, and the cheese and scabies mites, very different also.

The following brief description of a typical female rat mite, basically *Echinolelaps echidnius*, and reference to Plate 9.2, will help the student become familiar with basic morphological structures of these arthropods. The mite body is generally sac-like with no well-defined segmentation. The "head" region is known as the capitulum or gnathosome. In place of the mandibles and maxillae of true insects, the capitulum bears cutting structures known as chelicerae with two scissor-like blades called chelae. The chelae are modified in several ways and are used in biting. The structure of the chelicerae is used in identification. The chelae may have teeth as in *Laelaps*, be smooth like the blades of scissors as in *Ornithonyssus*, or be drawn out to a needle-like point as in *Dermanyssus*. The palpus may be simple or greatly modified as in *Cheyletus* with specialized hairs. Behind the capitulum in many species is a forked structure called the tritosternum.

The mite body usually bears four pairs of legs, except in the larval stage or in the adults of some gall mites. The mite leg differs from that of the true insects in having one more segment, the patella (kneecap), and in having the tarsus unsegmented in the majority of species. In many mites the tarsus bears a caruncle and two claws, but some species lack these structures, as in the first leg of *Macrocheles*. The bases of the legs, the four coxae, are inserted into cavities close to one another in the Mesostigmata (bird and rodent mites), and Ixodides (ticks). In the other two suborders, Sarcoptiformes and Trombidiformes, the first and second coxae are placed close together but are widely separated from the third and fourth coxae, as in the scabies and cheese mites.

The ventral sides of many mites bears three plates (Plate 9.2) known as the sternal plate, genito-ventral plate, and anal plate, which have various shapes and bear a variable number of setae used in classification (see the pictorial key Plate 9.3). Some species have sclerotized plates behind the fourth coxae, metapodal plates. Some species have a single dorsal plate (as *Laelaps* or *Ornithonyssus*) while others have two (*Dermanyssus*) or more. Many mites breathe directly through the skin, but others breathe through spiracles which have internal tubes of variable length known as peritremes.

PLATE 9.2
 DIAGRAM OF MITE
 (with structures labeled)



MITE IDENTIFICATION

There are thousands of species of mites in the United States. Some of the most important species affecting man and his animals can be determined with "A Key to Some Common Species of Female Acarina (Mites)", on pages IX - 11 to IX - 17. The most common species occurring on domestic rodents collected during murine typhus and plague surveys can be identified with the "Pictorial Key to Female Mites Commonly Found on Domestic Rats in Southern U. S." on page IX - 18.

Mites can be identified by use of these pictorial and couplet keys using the external structures of mites discussed and figured on pages IX-8 and IX-9.

In detailed survey work using technical literature listed on pages IX-27 to IX-28 different keys are used in identifying males, females, nymphs, and larvae.

The couplet (or dichotomous) key on pages IX-11 to IX - 17 is more typical of the usual identification keys found in reference works and scientific papers. There are couplets of statements numbered on the left margin. Starting with couplet 1 there are in each case two descriptive statements, only one of which will apply to the specimen being identified. The number on the right following the correct statement refers to the next couplet to be considered, which will again offer two choices. This method is continued until the correct identification has been made.

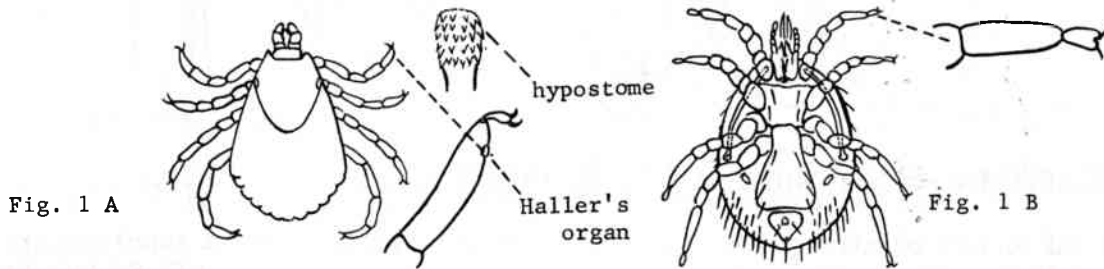
The pictorial key on page IX - 18 illustrates some of the most important characteristics used in determining rat mites. To use this key, start at the top of the page by observing the position of the four pairs of legs in two different types of mites. A choice first must be made depending on this one character. Other characters are used in a similar manner to work downward on the key to the correct generic or specific name of the mite.

ILLUSTRATED KEY TO SOME COMMON SPECIES OF FEMALE ACARINA (Mites)

Harry D. Pratt and Chester J. Stojanovich

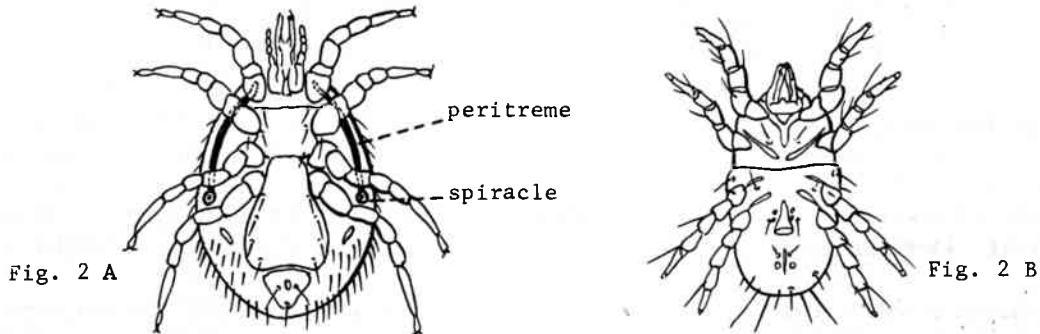
1. Last segment of first leg with a depression known as Haller's organ; most species with a toothed hypostome on capitulum; size usually over 4 mm. Ticks in the suborder Ixodides (Fig. 1 A). Chapter X of the Insect Control Training Manual.

Last segment of first leg without such a depression known as Haller's organ; hypostome not toothed; most species less than 4 mm. long (Fig. 1 B). Mites..... 2



2. Respiratory system with a spiracle on each side opening lateral to the bases of the 3rd or 4th pair of legs, frequently spiracles leading into slender tubes that extend forward laterally to the bases of the 1st or 2nd pairs of legs Fig. 2 A). Mesostigmatid Mites. 3

Respiratory system without spiracles, or with spiracles opening near bases of the chelicerae (Fig. 2 B)..... 13



3. Anus surrounded by a plate bearing only 3 setae, one on each side and one behind the anal opening; first tarsus bearing caruncle and claws at tip (Fig. 3 A)..... 4

Anus surrounded by a plate bearing more than 3 setae; first tarsus without caruncle and claws (Fig. 3 B)..... Many species of Macrocheles



4. Anal opening more than its length behind anterior margin of anal plate; chelicerae strongly narrowed apically, needle-like, movable chela absent or extremely small (Fig. 4 A). Genus Dermanyssus 5

Anal opening less than its length or about its length, behind anterior margin of anal plate; chelicerae not narrowed apically and needle-like, shear-like, bearing conspicuous shear-like chelae at tip which may or may not bear teeth (Fig. 4 B)..... 7

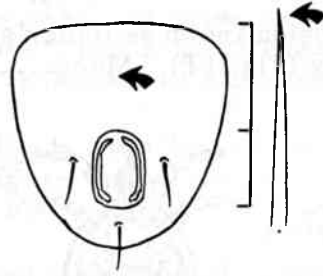


Fig. 4 A

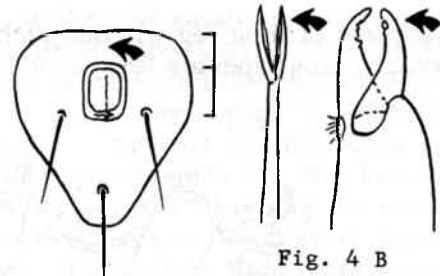


Fig. 4 B

5. Dorsal surface of body with a single plate (Fig. 5 A).....6

Dorsal surface of body with two plates, a large anterior plate and a small posterior plate (Fig. 5 B). Dermanyssus sanguineus..... HOUSE MOUSE MITE

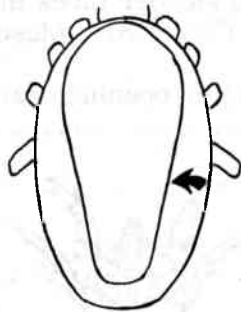


Fig. 5 A

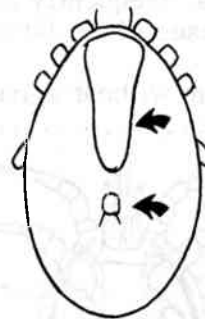


Fig. 5 B

6. Peritreme tube somewhat sinuous and extending anteriorly to a point opposite coxa 2 (Fig. 6 A). Dermanyssus gallinae..... CHICKEN MITE.

