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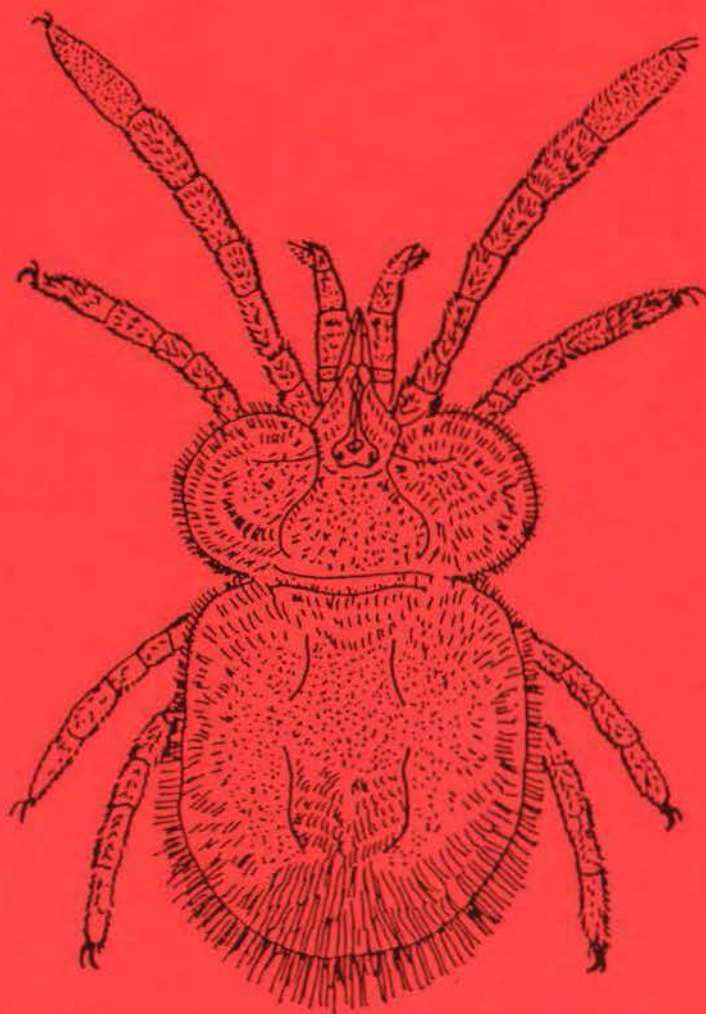
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VECTOR CONTROL SERIES

MITES

Training and Information Guide



WORLD HEALTH ORGANIZATION

Vector Biology and Control Division

1986

FOREWORD

Since 1970 the Vector Biology and Control Division of WHO has prepared, with the assistance of collaborators outside the Organization, a number of papers on vector control. The Expert Committee on Insecticides held in October 1974 (Technical Report Series No. 561) recommended that these documents - general reviews of the ecology and control of individual vector groups - should be continued and reviewed from time to time to provide workers with up-to-date practical information on the particular subject.

In 1985, with the greater demand for this material for use as training and information guides by different categories of personnel, particularly in the developing vector-borne disease endemic countries, it was decided to develop two separate series of these documents; an advanced series for students in medical entomology as well as for reference use by professional staff, and a middle-level series for less specialized workers in the community.

This advanced series will cover the relevant subject in considerably more detail and at a higher technical level. It is believed that this type of information will assist vector control specialists to acquire the knowledge required for their daily work.

In order to improve the value and usefulness of this guide, evaluation forms are attached, and users are requested to send the completed forms to the WHO Division of Vector Biology and Control in Geneva so that their comments may be taken into consideration when the guide is revised.



WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

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*Mites
Their control*

XIII. MITES OF PUBLIC HEALTH IMPORTANCE
AND THEIR CONTROL

Mites

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I. INTRODUCTION

Mites are placed as members, along with ticks, of the class Arachnida, subclass Acari. The subclass Acari is further divided into orders Acariformes (including astigmatid and prostigmatid mites) and Parasitiformes (including mesostigmatid mites and ticks). Mites are very important in human and veterinary medicine, many species by simply being bothersome and others by serving as both reservoirs and vectors of serious pathogens.

Mites are small arachnids ranging from 0.5 to 2.0 mm in length. As a consequence of their small size, mites are able to exploit habitats* unavailable to larger arthropods; among these habitats are many that are created by other animals (nests, burrows, etc.). More than 200 families, 1700 genera* and 30 000 species* of mites have been described and several thousand more species are estimated to exist.

The majority of mites are free-living, but thousands of species parasitize* animals (both vertebrate and invertebrate) and plants. Although parasitic mites are commonly thought of as external parasites, some species infest the inner and middle ear, the respiratory passages and lungs, skin, intestine and bladder of vertebrates. Some mites act as transmitting agents of a number of rickettsial and viral diseases. They cause considerable discomfort to human beings and their pets due to their biting and bloodsucking habits. They also serve as allergens* that can lead to serious hypersensitivity reactions.

The mites of public health importance belong to suborders Mesostigmata, Prostigmata, Astigmata and Tetrastigmata.

II LIFE HISTORY AND BIOLOGY

The basic stages in the life history of the mites consist of egg, larva, nymph and adult forms. Nearly all species of mites deposit eggs (1-3). However, a few are larviporous* (Family Laelapidae) or ovoviviparous * (Family Pyemotidae).

The mites generally pass through three stages after hatching of the eggs. Typically, there is a single larval stage followed by two or three nymphal stages (protonymph, deutonymph and tritonymph) and the adult (Fig. 1). The number of nymphal generations varies between species (1-3). Mites, like other arachnids, have four pairs of legs as nymphs and adults but only three pairs in the larval stage. The immature non-reproductive nymphal stages are smaller in size, but morphologically similar to the adults. The complete life cycle of many species requires less than four weeks.

The life histories for some of the important representatives of the suborders Mesostigmata, Prostigmata and Astigmata are given below.

Among the mesostigmatid mites, the tropical rat mite (Ornithonyssus bacoti) has been the subject of many detailed studies (4-8). This mite is an obligate* intermittent bloodfeeder which parasitizes rodents and birds throughout the world (6,8). The adult mites copulate 24 hours after emergence. The adult female survives about 70 days and produces up to a total of 100 eggs during this period (6,8). Eggs are laid singly in the hosts'* nests or burrows. The developmental stages include the nonfeeding larva, the bloodsucking protonymph, the nonfeeding deutonymph, and the adult. Under optimal conditions the life cycle (egg-to-adult) can be completed in 13 days. In other species, the length of the life cycle varies, as for example, for the Northern fowl mite (O. sylviarum) and the chicken mite (Dermanyssus gallinae), 7-9 days, and for the house mouse mite (Liponyssoides sanguineus) 17-23 days (2,8).

In ovoviviparous mites, such as the spiny rat mites (Laelaps echidninus), the females produce nonmotile larvae within five days after fertilization (6,8). When the larvae are cultured at 30°C and 80% relative humidity, they molt in 11.5 hours to the protonymph (2).

* Terms marked with an asterisk are defined in Section VIII - Glossary of Terms.

The protonymph and subsequent stages all feed. Fertilized females begin to deposit larvae five to six days from their deutonymph stage to the adult molt. Virgin females produce parthenogenetically*, but mate readily if males are provided. Fed mites live for about 70-80 days.

In general the life cycle of prostigmatid mites follows the same basic pattern as described above for mesostigmatid mites. However, there are some exceptions; for example, the gravid straw itch mites (*Pyemotes tritici*)¹ are viviparous and have the habit of retaining their eggs. The developing eggs (200-300) hatch within the abdomen, where they are nourished until ready to emerge as sexually mature mites (1,6,9).

In contrast to pyemotid mites, trombiculid mites (Fig. 1a) are oviparous* and deposit their eggs on the ground or leaves of low grass or bushes. After an initial egg stage of four to five days, the eggshell cracks in half, but the larval mite remains in a quiescent phase within the egg for a short period (prelarval or deutovum stage). Then the six-legged larva escapes and actively searches for a suitable host (10-12); these larvae can survive for about one to two weeks without food. Usually the larvae (chiggers*) congregate in a shaded area near the top of a blade of grass or a fallen leaf. There they remain quiescent until a vertebrate host comes along, then after prolonged feeding, the engorged larvae leave the host and molt (10, 12). Nymphs and adults are eight-legged and free-living (10, 12). Developmental time is affected by temperature and food supply (11, 12); for example, at 28°C in the laboratory it requires 75 days for *Leptotrombidium akumushi*, 60 days for *Ascoschoengastia indica* and 40 days for *L. deliense*. There are one or two generations per year in the tropics and subtropics. *Eutrombicula alfreddugesi* in the USA has one or two generations in Ohio, three generations in North Carolina and continuous development in Florida (1,6).

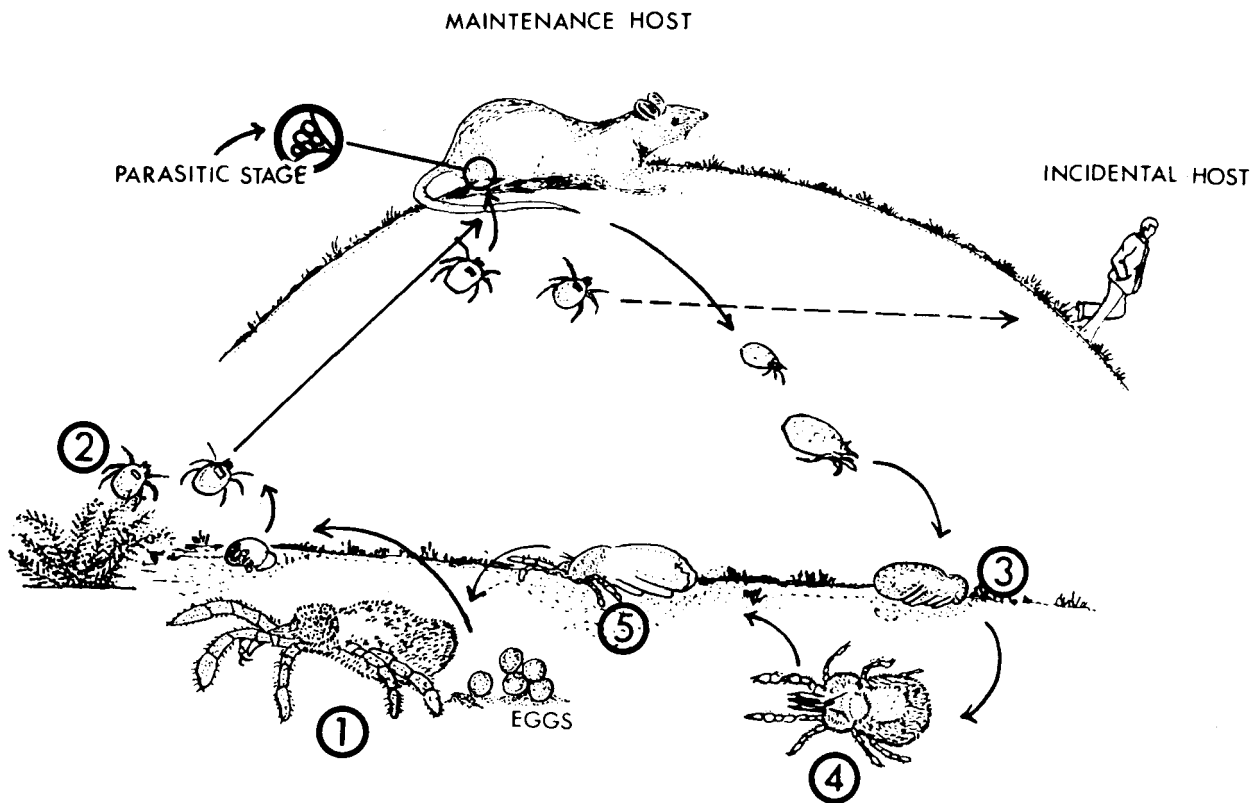


Fig. 1a. Life cycle of a trombiculid mite. (1) adult female laying eggs; (2) three-legged larva; (3) protonymph; (4) deutonymph; (5) tritonymph.

¹ Considered by some authorities to be the same species as *P. ventricosus*.

The life cycle of the human itch mites (Sarcoptes scabiei) and other species of the suborder Astigmata also follow the general pattern mentioned above. The majority of Astigmata are oviparous, with few species ovoviviparous (the Cytoditidae and some of the feather mite genera) (2). The human itch mite burrows in the skin and egg laying begins within a few hours of the commencement of burrowing (3,6). Thin-shelled and ovoid eggs are laid at the rate of 2-3 per day for a period of eight weeks. The eggs are cemented to the floor of a burrow in the host's epidermis. Eggs hatch in 3-4 days and the six-legged larvae migrate to the skin surface and molt (6,8,9,13). There follow two nymphal stages (a feeding protonymph and a non-feeding deutonymph). Morphologically, the deutonymph is unlike the preceding nymphal forms and is known as the hypopus. The complete cycle requires about 12-19 days (1,6). Thereafter, the adult survives for approximately 30 days (1,9).

The life cycle for the house dust mite, Dermatophagoides farinae is given in Fig. 1b. The fertilized females lay up to three eggs per day for a total of more than 200 eggs during their active reproductive life (1,2). After 6-12 days the eggshell splits and a six-legged larva emerges, feeds and molts to form the protonymph, which in turn feeds and molts to become the tritonymph; from the tritonymph, either the male or the female adult emerges (2). Under optimal conditions, the cycle from egg to egg requires about a month. Both the male and the female mate more than once (1,2). Adults live about two months if mated, but if unmated for about ten weeks at 21°C.

Many blood-sucking mites found on commensal rodents* or in their nests are known to feed on a wide variety of hosts. Some, such as Androlaelaps fahrenheitzi (= Haemolaelaps glasgowi) have been collected over a wide geographical range and from many host species as well as from the hosts' nests. In general among mesostigmatid and trombiculid mites host specificity is not marked (7,8). For example, in discussing Leptotrombidium deliense, Fuller (1952) (14) reported a host list consisting of 11 species of birds and 57 mammals. However, a few species of endoparasitic* chiggers may exhibit some degree of host specificity (6,11). Likewise, species specificity is present to a certain degree among members of Mesostigmata, Prostigmata and Astigmata.

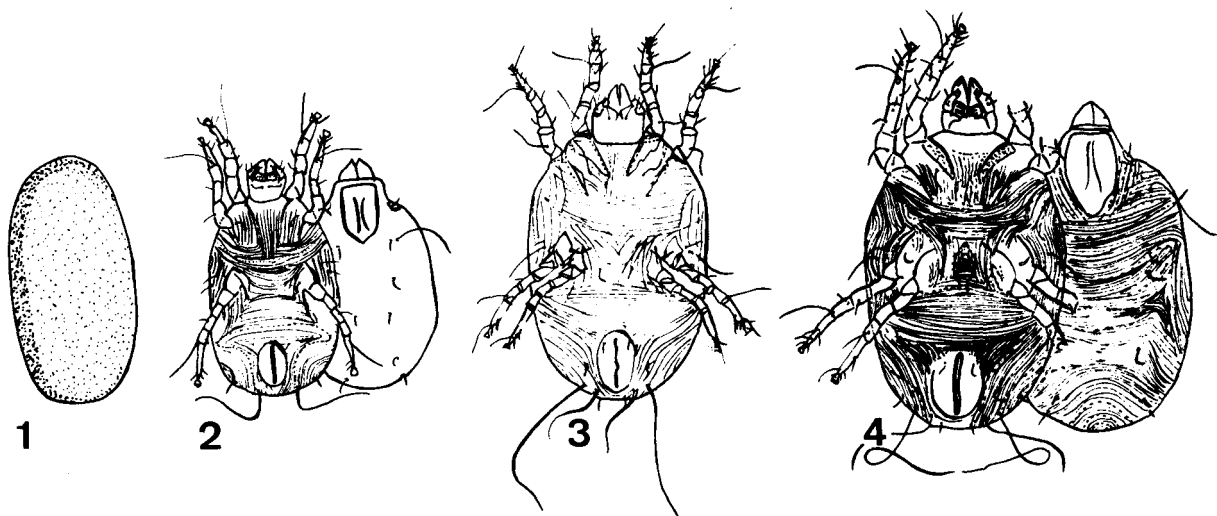


Fig. 1b Life cycle of housedust mite, Dermatophagoides farinae. (1) egg; (2) larva; (3) nymph (protonymph-tritonymph); (4) adult.

