PARASITES

ROBERT M. TIMM

Abstract

THE objective of this review is to bring together and summarize the diverse literature on parasites of New World *Microtus*, to summarize life cycles of the ectoparasitic fauna, and to put the different groups of parasites into a biological perspective. The literature on parasites of *Microtus* contains over 485 primary references covering the 91-year period from 1894 to 1984. However, of the 26 species of New World *Microtus* now recognized, parasite data exist for only 16 species. Most of the data available are for six of the most widely distributed species, *Microtus californicus, M. longicaudus, M. montanus, M. ochrogaster, M. pennsylvanicus,* and *M. pinetorum.*

The ectoparasites on *Microtus* belong to the orders Acari (mites and ticks), Anoplura (suckling lice), Coleoptera (beetles), Diptera (flies), and Siphonaptera (fleas). Twelve families of mites are known from *Microtus.* These range in size from minute demodicids that live within hair follicles and sebaceous glands to the large, active laelapids. Very little work has been done on any of the mites with the exception of chiggers (family Trombiculidae). Most groups are in need of taxonomic revision. Chiggers have been intensively studied, both taxonomically and biologically, as they are of direct medical importance to man. Eighteen species of ticks have been reported from *Microtus.* Several species of ticks carried by *Microtus* are responsible for diseases that affect man, and the systematics and ecology of these vectors have received much attention. Only two species of sucking lice are true parasites of *Microtus,* although a few other species have been reported in the literature as being found on *Microtus.* The systematic relationships of the lice are well understood; however, little work has been done on their biology. Lice have been reported on only 12 species of *Microtus*; the absence of lice on several species (for example, *M. chrotorrhinus*) has not been explained. Parasitic beetles belonging to two families have been found only occasionally on *Microtus.* It is likely that they are regularly

associated with *Microtus,* living primarily within the nest and hence seldom encountered. Two families of parasitic flies are known from *Microtus.* Both bot flies and flesh flies are uncommon parasites of *Microtus,* and if found in high numbers may have an adverse affect upon the host. Seventeen genera of fleas regularly parasitize *Microtus* in North America, and 26 other genera are reported as of accidental occurrence. A tremendous body of literature exists on the systematics and ecology of fleas, especially with respect to bubonic plague. However, little work has been undertaken on the effects of fleas or the diseases they transmit on *Microtus.* Most species of *Microtus* have several species of fleas; more than one species may be present on an individual host with additional species being restricted to the nest.

Endoparasites belong to the Acanthocephala, Cestoda, Nematoda, and Trematoda. Only two species of acanthocephalan have been found parasitizing *Microtus.* Several species of cestodes, nematodes, and trematodes have been reported from *Microtus,* and it is certain that this list will increase with additional study. A briefly annotated list of the endoparasites on New World *Microtus* is appended.

Introduction

Voles of the genus *Microtus* constitute one of the most widespread and intensively studied groups of mammals. However, of the species of *Microtus* now recognized from North America, parasites have been reported from only 16 species. This is not due to an absence of parasites, but rather reflects lack of study. Undoubtedly a diverse parasite fauna will be found on the remaining species of voles. Of the 16 species for which some parasite data exist, the vast majority of records are from six species, *M. californicus, M. longicaudus, M. montanus, M. ochrogaster, M. pennsylvanicus,* and *M. pinetorum.* The number of species of parasites recorded from a given vole species is a direct reflection of how well studied the host is. The extent of the host's geographic range can also affect the total number of parasite species as different parasites will occur in various habitats. Thus, widely distributed species like *M. pennsylvanicus* can be expected to have more species of parasites than a more restricted species. It is also possible that a single individual vole of a widely distributed species may harbor more species of parasites than an individual from a geographically restricted species. However, this

remains to be tested. In spite of the volume of literature available on *Microtus,* we actually know very little about the biology of the parasites, and even less of the effects on their hosts.