Peritreme tube short, extending forward for a distance less than half the diameter of coxa 3 (Fig. 6 B). Dermanyssus americanus..... AMERICAN BIRD MITE

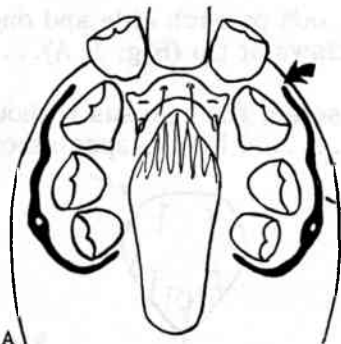


Fig. 6 A

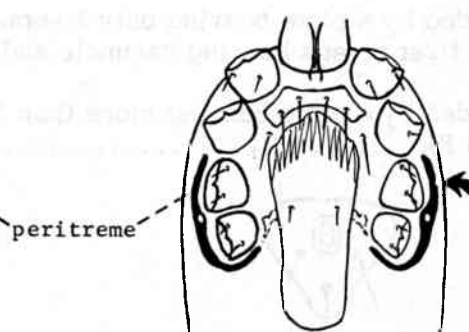


Fig. 6 B

7. Dorsal plate not covering entire dorsal surface of mite; genito-ventral plate typically narrowed posteriorly behind 4th coxae; chelae on chelicerae without teeth or setae (Fig. 7 A). Genus Ornithonyssus8

Dorsal plate almost covering entire dorsal surface of mite; genito-ventral plate typically expanded posterior to 4th coxae; one or both chelae of chelicerae with teeth and a seta (Fig. 7 B). Family Laelaptidae.....10

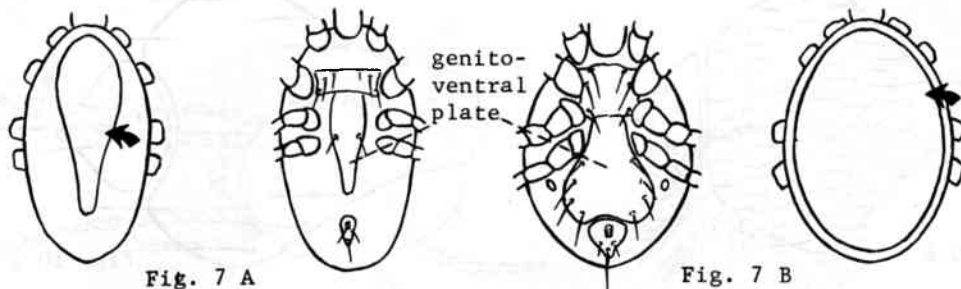


Fig. 7 A

Fig. 7 B

8. Sternal plate with anterior and middle pairs of sternal setae on the plate, posterior pair usually just off the plate (Fig. 8 A). On Birds... Ornithonyssus sylviarum.....
..... NORTHERN FOWL MITE

Sternal plate with the usual three pairs of setae on the plate (Fig. 8 B)..... 9

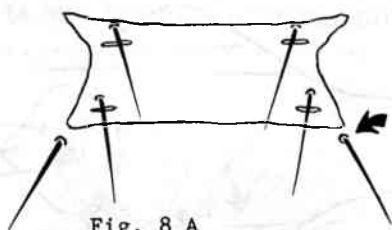


Fig. 8 A

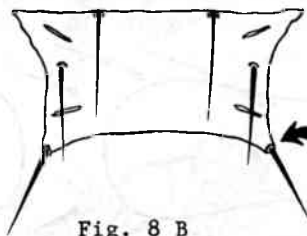


Fig. 8 B

9. Dorsal plate narrowed posteriorly; setae in middle dorsal row of plate longer than the distance between their bases (Fig. 9 A). Normally on mammals or man.....
Ornithonyssus bacoti..... TROPICAL RAT MITE

Dorsal plate broader posteriorly; setae in middle dorsal row of plate much shorter than the distance between their bases (Fig. 9 B). Normally on birds.....
Ornithonyssus bursa..... TROPICAL BIRD MITE

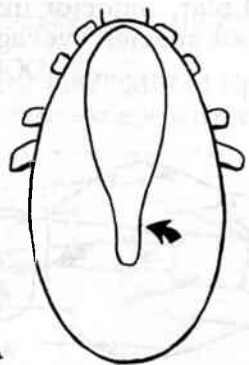


Fig. 9 A

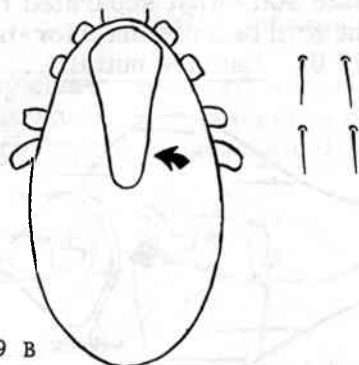


Fig. 9 B

10. Genito-ventral plate with many fine setae; anal plate transverse, wider than long (Fig. 10 A). On domestic rats and a wide variety of wild mammals..... Eulaelaps stabularis

Genito-ventral plate with one to four pairs of setae; anal plate longer than wide (Fig. 10 B).....11

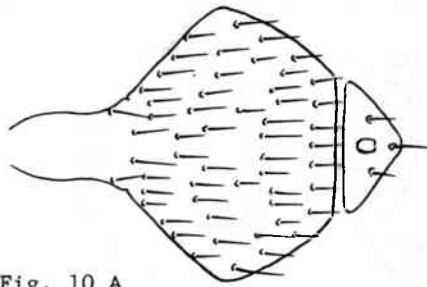


Fig. 10 A

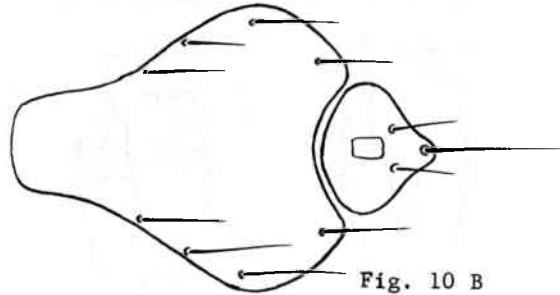


Fig. 10 B

11. Genito-ventral plate with only a single pair of setae (Fig. 11 A). On domestic rats and mice and a wide variety of mammals and birds.....
Haemolaelaps glasgowi.....COMMON RODENT MITE

Genito-ventral plate with four pairs of setae (Fig. 11 B). Normally on domestic rats..12

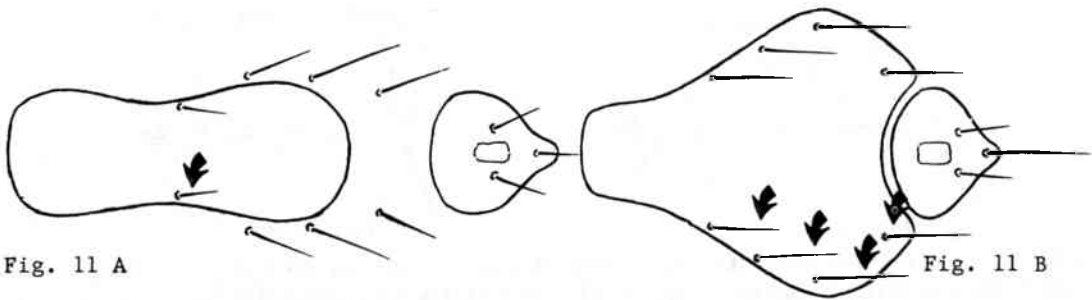


Fig. 11 A

Fig. 11 B

12. Anal plate contiguous with the genito-ventral plate, anterior margin rounded and fitting into a strong concavity in genito-ventral plate; larger species averaging 1-2 mm. long. (Fig. 12 A). Echinolaelaps echidninus.....SPINY RAT MITE