III TAXONOMY AND IDENTIFICATION

More than 200 families, 1700 genera, and 30 000 species of mites have been described and several thousand more species are thought to exist. The identification of mites, even those affecting man and animals, is difficult (1), because of the large number of species and because of the great ecological diversity of the group. There is no single, simple publication that can be used for their classification down to the level of the species. However, there are several outstanding works which are concerned with one or more aspects of mites. The reader is referred to: Radford (1943) (15), Baker and Wharton (1952) (16), and Whitaker and Wilson (1974) (17) for a general introduction to the group; Ewing (1929) (18), Wharton and Fuller (1952) (19), Fuller (1952) (14) and Baker, *et al.* (1956) (20) for mites of economic importance; Baker, *et al.* (1956) (20) and Krantz (1978) (21) for a guide to families; Strandtmann and Wharton (1958) (8), Wharton *et al.* (1951) (22), Wharton and Fuller (1952) (19), Bernnan and Jones (1959) (23), Radovsky (1967) (24), Vercammen-Grandjean and Langston (1975) (25) and McDaniel (1979) (26), for classification and interrelationships in this group; Flynn (1973) (27) for accounts of mites of wild and laboratory animals; and Baker, *et al.* (1956) (20) and Pratt and Good (1954) (28) for mites of public health importance. For the detailed treatment of external morphological characters which are useful in identification of chiggers, van der Hammen (1980) (29) and Goff and coworkers (1982) (30) should be consulted. However, only those structures that aid in the identification are discussed or graphically illustrated in the present text.

Mites have undergone great modification in their anatomy; therefore, very little evidence remains of their basic segmentation. The head, thorax, and abdomen are combined into a single structure. The two main regions of the body are the anterior proterosoma and the posterior hysterostoma. These in turn are subdivided into four subregions: the gnathosoma (syn: hypostoma*) comprising the mouthparts; the propodosoma extending from the base of the gnathosoma to about the middle of the body bearing the first two pairs of legs; the metapodosoma bearing the third and fourth pairs of legs; and the opisthosoma extending from the fourth coxa to the posterior margin of the body. Since these regions are closely fused and their boundaries obscured by plates covering the entire body, two main divisions are generally recognized - the head or gnathosoma and the body or idiosoma (Figs. 2,3). The leg bearing area, combining the propodosoma and metapodosoma, is also recognized as the podosoma. The gnathosoma is lacking in many groups, with the exception of Mesostigmata in which it is well developed (Fig. 2).

The chelicerae or claws in parasitic mites are adapted for piercing or tearing. The genital and anal orifices vary in position, although usually the former is situated between coxae IV, and the latter is subterminal. Two, three or four pairs of legs may be present in the adult stage. In most species the respiratory system is tracheal, though some absorb oxygen through the body surface (1). The general morphology and some of the features used in identification of a mesostigmatid mite and a chigger are illustrated in Figs. 2 and 3.

The important mite species with which the medical entomologists and parasitologists are primarily concerned belong to the following four suborders: Tetrastigmata (= Holothyroidea), Mesostigmata, Prostigmata and Astigmata (Table I).

Suborder Tetrastigmata

Tetrastigmata possesses at least four lateral stigmata*. These reddish mites are heavily sclerotized, non-segmented and include the largest of the known mites (7 mm in length). This suborder does not include any parasitic species. However, certain species of the family Holothyridae on the island of Mauritius are said to cause ill effects among children who accidentally swallow the mites (1).

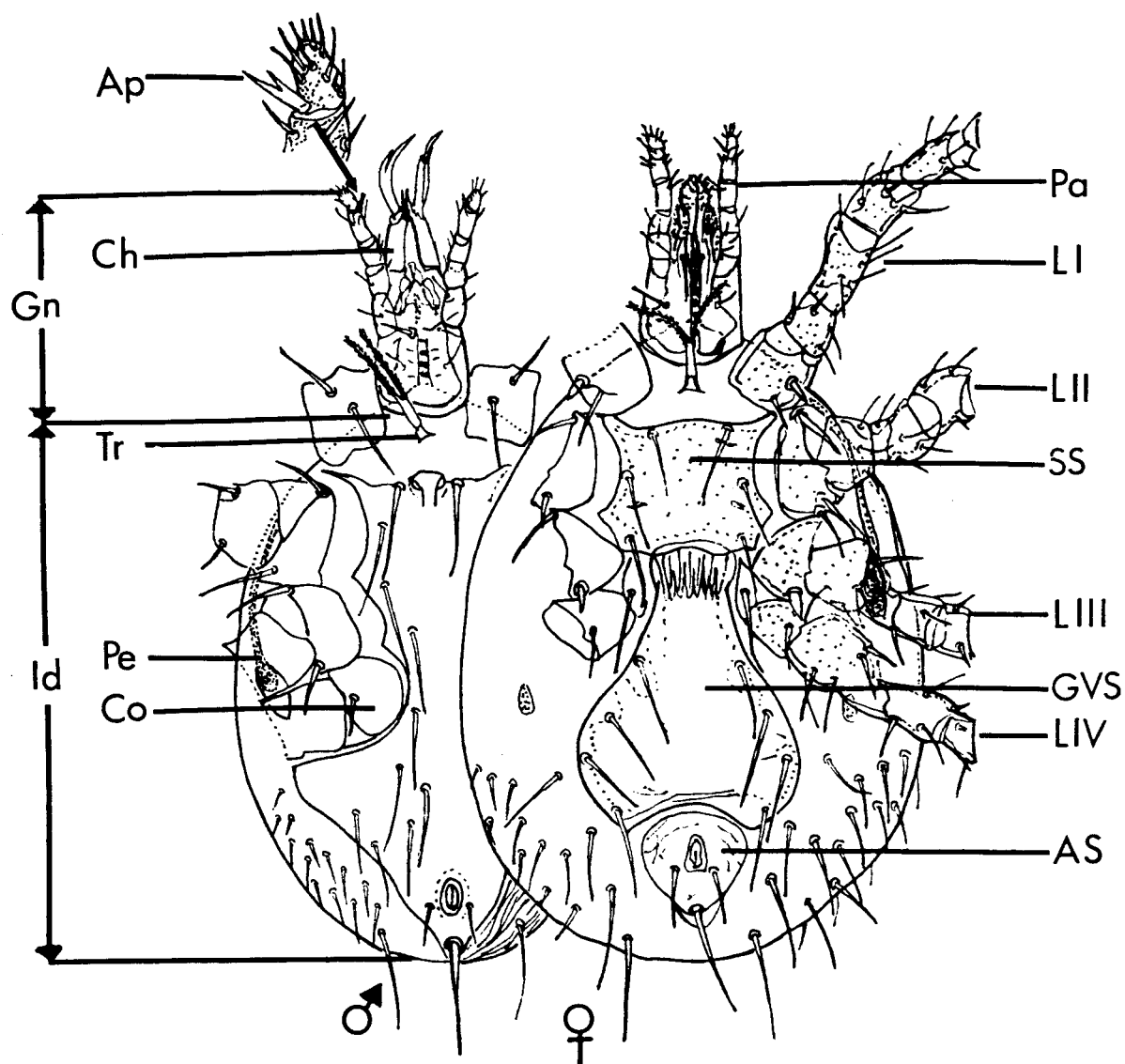


Fig. 2. Ventral* view of male and female *Laelaps echidninus*.
Legend: Ap = apotele, Ch = chelicera, Co = coxa (of leg IV),
Gn = gnathosoma, Id = idiosma, L = leg (I-IV), Pa = palp,
Pe = peritreme, Tr = tritosternum, SS = sternal shield,
AS = anal shield, and GVS = genitoventral shield
(epigynial shield).

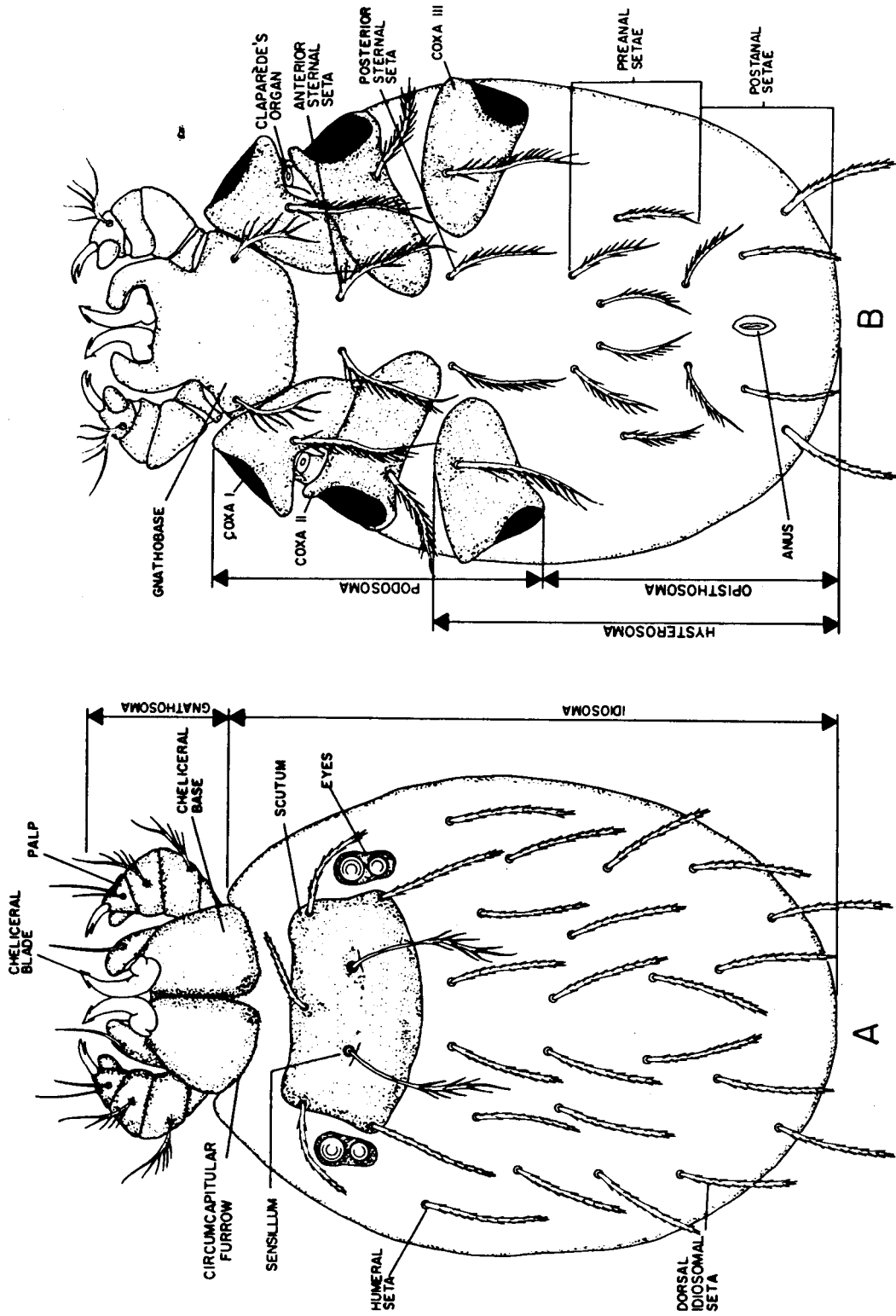


Fig. 3. Idiosoma and gnathosoma of trombiculid larval mite (*Eutrombicula alfreddugesi*):
A = dorsal* aspect; B = ventral aspect (from Goff, et al., 1982, Ref. 30).

Table I. Most important species, genera and families of mites of public health and veterinary significance.

Suborder Tetrastigmata	Suborder Mesostigmata	Suborder Prostigmata	Suborder Astigmata
Family Holothyridae	Family Dermanyssidae	Family Cheyletidae	Family Acaridae
<u>Holothyrus coccinella</u>	<u>Dermanyssus gallinae</u>	<u>Cheyletiella parasitivorax</u>	<u>Acarus siro</u>
	<u>Liponyssoides sanguineus</u>	<u>Cheyletiella yaguri</u>	<u>Suidasia nesbitti</u>
			<u>Tyrophagus putrescentiae</u>
	Family Halarachnidae	Family Demodicidae	Family Carpoqlyphidae
	<u>Pneumonyssus simicola</u>	<u>Demodex folliculorum</u>	<u>Carpoqlyphus lactis</u>
		<u>Demodex brevis</u>	
	Family Laelapidae	Family Pyemotidae	Family Glycyphagidae
	<u>Eulaelaps stabularis</u>	<u>Pyemotes tritici</u>	<u>Glycyphagus domesticus</u>
	<u>Androlaelaps casalis</u>	<u>Pyemotes ventricosus</u>	<u>Glycyphagus destructor</u>
	<u>Androlaelaps fahrenheitzi</u>		<u>Goheria fusca</u>
	<u>Haemogamasus pontiger</u>	Family Tetranychidae	Family Pyroglyphidae
	<u>Hirstionyssus isabellinus</u>	<u>Bryobia praetiosa</u>	<u>Dermatophagoides farinae</u>
	<u>Laelaps echidninus</u>		<u>Dermatophagoides pteronyssinus</u>
	<u>Laelaps muris</u>	Family Trombiculidae	<u>Euroglyphus maynei</u>
	<u>Laelaps nuttalli</u>	<u>Eutrombicula alfreddugesi</u>	
	Family Macronyssidae	<u>Eutrombicula batatas</u>	Family Sarcoptidae
	<u>Ornithonyssus bacoti</u>	<u>Leptotrombidium akamushi</u>	<u>Sarcoptes scabiei</u>
	<u>Ornithonyssus bursa</u>	<u>Leptotrombidium arenicola</u>	
	<u>Ornithonyssus sylviarum</u>	<u>Leptotrombidium deliense</u>	
	<u>Ophionyssus natricis</u>	<u>Leptotrombidium fletcheri</u>	
		<u>Leptotrombidium pallidum</u>	
		<u>Leptotrombidium pavlovskyi</u>	
		<u>Leptotrombidium scutellare</u>	
		<u>Neotrombicula autumnalis</u>	

Suborder Mesostigmata

The suborder Mesostigmata includes 15 families and 125 genera. They possess a pair of lateral stigmata usually located behind the third coxa. The body is well chitinized*, possesses dorsal* and ventral* plates and usually is brown in colour. Some 200 species of mesostigmatid mites are parasitic on vertebrates and invertebrates. They feed on the body fluids or tissues of their hosts (1). Some of these parasitic mites are of considerable economic importance. Most mesostigmatid mites affecting man and animals belong to the families Dermanyssidae, Macronyssidae and Laelapidae (Tables I & II). The books of Harwood and James (1979) (1), Radovsky (1967) (24) and McDaniel (1979) (26) provide an excellent coverage of parasitic mesostigmatids. A key to the important species of mesostigmatid mites of worldwide distribution that infest rats and other commensal rodents and household pets is given below. A simple pictorial key to the female of six species of mites which are frequently encountered is also included (Fig. 4).