The objective of this chapter is to bring together the literature on ectoparasites of New World *Microtus,* and to put the various groups of parasites into a biological perspective, rather than just provide a list of names. A list of endoparasite records is presented in Appendix A. Because more is known about the distribution and systematics of North American ticks, lice, and fleas parasitizing *Microtus,* each genus and species is discussed briefly. Since the systematics and ecology of the mites are less well known and there are so many more of them, mites are discussed by family. The discussions of each group of parasites vary considerably in content, reflecting the current state of knowledge of that particular parasite on *Microtus.* Brief, informative summaries of all the ectoparasites reported from *Microtus* are presented, with an emphasis on what is known about the biology of those species on *Microtus.* This chapter should also guide the reader to the primary literature and point out interesting and fruitful areas for future research.

References included are those to the primary literature; secondary listings of parasites from the various species of *Microtus* are generally not mentioned. No human-created experimental infections are included. Current scientific names for all species of parasites are used throughout. Synonymies are included within species lists for ticks, lice, and fleas. For synonymies of mites see the review paper of North American mites parasitizing mammals by Whitaker and Wilson (1974). Whitaker's (1968) review of parasites on *Peromyscus* provides an excellent summary on collecting and preserving parasites, and his (Whitaker, 1982) "Ectoparasites of mammals of Indiana" provides keys to many of the species dealt with here.

Mites

The largest group of ectoparasites of *Microtus* are the mites and ticks of the order Acari. At least 12 families of mites and dozens of species are known to parasitize New World *Microtus* and undoubtedly more will be found. The life cycle of a typical parasitic mite includes the following stages: egg, larva (a relatively inactive stage that often does not feed), protonymph (usually an active feeding stage), deutonymph (an active feeding stage), and adult. Some mites

are ovoviviparous so that the egg stage and perhaps the larval stage are bypassed. Considerable morphological diversity is found within parasitic mites, ranging from the large active laelapids (about 1 mm in length) to the minute follicle-inhabiting mites with reduced or highly modified legs. There are numerous reports of mites on *Microtus,* but surprisingly little work has been done on the effects of these mites on their hosts. An excellent list, including synonymies, of North American mites found on mammals was published by Whitaker and Wilson (1974). Because of the diversity and complexity of parasitic mites, a brief summary is presented of the families known to be parasitic on *Microtus.*

Cheyletidae.—Cheyletids are a diverse group of mites including both parasitic species living in fur of the host and free-living predatory species. Parasitic forms feed on tissue fluids and usually occur in low numbers. They seldom cause much damage to the host although they can cause dermatitis. The group is in need of revision.

Demodicidae.—Demodicid mites are minute (0.1 to 0.4 mm in length), vermiform, and live within hair follicles, lymph nodes, and sebaceous glands. They are thought to be rigidly host specific. *Demodex* is often found within the meibomian glands of the eyelids. Severe infestations of *Demodex* cause the eyelids to be sealed shut in mice, a disease known as pseudoblepharitis simplex (lid sealing).

Ereynetidae.—Nasal mites are widely distributed in birds, but few species are known from mammals. Within the genus *Speleorodens* there is no active nymphal stage; the larva gives rise directly to the adult. They reside within the nasal mucosa and apparently ingest whole blood. The only transfer between hosts apparently occurs between parents and offspring. Three adult females and a single larva of *S. michigensis* were taken by Ford (1962) from a single *Microtus pennsylvanicus* in Michigan. A review of what little is known about the biology of these nasal mites is found in OConnor (1978). It is likely that nasal mites will be found on other species and populations of *Microtus.*

Glycyphagidae.—Adult glycyphagids are free-living inhabitants within nests of mammals where they probably feed on fungi. The deutonymphs are usually found only on the mammalian host, either as a parasite in hair follicles or externally phoretic. Spicka and OConnor (1980:474) reported 500–1,000 *Glycyphagus microti* on *Microtus pinetorum,* and stated that the deutonymphs "may serve two purposes: 1) to disperse the species by transferral from host to

host and nest to nest, and 2) to relieve pressures of overpopulation in the nest."

Laelapidae.—Laelapids are a large group of both parasitic and free-living mites. Most of the large, active mites commonly observed on small mammals belong to this family, with both *Androlaelaps* and *Laelaps* being especially abundant on *Microtus*. Timm (1972*a*) reported 61 *Laelaps kochi* from an apparently healthy adult *M. pennsylvanicus* in Nebraska, which is an unusually high parasite load. Not all laelapids found on mammals are obligate parasites; many of the free-living forms are found as predators of other mites in mammal nests. *Haemogamasus ambulans,* a common parasitic mite on *Microtus,* is known to feed on a variety of substances in addition to blood. Some of the nominal species actually represent species complexes that have yet to be investigated adequately (i.e. *Androlaelaps fahrenholzi* and *Eulaelaps stabularis*). Several species of laelapids are known to transmit tularemia.