Anal plate somewhat separated from genito-ventral plat, anterior margin almost straight with definite anterior-lateral corners; small species averaging 0.5-1 mm long (Fig. 12 B). Laelaps nuttalli.....DOMESTIC RAT MITE

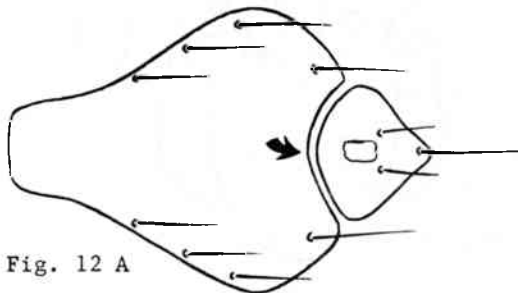


Fig. 12 A

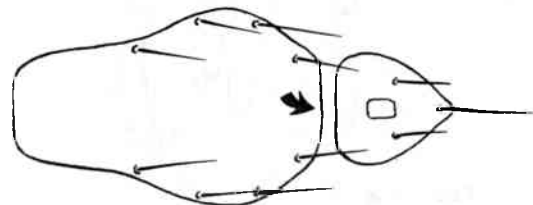


Fig. 12 B

13. First pair of legs very long, much longer than other three pairs; anterior margin of body with four distinct flattened scales and somewhat flattened scales on other dorsal surfaces of body (Fig. 13 A). Plant feeders which invade buildings but do not bite man. Bryobia praetiosa..... CLOVER MITE

First pair of legs not markedly longer than the other three pairs of legs; no flattened scales on body (Fig. 13 B)..... 14

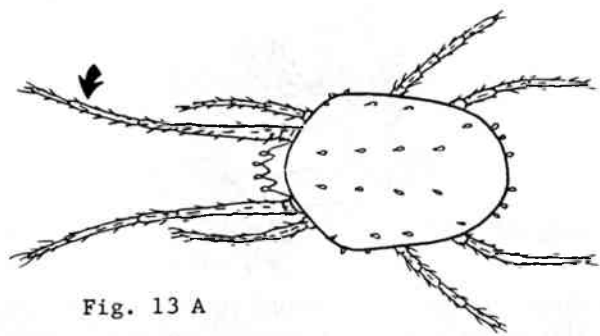


Fig. 13 A

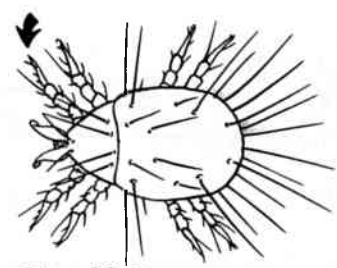


Fig. 13 B

14. Surface of body without fine parallel lines or folds; tarsi without stalked suckers (Fig. 14 A). Adults never true parasites (Cheese or Flour mites)..... 15

Surface of body with fine parallel lines or folds; tarsi often provided with stalked suckers (Fig. 14 B). Scabies or mange mites parasitic in all stages, chiefly on vertebrates 16

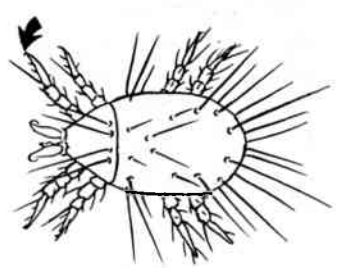


Fig. 14 A

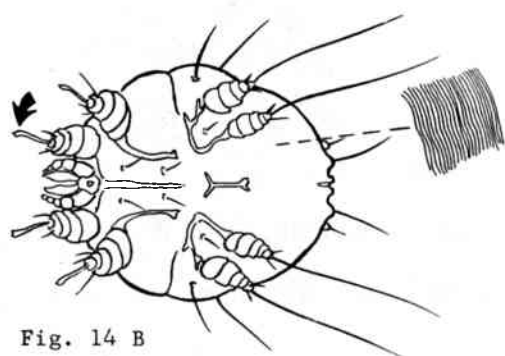


Fig. 14 B

15. Tarsi tapering markedly to tip (Fig. 15 A)..... Glycyphagus prunorum

Tarsi not tapering markedly to tip (Fig. 15 B). Many cheese and flour mites which are difficult to separate except with very specialized literature and a reference collection. Genus Tyrophagus, Genus Caloglyphus, Etc.

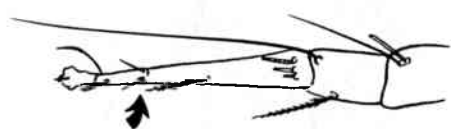


Fig. 15 A

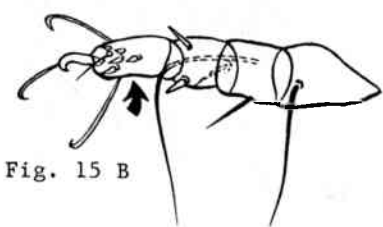


Fig. 15 B

16. Body elongate, somewhat cigar-shaped and prolonged behind; the abdomen somewhat ringed; legs very short, apparently three-segmented; tiny species less than 1 mm. (Fig. 16 A). In hair follicles or sebaceous glands of mammals.....
Demodex folliculorum..... PORE OR FOLLICLE MITE

Body not prolonged behind and cigar-shaped (Fig. 16 B). Occasionally female grain itch somewhat balloon-shaped; larger species not found in hair follicle or sebaceous glands of mammals..... 17

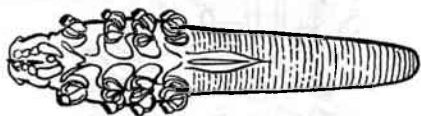


Fig. 16 A

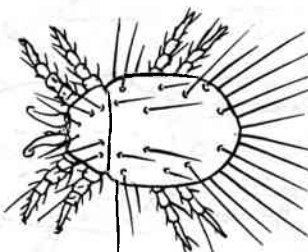


Fig. 16 B

17. A club-shaped or clavate hair between bases of first and second pairs of legs, body divided into cephalothorax and abdomen, the latter often enormously enlarged (Fig. 17 A)
Pyemotes ventricosus formerly Pediculoides ventricosus..... STRAW ITCH MITE

Setae on cephalothorax normal, no club-shaped or clavate hair between bases of first and second pairs of legs; no distinct division into cephalothorax and abdomen (Fig. 17 B)
18

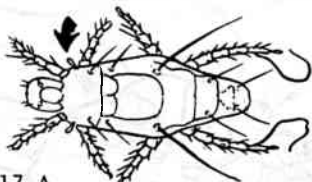


Fig. 17 A

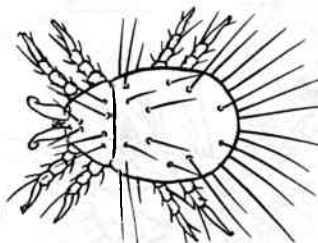


Fig. 17 B

18. Legs short and stubby (Fig. 18 A).....20
 Legs longer and more slender (Fig. 18 B).....19

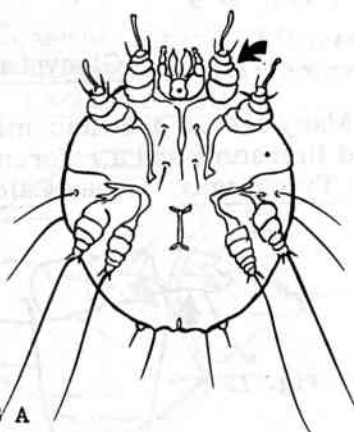


Fig. 18 A

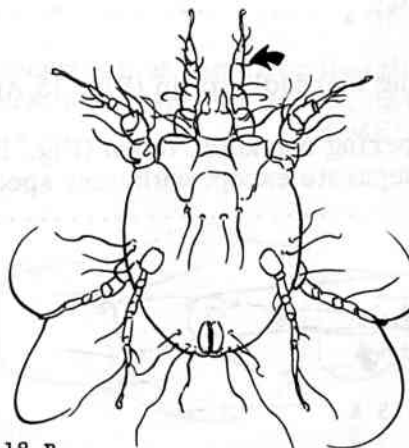


Fig. 18 B

19. Suckers of tarsi with segmented pedicels (Fig. 19 A). Non-burrowing itch mites on mammals in the genus Psoroptes, a common species causing scabs and crusts in the ears of rabbits is the Psoroptes cuniculi..... RABBIT EAR MITE