Suborder Prostigmata

This is a very diverse group and includes a large number of species of mites of medical, veterinary and agricultural importance (Tables I, III). Most prostigmatid mites have a pair of stigmata at the base of the chelicerae. Because of their diverse food habits which range from parasitic to phytophagous* or predacious, the chelicerae exhibit a variety of structural forms due to adaptation to a particular method of feeding (26). The number of legs may also vary from two to eight among adult members of some families, for example: males of the family Podapolipodae have 3-4 pairs of legs, while females have 0-3 pairs; however, the larvae of all prostigmata have three pairs of legs.

The key given below provides a simple means for the identification of some of the more common and important species of prostigmatid mites. Neither this key nor the pictorial key (Fig. 4) includes the identification to the genera and species of the family Trombiculidae. For identification of chiggers the following publications should be referred to: Wharton and Fuller (1952) (19) for a general introduction; Goff, et al. (1982) (30) for the glossary of chigger terminology; Vercammen-Grandjean and Langston (1976) (25) for chigger mites of the world; Whitaker and Wilson (1974) (17) for families of trombiculids; Vercammen-Grandjean (1968) (31) and Brennan and Goff (1977) (32) for chiggers of Western Hemisphere and Far East.

Suborder Astigmata

Astigmata are slow-moving and weakly sclerotized mites (1). The suborder includes 69 families and 785 genera. The species within the suborder Astigmata may range in their feeding habits as saprophytic*, predaceous or parasitic. They include the species of mites most commonly found feeding on stored food products (Table IV), but there are also a large number of forms that parasitize warm blooded animals (Table IV). Mites of the family Sarcoptidae live in the skin itself, where most make a burrow through the upper layers (26). These species of medical importance are included in the general key as well as pictorial key (Fig. 5). Many species of mites of medical importance belong to the following families: Acaridae, Glycyphagidae, Carpoglyphidae, Pyroglyphidae, and Sarcoptidae (Table I).

Table II. Some mesostigmatid mites of public health importance

Mite species	Geographical distribution	Hosts	Usual habitat	Effects on man
<u>Ornithonyssus bacoti</u> ¹	Worldwide	Mice, rats, chickens, wild rodents, carnivores, wild birds, man	Nest-acquired mites, rodent burrows, cracks in buildings	Irritation, dermatitis,* vector of human pathogens*
<u>Ornithonyssus sylvarium</u> ¹	Worldwide (temperate zones)	Mice, rats, chickens, pigeons, wild rodents man	Cracks and crevices in buildings, skin, feathers	Pruritus,* dermatitis, vector of human pathogens
<u>Ornithonyssus bursa</u> ¹	Worldwide (tropics & subtropics)	Chickens, pigeons, ducks, wild birds, man	Skin, feathers, cracks and crevices in animal buildings	Pruritus, dermatitis, vector of human pathogens
<u>Dermanyssus gallinae</u> ¹	Worldwide	Chickens, wild birds, pigeons, rats, rabbits, man	Nests of chickens and other birds, rodent burrows	Irritation, papular urticaria*, potential vector of human pathogens
<u>Liponyssoides sanguineus</u> ¹	Worldwide	Mice, rats, wild rodents, man	Cracks and crevices in buildings, rodent burrows	Dermatitis, vector of human pathogens
<u>Hirstionyssus isabellinus</u>	Worldwide	Mice, rats, wild rodents	Skin, pelage*, nests	Dermatitis, potential vector
<u>Haemogamasus pontiger</u> ¹	Worldwide	Mice, rats, wild rodents, man	Skin, pelage, rodent burrows, bedding, buildings	Irritation, dermatitis, vector

Table II. Some mesostigmatid mites of public health importance - continued

Mite species	Geographical distribution	Hosts	Usual habitat	Effects on man
<u>Laelaps echidninus</u>	Worldwide	Rats, mice, wild rodents, man	Skin, pelage, rodent burrows, bedding, buildings	Irritation, dermatitis, vector
<u>Laelaps nuttalli</u>	Worldwide (tropics & subtropics)	Mice, rats, wild rodents, carnivores, wild birds	Skin, pelage, rodent burrows, animal nests	Occasional irritation
<u>Proctolaelaps pygmaeus</u>	Worldwide	Birds, rodents, man	Soil & leaf mold, poultry litter, nests of small mammals	Papular dermatitis
<u>Androlaelaps casalis</u>	Worldwide	Mice, rats, wild birds, wild rodents, man	Skin, pelage, rodent burrows, animal nests	Sometimes causes dermatitis

1 Discussed in the text.

Pictorial Key To Female Mesostigmatid Mites Of Public Health Importance

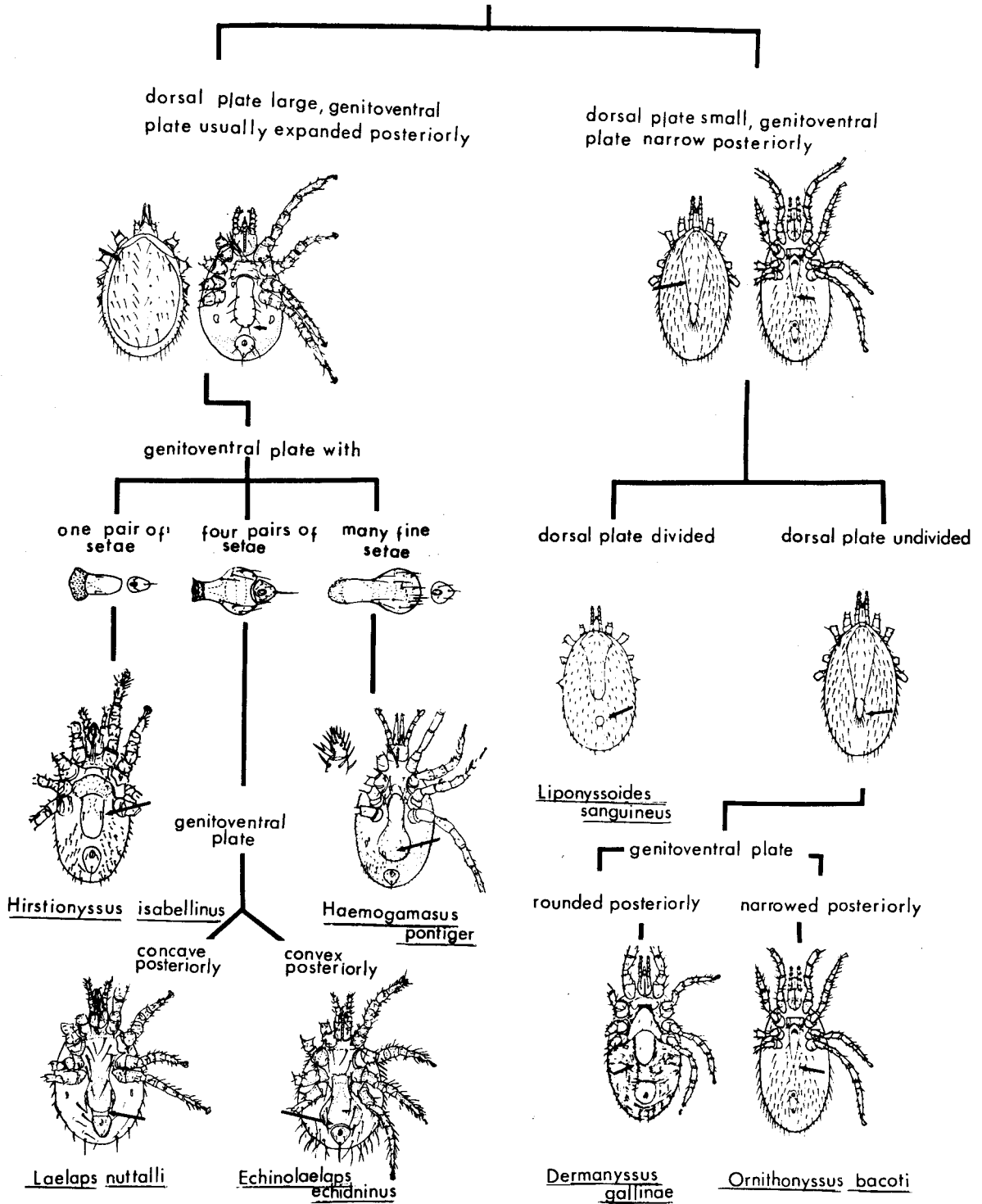


Fig. 4. Pictorial key to female Mesostigmatid mites of public health importance.

Table III. Some prostigmatid mites of public health, veterinary and agricultural importance

Mite species	Geographical distribution	Hosts	Usual habitat	Effects on man
<u>Bryobia praetiosa</u>	Worldwide	Commonly infesting vegetation; occasionally parasitize man	Found in numbers on plants, enter home and building	Annoyance, itching
<u>Pyemotes ventricosus</u>	Worldwide	Parasites of stored grain insects, man	Straw, grain, buildings storage facilities, straw mattresses	Pruritic dermatitis
<u>Pyemotes tritici</u> ¹	Worldwide	Parasites of stored grain insects, man	Straw, grain, straw mattresses	Pruritic dermatitis
<u>Cheyletiella yasguri</u> ¹	Worldwide	Dogs, man	Skin, pelage, floors, furniture, mattresses	Dermatitis
<u>Cheyletiella parasitivorax</u>	Worldwide	Rabbits, cats, man	Skin, pelage	Dermatitis
<u>Demodex folliculorum</u>	Worldwide	Man	Sebaceous glands, hair follicles	Occasional skin reactions
<u>Eutrombicula alfreddugesi</u> ¹	North & South America	Wide range of domestic animals, wild birds, man	Grass, skin of host	(larva); irritation, local inflammation, pruritus
<u>Eutrombicula batatas</u>	Central & South America, southwest USA	Chicken, wild birds, rodents, domestic animals, man	Grass and weeds, skin of host	(larva); irritation

Table III. Some prostigmatid mites of public health, veterinary and agricultural importance - continued

Mite species	Geographical distribution	Hosts	Usual habitat	Effects on man
<u>Leptotrombidium akamushi</u> ¹	S.E. Asia, India, Pacific Islands	Mammals, birds, man	Grass, skin of host, secondary or transitional vegetation	(larva); vector of scrub typhus
<u>Leptotrombidium deliense</u>	India, Pakistan, Papua New Guinea, southern USSR	Mammals, man	Grass, skin of host	(larva); vector of scrub typhus
<u>Neotrombicula autumnalis</u> ¹	Europe	Dogs, horses, rabbits various birds, man	Grass, skin of host	(larva); severe dermatitis

¹ Discussed in the text.

Table IV. Some astigmatid mites of public health, veterinary and agricultural importance

Mite species	Geographical distribution	Hosts	Usual habitat	Effects on man
<u>Sarcoptes scabiei</u> ¹	Worldwide	Domestic animals, man	Skin	Occasionally causes severe dermatitis
<u>Notoedres cati</u>	Worldwide	Cats, rabbits, dogs, man	Skin	Transient dermatitis
<u>Acarus siro</u>	Worldwide	Pest of stored foods and vegetable products Free living mite	Stored hay and grain, house dust	Dermatitis dust-allergy; allergic respiratory disease
<u>Tyrophagus putrescentiae</u> ¹	Worldwide	Free living mite	House dust, pests of stored food products	Dermatitis, dust-allergy; allergic respiratory disease
<u>Lepidoglyphus destructor</u>	Worldwide	Free living mite	Grain dust, barn dust, surface of mattresses, stored hay and grain	Dust-allergy; allergic symptoms

Table IV. Some astigmatid mites of public health, veterinary and agricultural importance - continued

Mite species	Geographical distribution	Hosts	Usual habitat	Effects on man
<u>Dermatophagoides farinae</u>	Worldwide	Free living mite	House dust: surface of mattresses, blankets, pillows, floors, pets	Dust-allergy; bronchospasm, dyspnoea,* asthma*
<u>Dermatophagoides pteronyssinus</u>	Worldwide	Free living mite	House dust: surface of mattresses, blankets, pillows, floors, pets bedding and cages	Dust-allergy; bronchospasm, dyspnoea, asthma
<u>Euroglyphus maynei</u>	Worldwide	Free living mite	House dust: surface of mattresses, blankets, pillows, floors, pets bedding and cages	Dust-allergy; bronchospasm, dyspnoea, asthma

1 Discussed in the text.

Key to Selected Mites of significance in Medical Entomology

1. With lateral stigmata; usually associated with an elongated peritreme (Fig. 2);
palpal tarsus usually bearing a tined or subdivided apotele-----suborder Mesostigmata
-----3
- Without stigmata at sides of the body; palpal tarsus with or without tarsal claw-----2
2. No stigmal openings; coxae forming strong apodemes* beneath skin on venter of body
(Fig. 5); anal suckers may be present (Fig. 5) ----- suborder Astigmata---13

- Stigmata if present, near the base of chelicerae (Fig. 3); no coxal apodemes; anal
suckers absent ----- suborder Prostigmata -----15
3. Chelicerae long, whiplike (Fig. 4) -----4
- Chelicerae shorter, stronger -----5
4. Dorsum of female with one shield; anal plate of female not egg-shaped and with anal
opening in its posterior end (Fig. 4) -----Dermanyssus gallinae
- Dorsum of female with two shields; anal plate of female egg-shaped and with its anal
opening situated centrally(Fig. 4)-----Liponyssoides sanguineus
5. Cheliceral shears without teeth; tritosternum (leg segment I) with membranous flange
near base (Fig. 4) -----6
- Cheliceral shears with teeth; tritosternum without membranous flange -----9
6. Genitoventral plate narrowing to a point posteriorly -----7
- Genitoventral plate rounded posteriorly (Fig. 4) -----Hirstionyssus isabellinus
7. Female with dorsal plate broad; dorsal plate setae short, reaching about halfway to
bases of setae* of next row -----8

- Female with dorsal plate narrow, tapering rapidly posteriorly; dorsal plate setae
long, reaching to or past bases of setae of next row giving the mite a hairy appearance
-----Ornithonyssus bacoti
8. Sternal plate of female with three pairs of setae -----Ornithonyssus bursa
- Sternal plate of female reduced and with only two pairs of setae Ornithonyssus sylviarum
9. Body densely covered with setae; genitoventral plate with 10 or more pairs of setae
-----10
- Body with few setae arranged in transverse rows -----11

10. Genitoventral plate strongly expanded posteriorly and with many setae -----
-----Eulaelaps stabularis
- Genitoventral plate drop-shaped posteriorly, with many setae (Fig. 4)
-----Haemogamasus pontiger
11. Genitoventral plate with only one pair of setae; pilis dentili of chelae inflated
basally and with distal hooklike tips -----Androlaelaps fahrenheiti
- Genitoventral plate with four pairs of setae -----12
12. Genitoventral plate greatly enlarged, concave posteriorly, and surrounding anterior
portion of anal plate (Fig. 2) -----Laelaps echidninus
- Genitoventral plate drop-shaped, not enlarged, and not surrounding anal plate
-----Laelaps nuttalli
13. Free-living; with two pairs of well-developed genital discs; tarsi with clawlike
empodia* (Fig. 6) -----14
- Parasitic; genital discs greatly reduced or absent; tarsi without empodial claw;
pretarsi usually well-developed into flaplike organs (Fig. 5) -----Family Sarcoptidae
-----Sarcoptes scabiei
14. Tarsal tip bearing a large conspicuous clawlike empodium, dorsal propodosoma without
crista metopica* (Fig. 6) -----Family Acaridae
- Tarsal tip bearing a small clawlike empodium; dorsal propodosoma with crista metopica
(prodorsal sclerite*) (Fig. 6) -----Family Glycyphagidae
15. Body elongate, worm like, annulate*, without setae (Fig. 5) -----Demodex folliculorum
- Body not as above -----16
16. With four pairs of legs -----14
- With three pairs of legs; usually attached to host; larval forms -----
-----Family Trombiculidae (page 23)
17. Gnathosoma not conspicuous, palpi simple, coxal apodemes obvious; female usually with
gravid body -----Pyemotes tritici
- Gnathosoma usually conspicuous, palpi well developed; female nongravid-----18
18. Palpi claw large, curved downward, with many weak teeth-like structures (Fig. 5); first
pair of legs short -----Cheyletiella parasitivorax
- Palpi claw small, simple without teeth-like structures; first pair of legs very long
(Fig. 5) -----Bryobia praetiosa