Listrophoridae.—Fur mites feed in hair follicles, and are often abundant on rodents. They cause loss of hair, dermatitis, and skin inflammation from scratching.

Macronyssidae.—Mesostigmatic mites of the genus *Ornithonyssus* are large obligatory blood feeders. In laboratory colonies they cause severe exsanguination in sucklings; however, they apparently cause little damage to healthy adult animals when found in moderate numbers. *Ornithonyssus bacoti* has been shown to transmit murine typhus. *O. bursa* is commonly known as the tropical fowl mite; the single report from *Microtus* may be accidental.

Myobiidae.—Fur mites live in the pelage of their hosts, feeding on interstitial fluids, and may be found in high numbers, but they apparently cause little damage. Adults, larval stages, and eggs are found attached to the base of hairs; the entire life cycle is spent on the host.

Myocoptidae.—Myocoptid fur mites feed on the surface of the skin by attaching to the proximal portion of the hair shaft, and may be very abundant. Damage to the host includes dermatitis, pruritus, and hair loss.

Psorergatidae.—Psorergatic mange mites are cutaneous and subcutaneous parasites on a wide variety of mammals. *Psorergates canadensis* was found on *Microtus pennsylvanicus* by Kok et al. (1971: 1243) "within the epidermis of the ear concha, causing hyperceratosis. In the hosts observed they seem to be a low-grade pathogen."

Psorergates simplex is known to cause subcutaneous cysts and ulcerous nodules in its hosts, and is an important parasite in laboratory colonies of mice.

Sarcoptidae.—Sarcoptic itch mites or scabies mites live in the skin and burrow in the upper layers. Sarcoptids usually do not cause pathologies. In a severe infestation in *Microtus californicus, Notoedres muris* was found to "invade the ears, eyelids, and nose as well as the feet, tail, and anal region" (Lavoipierre, 1964:10); Lidicker (1973) reported that the highest incidence on Brooks Island (California) occurred during the winter months.

Trombiculidae.—Larval trombiculid mites are known as chiggers, and are parasites on mammals, birds, reptiles, and amphibians. They are parasitic only in the larval stage; all post-larval stages are free-living. Chiggers show a broad range of host specificity, with many occurring on a large number of hosts, whereas others are restricted to very few hosts. They are often associated with particular soil or habitat types rather than specific hosts. The larvae inject saliva into the host and feed on partly digested fluids; nymphs and adults are predaceous on small arthropods or arthropod eggs. Trombiculid mites have a complex life cycle that includes four major stages: the egg, larva, nymph, and adult; there are three intervening inactive stages (see Table 1). Population levels of chiggers on rodents vary considerably, but there is seldom much damage to the host. The site of attachment is often clustered, especially on the ears and genitalia. Attached larvae are generally orange or red in color, and usually feed on a host for just a few days. Within the north temperate zone most species have one generation per year and a distinct seasonal pattern of abundance, with late summer and fall peaks being typical. *Eutrombicula alfreddugesi,* a common chigger on both man and *Microtus,* is known to have a single generation per year in the northern part of its range, and several generations per year in the south. Chiggers are responsible for the transmission of several rickettsial diseases, including scrub typhus. Additionally, dermatitis may be produced as a result of the salivary secretions of the feeding mite. A tremendous body of literature exists on the ecology and systematics of chiggers since they are of direct medical importance to humans. Keys and synopses to the various groups of North American chiggers were provided by Brennan and Goff (1977), Brennan and Jones (1959), Gould (1956), Jenkins (1949), Kardos (1954), Loomis (1956), and Wharton and Fuller (1952).