Suckers of tarsi without segmented pedicels (Fig. 19 B).....
 Dermatophagoides scheremetewskyi

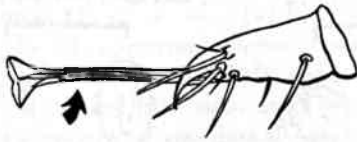


Fig. 19 A

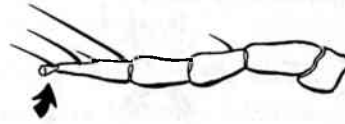


Fig. 19 B

20. Anal opening on the dorsal surface of the body; dorsal surface of the body with only short, sharp setae (Fig. 20 A).....Notoedres

Anal opening at tip of body or slightly on ventral side; dorsal surface of body with pointed scales and blunt stout spines (Fig. 20 B). Sarcoptes scabiei.....
 SCABIES OR MANGE MITE

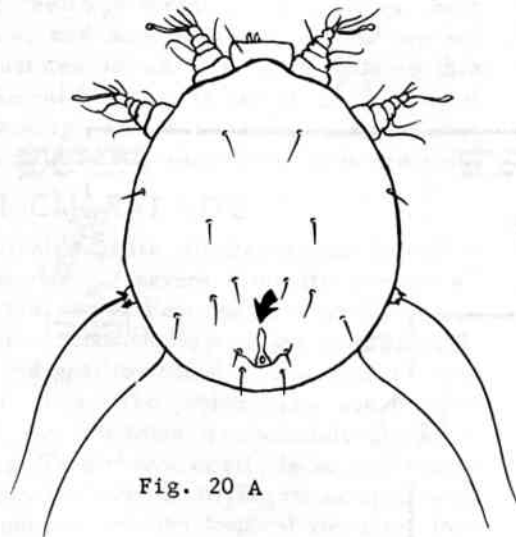


Fig. 20 A

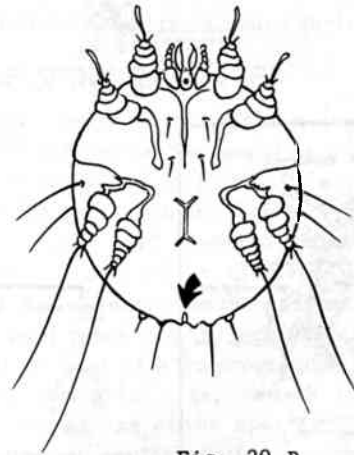
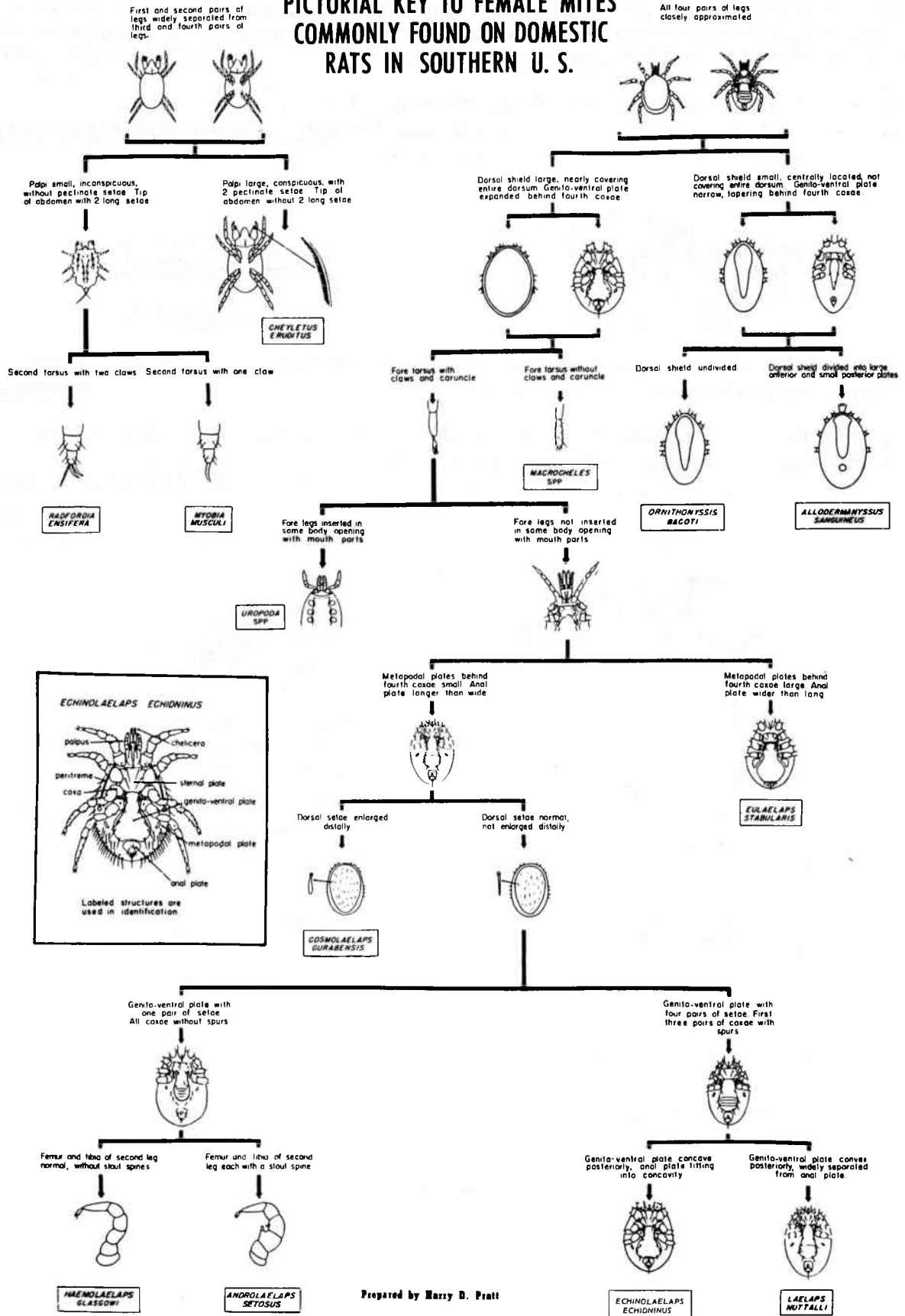


Fig. 20 B

PLATE 9.3

PICTORIAL KEY TO FEMALE MITES COMMONLY FOUND ON DOMESTIC RATS IN SOUTHERN U. S.



Prepared by Harry D. Pratt

SOME IMPORTANT MITE SPECIES

THE HOUSE MITE

The house mouse mite (*Dermanyssus sanguineus*) occurs locally from Arizona and Utah east to Boston and Washington (Pratt *et al.*, 1949), sometimes by the thousands in apartment houses where house mice are abundant, less commonly on rats. The female can be separated from most other blood-sucking mites by the presence of two dorsal shields, a large anterior and small posterior plate. Baker *et al.*, (1956) state that protonymphs, deutonymphs, and adults all suck blood. The house mouse mite is a proven vector of rickettsialpox in Massachusetts, Connecticut, New York, and Pennsylvania (see p.3).

THE CHICKEN MITE

The chicken mite (*Dermanyssus gallinae*) is found throughout most of the world, on domestic fowl, pigeons, English sparrows, starlings, and many other birds. The large dorsal and anal plates, short sternal plate, and needle-like chelicerae are important structures to observe in identifying this species. The chicken mite is one of the commonest species causing dermatitis in homes, chicken ranches, or in markets where live birds are sold.

THE TROPICAL RAT MITE

The tropical rat mite (*Ornithonyssus bacoti*) is often responsible for severe "rat-mite dermatitis" throughout the world. Females are usually recognized by scissor-like chelicerae, the narrow, tapering dorsal and genito-ventral plates, and the egg-shaped anal plate. The protonymphs and females suck blood, and are often tremendously distended after feeding. This characteristic is so pronounced that laboratory workers identifying rat ectoparasites often sort out the swollen tropical rat mites from other species with the naked eye and then confirm identifications with the microscope. A complete generation usually takes about two weeks. Unfed females may live ten days or more after rats have been trapped out of a building, while laboratory females with opportunities for regular blood meals are reported to live up to sixty-three days. Skaliy and Hayes (1949) report that unfertilized females will lay eggs resulting in males, while fertilized females will produce both males and females.