Pictorial Key To Some Common Mites (excluding Mesostigmata)
Of Public Health Importance

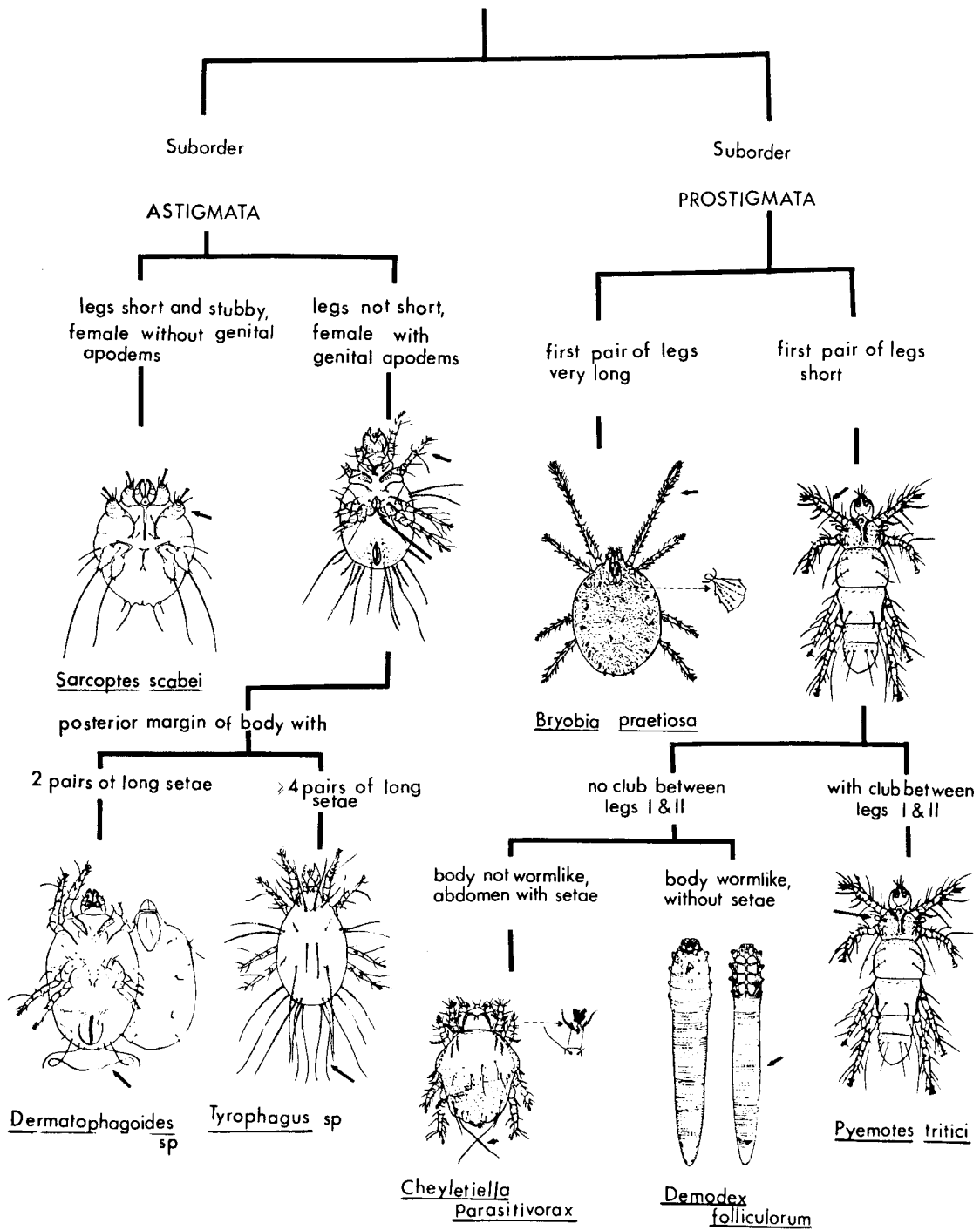


Fig. 5. Pictorial key to some common mites (excluding Mesostigmata) of public health importance.

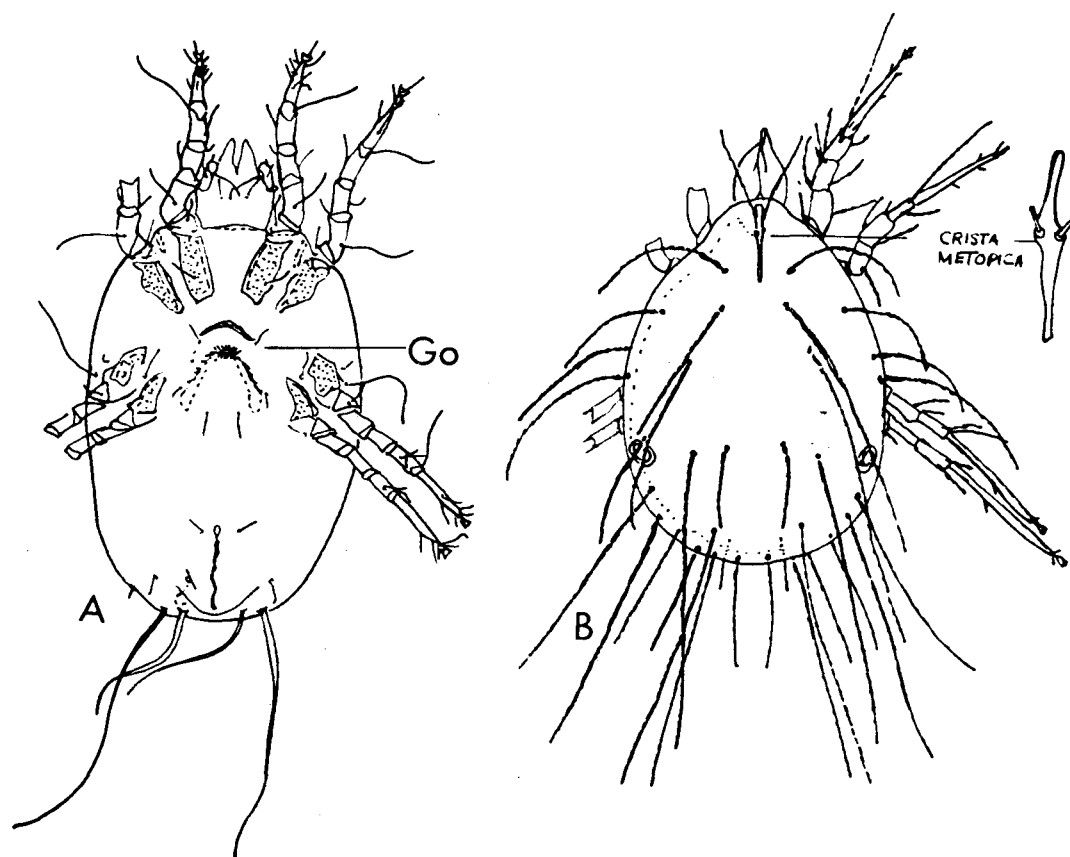


Fig. 6. Examples of mites of stored food and houses. A = Dermatophagoides farinae: ventral view of female (Go = genital openings). B = Glycyphagus domesticus: dorsal view of male.

IV MITE SPECIES ATTACKING MAN

1. Common mites of cosmopolitan distribution

Suborder Mesostigmata. This suborder includes some 200 species of parasitic mites (Table II). Some of the species that parasitize vertebrates are of considerable economic and public health importance and are discussed below.

Family Dermanyssidae. This family is characterized by a stylet-like chelicera which is modified for piercing the skin of its host. Many representatives of this family are obligatory bloodfeeding ectoparasites dwelling primarily in nests or burrows (1, 20, 21). The family contains the well-known chicken mite, Dermanyssus gallinae, and house mouse mite, Liponyssoides sanguineus, which are very bothersome ectoparasites of birds and mammals respectively.

Dermanyssus gallinae, the chicken mite, is associated with domestic fowl, turkeys, ducks, pigeons, and many other birds (Table II). It has also been reported from the rat and rabbit (8), and is cosmopolitan in its distribution. It is known to attack man and cause discomfort and skin disorders (1, 20), and is also a suspected vector of arthropod-borne virus encephalitides (1,20). As a parasite of chickens, D. gallinae may cause serious illness or death through exsanguination (1, 3, 33), infested birds become restless, and the egg laying is affected (1, 35).

Liponyssoides sanguineus, the house mouse mite, has been collected from many species of mammals throughout the world (Table II) (1, 20, 34). The common house mouse, Mus musculus, is the preferred host, but this mite occurs also on rats and other rodents. It readily attacks human beings, causing a rash (1, 20). This mite is very important as a vector of Rickettsia akari, the agent of rickettsialpox, to man. It has been reported to transmit tularaemia in the USSR (8).

Family Macronyssidae. This family contains some of the common parasitic mites associated with man, rodents and birds (8, 20). Most macronyssid mites are characterized by their frequent biting habits (35). Attacks of these mites commonly produce localized or generalized dermatitis.

Ornithonyssus bacoti, the tropical rat mite, was first recorded from the Norway rat, Rattus norvegicus, in Egypt (20). It is associated with rats in both tropical and temperate areas of the world (Table II). This mite readily attacks people living in rat-infested buildings. Persons working in granaries and food supply houses frequented by rats may be greatly annoyed by this mite. It is capable of inflicting an irritating or painful bite (20).

Ornithonyssus bursa, the tropical fowl mite, is a poultry ectoparasite both in tropical and subtropical areas of the world. It is widely distributed in Argentina, Brazil, China, India, parts of Africa, South America and southern USA. This species is found on chickens, sparrows and other birds (Table II). It readily bites man and causes skin irritation (1,2). Like Dermanyssus gallinae, it is a serious pest of poultry.

Ornithonyssus sylviarum, the northern fowl mite, is a very serious pest of domestic fowl and wild birds. It has also been recorded as feeding on man and wild rodents. This species is found throughout the temperate regions of the world, mainly as a parasite of poultry (8, 20), with mice, rats and man as incidental hosts (Table II). This mite will attack man in the absence of its preferred hosts.

Ophionyssus natricis, the snake mite, infests all kinds of captive snakes in zoos and pet stores throughout the world. It has been reported from other animals such as rats. Infestation of human beings by snake mites is documented (36).

Family Laelapidae. This family is a very complex group of mites, largely parasitic. Members of the family are of considerable public health importance because of their intimate association with commensal rodents. Almost all members of the haemogamasid subfamily are found on small mammals throughout the world (1, 20). Some, such as Haemogamsus pontiger, Hirstionyssus isabellinus, and Androlaelaps fahrenheitsi, which have been collected from rodents or their burrows, have been shown to harbour the etiological agent of haemorrhagic nephrosonephritis of the Far East (34, 37). They may also play an important role in the maintenance and transmission of plague, murine typhus and tularaemia (16).

Haemogamasus pontiger is both free living and parasitic in the burrows of various rodents. This mite was suspected of causing dermatitis among soldiers who slept on straw-filled mattresses in England during the Second World War (20). It is known to occur in Africa, China, Europe and the USA (8).

Eulaelaps stabularis is a very common mite in the nests and on the bodies of rodents and insectivores* throughout the world. This mite has been incriminated as the cause of dermatitis in man on several occasions (8, 20).

Other species of family Laelapidae, such as Laelaps echidninus, Laelaps nuttalli and Hirstionyssus isabellinus are important because of their association with commensal and wild rodents, which may serve as reservoirs* for diseases transmissible to man, and their potential for harbouring etiological agents of human diseases. Furthermore, many of these mites have been reported to attack human beings in the absence of their preferred hosts (8, 20).

Suborder Prostigmata

Family Pyemotidae. This family includes some mites of medical importance. Many members, such as those associated with grain, have a widespread distribution. The straw itch mite, Pyemotes tritici, (Table III), a common parasite of a variety of stored-grain insects, will attack people who come into contact with infested grain, straw, hay or grasses (1, 20). The bite of P. tritici may cause mild to severe cutaneous reactions with severe itching and nausea (1, 38).

Family Cheyletiellidae. Members of this family are primarily predators, but some species are parasitic on mammals and wild birds (1, 3, 20). "Walking dandruff" is a veterinary name for the infestation of the hair coat of the dog and cat with Cheyletiella yasguri and C. blakei respectively. Dermatitis in people associated with dogs, cats and rabbits has been attributed to C. yasguri, C. blakei and C. parasitivorax (1, 3, 39, 40). Cheyletiella species spend their entire life cycle within the hair coat of the host and cause a scurfy pruriginous* dermatitis (mange) on their normal hosts as well as an itching dermatitis on persons who handle these pets.

Family Trombiculidae. This family, of which nearly 3000 species have been described (1), includes the chigger mites which are of medical importance due to their ability to both cause dermatitis and transmit scrub typhus (Table III). The adult mites are bright red or reddish-brown in colour and have a velvety appearance. The larvae of this family are parasitic on terrestrial vertebrates. Most species of chiggers attach themselves to the external parts of the body of the host, usually the ears, the belly and on thighs. A few species burrow under the skin or live inside nasal passages. One species, Vatacarus ipoides, infests the trachea of amphibious sea snakes (34). The chigger larvae are important because their bites commonly result in dermatitis and certain species serve as vectors of scrub typhus (vide infra). The adults and nymphs (postlarval stages) unlike the larvae, are not parasitic, but are free-living predators* (1, 20). Numerous species attack human beings throughout the world.

Neotrombicula autumnalis, the harvest mite, occurs over most of northern Europe, including the United Kingdom (1,3). The chigger larvae feed on vertebrate hosts, commonly rodents or rabbits, and readily attack man.

Eutrombicula alfreddugesi, the red bug, is the most common chigger attacking man in the USA, existing in many different habitats throughout that country (1,19). The habitat where a person is likely to encounter the chigger is in an area between forest and grassland, along the periphery of swamps, or in brush thickets (19); in much of the USA chiggers are encountered on lawns. Trombicula batatas, which is recorded from southern USA, also causes severe dermatitis in man. The adult mites are free-living and feed primarily on insect eggs. Further species of chiggers in the Trombicula, Euschoengastia, Schoengastia, and Apolonia genera from the Americas, Pacific Islands, Australia, Indonesia, Malaysia and Papua New Guinea are reported to attack man and cause dermatitis (1,19).

Leptotrombidium akamushi. This species as well as several other species within the L. deliense-group (L. deliense, L. fletcheri, L. arenicola, L. pallidum, L. pavlovskyi and L. scutellare), which readily attack man, are known as vectors of chigger-borne rickettsiosis (scrub typhus) (vide infra). L. akamushi have been collected from Honshu, Japan (12), while

members of L. deliense group have been found from Papua New Guinea and the coastal fringe of Queensland, Australia, the Philippines and China (including the Province of Taiwan), westward through southeastern Asia to Pakistan (1,12).