TABLE 1
LIFE CYCLE OF *Eutrombicula alfreddugesi* (AFTER WOLFENBARGER, 1952)

Major stages	Intervening stages	Characteristic features	Duration (days)
Egg		Spherical, laid singly	15–20
	Deutovum	Quiescent, within broken egg shell, unsegmented appendages	(minimum 13)
Larva		Active, six segmented legs	Up to 24 before feeding (over 30)
			1–4 on host (1–48)
			1–8 after leaving host (average 2)
	Prenympha	Quiescent, within dead larval integument	9–10 (about 6)
Nymph		Active with eight legs, two pairs of genital suckers	12–32 (minimum 7)
	Preadult	Quiescent, within nymphal integument	5–10 (minimum 7)
Adult		Active, with eight legs, three pairs of genital suckers	Up to 52 (over 20 months)
			Eggs laid within 14 (12)

Ecological studies of chiggers in the midwest were conducted by Kardos (1954) and Loomis (1956).

The records of mites parasitizing *Microtus* are as follows:

Microtus abbreviatus
Laelapidae
Haemogamasus ambulans (Thorell, 1872) (Rausch and Rausch, 1968 [reported as *H. alaskensis* Ewing])
Laelaps clethrionomydis Lange, 1955 (Rausch and Rausch, 1968)
Laelaps kochi Oudemans, 1836 (Rausch and Rausch, 1968)
Microtus breweri
Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Strandtmann, 1949)
Laelaps kochi Oudemans, 1836 (Winchell, 1977)
Microtus californicus
Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Holdenried et al., 1951; Jameson, 1947; Strandtmann, 1949)

Haemogamasus ambulans (Thorell, 1872) (Furman, 1959*a*, 1959*b*; Holdenried et al., 1951; Keegan, 1951)
Haemogamasus liponyssoides Ewing, 1925 (Furman, 1959*a*; Holdenried et al., 1951; Radovsky, 1960*a*, 1960*b*)
Haemogamasus reidi Ewing, 1925 (Keegan, 1951; Redington, 1971)
Laelaps kochi Oudemans, 1836 (Evans and Till, 1966; Ewing, 1933; Grant, 1947; Holdenried et al., 1951; Jameson, 1947)

Sarcoptidae
Notoedres muris Mégnin, 1877 (Lavoipierre, 1964; Lidicker, 1973)

Trombiculidae
Acomatacarus hirsutus (Ewing, 1931) (Brennan and Jones, 1954)
Euschoengastia ambocalis Wrenn and Loomis, 1973 (original description)
Euschoengastia criceticola Brennan, 1948 (Brennan and Jones, 1954; Gould, 1956)
Euschoengastia oregonensis (Ewing, 1929) (Gould, 1956)
Euschoengastia peromysci (Ewing, 1929) (Gould, 1956)
Euschoengastia pomerantzi Brennan and Jones, 1954 (original description)
Euschoengastia radfordi Brennan and Jones, 1954 (original description)
Neotrombicula californica (Ewing, 1942) (Brennan and Jones, 1954; Ewing, 1942; Gould, 1956; Holdenried et al., 1951)
Neotrombicula cavicola (Ewing, 1931) (Gould, 1956)
Neotrombicula dinehartae (Brennan and Wharton, 1950) (Brennan and Jones, 1954)
Neotrombicula jewetti (Brennan and Wharton, 1950) (Brennan and Jones, 1954)
Odontacarus hirsutus (Ewing, 1931) (Brennan and Jones, 1954)
Walchia americana (Ewing, 1942) (Brennan and Jones, 1954)

Microtus chrotorrhinus

Glycyphagidae
Glycyphagus hypudaei (Koch, 1841) (Whitaker and French, 1982)
Glycyphagus sp. (*hypudaei* group) (Kirkland and Jannett, 1982)
Orycteroxenus canadensis Fain, Kok, Lukoschus, and Clulow, 1971 (Whitaker and French, 1982)
Orycteroxenus soricis (Oudemans, 1915) (Whitaker and French, 1982)

Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Timm, pers. observ.; Whitaker and French, 1982)
Echinonyssus isabellinus (Oudemans, 1913) (Whitaker and French, 1982)
Eulaelaps stabularis (Koch, 1836) (Whitaker and French, 1982)
Haemogamasus ambulans (Thorell, 1872) (Martin, 1972; Timm et al., 1977; Whitaker and French, 1982)
Haemogamasus liponyssoides Ewing, 1925 (Whitaker and French, 1982)
Laelaps alaskensis Grant, 1947 (Kirkland and Jannett, 1982; Martin, 1972; Timm, 1974, 1975; Tipton, 1960; Whitaker and French, 1982)
Laelaps kochi Oudemans, 1836 (Kirkland and Jannett, 1982; Komarek and Komarek, 1938; Linzey and Linzey, 1973; Timm, 1974, 1975; Timm et al., 1977; Tipton, 1960; Whitaker and French, 1982)