THE TROPICAL FOWL MITE

The tropical fowl mite (*Ornithonyssus bursa*) is similar to the tropical rat mite, but has a wider dorsal plate and is found on domestic and wild birds, seldom on rodents.

THE NORTHERN FOWL MITE

The northern fowl mite (*Ornithonyssus sylviarum*) is similar to the tropical rat mite but has a much shorter sternal plate with only four setae on the plate, and short setae on the dorsal plate. It is a common species on domestic fowl, pigeons, sparrows, and starlings and will bite man readily. These mites may overwinter in bird nests, such as those of barn swallows and phoebes, or in cracks in buildings. There are several generations a year and the build-up of populations is very rapid. In some of the nests of starlings in Atlanta, Georgia, examined by the writer, there were literally thousands of mites sucking blood from the nestling birds, perhaps in sufficient numbers to cause their death.

THE SPINY RAT MITE

The spiny rat mite (*Echinolaelaps echidninus*) is found throughout the world as a specific parasite of the Norway and roof rats. It is often the commonest species on rats in the United States, particularly in the central and northern parts. This species is easily recognized by the large genito-ventral plate with the concavity on the posterior margin into which the anal plate fits. *E. echidninus* serves as the definitive host of a haemogregarine parasite, *Hepatozoon muris*, of rats, and is reported by Russian workers as one of the species of mites in a pool of "water rat" ectoparasites from which tularemia was isolated.

CHIGGERS

Chiggers (*Trombicula alfreddugesi*, *splendens*, and *batatas*) feed on man only in the larval stage. They have the following developmental stages: egg, deutovum, larva, nymphochrysalis, nymph, imago-chrysalis, and adult. Only the larvae feed on man and higher animals. On man they attach themselves in those areas of the body where clothing is restricted such as the ankles, waistline, and arm-

pits. As a rule the larva feeds only once, (sucking lymph and partially digested skin tissue through a stylostome, not blood, p. 5), engorgement taking three days. The nymphs and adults do not feed on man, but rather on the eggs or young of various arthropods such as mosquito or Collembola eggs. In most of the United States, there are one to three generations a year, depending on the season and latitude, but breeding may be continuous on the Gulf Coast and in Florida. Chiggers feed on a wide variety of snakes, turtles, birds, and small mammals as well as man. The American species are not known to transmit disease, but in Asia chiggers are important vectors of the rickettsiae causing scrub typhus.

THE STRAW ITCH MITE

The straw itch mite (*Pyemotes ventricosus*) is normally a parasite of grain-boring insects, but sometimes bites man severely. The unfed females are very small, but the mated female becomes greatly enlarged, appearing to the naked eye like a tiny pearl, due to the swelling of the body behind the last pair of legs. A single female may produce 200 to 300 eggs which are retained within the body until the mites have passed through all stages of development. The young males and females are produced viviparously and are sexually mature at birth. Mating takes place soon after birth. The first and second pairs of legs are widely separated from the third and fourth pairs of legs. The club-shaped hair between the base of the first and second pairs of legs is an important structure used in identifying the grain itch mite.

THE FOLLICLE MITE

The follicle mite (*Demodex folliculorum* and related species) is found in the pores of man, especially around the nose and eyelids, and also on other parts of the body. They occasionally are found in cysts on the face and can be identified when examined with a compound microscope by their cigar-shaped bodies and very short legs. Related species cause very serious demodectic mange in dogs and cats, goats, and other domestic animals. These mites are entirely parasitic, the entire life cycle being spent on the host animals, usually in the pustules.

THE CLOVER MITE

The clover mite (*Bryobia praetiosa*) is a tiny

reddish-brown mite approximately 0.8 mm. (3/100 inch) long. There are two good characters to use in identifying this species: the very long first pair of legs in combination with the expanded body hairs, particularly the four cone-shaped projections bearing fan-shaped setae on the anterior margin of the body.

Two species of *Bryobia* are often confused. Morgan and Anderson (1957) proposed that the name clover mite be applied to *Bryobia praetiosa* found on herbaceous plants such as grass and clover, while the name brown mite be used for *Bryobia arborea* occurring on deciduous trees, particularly fruit trees. The young mites are known as larvae and nymphs, each stage requiring two to six days or more. There are several generations a year. In the fall they migrate to sheltered places to spend the winter. They may invade houses and hide under shingles or siding, behind windows and door casings, between walls and floors, in attics, and other places that provide protection. There is occasionally a summer migration due to the cutting and drying up of their food plants. On warm winter days or during short periods of the day when sun strikes their hiding places, some of the mites may become active and crawl inside houses. In the spring all the mites become active and large numbers may crawl out of hiding inside the house, attempting to get outside to growing plants.

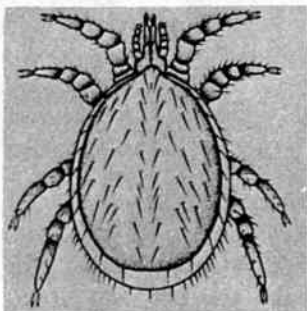
Evidence indicates that the fall migration into homes is greatest on the south-facing sides of buildings and that white or light-colored buildings tend to attract more mites than darker surfaces because of the heat reflecting from these light areas.

Many complaints of these invasions are from people in new subdivisions where new lawns have been seeded or renovated, or refertilized. In other words, clover mites appear to develop where there is succulent and vigorous-growing vegetation, particularly homes with planting of shrubbery that are close to or touching the buildings.

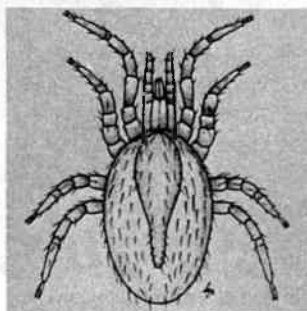
THE GRAIN AND FLOUR MITES

The grain and flour mites (Family Acaridae or Tyroglyphidae) are tiny, pale-gray or yellowish-white with conspicuous long hairs. The first two pairs of legs are widely separated from the third and fourth pairs of legs. They feed on a wide variety of organic materials, may become very common in leaf mould, flour, hair mattresses, and similar substances. These mites may cause "grocer's itch" or "copra itch",

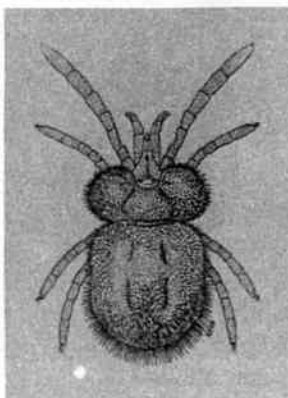
SOME COMMON MITES



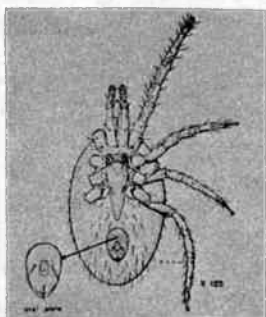
Spiny Rat Mite
Laelaps echnidnius
Dorsal Aspect



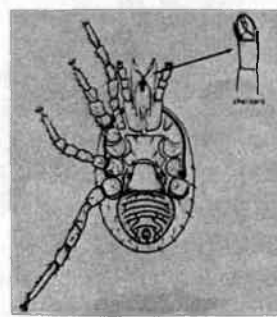
Tropical Rat Mite
Ornithonyssus bacoti
Dorsal Aspect



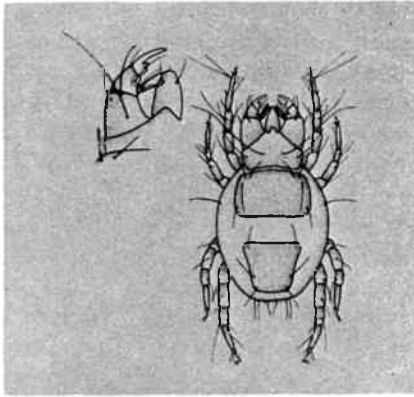
An Adult Chigger
Trombicula species
Dorsal Aspect