Suborder Astigmata

Families Acaridae, Glycyphagidae and Pyroglyphidae. Mites in these families are pests of stored food products. Also, they can cause skin reactions and lung or intestinal infections in man and animals (1,41). They are mostly scavengers, feeding on grain, flour, dried fruits and meat products (20,41). Persons handling infested products may experience dermatitis. The following species are of public health importance (Table IV): Tyrophagus putrescentiae, Acarus siro, Dermatophagoides farinae and D. pteronyssinus, and Glycyphagus domesticus. Most of these species are widely distributed throughout the world from Arctic tundra to tropical forests (34,41), and some of these mites have been incriminated as sources of antigens associated with allergies to house dust (Section V.4).

Family Sarcoptidae. Members of this family are known as scabies mites and include mites which produce a particular type of dermatosis. Sarcoptes scabiei causes scabies in man and is cosmopolitan in its distribution (1).

2. Other mites reported to attack human beings

Other species of mites have been reported to attack man. In most cases, the proper identification of the mite species involved remained questionable. Several species of mites may be involved in so-called "occupational acarine dermatitis" (1,40). Grocer's itch or copra itch is caused by the mold mite, Tyrophagus putrescentiae, and baker's itch by the house mite, Glycyphagus domesticus. Some species of the cheyletid mites were suspected of biting and causing dermatitis among wheat warehouse employees in Japan and recently Yashikawa (1985) (42) reported that Cheyletus malaccensis and Chelacaropsis sp., may have been partly responsible for these episodes of dermatitis.

V. MITES AND DISEASE

1. Rickettsial diseases

The rickettsial diseases of human beings are widely distributed in both tropical and temperate zones. Some are almost worldwide in distribution, and others have a more restricted distribution. Evidence is accumulating to indicate that some mite-borne rickettsial diseases of man constitute substantial health problems (43). Nearly all rickettsial diseases of man are transmitted by arthropods, including insects and acarines. The following rickettsial diseases are discussed below: scrub typhus (transmitted by trombiculid mites) and rickettsialpox (transmitted by mesostigmatid mites). The possibility of other rickettsioses being carried by mites is also explored.

Scrub typhus (chigger-borne rickettsiosis). Scrub typhus is an acute febrile disease of rural Asia and Australia (Fig. 7). It is known in Japan as tsutsugamushi disease (dangerous bug disease), in Indonesia as mite typhus, and in Malaysia as rural or scrub typhus. The disease is caused by infection with Rickettsia tsutsugamushi (= R.orientalis). Scrub typhus in man is often characterized by a primary skin lesion consisting of a punched out ulcer covered by eschar or tache noir at the site of the attachment of the vector mite. The bite of the mite is usually unnoticed by the host. After an incubation period of 10 to 12 days (range 6 to 21 days), the disease commences with an acute fever (39.5° to 40.5°C), severe headache and lymphadenopathy (2,43,44). The fatality rate varies from 0.6% to 40% depending on the geographical area, strain of rickettsia, and susceptibility of the infected person.

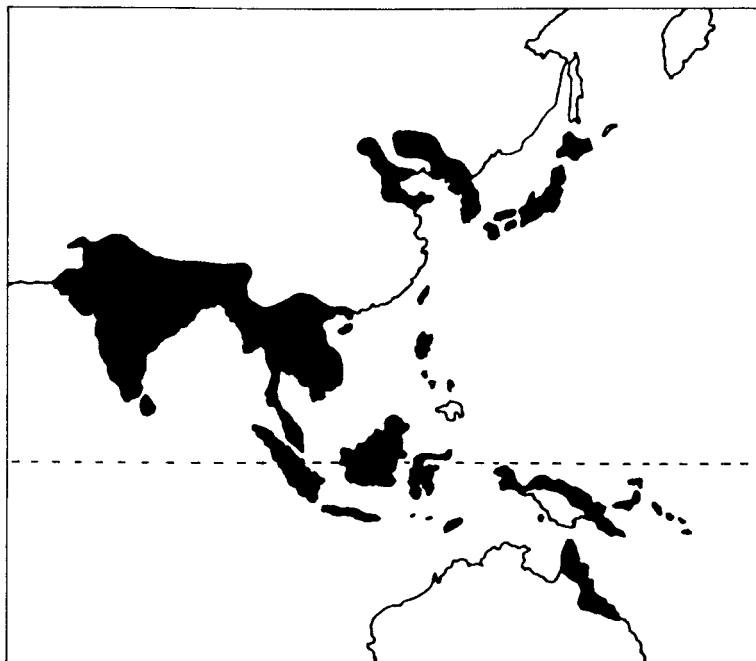


Fig. 7. Areas in Southeastern Asia and the Western Pacific where cases of scrub typhus occur. From Harwood & James, 1979, p. 367 (Ref. 1).

R.tsutsumushi is closely associated with trombiculid mites and their rodent hosts (12,14,45). It is transmitted by the bite of the infected mite larva (12,45). Infections due to inhalation of an infectious aerosol have been reported only in laboratory accidents. Among the numerous species within the Trombiculidae, the genus Leptotrombidium contains the only proven vectors of scrub typhus. Chiggers of the Leptotrombidium deliense-group are the main vectors to man and to other hosts and include: L. deliense, L. akamushi, L. fletcheri, L. arenicola, L. pallidum, L. pavlovskyi and L. scutellare (Table V) (12,45). The naturally infected chiggers constitute the reservoir for this rickettsiosis, maintaining and perpetuating the cycle of infection by passing the rickettsiae through the nymphal and adult stages and via eggs to the next mite generation (12,14,46,47). Wild rats, field mice and voles serve as the primary hosts of Leptotrombidium throughout their ranges, and shrews often serve as secondary hosts. These hosts acquire their infections from infected chiggers.

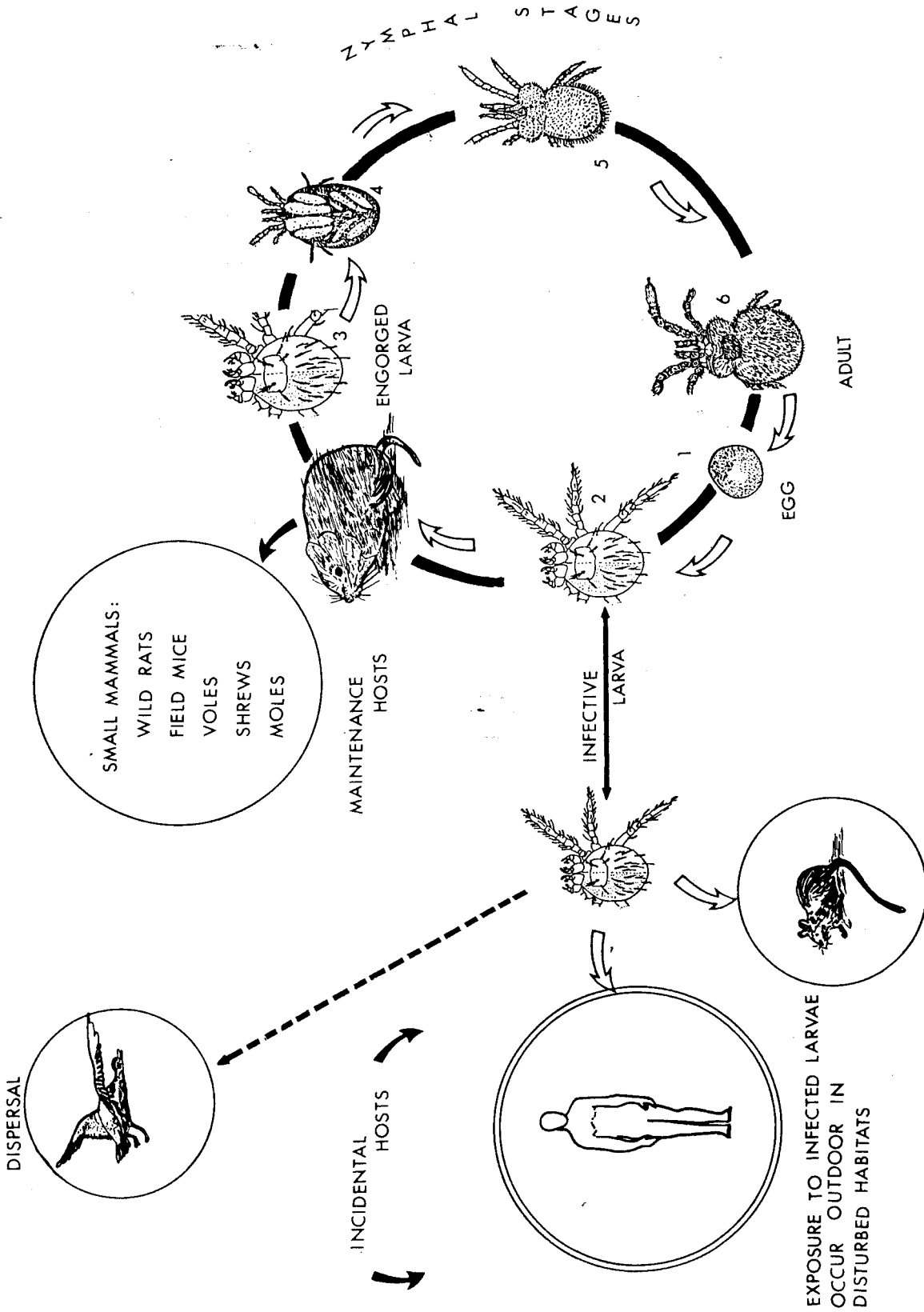
Scrub typhus occurs in Australia, Burma, China, the Indochina peninsula, Indonesia, Japan, Malaysia, the Philippines, Thailand, the South Pacific Islands and in the Indian subcontinent (Table V & Fig. 7) (45,46). This rickettsiosis is endemic in a variety of habitats, ranging from the equatorial rain forests of Malaysia to the semi-deserts of Pakistan and to the alpine meadows high in the Himalayas (12).

All the endemic foci are characterized by the presence of the following features (Fig. 8): (1) Rickettsia tsutsumushi; (2) chiggers of the Leptotrombidium deliense-group; (3) small mammals as suitable hosts and (4) natural or manmade environmental modifications (e.g. after forest fires, cutting of forests and abandonment of agricultural fields) (12,45). Endemicity varies from area to area. In temperate areas, the human cases of scrub typhus are acquired during the warm months when the infected chiggers are usually active (12,45). In contrast, year-round transmission occurs in tropical areas. The disease may be contracted in grassy fields, shrubby areas, forests, abandoned rice fields, and cleared forest areas where ecological conditions for the chigger/mammal association are suitable (12,44,45). Within such habitats, infected chiggers may aggregate in very confined foci, or "mite islands", accounting for the marked localization of scrub typhus cases and sudden outbreaks among field personnel (e.g. road builders, military personnel and other transmigrants) (12,47). Within these mite islands the chiggers aggregate in clusters, a few

Table V. Mite species harbouring rickettsiae in nature¹

Disease	Agent	Mite species	Country	Reference
Murine typhus	<u>Rickettsia typhi</u> (= <u>R. mooseri</u>)	<u>Ornithonyssus bacoti</u> <u>Laelaps echidninus</u> <u>Ascoschoengastia indica</u>	China, USSR USSR Java, Indonesia	Traub et.al. 1978 (53)
Q fever	<u>Coxiella burnetii</u>	<u>Leewenhoekia major</u> <u>Dermanyssus gallinae</u> <u>Dermanyssus passerinus</u> <u>Liponyssoides sanguineus</u> <u>Ornithonyssus bacoti</u> <u>Androlaelaps casalis</u>	USSR Central Czechoslovakia	Burgdorfer 1980 (51) Nutting 1984 (2) Rehacek 1975 (52)
Rickettsialpox	<u>Rickettsia akari</u>	<u>Liponyssoides sanguineus</u> <u>Ornithonyssus bacoti</u>	Rep. of Korea, USA Egypt, USSR, Africa	Burgdorfer 1980 (51) Harwood & James 1979 (1)
Scrub typhus	<u>Rickettsia tsutsugamushi</u>	<u>Leptotrombidium deliense</u> <u>L. fletcheri</u> , <u>L. akamushi</u> <u>L. arenicola</u> , <u>L. pallidum</u> <u>L. pavlovskiyi</u> , <u>L. scutellare</u>	W. Pakistan, S.E. Asia Indonesia to Australia Iran, Japan, Papua New Guinea China, USSR	Traub & Wisseman 1974 (12) Tarasevich 1978 (54)
Spotted fever group	<u>Rickettsia slovaca</u> <u>Rickettsia sibirica</u>	<u>Haemogamassus sp. (5 species)</u> <u>Androlaelaps sp. (12 species)</u>	Czechoslovakia USSR	Rehacek 1975 (52), Tarasevich 1978 (54)

¹ Unverified reports are not included.



DOMESTIC RODENT

Fig. 8. Epidemiological cycles of scrub typhus. Open arrow = transmission of *Rickettsia tsutsugamushi*. Rickettsiae survive through nonparasitic nymphal and adult states (3-6) and are transovarially transmitted to the next mite generation (1,2).

inches above the soil on leaves or dry grass stems in fields or in forests and wait there for the hosts to come into contact with them (12).

Numerous studies conducted in endemic areas during the past ten years have revealed that scrub typhus is a leading cause of febrile disease and often requires hospitalization (43,48,49).

Rickettsialpox. Rickettsialpox is a mild febrile and self-limiting disease, characterized by an initial eschar-like lesion, fever, headache, backache and rash (50,51). The disease was first observed in New York City in 1946, when 124 cases were reported. The causative agent is Rickettsia akari, a member of the spotted fever group of rickettsiae (50,51). Transmission of rickettsialpox to man occurs through bites of infected Liponyssoides sanguineus (Table V & Fig. 9). This mite normally parasitizes the house mouse, Mus musculus. The mite has also been recovered from Rattus norvegicus, but it is found predominantly in mice-infested homes (51). Since the larvae of the housemouse mite do not feed, transmission is by feeding nymphs and adults of both sexes. Transovarial transmission of the rickettsia in L. sanguineus has also been demonstrated (51).

Brettman and his colleagues (1981) (50) have described a recent outbreak in New York and have reviewed published work. Over 800 human cases have been reported, mostly in urban areas. Since the first epidemic in 1946, the reported cases in the USA have declined markedly, possibly owing to underreporting or to control measures. In at least one of the outbreaks of rickettsialpox in New York, the removal of a garbage dump in a nearby residential area forced the mice and rats inhabiting it and their ectoparasites to move into apartment buildings and start the outbreak. (50,51). Although rickettsialpox has been reported from urban areas in the USA and USSR, there is some evidence that it may be contracted in natural cycles not involving house mice (1,44). In the Republic of Korea, and in equatorial and southern Africa, cases apparently have been acquired in the settings involving field rodents and their ectoparasites. R. akari has been isolated from rats (Rattus) in the USSR and from wild field vole (Microtus fortispellicous) in the Republic of Korea (1, 44). Other species of mite, especially Ornithonyssus bacoti, which has been frequently found in rodent-infested premises throughout the world, have been found capable of acquiring R. akari and transmitting it to mice under laboratory conditions, but are not known to be involved in the natural transmission of R. akari.

Other rickettsioses. There appears to be no reason why ectoparasitic bloodsucking mites of commensal and wild rodents should not serve as vectors of other blood-borne rickettsiosis. While it has been claimed that some species of mesostigmatid mites and chiggers may acquire rickettsiae from experimentally infected animals (2, 51-53), and subsequently transmit the infection to other animals, such reports require further clarification. Although several species of mites have been found naturally infected with murine typhus and the spotted fever group of rickettsiae (Table V), their importance in natural transmission has in general been disregarded, largely because of lack of epidemiological support. The causative agent of Q fever (Coxiella burnetii) has been found in a number of species of mesostigmatid mites: Dermanyssus gallinae, Liponyssoides sanguineus, and Ornithonyssus bacoti in central Czechoslovakia and the USSR (2,52). In addition, a number of other mesostigmatid mites associated with birds or mammals have been found infected with Coxiella burnetii, but their exact role in the epidemiology of this disease is not known.