Listrophoridae
Listrophorus mexicanus Fain and Hyland, 1972 (Whitaker and French, 1982)
Listrophorus squamiferus Fain and Hyland, 1972 (Kirkland and Jannett, 1982)

Myobiidae

Radfordia hylandi Fain and Lukoschus, 1977 (Whitaker and French, 1982)

Radfordia sp. (Kirkland and Jannett, 1982; Whitaker and French, 1982)

Myocoptidae

Myocoptes canadensis Radford, 1955 (Kirkland and Jannett, 1982)

Myocoptes japonensis Radford, 1955 (Whitaker and French, 1982)

Myocoptes squamosus Fain, Munting, and Lukoschus, 1969 (Whitaker and French, 1982)

Trichoecius tenax (Michael, 1889) (Whitaker and French, 1982)

Trichoecius sp. (Kirkland and Jannett, 1982; Whitaker and French, 1982)

Trombiculidae

Euschoengastia blarinae (Ewing, 1931) (Whitaker and French, 1982)

Euschoengastia peromysci (Ewing, 1929) (Farrell, 1956; Komarek and Komarek, 1938)

Euschoengastia setosa (Ewing, 1937) (Whitaker and French, 1982)

Miyatrombicula esoensis (Sasa and Ogata, 1953) (Whitaker and French, 1982)

Neotromibucla harperi (Ewing, 1928) (Kirkland and Jannett, 1982; Martin, 1972?; Timm et al., 1977; Whitaker and French, 1982)

Neotrombicula microti (Ewing, 1928) (Buech et al., 1977; Timm et al., 1977)

Microtus longicaudus

Laelapidae

Androlaelaps fahrenholzi (Berlese, 1911) (Allred and Beck, 1966; Augustson, 1941*b*; Hansen, 1964; Whitaker and Maser, 1984)

Echinonyssus incomptis (Eads and Hightower, 1952) (Allred and Beck, 1966)

Echinonyssus isabellinus (Oudemans, 1913) (Allred and Beck, 1966; Hansen, 1964; Herrin, 1970; Jameson and Brennan, 1957; Kinsella and Pattie, 1967)

Eubrachylaelaps debilis Jameson, 1950 (Allred and Beck, 1966; Furman, 1955)

Eulaelaps stabularis (Koch, 1836) (Whitaker and Maser, 1984)

Haemogamasus ambulans (Thorell, 1872) (Allred and Beck, 1966; Hansen, 1964; Jameson and Brennan, 1957)

Haemogamasus liponyssoides Ewing, 1925 (Allred and Beck, 1966; Augustson, 1941*b*; Hansen, 1964; Jameson and Brennan, 1957)

Haemogamasus longitarsus (Banks, 1910) (Allred and Beck, 1966)

Haemogamasus occidentalis (Keegan, 1951) (Allred and Beck, 1966; Whitaker and Maser, 1984)

Haemogamasus reidi Ewing, 1925 (Allred and Beck, 1966; Hansen, 1964; Jameson and Brennan, 1957; Redington, 1971; Whitaker and Maser, 1984)

Laelaps alaskensis Grant, 1947 (Jameson and Brennan, 1957)

Laelaps incilis Allred and Beck, 1966 (original description)

Laelaps kochi Oudemans, 1836 (Allred and Beck, 1966; Augustson, 1941*b*; Hansen, 1964; Jameson and Brennan, 1957; Whitaker and Maser, 1984)

Trombiculidae

Chatia ochotona (Radford, 1942) (Gould, 1956; Traub and Nadchatram, 1966)

Euschoengastia oregonensis (Ewing, 1929) (Allred and Beck, 1966)

Euschoengastia peromysci (Ewing, 1929) (Jameson and Brennan, 1957)