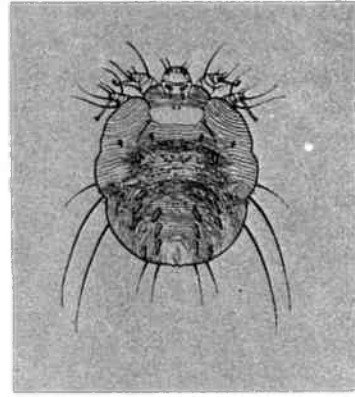
House Mouse Mite
Allodermanyssus sanguineus
Ventral Aspect



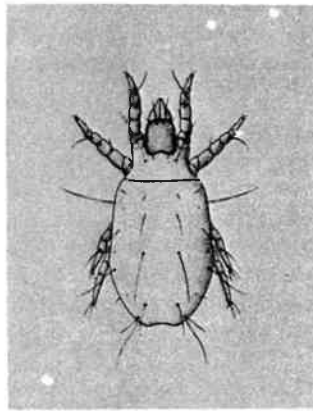
A Common Mite on Flies and Rats
Macrocheles species
Ventral Aspect



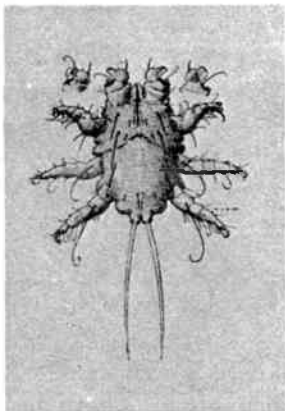
A Predaceous Mite
Cheyletus species
Dorsal Aspect



Scabies or Mange Mite
Sarcoptes scabiei
Dorsal Aspect



A Cheese Mite
Caloglyphus species
Dorsal Aspect



A Fur Mite
Radfordia species
Dorsal Aspect



A Fur Mite
Myobia musculi
Dorsal Aspect

THE ITCH MITES

The itch mites (*Sarcoptes scabiei*) are very tiny, females averaging 0.3-0.4 mm (about 1/75 of an inch) long and the males somewhat smaller. Each mite is oval, saclike, with the body surface finely wrinkled. The mouthparts containing paired palps and chelicerae are located at the anterior end and the anus at the posterior end. The dorsal surface has a number of rather conspicuous blunt spines and many backward-pointing triangular scales. The legs are short and stocky, the two anterior pairs being well-separated from the two posterior pairs. Other important identifying characters are given in the key to common mites in this chapter.

The female burrows beneath the outer, horny layer of skin, laying her eggs in tunnels. The eggs hatch into six-legged larvae which become eight-legged nymphs and finally adult males and females. Some writers believe that males have only one nymphal stage and complete their life cycle in nine to eleven days, while the females have two nymphal stages and require fourteen to seventeen days, perhaps longer in cold weather. The adults live about a month. Scabies mites occur most commonly in tiny papules, particularly in webbing between the fingers and folds of the wrists. Positive identification is made by excising a tiny bit of flesh, treating it with ten percent NaOH or KOH solution, and examining the tissue on a slide with a good compound microscope.

CONTROL OF MITES AND MITE-BORNE DISEASES

Control measures may be divided into two main categories: **chemical control of mites**, and **control of mites by sanitation**.

CHEMICAL CONTROL OF MITES EMERGENCY MEASURES

Emergency measures include the use of pyrethrum or allethrin aerosol bombs to control infestations of such species as bird, rodent, or clover mites. Pyrethrum and rotenone when used as sprays are mainly contact insecticides. They knock down and kill quickly, particularly when used in combination or with synergists, but have little residual action. If no other materials are available, wipe furniture or woodwork lightly with a cloth saturated with refined kerosene which will act as a contact insecticide, taking full precautions against fire. Many householders have used a vacuum cleaner successfully to suck up limited infestations of bird, rodent, or clover mites, shaking the contents of the vacuum bag onto papers which are burned immediately for complete disposal.

RESIDUAL TREATMENT

Residual treatments indoors include both sprays and dusts. *DDT is usually not the insecticide*

of choice, because it has given variable results in mite control. Chlordane, lindane, malathion, chlorobenzilate, aramite, ovex, and dimite have given good results in controlling a number of species of mites. Two percent chlordane, 0.5 to 1% lindane, and 0.5 to 1% malathion are three of the better, generally available insecticides to use — malathion often the insecticide of choice. These are frequently used as spot treatments applied evenly and thoroughly in "trouble areas" such as around windows and doors, at the top of foundations, around the plate and the ends of joists, baseboards, and edges of floor areas. If odor is a problem, lindane may be preferable; if odor is not a real problem, malathion has been reported as giving satisfactory control in many areas. This last chemical is now available in highly refined, largely deodorized forms or mixtures containing a masking agent.

Residual treatment outdoors has been used for the control of clover mites and chiggers especially, less commonly on the outside of buildings for control of bird or rat mites.

The following table is based to a large extent on information included in Baker *et al.*, (1956) supplemented from a variety of sources:

INSECTICIDES FOR AREA CONTROL OF MITES

Insecticides	Rate of Application	
	Amount of insecticide per 100 gals. water applied at rate of 20-25 gals. of finished spray per acre	Lbs. of dust per acre
Sulfur		50 to 100
Lindane	4 lbs. of 25% wettable powder, or 2 quarts of 25% emulsifiable concentrate	
Chlordane	32 lbs. of 25% wettable powder, or 2.5 gals. of 40% emulsifiable concentrate	40 lbs. 5% dust
Toxaphene	32 lbs. of 25% wettable powder, or 2.5 gals. of 40% emulsifiable concentrate	40 lbs. 5% dust
Dieldrin	3 gals. of 1.5 lbs. per gallon concentrate	20-40 lbs. 5% dust
Chlorobenzilate	1.5 lbs. of 25% wettable powder, or 1.5 pts. of 25% emulsifiable concentrate	

For clover mite control malathion has given good results as 0.5 to 1% spray at a rate of 30 to 40 gallons per 1000 square feet. The over-wintering eggs of brown mites laid on bark of dormant trees may be killed by oil sprays, or insecticides such as one gallon of ovex and one gallon of 45% chlordane emulsifiable concentrate per 400 gallons of water.

For bird and rodent mites on buildings outdoors, residual spray applications of 2% chlordane, 1% lindane or 1% malathion have been used successfully.

INSECTICIDAL CONTROL

Grain and Flour Mites

Insecticidal control of flour and grain mites is rather difficult and should be carried out **only by a licensed pest control operator**. Fumigation with chloropicrin and carbon bisulfide has given good results. Other materials which have been tested include hydrogen cyanide, methyl bromide, paradichlorobenzene, and ammonia. All of these materials are poisons and should be used with great care.

Mites on Man and Animals

Insecticidal control of mites on man and animals has been recently improved. Within the last fifteen years a number of new remedies have been developed for the treatment of scabies and related mites. Sulfur ointment, long used in the treatment of scabies, is no longer recommended because it may cause equally severe dermatitis. The three treatments listed below have been tested extensively and found effective according to Hunter, Fyre, and Swartzwelder (1960). It may be noted that the scabies mite lesions have been found on all parts of the body except the head and scalp, possibly due to the constant exposure of these areas to low temperatures both night and day. Since some of these treatments are irritating to the eyes, nose, and mouth, the chemicals should not be applied to the head or scalp.

Five-tenths to one percent lindane in vanishing cream, water emulsion, or olive oil. Commercially, 1% lindane is available in a vanishing cream which has been widely used to control both scabies and human lice. This should be applied twice a day, care being taken to avoid contact with the eyes.

Benzyl benzoate – the NBIN formula contains the following ingredients by weight:

- 68% benzyl benzoate
- 6% DDT
- 12% benzocaine
- 14% Tween 80 as a non-ionic emulsifier

This stock solution is diluted one part to five parts of water and applied with a brush, sponge, or a spray. It is usually recommended that the body be washed thoroughly with soap and warm water before application and that the material be left on for 24 hours before washing the hands or bathing again. A second treatment should not be made for from ten to fourteen days. Another formulation is known as Topocide, an aqueous emulsion containing in each 100 ml. about 12.5 grams of benzyl benzoate, 2 grams of benzocaine, and 1 gram of DDT.