Seventeen species of mites belonging to five genera have been found naturally infected with rickettsiae of the spotted fever group in Czechoslovakia and the USSR (Table V) (2,52). Although several strains of R. siberica and R. slovacica have been isolated from these mites, their role in the epidemiology of this infection has not been precisely demonstrated.

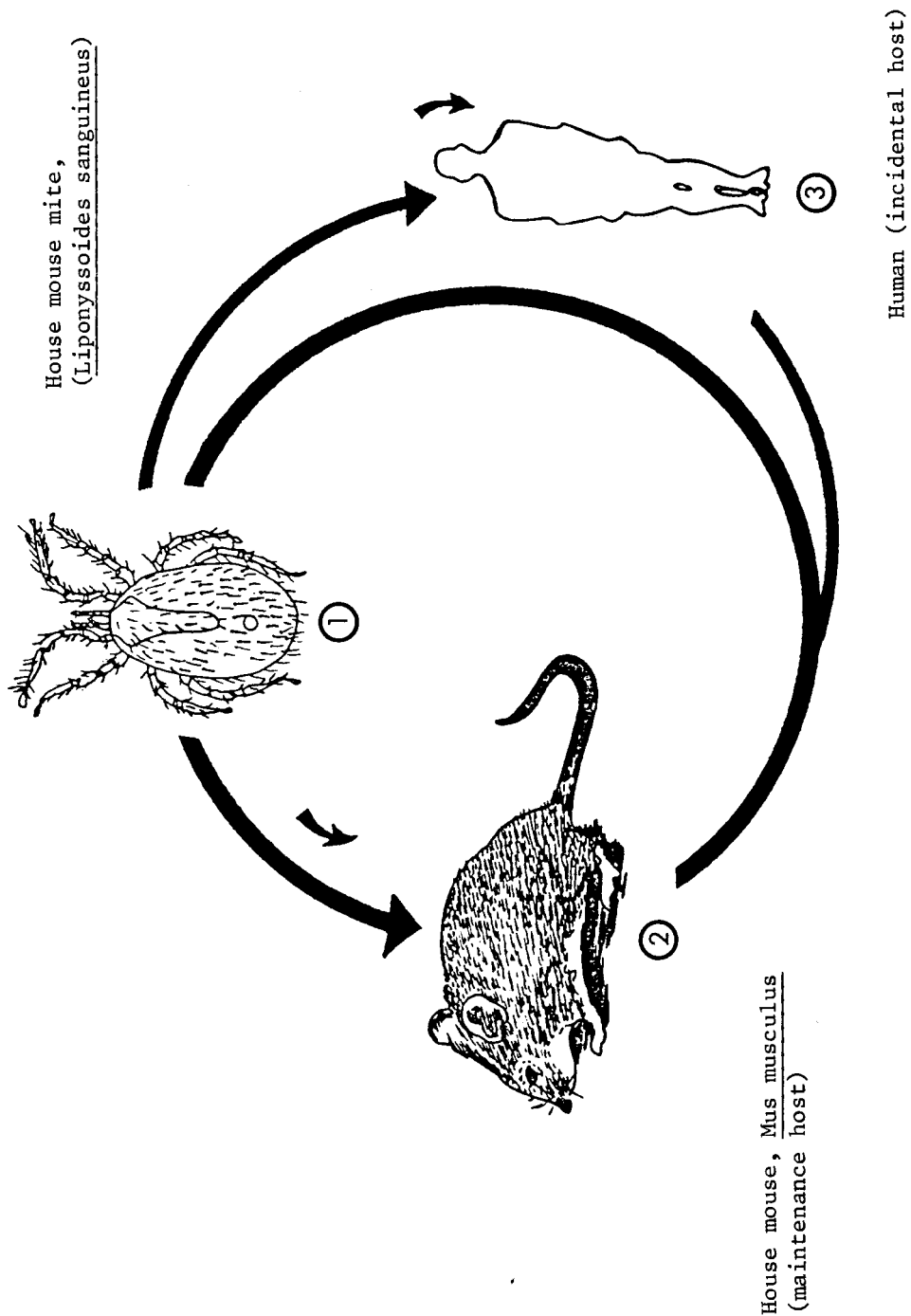


Fig. 9. Composit diagram of the transmission cycle of rickettsialpox in urban environment.
Close arrow = transmission of Rickettsia akari.

2. Other diseases due to microorganisms

Under experimental conditions, and in some cases in nature, mites are capable of acquiring, maintaining and transmitting agents from nearly every major group of microbial pathogens including viruses, spirochaetes, bacteria, and protozoa.

Viruses. Bloodsucking mesostigmatid mites have been reported as naturally or experimentally associated with the acquisition, maintenance and transmission of seven viral diseases (Table VI). These are Eastern equine encephalitis, Western equine encephalitis, St. Louis encephalitis, fowl pox, Korean haemorrhagic fever, Omsk haemorrhagic fever, Argentinian haemorrhagic fever, Newcastle disease, and ornithosis (2,55,56). Table VI lists six species of mesostigmatid mites harbouring viral agents in nature. The viruses of Eastern and Western equine encephalitis and St. Louis encephalitis have been isolated from Dermanyssus gallinae and Ornithonyssus sylviarum on several occasions (2, 55, 56). Experimental studies with St. Louis encephalitis and fowl pox in D. gallinae revealed that these viruses persisted in mites for at least a month and could be passed to the next mite generation transovarially. Furthermore, the infected mites have been shown to be capable of transmitting the virus to chickens by bites (2,55,56). The virus of Omsk haemorrhagic fever has been isolated from five species of mesostigmatid mites taken from experimentally infected water voles (Arvicola terrestris) (2,56). Other members of bloodsucking mites have also been found infected with virus of Russian spring-summer encephalitis (2,56).

Table VI. Principal mite species harbouring viral agents in nature

Viral diseases	Mite species
Western equine encephalitis	<u>Dermanyssus gallinae</u> <u>Ornithonyssus sylviarum</u>
Eastern equine encephalitis	<u>Dermanyssus gallinae</u> <u>Ornithonyssus bacoti</u> <u>Ornithonyssus sylviarum</u>
St. Louis encephalitis	<u>Dermanyssus gallinae</u> <u>Ornithonyssus bacoti</u> <u>Ornithonyssus sylviarum</u>
Omsk haemorrhagic fever	<u>Laelaps muris</u> <u>Hirstionyssus isabellinus</u>
Korean haemorrhagic fever	<u>Laelaps jettmani</u>
Argentinian haemorrhagic fever (Junin virus)	<u>Laelaps echidninus</u>
Ornithosis	<u>Ornithonyssus sylviarum</u>

Recently, Naumov and Gutov (1984) (56) reported that nine species of mesostigmatid mites could maintain and transmit tick-borne encephalitis virus under laboratory conditions. In Australia, the myxoma virus, the causative agent of myxomatosis ("big-head") of rabbits, has been recovered from the rabbit mite Cheyletiella parasitivorax. However, this species is shown to be an inefficient vector.

In general, laboratory and epidemiological studies suggest that mites are not important components in the maintenance of these pathogens in nature. Furthermore, the above findings are not conclusive and the role of these mites in the epidemiology of viral diseases has yet to be properly elucidated.

Tularaemia and other bacterial diseases. Tularaemia is an acute disease which is normally found in lagomorphs (rabbits) and rodents. The etiological agent of tularaemia, Francisella tularensis, is transmitted directly by bloodsucking arthropods, primarily by the deer fly (Chrysops sp.). Mites, ticks and fleas are also involved in transmission. The organism may be transmitted to man by contact with infected vertebrates, ingestion of infected vertebrate carcasses and insufficiently cooked infected meat or contaminated water (57). Tularaemia occurs in temperate countries, particularly in the Americas and Europe, but also in Africa and Asia (2). In the USA, lagomorphs are the source of infection in 90% of human cases (2, 57, 58). Several species of mesostigmatid mites have been implicated in the transmission cycle, either found naturally or experimentally infected with Francisella tularensis: Laelaps echidninus, Eulaelaps stabularis and Ornithonyssus bacoti (2,57). O. bacoti and several other bloodsucking mites have been found to harbour plague bacilli (Yersinia pestis) and other bacterial agents, for long periods following their ingestion in a bloodmeal. The role of mites in the epidemiology of other bacterial diseases of public health importance needs further clarification.

3. Parasitic infections

A few protozoan parasites have been shown to be transmitted by mites (1,59). Among these are haemogregarines of rodents and birds and trypanosomes of rodents. Several species of bloodsucking mesostigmatid mites are involved in the transmission cycles of rodent Hepatozoon. The genus Hepatozoon contains several species which are intracellular parasites and are commonly found in blood and tissues of vertebrates throughout the world. Laelaps echidninus transmits H. griseiciuri from squirrel to squirrel (59). Transmission probably occurs when the mites are eaten by the squirrel. There is also some evidence to suggest that several species of mites may be involved in the transmission cycles of murine trypanosomiasis.

Mites have also been found to serve as intermediate hosts of several parasitic helminths. Ornithonyssus bacoti is the intermediate host of the rodent filarial nematode, Litomosoides carinii. Some members of the suborder Cryptostigmata, especially oribatoid mites (beetle mites), may serve as developmental hosts of tapeworms including Moniezia expansa, a common parasite of ruminants. These mites are all free-living, found in damp places, in grass and similar habitats. The grazing animals (cattle, sheep and goats) ingest the mites which contain the cystocercoids of the tapeworm (1).

4. Direct effects on man and animals

Quite apart from their importance as vectors or reservoirs of pathogens, mites can directly affect the health of man and animals in the following ways: (1) by causing dermatitis or other tissue damages, (2) through loss of blood or other tissue fluids (3) by causing strong allergic reactions to mite bites or mite body parts (dead or alive). This section covers three major subjects: dermatitis, scabies and mite allergy.

Dermatitis. A number of species of mites belonging to the mesostigmatid, prostigmatid and astigmatid suborders can attack man and animals and cause irritating rashes (see Tables III, IV and V). Among the mesostigmatid mites, members of the Dermanyssidae, Macronyssidae and Laelapidae families are known to attack human beings and cause dermatitis. In rodent-infested buildings it is not uncommon for people to be bitten by the tropical rat mite (Ornithonyssus bacoti) and the house mouse mite (Liponyssoides sanguineus) (Table II). Other species such as the chicken mite (Dermanyssus gallinae), the tropical fowl mite O. bursa and northern fowl mite (O. sylviarum) frequently attack human beings and their pets. The severity of the dermatitis resulting from the bite of these mites varies with the sensitivity of the individual. The bite causes small urticarial wheals and papules which may be associated with pruritus (1,60). Many other species of mites which commonly parasitize poultry, wild birds, commensal and wild rodents may also cause dermatitis in human beings and their pets (1,2,60) and from laboratory animals by Proctolaelaps pygmaeus in New Zealand (60).

Among prostigmatid mites, the straw itch mite (Pymotes tritici) and cheyletid mite (Choylethiella parasitivorax) are common nuisances to man, causing multiple lesions (Table III). Dermatitis associated with P. tritici is commonly known as straw, hay or grain itch. Among the chiggers, the harvest mite (Neotrombicula autumnalis), Eutrombicula alfreddugesi, and several other species cause severe dermatitis consisting of pustules and wheals (Table III) (1, 61). Not all chiggers cause an itch reaction or dermatitis. Indeed, those chiggers that serve as vectors of scrub typhus are not associated with itch or skin reactions (1,12).

Among the astigmatid mites, members of several families cause dermatitis in man and animals. The Sarcoptidae contains the important parasitic species that cause scabies in man and mange and other skin diseases in domestic and wild animals. Human scabies is dealt with below. Other astigmatid mites, especially members of the families Acaridae, Glycyphagidae, and Pyroglyphidae are very important from an economic point of view. They contain many of the "stored product mites" which cause destruction to such commodities as straw, grain, fruits, milk products and many others. Occasionally, some of these mites attack human beings and cause severe dermatitis known as "grocer's itch" (Glycyphagus domesticus) (Fig. 6), "baker's itch" (Acarus siro), and "copra itch" (Tyrophagus putrescentiae) (Table IV) (1). For more detailed information, Hughes (1976) (62) and Hillerdal and coworkers (1982) (63) should be consulted.

Scabies. Scabies is a common skin disorder of man caused by infestation with the astigmatid mite Sarcoptes scabiei var hominis. Infestations are seen in all socioeconomic groups and communities throughout the world. The mite is an obligatory parasite of man. The adult male and female mites are 200 μ m and 400 μ m in length, respectively. They walk rapidly on human skin, covering 2.5 cm per minute (1,64,65). The fertilized females burrow into the horny layer of the skin, where they feed and lay eggs. The egg-to-egg life cycle may be as short as two weeks. The average number of adult female mites on a typical patient is eleven (range 3-50). In a rare condition known as Norwegian scabies, thousands of mites may infest a person (64,65). The mite burrow consists of a short wavy tunnel about 1 cm long. The skin between fingers, the sides of the feet or hands, the bend of the knee and elbow, the penis, the breasts, and the shoulder blades are most often attacked (1).

In newly infested persons, itching and skin eruption are usually delayed for several weeks, then in about a month a rash and intense itching occur. Typical scabies rashes are found all over the body, but do not correspond to the location of active females' burrows (1,65). In infants and children the face and scalp may be affected. The rash and itch associated with scabies is perhaps a manifestation of an immune* response. The human immune response may help to decrease the parasite load either by evoking scratching or by production of toxic products (64). Patients with crusted or Norwegian scabies have a defective immunological response, which allows the mites to flourish on the skin surface (1,65). These patients have a very large parasite load (≥ 1000 mites/person) as compared to a patient with typical scabies (≤ 50 mites/person).

The prevalence of scabies varies; in some developing countries, it has been reported to range from 6% to 27% among the general population. Scabies affects persons of all ages. In Denmark the incidence of scabies is similar in all age-groups, whereas in India the prevalence is higher in children under five years of age (64). Fluctuations in case incidence of scabies have been noted to follow 15-20 year cycles. Two pandemics of scabies occurred that coincided with the two world wars; this may have been due to the overcrowding, poor hygiene, major economic depressions and population movements (64). Outbreaks of scabies are reported to occur frequently in dormitories, mental institutions and nurseries (64).

Scabies is most often transmitted by close personal contact such as holding hands, and sleeping together. Transmission occurs mostly within families; if one member of the family becomes infested, the entire family may eventually be affected. The likelihood of transmission is related to the parasite load; individuals with a high parasite burden, such as patients with crusted scabies, are contagious (64,65).

Sarcoptes scabiei var hominis is host-specific, and other closely related species that infest other mammals will not survive and reproduce on the human skin (1,9). Although mites of various domestic animals, such as horses, pigs, dogs, cats and camels, can infest man and penetrate the human skin, they cannot complete their life cycle (1,9). The works of Harwood and James (1979)(1), Nutting (1984)(2) and Yunker (1973)(9) should be referred to for further information on sarcoptic mites of domestic and wild animals.

House dust mite allergy. The role and importance of mites in house dust allergy was not realized until 1964, when Dutch and Japanese workers (66,67) implicated the pyroglyphid mite, Dermatophagoides species as the cause of house dust allergy. Since that time extensive research has been carried out on house dust mite allergy and there is a considerable body of evidence to suggest that house dust mites, especially certain species of pyroglyphids, are the cause of allergic reactions of the respiratory tract (asthma and rhinitis*). In recent years, house dust mite allergy has been identified as a frequent cause of asthma, especially among children (45). The inhalation of mite-laden dust can produce rhinitis and bronchial asthma. Clinically, this is commonly associated with species of the genus Dermatophagoides. Mites in the family Pyroglyphidae frequently infest stored food products and can also be found in dust from granaries and houses.