Euschoengastia radfordi Brennan and Jones, 1954 (Jameson and Brennan, 1957)
Leptotrombidium potosina Hoffmann, 1950 (Brennan and Beck, 1955)
Neotrombicula browni (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description]; Kardos, 1954; Radford, 1954; Wharton and Fuller, 1952)
Neotrombicula californica (Ewing, 1942) (Brennan and Beck, 1955)
Neotrombicula harperi (Ewing, 1928) (Allred and Beck, 1966; Brennan and Beck, 1955; Brennan and Wharton, 1950; Kardos, 1954; Wharton and Fuller, 1952)
Neotrombicula jewetti (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description]; Jameson and Brennan, 1957; Radford, 1954; Wharton and Fuller, 1952)
Neotrombicula microti (Ewing, 1928) (Brennan and Beck, 1955; Kardos, 1954)

Microtus mexicanus

Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Allred and Beck, 1966; Bassols, 1981)
Echinonyssus breviseta Strandtmann and Morlan, 1953 (Bassols, 1981)
Echinonyssus utahensis Allred and Beck, 1966 (Hoffman et al., 1972)
Haemogamasus ambulans (Thorell, 1872) (Bassols, 1981)
Haemogamasus reidi Ewing, 1925 (Redington, 1971)
Laelaps kochi Oudemans, 1836 (Bassols, 1981)

Listrophoridae
Listrophorus mexicanus Fain, 1970 (Fain and Hyland, 1974)

Myobiidae
Radfordia hylandi Fain and Lukoschus, 1977 (original description)

Trombiculidae
Neotrombicula microti (Ewing, 1928) (Brennan and Wharton, 1950; Wharton and Fuller, 1952)

Microtus montanus

Glycyphagidae
Glycyphagus hypudaei (Koch, 1841) (Whitaker and Maser, 1984)

Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Allred, 1970; Allred and Beck, 1966; Augustson, 1941*b*; Hansen, 1964; Kartman et al., 1958*b*; Strandtmann, 1949; Whitaker and Maser, 1984)
Brevisterna utahensis (Ewing, 1933) (Kartman et al., 1958*b*)
Echinonyssus isabellinus (Oudemans, 1913) (Allred, 1970; Allred and Beck, 1966; Hansen, 1964; Herrin, 1970; Kinsella and Pattie, 1967; Whitaker and Maser, 1984)
Echinonyssus occidentalis (Ewing, 1923) (Augustson, 1941*b*)
Eubrachylaelaps croweri Jameson, 1947 (Hansen, 1964)
Eubrachylaelaps debilis Jameson, 1950 (Whitaker and Maser, 1984)
Eulaelaps stabularis (Koch, 1836) (Hansen, 1964; Whitaker and Maser, 1984)
Haemogamasus ambulans (Thorell, 1872) (Allred and Beck, 1966; Hansen, 1964; Keegan, 1951)
Haemogamasus liponyssoides Ewing, 1925 (Augustson, 1941*b*; Hansen, 1964)
Haemogamasus occidentalis (Keegan, 1951) (Whitaker and Maser, 1984)

Haemogamasus reidi Ewing, 1925 (Augustson, 1941*b*; Whitaker and Maser, 1984)
Ischyropoda armatus Keegan, 1951 (Allred, 1970)
Laelaps alaskensis Grant, 1947 (Hansen, 1964; Kartman et al., 1958*b*; Kinsella and Pattie, 1967; Whitaker and Maser, 1984)
Laelaps incilis Allred and Beck, 1966 (original description)
Laelaps kochi Oudemans, 1836 (Allred and Beck, 1966; Augustson, 1941*b*; Hansen, 1964; Kartman et al., 1958*b*; Kinsella and Pattie, 1967; Tipton, 1960; Whitaker and Maser, 1984)
Listrophoridae
Listrophorus mexicanus Fain, 1970 (Whitaker and Maser, 1984)
Psorergatidae
Psorergates townsendi Giesen, Lukoschus, Whitaker, and Gettinger, 1983 (original description and type-host)
Trombiculidae
Comatacarus americanus Ewing, 1942 (Easton, 1975)
Neotrombicula californica (Ewing, 1942) (Gould, 1956)
Neotrombicula cavicola (Ewing, 1931) (Easton, 1975)
Neotrombicula harperi (Ewing, 1928) (Allred and Beck, 1966; Easton, 1975; Kardos, 1954)
Neotrombicula microti (Ewing, 1928) (Kardos, 1954; Kinsella and Pattie, 1967)