Eurax, a salve incorporating 10% N-ethyl-O-crotonoluide in vanishing cream. Two applications at 24-hour intervals are reported to give complete cure. No prior bathing and

scrubbing is necessary which makes it somewhat easier to use.

Baker *et al.*, (1956) also report good results with tetraethylthiuram monosulfide (Tetmosol), either as a separate treatment or incorporated at five to ten percent strength into soap.

In treating scabies, absolute thoroughness is essential. It is advisable to sterilize every article of clothing and bedding that may have come into contact with the patient. If one member of a family or group of people has scabies, it is well to inspect or treat all close contacts.

On animals, lindane sprays at one-tenth of one percent or less, have given good control of scabies on hogs, dogs, and cattle. Many of the same materials listed above for scabies control have been tried for demodectic mange, but with variable results.

For control of free-ranging mites on animals, dusts are generally safer than emulsions or solutions because they are less frequently absorbed. Baker *et al.*, (1956) report that one to four percent dusts malathion has given safe and effective control of northern fowl mites and that ten percent DDT dust worked well on tropical rat mites on laboratory hamsters and rats, but not on mice since DDT may kill mice. They also report that one percent water sprays of Sulphenone plus Triton X-100 have given good control of northern fowl mites on chickens during mild weather.

MITE REPELLENTS

Sulfur has long been a standard remedy as a chigger repellent. Although the results are often variable, it has given control when dusted into socks, underwear, and outer clothing, particularly by children at summer camps who sometimes prefer sulfur to some of the new repellents with a disagreeable odor.

Many of the mosquito repellents such as Indalone and dimethyl phthalate give good results for two to four hours as chigger repellents when applied to the skin.

According to Smith (1958) one of the best newer repellents is diethyl toluamide, sold commercially as OFF.

Most of the good mosquito repellents are also effective acaricides for clothing treatments; applications at two grams per square foot will provide

one hundred percent protection through various periods of aging, but will not withstand washing. The most durable treatment recommended at present is benzyl benzoate, which will withstand two or three washings. M-1960, which contains thirty percent of benzyl benzoate, withstands one or two washings. Resistance to removal by water is of importance to troops exposed to rain or obliged to ford streams particularly in areas where scrub typhus occurs.

CONTROL OF MITES BY SANITATION

Mite control through basic sanitation is fundamental both for the immediate and long-term control of mites of public health importance, as discussed below:

RAT AND HOUSE MITES

Rat and house mouse mite control is based primarily on:

1. Trapping or poisoning the rats and mice to do away with the host providing the blood meal essential for food and reproduction of mites;
2. Starving out rodents by storing garbage and food in rat-proof containers, rooms, or buildings;
3. Rodent-stoppage to keep rodents out of buildings; and
4. Harborage elimination to do away with shelter and breeding places for rodents.

BIRD MITES

Bird mite control is based primarily on:

1. Building modification so that birds cannot enter or nest, with special attention to louvres, gables, eaves, and attics. This may require screening, carpentry or masonry; and
2. Trapping or poisoning the birds to eliminate the source of blood meals for the mites.

CLOVER MITES

Clover mite control may often be achieved as much by basic sanitation (keeping the mites away from buildings) as by chemicals. This type of control should include:

1. Removal of vegetation near houses, or pruning shrubs so that they are at least

- least a yard from the building; and
2. A strip of bare ground along the base of a building, two to three feet wide.

CHIGGERS

Chigger control is essentially modification of the environment to permit the sunlight and air to circulate freely, drying up the habitat in which the tiny, delicate chiggers live. This modification may be achieved by:

1. Close-cut lawns and gardens with well-kept paths and weed-free beds;
2. Elimination of tall weeds and shrubs, particularly blackberries and raspberries furnish food and shelter for the bird and rodent hosts of chiggers; and
3. Employing, in scrub typhus areas, the following additional measures:

Clearance of all camp sites by mechanical equipment such as bulldozers, or by flamethrowers, to eliminate as much as possible human contacts with infected chiggers, and: rodent control to eliminate the hosts of chiggers.

GRAIN AND FLOUR MITES

Flour and grain mite control should include:

1. Rotation of food material to remove the

oldest materials first, thus preventing build-up of infestations;

2. Good ventilation to prevent the build-up of moisture in food-stuffs. Mites thrive in foods with moisture content above twenty percent; and
3. Proper clean-up to eliminate foci of infestations, often with thorough vacuum-cleaning of the entire warehouse with particular attention to horizontal surfaces such as beams, window ledges, etc.

MITES IN LABORATORIES

Control of mites in laboratories is often a serious problem, since several species may be involved. Laboratory white mice, rats, hamsters and guinea pigs may be found swarming with tropical rat mites, flour and grain mites, and occasionally other species. It is often possible to control such infestations, particularly of the grain mites which do not suck blood, without treating the animals with insecticides; this control may be accomplished by:

1. Thorough cleaning of cages, with steam sterilization if possible;
2. Removal of all infested bedding in cages or pans; and
3. Sterilization by steam or dry heat of bedding and food such as rabbit pellets if necessary.

MITE SURVEYS

The methods used for surveying mites vary greatly according to the habits of the different species.

Black plates are placed in chigger-infested areas and counts made at definite time intervals.

Berlese funnels are frequently used for flour and grain mites and other free-ranging species such as bird mites in nesting materials. Details of Berlese funnels are given in Baker and Wharton (1952).

Ectoparasite surveys may be used to obtain estimates of chiggers, bird and rodent mites, either (1) by combing or beating the mites into white enameled pans from dead, trapped animals after the ectoparasites have been stunned or killed by ether

or chloroform, (2) by picking the mites off with fine forceps, particularly in the case of chiggers fastened to animals, or (3) by placing the live host animals in cages that have wire or hardware cloth bottoms so that the mites that fall off after engorgement may be trapped in the water film and collected (this procedure is often followed in collecting chiggers from snakes, turtles or small rodents); or (4) placing the dead host animal in a glass jar containing water and a detergent. The jar is shaken thoroughly to separate ectoparasites from the animal. The liquid is poured into a funnel containing filter paper. Any mites strained out on the paper may then be collected and preserved in seventy percent alcohol.