Commonly the European house dust mite, D. pteronyssinus, and the American house dust mites, D. farinae, Euroglyphus maynei and Lepidoglyphus destructor appear to be the species most frequently encountered in the samples of the house dust, though D. pteronyssinus and E. maynei produced the most potent allergen (41). In some cases, the entire bodies of mites (dead or alive) may be the source of allergen. Many other species of mites are also present in-house dust. Mumcuoglu (1976) (68) collected 38 species of mites in samples of house dust from northwestern Switzerland. Out of 11 000 mites: D. pteronyssinus comprised 70.7% of the total, E. maynei 17.7%, D. farinae 5.7%, L. destructor 2.0% and various other species 3.9%. In general pyroglyphid mites represent from 70 to 92% of the house dust mite fauna.

Mites have been collected from furniture, beds (e.g. mattresses, blankets, pillows, bedspreads), bedside rugs and from floors and carpets. The incidence of up to 10 000 mites/g of dust has been reported from house dust samples taken in Switzerland (68). In England a sample of air during and just after bedmaking yielded 44-136 mites/g of airborne dust (41). Over 90% of the mites isolated in these studies belong to pyroglyphids (>70% D. pteronyssinus). In another study, in Finland, using a hard brush on a mattress to collect dust resulted in the collections in which pyroglyphids accounted for 92% of the mites. Recent studies also indicate that D. farinae, D. pteronyssinus, as well as E. maynei, are more common in beds than elsewhere in the house (41,68). Based on these findings, beds are the primary breeding grounds for the house dust mites.

As pointed out by Wharton (1976) (41), in the Netherlands as well as in California, USA, breeding populations of house dust mites are found throughout the year only in beds. In contrast, house dust mites collected from the living room floors showed a seasonal peak in numbers in late summer and early autumn (41). The findings that D. farinae, D. pteronyssinus and E. maynei are well adapted for living in the bed, illustrate the fact that the bed environment provides both a physical habitat and the optimal conditions for the survival of these mites. Other studies have shown the presence of large numbers of mites and mite products in a single bedroom (41,68). Using extracts of mite culture for skin testing, many people with allergic asthma show positive skin tests (41). Detailed information regarding mite allergies can be found in the works of Mumcuoglu (1976) and Wharton (1976) (68,41). Allergy to mites is not limited to the house dust mite. Recently, several cases of mite allergies due to Lepidoglyphus destructor and Acarus siro have been reported among farmers handling infested hay (63). Furthermore, the grain storage mite, Tyroglyphus sp. has been identified as a cause of occupational allergic respiratory disease among farm workers (41,69). Recently, Lutsky and coworkers (1984) (69) reported the possible role of northern fowl mite, Ornithonyssus sylviarum, in occupationally related respiratory disease in poultry workers in Israel.

VI. MITE SURVEYS AND SURVEILLANCE

This section deals with methods of collecting mites for identification and microbiological studies. The entomologist should be thoroughly familiar with the habits of the mite being studied. Furthermore, to collect parasitic mites of vertebrates, familiarity with capturing and handling of the host is essential. As many of the vertebrates may be infected with human pathogens at the time of collection, care should be taken to handle the animals and their ectoparasites properly where there is a danger of such infection.

The hosts of blood-sucking mites are mammals, birds and reptiles. Some of the mites attach themselves to the host mainly to obtain food and thus are found on the host only at feeding time. Others spend part or all of their life cycle in the skin, fur or feathers of their hosts. Success in detecting and recovering mites from such diverse sources depends upon a sound knowledge of the biology of both the hosts and the mites.

Bahmanyar and Cavanaugh (1976) (70) and Brooks and Rowe (1979) (71) both described in detail the procedures for the collecting mammals and their ectoparasites for plague studies. In general, rodents and other small mammals may be trapped alive or dead. Live trapping is essential if the mite infestation rates are to be measured. Trapping success is much higher if traps are set where the animals occur or signs of them have been observed. However, traps may be distributed either systematically or randomly, if the results are to be used as an index of the abundance of the mammals and their ectoparasites (70,72). Traps should be placed before dusk and visited as early as practical the next morning. When snap traps are used, they should be checked every 4-5 hours.

Many of the ectoparasitic mites leave an animal soon after it dies. Therefore, the dead host should be placed in a tightly closed plastic or cloth bag to prevent the exodus of mites. The most commonly used baits in traps include groundnut butter, fish products, mixtures of grain, fruits and animal fat. Bait attractiveness may be assessed for particular areas, if this is deemed necessary (70,72). Traps containing live rodents are put into a plastic or cloth bag (70,72) and taken to the laboratory or field station. It is always wise to kill both the host and its ectoparasites before removing them from the bag; to do this the bag containing the live rat should be placed in a large jar with a piece of cotton saturated with chloroform or ether. The rat is removed from the bag after 3-5 minutes and held over a large white enamelled pan. The rat should then be shaken or the hair brushed to dislodge the mites. The bag must be turned inside out and also brushed or shaken over the pan to ensure all the mites are found. The mature mites will stand out clearly against the white background. Immature stages may be seen with the aid of a hand lens. The mites can be collected from the pan either with a camel's hair brush or a moistened applicator stick. They are then placed into vials containing 70-80% ethyl alcohol. The brush should be examined carefully to make certain that it retains no mites. The mites from each host should be properly labelled as to location, date of collection and host tag number (73).

Chiggers tend to be closely grouped in clusters on the host. On small mammals, some chiggers are generally found in clusters within the tragus of the ear, on the belly and on the thighs (12,16). Since the chiggers imbed their mouthparts in the tissue, they may not relax and drop off, so each host should be carefully examined. Chiggers can be collected by soaking and shaking the animal in water containing a few drops of household detergent (12,16) after which the animal should be returned to its original plastic bag. The water-detergent mixture is then suctioned off into a Petri dish or poured into a Buchner funnel (Fig. 10) and examined for the presence of mites under a dissecting microscope. This method is slow and time-consuming, but is quite effective. Unfed chiggers of some species can be obtained from the collector's shoes, or on white pieces of cardboard placed on the surface of the ground. The use of sentinel animals (laboratory white rats or mice) can also be recommended. The animal, supplied with food and water, may be confined in a cage and placed in the study area in the field where it will attract the starving chiggers as well as other bloodsucking mites. Nymphs and adult trombiculid mites can also be collected by flotation of surface soil (12,74) or debris obtained from burrows, tree holes, bat guano, etc. (2,16,74). The basic funnel-desiccation method, originally developed by Berlese in 1905, has also proved to be useful (Fig. 10) (see below).

Nest-burrow bloodsucker mites are bound to the host by a common habitat, where their life cycles are completed. Many species belonging to Dermanyssidae and Laelapidae families are nest inhabitants. To obtain these mites, the nests of birds and mammals should be collected and placed in plastic bags for later processing.

Collection of nests, especially those of terrestrial rodents, requires time and patience. Other techniques are also available for collection of mites from burrows (16,70). Sentinel animals (white mice) can be introduced into rodent burrows (70,72) to collect some of the mesostigmatid mites. Also, a gas-powered vacuum pump may be used to

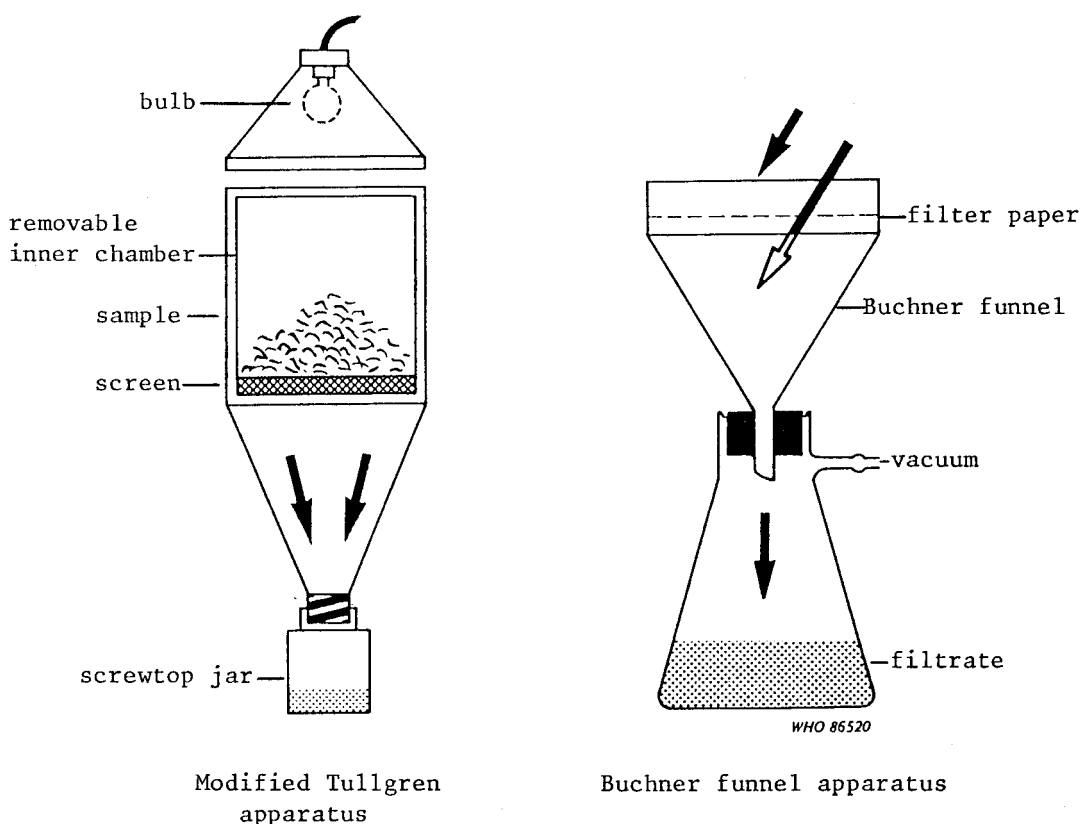


Fig. 10. Illustration of the funnel desiccation method of collecting mites.

suck out the nest material (41,70). The nest material can be processed using the modified Berlese funnel, which was revised by Tullgren in 1918, or the Buchner funnel (16,70,73). A Tullgren apparatus (Fig. 10) is an ordinary metal funnel 36-50 cm in diameter, within which is a series of four sieves with an incandescent light shining above it. The funnel is suspended or held above a jar of 70% alcohol. The heat produced by the light bulb (40 watts) drives the mites down into the funnel and they fall into the alcohol. In most cases, the extraction of mites from samples of soil, litter, or other similar material can be accomplished by using such a funnel. The WHO document "Fleas - biology and control" (73) and the article by Sasa and coworkers (1970) (74) provide full descriptions and details of the Berlese and Buchner funnels.

The house dust mite may be collected by using a vacuum cleaner. Such pyroglyphid mites are collected by vacuuming floors, mattresses, pillows, and the padding from upholstered furniture (41). Domestic vacuum cleaners may be used, the bags of dust from these cleaners being brought to the laboratory for further analysis. The house dust samples are processed using the large volume alcohol-washing technique (41). Briefly, this method consists of washing the dust preserved in 70% ethyl alcohol through a series of three sieves (840, 420, and 75 μ m sieves) and this material is washed with 70% alcohol into labelled vials. A live

trap for house dust mites, consisting of a mineral oil pool in the cavity of a microscope depression slide can also be used (41). Other methods such as flotation should be used to separate particular species (16,41).

A specific procedure for collecting house dust mites for quantitative purposes is described by Wharton (1976) (41). Briefly, dust samples are collected on a specially made dust "trap filter" (7 cm diameter x 7 cm length) attached to the end of the hose of a vacuum cleaner. Surface samples from different areas are vacuumed. Several 0.05 g subsamples of dust from each area are suspended in 30 ml of saturated sodium chloride and a few drops of soap. The suspension is then filtered through a 45- μ m mesh sieve, and rinsed in distilled water, and the material retained on the sieve is stained with crystal violet, rinsed with distilled water and added into a gridded Petri dish for the mite analysis.

Mites of the Sarcoptidae live in the skin, where most species burrow through the upper layers. The human itch mite, Sarcoptes scabiei is collected by scraping the affected skin (75). Mineral oil is placed on a sterile scalpel blade and allowed to flow onto the lesions; the scraping with the blade will remove the top of the mite burrows. The oil and scraped material are transferred to a clean glass slide and examined under a microscope for immature or adult mites.

Endoparasitic mites which live in the respiratory passages, the orbit of eye or the stomach lining of mammals may be collected from autopsy materials. Usually the formalin-preserved tissues are sliced into thin (2-3 mm) sections with a scalpel blade and the mites are teased from the tissue under the low power of a dissecting microscope. Intranasal chiggers are collected by flushing with water the nasal passages of the animal using a low power magnification.

If the mites are required for bacteriological assays, they should preferably be collected alive. The general procedure is as described by Sudia and Chamberlain (1967) (76) and Bahmanyar and Cavanaugh (1976) (70). The animal should be lightly anaesthetized by using either chloroform or carbon dioxide from dry ice which will allow the mites to recover. If it is not intended to anaesthetize the mites, then sodium pentobarbital can be used to anaesthetize the host. In either case the host should then be held over a pan of cold water (4°C), and brushed carefully to dislodge the live mites. Live mites can be immobilized on crushed ice, identified under a dissecting microscope, and placed into labelled vials containing cold saline (see below).

Selected samples of mites may be checked for the presence of rickettsiae or viral antigens by the direct immunofluorescent antibody test (41,70,72). Individual mites are smeared on a clean glass slide, air dried and fixed in cold acetone (4°C) for 10 minutes. The mite smears may then be kept at -20° or -70°C in a freezer. The dissection and excising of the entire mite can be done either in the field, using freshly caught mite specimens, or in the laboratory using frozen specimens. The isolation of microbiological agents from the mites is accomplished by inoculation of the homogenate of either an individual or pooled samples into laboratory animals (41,70,72).

Mites should be examined under a binocular microscope with a 10X objective and 10X or 20X oculars. For smaller mites such as house dust mites, chiggers and human itch mites, higher magnification and phase contrast microscopy may be required. For identification, specimens are mounted permanently on microscope slides. Most mite specimens are mounted in Hoyer's medium (chloral hydrate-gum arabic formulations) or a polyvinyl alcohol formulation (PVA) (8,16). Specimens are mounted directly in PVA. For temporary mounting the mite specimens should be immersed in glycerin, phenol, or lactic acid, any of which should clear the specimens for identification (8,16,41). If Hoyer's medium is used for mounting, the directions below should be followed.

1. For clearing, the mite specimens (alive, dead or dry) are put directly into lactic acid or lactophenol. The clearing time varies from a few hours for soft-bodied mites to several days for those heavily sclerotized.
2. The cleared specimens are then put through several changes of water to remove all traces of the clearing medium.

3. The cleared mite is placed in the centre of a drop of Hoyer's medium on a clean slide. One mite per slide with a coverslip is preferable.
4. The slide is then labelled.

If a rapid preparation is necessary, the live or alcohol-fixed mite should be placed in the centre of a drop of Hoyer's medium and boiled momentarily on a fine flame after mounting with a coverslip.

Since Hoyer's mounting medium is not commercially available, the following directions should be used for its preparation.

Distilled water	50 grams
Gum arabic (crystal)	30 grams
Chloral hydrate	200 grams
Glycerine	20 grams

These ingredients are added in the order shown and the resulting material is filtered through clean cheesecloth. Hoyer's mounting medium has a good index of refraction and permits mounting directly from water or alcohol solutions.