REFERENCES

- Allred, D. M. 1954. Mites as intermediate hosts of tapeworms. *Proc. Utah Acad. Sci. Arts Letters*, 31:44-51.
- Baker, E. W. 1955. Mites as household pests. *Pest Control*, 23(9):9-12.
- Baker, E. W., Camin, J. H., Cunliffe, F., Wooley, T. A., and Yunker, C. E. 1958. Guide to the families of mites. Institute of Acarology, U. Maryland, College Park, Md., ix + 242 pp.
- Baker, E. W., and Wharton, G. W. 1952. An introduction to acarology. MacMillan Co., New York, N. Y. xiii + 465 pp.
- Baker, E. W., Evans, T. M., Gould, D. J., Hull, W. B., and Keegan, H. L. 1956. A manual of parasitic mites of medical or economic importance. *Natl. Pest Control Assoc. Tech. Pub.*, New York, N. Y. 170 pp.
- Booth, B. H., and Jones, R. W. 1952. Epidemiological and clinical study of grain itch mites. *J.A.M.A.*, 150:1575-1579.
- Brennan, J. M., and Jones, E. K. 1959. Keys to the chiggers of North America with synonymic notes and descriptions of two new genera (Acarina: Trombiculidae). *Ann. Ent. Soc. Amer.*, 52(1): 7-16.
- Busvine, J. 1951. *Insects and hygiene*. Methuen Co., London, England, xiv + 482 pp.
- Camin, J. H. 1948. Mite transmission of a hemorrhagic septicemia in snakes. *J. Parasit.*, 34 (4):345-354.
- Camin, J. H., and Rogoff, W. M. 1952. Mites affecting domesticated mammals. *South Dakota State Coll. Agr. Mech. Arts, Agr. Exp. Sta. Tech. Bull.* no. 10, 11 pp.
- Chadwick, P. R. 1960. Pyrethrum for the control of red mite (*Dermanyssus gallinae*) in poultry houses. *Pyrethrum Post* 5(3):3-4, 34.
- Chamberlain, R. W., and Sikes, R. K. 1955. Laboratory investigation on the role of bird mites in transmission of eastern and western equine encephalitis. *Amer. J. Trop. Med. Hyg.* 4(1): 106-118.
- Chandler, A. C., and Read, C. P. 1961. Introduction to parasitology with special reference to the parasites of man. Wiley, New York, 822 pp.
- Communicable Disease Center. 1963. 1963 Report. Public health pesticides for mosquitoes, flies, fleas, roaches, bed bugs, ticks, chiggers, lice, rodents. *Pest Control*, 31(3):11-32.
- Dove, W. E., and Shelmire, B. 1931. Tropical rat mite, *Liponyssus bacoti* Hirst, vector of endemic typhus, *J.A.M.A.*, 97:1506-1510.
- Ebeling, W. 1960. Control of the tropical rat mite (*Bdellonyssus bacoti*). *J. Econ. Ent.* 53(3): 475-476.
- Ewing, H. E. 1929. A manual of external parasites. Charles C. Thomas, Pub., Springfield, Ill. xiv + 225 pp.
- Faust, E. C., Beaver, P. C., and Jung, R. C. 1962. Animal agents and vectors of human disease. Lea & Febiger, Philadelphia, Pa. 485 pp.
- Fine, R. M., and Scott, H. G. 1963. Straw itch mite dermatitis caused by *Pyemotes ventricosus*. *J. Med. Assoc. Georgia*, in press.
- Flynn, R. J. 1959. Follicular acariasis of mice caused by *Psorergates* successfully treated with aramite. *Amer. J. Vet. Res.*, 20(74):198-200.
- Fuller, H. S. 1956. Veterinary and medical acarology. *Ann. Rev. Ent.*, 1:347-366.
- Harris, J. M., and Stockton, J. J. 1960. Eradication of the tropical rat mite *Ornithonyssus bacoti* (Hirst, 1913) from a colony of mice. *Amer. J. Vet. Res.*, 21(81):316-318.
- Hirst, S. 1922. Mites injurious to domestic animals. *Brit. Mus. Nat. Hist. Econ. Ser.*, 13:107 pp.
- Hopla, C. E. 1951. Experimental transmission of tularemia by the tropical rat mite. *Amer. J. Trop. Med.*, 31:768-782.
- Horn, M. B. 1949. Rickettsialpox survey in New York, *CDC Bulletin*, April-June: 38-39.
- Horsfall, W. R. 1962. Medical entomology. Arthropods and human disease. Ronald Press, New York, N. Y. ix + 467 pp.
- Huebner, R. J., Jellison, W. L., and Pomerantz, C. 1946. Rickettsialpox - a newly recognized rickettsial disease. IV. Isolation of a rickettsia apparently identical with the causative agent of rickettsialpox from *Allodermanyssus sanguineus*, a rodent mite. *Public Health Rep.*, 61:1677-1682.
- Hughes, A. M. 1961. The mites of stored food. H. M. Stationery Off., London, England, vi + 287 pp.

- Hughes, T. E. 1959. Mites or the Acari. Univ. London, Athlone Press, London, England, viii + 225 pp.
- Hunter, G. W., III, Frye, W. W., and Swartzwelder, J. C. 1960. A manual of Tropical Medicine, W. B. Saunders, Philadelphia, Pa. xxx + 892 pp.
- Ireland, M. W. 1928. The Medical Department of the U. S. Army in the World War. IX - Communicable and Other Diseases. U.S.G.P.O., Washington, D. C., 627 pp.
- Knapp, F. W., and Frause, G. F. 1960. Control of the northern fowl mite, *Ornithonyssus sylviarum* (C. & F.), with ronnel, Bayer L13-59 and Bayer 21/199. J. Econ. Ent., 53(1):4-5.
- Mallis, A. 1960. Handbook of pest control. MacNair-Dorland Co., New York, N. Y. 1132 pp.
- Mellanby, K. 1943. Scabies. Oxford Univ. Press, London, England, 81 pp.
- Metcalf, C. L., Flint, W. P. and Metcalf, R. L. 1962. Destructive and useful insects. McGraw-Hill Book Co., New York, N. Y. xii + 1087 pp.
- Mohr, C. O. 1951. Entomological background of the distribution of murine typhus and murine plague in the United States. Amer. J. Trop. Med., 31:355-372.
- Morgan, C. V. G., and Anderson, N. H. 1957. *Bryobia arborea* n. sp. and morphological characters distinguishing it from *B. praetiosa* Koch (Acarina: Tetranychidae). Can. Ent. 89(11): 485-490.
- Nichols, E. M., Rindge, E., and Russell, G. C. 1953. The relationship of the habits of the house mouse and the mouse mite (*Allodermanyssus sanguineus*) to the spread of rickettsialpox. Ann. Intern. Med., 39(1):92-102.
- Philip, C. B. 1948. Tsutsugamushi disease (scrub typhus) in World War II. J. Parasit., 34(3):169-191.
- Philip, C. B., and Hughes, L. E. 1948. The tropical rat mite, *Liponyssus bacoti* as an experimental vector of rickettsialpox. Amer. J. Trop. Med., 28:697-705.
- Pratt, H. D., Lane, J. E., and Harmston, F. C. 1949. New locality records for *Allodermanyssus sanguineus*, vector of rickettsialpox. J. Econ. Ent., 42(3):414-415
- Pratt, H. D., and Good, N. E. 1954. Distribution of some common domestic rat ectoparasites in the United States. J. Parasit., 40(2):113-129.
- Radford, C. D. 1943. The genera and species of parasitic mites. Parasitology, 35(1-2):58-81.
- Radford, C. D. 1950. Systematic check list of mite genera and type species. Union Internat. Sci.-Biol., ser. G, sec. Ent., 1:1-252.
- Radford, C. D. 1955. Acarology, or the study of mites (Acarina). Riv. di Parassitologia, 16(1): 41-58.
- Reeves, W. C., Hammon, W. M., Doetschman, W. H., McClure, H. E., and Sather, G. 1955. Studies on mites as vectors of western equine and St. Louis encephalitis viruses in California. Amer. J. Trop. Med. Hyg., 4(1):90-105.
- Schwab, M., Allen, R., and Sulkin, S. 1952. Tropical rat mite (*Liponyssus bacoti*) as experimental vectors of Coxsackie virus. Amer. J. Trop. Med. Hyg., 1:982-986.
- Scott, H. G. 1958. Control of mites on hamsters. J. Econ. Ent., 51(3):412-413.
- Skaliy, P., and Hayes, W. J. 1949. The biology of *Liponyssus bacoti* (Hirst 1913) (Acarina, Liponyssidae). Amer. J. Trop. Med., 29:759-772.
- Smith, C. N. 1958. Insect repellents. Soap and Chem. Specialities, March issue, pp. 126-127, 129, 131, 133.
- Snodgrass, R. E. 1948. The feeding organs of Arachnida including mites and ticks. Smithsn. Misc. Coll., 110(10):1-93.
- Strandtmann, R. W., and Wharton, G. W. 1958. Manual of Mesostigmatid Mites. Contrib. 4 Institute of Acarology, U. Maryland, College Park, Md., xi + 330, 69 pls.
- Sulkin, S. E., Wisseman, C. L., Izumi, E. M., and Zarafonetis, C. 1955. Mites as possible vectors or reservoirs of equine encephalomyelitis in Texas. Amer. J. Trop. Med. Hyg., 4(1):119-135.
- Traub, R., Newson, H. D., Walton, B. C., and Audy, J. R. 1954. Efficacy of dieldrin and aldrin in area control of the chigger vectors of scrub typhus. J. Econ. Ent., 47:429-435.
- Traver, J. R. 1951. Unusual scalp dermatitis in humans caused by the mite, *Dermatophagoides*. Proc. Ent. Soc. Wash., 53:1-25.
- Wharton, G. W. 1960. Host-parasite relationships between *Myobia musculi* (Schrank, 1781) and *Mus musculus* Linnaeus, 1758. Sobretiro del libro Homenaje al Doctor Eduardo Caballero y Cabellero, Mexico, D. F. pp. 571-575.
- Wharton, G. W., and Fuller, H. S. 1952. A manual of the chiggers. Mem. Ent. Soc. Wash., no. 4, 185 pp.