VII CONTROL

Control procedures for mites vary considerably, depending on their geographical distribution and habits. The methods and materials to be chosen for mite control are based on whether they are directed at prevention and interruption of the transmission of mite-borne diseases, or they are to control mites as household pests in human habitations, parks, recreational and other natural areas often frequented by human beings or their pets. This section will, therefore, consider the various approaches to control from these aspects.

1. Control of mites as vectors of disease

Among the mite-borne infectious diseases discussed in the preceding section, scrub typhus and rickettsialpox are of considerable public health importance. Because of the marked differences in their distributional patterns, life cycles, transmission and host utilization, scrub typhus and rickettsialpox require different control measures, and will be treated accordingly.

Scrub typhus. Despite intensive efforts, an effective killed vaccine for human use against scrub typhus is not yet available. Therefore, a campaign against the chigger vector has remained as the primary method of disease control (18). However, the complexity of the chigger life cycle, and its wide and patchy distribution make the control very difficult and expensive. Such control measures directed at the life cycle and habitat of the chigger and its host animals require, in addition to extensive application of acaricides* on the ground, control of small mammals and use of herbicides* and defoliants.*

Chlorinated hydrocarbons have been shown to be very effective in killing chiggers on the ground. The application of dieldrin, when used as a spray, mist, or fog produces a reduction of more than 90% of chiggers for at least two years (62,77), but where environmental considerations are of overriding importance, the more biodegradable organophosphorus (fenthion or malathion) or carbamate (propoxur) compounds should be used (79).

Control measures against the chigger host should be accompanied by an integrated control programme. Removal and burning of ground cover, followed by scraping and ploughing the top soil, render the areas unsuitable for chiggers and their hosts. Such cleaning practices have been used to keep the environs of camp sites and buildings free of chiggers (78). In

areas used frequently by human beings, ultra-low-volume (ULV*) applications of approved miticides such as permethrin or propoxur (62,78) may be added to the control programme.

Preventive measures include the avoidance of the infected terrain and use of individual prophylaxis against attack by chigger mites. Topical repellents have played an important role in endemic areas, especially where habitat modification and application of miticides are not practical. Protection against chigger infestation may be achieved either by applying a repellent to the exposed skin or by wearing protective clothing impregnated with a repellent, e.g. benzyl benzoate, dimethyl phthalate and diethyl toluamide (77,79). Attacks of chigger mites can be completely prevented by the proper application of an effective repellent. Satisfactory repellents have been shown to be deet (N-N-diethyl-m-toluamide), dimethyl phthalate, dimethyl carbate, and ethyl hexanediol.

The effectiveness of these repellents was studied against different species of chigger mites. Kulkarni (1977) tested five repellents against Leptotrombidium deliense and L. akamushi using an impregnated filter-paper or cotton/nylon fabric assay. A combination of deet and dimethyl phthalate was proved to be the most effective (80). More recently Buescher and coworkers (77) reported that both deet and dimethyl phthalate were significantly more effective against L. fletcheri than acetydimethyl heptenyloxazalidine (Citronyl), butopyronoxyl (Indalone), ethyl hexanediol, dibutyl phthalate or permethrin. Deet and dimethyl phthalate were the most potent compounds at both the 50% and 95% levels of protection (77,80). Impregnation of clothing with repellents is very useful, and the best control is achieved by application of repellents to socks and to the bottom of the trouser legs.

Rickettsialpox. Rickettsialpox occurs enzootically in house mice and rats and in man, primarily in urban areas. The vector is Liponyssoides sanguineus which is commonly found on mice and rats. Prevention is best attained by reducing the number of rodents and the control of mites in rodent-infested areas. The use of rodenticides should be accompanied by mite control measures (41,71,79). Mites carried by rodents or present in their burrows can be controlled by using insecticides or approved acaricides (Table VII).

For information on control of commensal rodents Brooks and Rowe (1979) (71) should be consulted. Methods are now available to control and eliminate domestic rats and mice infestations (80). Once the preliminary surveys of the area have established the magnitude of the rodent infestation, suitable control measures may be taken. Elimination of rodents should be achieved by applying rodenticides to their burrows and runways. Care should be taken to control ectoparasitic mites and prevent the starving parasites wandering around in the area in search of blood meal. The application of insecticides along with rodenticides has proved useful in killing the mites (71,78).

Comprehensive accounts on the control of commensal and wild rodents and their ectoparasites are given by Brooks and Rowe (1979) (71), Gratz and Brown (1983) (73) and in the publication "Vector control in international health" (1972) (72) all of which can be obtained upon request from Vector Biology and Control Division, WHO, Geneva, Switzerland.

2. Control of mites as household pests

Although insecticides are the major tools to control household pests, there are limited alternative methods that can be used. Since most of the bothersome bloodsucking mites encountered in human dwellings or on pets are those commonly found on commensal rodents or wild birds, several measures can be taken to eliminate or reduce the mite numbers. To break the mite life cycle, the home and the pets should be treated as well as the outside surroundings of the house. Control of mites outdoors requires more than one application of insecticides and the pets require several treatments. Moreover, the source of mites should be eliminated to prevent repeated reinfestation of the home and the pets.

Mites in poultry are controlled with sprays or dusts of approved miticides (Table VII). To control Dermanyssus gallinae and Ornithonyssus sylviarum, mite habitats and crevices should be thoroughly sprayed with suspensions or solutions of insecticides. Malathion, as 4% to 5% dust; coumaphos, as 0.5% dust; carbaryl, as 0.25% emulsion or 5% dust may be

used. Attention should be paid to avoid the contamination of food and water (81). Although malathion is a relatively safe organophosphate, its toxicity should not be underestimated. These organophosphates are the third most common cause of toxicity in dogs and cats (82). Most formulations of carbaryls are for outdoor or kennel usage. Carbamates are the most common cause of poisoning in dogs and cats in California, USA (82). Wild bird nests should be removed from the premises to prevent reinfestation of the poultry.

The tropical rat mite, *O. bacoti*, can be effectively controlled or eliminated by the use of chemical acaricides. Various chlorinated hydrocarbons such as DDT, as a 5% emulsion or 8% powder; lindane, as a 1% powder; and malathion, as a 1% emulsion have been found effective (81). Inert insecticides such as silica aerogel, especially with 2% naled has been found to be very effective against *O. bacoti* (81). All insecticides for indoor use should be safe when used according to their labels.

Chigger mite populations may be controlled in much frequented areas such as parks by the use of areal acaricides. Chlorinated hydrocarbons, permethrin and propoxur have been used as areal acaricides for the control of *Eutrombicula alfreddugesi*. Malathion (4.0% dust) is recommended as a miticide for the control of chiggers in poultry ranges (81). Use of mite repellents such as deet and dimethyl phthalate has proved to be the most effective measure for personal protection against chigger attacks (77,79,80).

Interdermal mites, such as those causing sarcoptic or demodectic mange of mammals, must be treated by a physician or veterinarian. For human scabies repeated treatment with lindane cream or lotion, sulfur, benzyl benzoate and crotamiton have proved to be successful (41,81); treatment of all members of a family is necessary to prevent reinfection. Sarcoptic mange of animals requires repeated spraying or dipping with approved insecticides (41,81). Control of sarcoptic mange of dogs includes supportive nutrition, bathing with nonirritating soap, and weekly application of medication (0.25% chlordan, 0.03 to 0.06% lindane suspension in water). For further details, the book of Kirk (1980) should be referred to (83).

Table VII. Pesticides commonly used in control of mites¹

Pesticide	Chemical type ²	Formulation	Concentration %	Toxicity for rats ³ Oral LD ₅₀ mg/kg body weight	
				Males	Females
Carbaryl	C	Dust	5.0 - 10.0	850	500
Coumaphos	OP	Dust	0.25 - 0.5	41	15
Chlorodane	OC	Suspension	0.25	335	430
Diazinon	OP	Dust	2.0	108	76
Lindane	OC	Dust	1.0 - 3.0	88	91
Malathion	OP	Dust	4.0 - 5.0	1 375	1 000
Permethrin	PY	Dust	0.5	132	1 500
Propoxur	C	Dust	1.0	25	104
Rotenone	B	Dust	1.0	132	1 500

¹ See references 73, 80 and 82.

² OC = organochlorine; OP = organophosphate; C = carbamate; PY = synthetic pyrethroid; B = botanical (extract of derris root).

³ Toxicity and hazard are not necessarily parallel.

Control of house-dust mite may be achieved either by physically excluding the mites or the use of proper miticides. Limitation of the mites' food supply in the environment has proved to be very effective since Dermatophagoides sp. feeds on shed human epidermal scales. It is estimated that between 0.5 to 1 g of scales a week is shed into the bedding. Shaking the bedclothes and frequent washing of the bedsheets and blankets may be useful in reducing the number of mites (41,84). Mattresses should be enclosed in plastic covers. Vacuum cleaning of the beds, carpets, furniture, etc. should be done at least once a week. It has been shown that a high humidity improves the survival of house dust mites in homes (41,84). Reduction of the dampness in the house is a very effective measure in reducing the numbers of mites. In general, exclusion of dust from the beds and bedrooms, a good house cleaning, and some environmental modifications can drastically reduce the mite population (41,84). In addition, the use of acaricides to control house dust mites is also suggested (84). Since house dust mite allergens cause asthma in sensitized individuals, especially in children, desensitization has also been recommended (41).

VIII GLOSSARY OF TERMS

- ACARICIDE - any chemical substances used for killing acari (mites and ticks).
- ALLERGY - antigen-antibody response on the part of sensitized persons to substances known as allergens.
- ANNULATE - composed of rings.
- APODEME - a chitinous ridge forming part of the endoskeleton and providing attachment sites for muscles.
- ASTHMA - periodic difficulty in breathing caused either by spasm of bronchial tubes or by swelling of mucous membranes in the bronchial tubes.
- CHIGGER - the parasitic, hexapod larval stage of a mite of the family Trombiculidae.
- CHITIN - substance forming a horny constituent in the exoskeleton of arthropods.
- CRISTA METOPICA - a reduced propodosomatal shield.
- DEFOLIANT - a substance that kills foliage
- DERMATITIS - skin inflammation.
- DORSAL - pertaining to the back or upper surface.
- DYSPNOEA - difficult or laboured breathing.
- ECTOPARASITE - a parasite that lives on the external surface of an animal, e.g. fleas, lice, mites, ticks.
- EMPODIUM - thin claw-like structure arising medially between the claws of the tarsi.
- GENUS - (plural, genera) a taxonomic category within a family, consisting of one or more generally similar species.
- HABITAT - the physical place (home) where an organism lives.
- HERBICIDE - a substance used to destroy herbaceous plants, weed killer.
- HOST - the animal parasitized by a parasite or disease organism.
- HYPOSTOMA - rod-like organ arising from the base of the mouth parts; a synonym for gnathosoma.
- IMMUNITY - resistance to parasites or other noxious agents or organisms.
- INSECTIVORE - any member of the mammalian order Insectivora; a primitive insect-eating (insectivorous) group; for example, moles, hedgehogs and shrews.
- LARVIPOROUS - giving birth to larvae in place of eggs.
- OBLIGATE - organism that must live as a parasite of its host.
- OVIPAROUS - producing young by means of eggs expelled from the body before they are hatched.

- OVOVIVIPAROUS - producing young by means of eggs hatched within the body.
- PARASITE - an organism which derives its nutrition by competing with its host, often with deleterious results to the host, or by feeding upon its tissues.
- PARTHENOGENESIS - non-sexual reproduction by means of an egg independent of fertilization by the male.
- PATHOGEN - an organism which causes disease.
- PELAGE - hair covering the body of man or lower mammals.
- PHYTOPHAGOUS - feeding on plants.
- PREDATOR - an organism that kills and eats another organism (prey).
- PRURIGO - a disease of the skin with violent itching (adj. - pruriginous).
- PRURITUS - severe itching.
- RESERVOIR - any vertebrates, invertebrates, plants, or soil in which an infectious agent normally lives and multiplies, and on which it depends primarily for survival and reproduces itself in such a manner that it can be transmitted to a susceptible host.
- RHINITIS - inflammation of the nasal mucous membrane.
- RODENT - any of various animals of the mammalian order Rodentia, such as a mouse or rat.
- SAPROPHYTIC - feeding on decaying matter.
- SCLERITE - hard chitinous plate on the cuticle.
- SETA - exteroceptor sensory organ.
- SPECIES - group of interbreeding natural populations that are reproductively isolated from other such groups.
- STIGMA - small opening.
- ULV - ultra-low-volume concentrate.
- URTICARIA - an acute or chronic affection of the skin characterized by the formation of weals attended by itching.
- VENTRAL - pertaining to the front or lower surface.

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X. EVALUATION

A. Questionnaire for self-evaluation

Complete with the correct answer

1. The four stages that the mites go through are: (Page 3)
 - a.
 - b.
 - c.
 - d.
2. Mites, like other arachnids generally have _____ pairs of legs as nymphs and adults but only _____ pairs of legs in the larval stage: (Page 4)
3. State three reasons why mites are important in public health: (Page 3)
 - a.
 - b.
 - c.
4. Which kind of mite is the most important vector of scrub typhus? (Pages 24, 25, 27)
 - a.
5. Which kind of mite is the vector of rickettsialpox? (Page 26)
 - a.
6. Name three important mite-borne diseases: (Pages 24-33)
 - a.
 - b.
 - c.
7. Which state of a trombiculid mite is parasitic? (Pages 24-26).
8. Recognize the different mite-borne diseases and their characteristics: (Pages 24-33)
 - a. Infection of man by Rickettsia akari
 - 1.
 - b. Infection caused by itch mite
 - 1.
 - c. Infection of man by R. tsutsugamushi
 - 1.
9. Which of the following statements is true? (Page 9)
 - a. Ornithonyssus bacoti is a mesostigmatid mite
 - b. Liponyssoides sanguineus is an astigmatid mite
 - c. Eutrombicula alfreddugesi is a mesostigmatid mite
 - d. Acarus siro is a mesostigmatid mite

10. Which of the following mites are bloodsuckers? (Pages 21-24)
 - a. straw itch mite
 - b. house dust mite
 - c. house mouse mite
 - d. chicken mite
11. State two methods for collection of house dust mites: (Pages 35-36)
 - a.
 - b.
12. List at least three repellents used as preventive measures against chigger infestations (Page 38)
 - a.
 - b.
 - c.
 - d.
13. Which of the following statements is true? (Page 38)
 - a. Rickettsialpox occurs enzootically in house mice in urban areas.
 - b. Rickettsialpox occurs enzootically in rural areas.
14. Which of the following statements is true? (Page 38)
 - a. Prevention of rickettsialpox is attained by reducing rats and mice in rodent-infested areas.
 - b. Prevention of rickettsialpox is attained by reducing mice and rats and the control of mites in rodent-infested areas.
15. List two insecticides for the chicken mite control: (Page 38)
 - a.
 - b.

B. Questionnaire for return to VBC

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How was the presentation of this document?

very good	good	fair	bad
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How important for your work was the information provided in this document?

very important	important	not very important	not at all important
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What do you think about the terminology?

easy	clear enough	difficult	very difficult
------	--------------	-----------	----------------

Comments:.....

Which information did you find irrelevant for your work?

.....
.....
.....

What do you think about the illustrations?

poor	fair	good	very good
------	------	------	-----------

What do you think about the style of writing?

too simple	very easy	just easy	not easy
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Was the document the right length?

too short	about right	too long
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How valuable were the different sections of this document?

Extremely valuable	Valuable	Of little value	No value
-----------------------	----------	--------------------	----------

Life history
and biology

Public health
importance

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