Microtus ochrogaster
Glycyphagidae
Glycyphagus hypudaei (Koch, 1841) (Basolo and Funk, 1974; Buckner and Gleason, 1974; Fain and Whitaker, 1973; McDaniel, 1979; Mumford and Whitaker, 1982; Rupes and Whitaker, 1968; Turner, 1974; Whitaker and Wilson, 1968)
Orycteroxenus soricis (Oudemans, 1915) (Mumford and Whitaker, 1982)
Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Amin, 1973, 1976*b*; Basolo and Funk, 1974; Batson, 1965; Buckner and Gleason, 1974; Jameson, 1947; Mumford and Whitaker, 1982; Rapp, 1962; Strandtmann, 1949; Timm, 1972*b*; Turner, 1974; Whitaker and Wilson, 1968)
Echinonyssus utahensis Allred and Beck, 1966 (Timm, 1972*b*)
Eulaelaps stabularis (Koch, 1836) (Batson, 1965; Jameson, 1947; Mumford and Whitaker, 1982; Whitaker and Wilson, 1968)
Haemogamasus ambulans (Thorell, 1872) (Turner, 1974)
Haemogamasus liponyssoides Ewing, 1925 (Keegan, 1951; Mumford and Whitaker, 1982; Whitaker and Wilson, 1968; Wilson, 1957 [reported as *H. barberi* Ewing])
Laelaps alaskensis Grant, 1947 (Mumford and Whitaker, 1982; Whitaker and Wilson, 1968)
Laelaps kochi Oudemans, 1836 (Basolo and Funk, 1974; Buckner and Gleason, 1974; Jameson, 1947; Mumford and Whitaker, 1982; Rapp, 1962; Timm, 1972*b*; Tipton, 1960; Turner, 1974; Whitaker and Wilson, 1968; Wilson, 1957)
Listrophoridae
Listrophorus mexicanus Fain, 1970 (Basolo and Funk, 1974; Buckner and Gleason, 1974 [reported as *L. leuckarti*]; Mumford and Whitaker, 1982)
Listrophorus sp. (Jameson, 1947)

Macronyssidae

Ornithonyssus bacoti (Hirst, 1913) (Buckner and Gleason, 1974; Mumford and Whitaker, 1982; Turner, 1974)

Myobiidae

Radfordia ensifera (Poppe, 1896) (Manischewitz, 1966)

Radfordia hylandi Fain and Lukoschus, 1977 (Mumford and Whitaker, 1982)

Radfordia lemnina (Koch, 1841) (Basolo and Funk, 1974; Buckner and Gleason, 1974; Whitaker and Wilson, 1968)

Myocoptidae

Myocoptes japonensis Radford, 1955 (Basolo and Funk, 1974)

Myocoptes musculinus (Koch, 1844) (Basolo and Funk, 1974; McDaniel, 1979; Mumford and Whitaker, 1982; Turner, 1974; Whitaker and Wilson, 1968)

Myocoptes sp. (Basolo and Funk, 1974; Buckner and Gleason, 1974; Jameson, 1947)

Trichoecius tenax (Michael, 1889) (Mumford and Whitaker, 1982)

Trombiculidae

Euschoengastia diversa Farrell, 1956 (Farrell, 1956 [original description]; Loomis, 1956)

Euschoengastia peromysci (Ewing, 1929) (Basolo and Funk, 1974; Jameson, 1947 [reported as *Ascoschöngastia breviceps*]; Loomis, 1956)

Euschoengastia setosa (Ewing, 1937) (Lampe et al., 1974; Mumford and Whitaker, 1982; Turner, 1974; Whitaker and Loomis, 1979)

Euschoengastia trigenuala Farrell, 1956 (Loomis, 1956)

Eutrombicula alfreddugesi (Oudemans, 1910) (Loomis, 1956; Mumford and Whitaker, 1982; Turner, 1974; Whitaker and Loomis, 1979; Wolfenbarger, 1952)

Eutrombicula lipovskyana Wolfenbarger, 1952 (Loomis, 1956; Wolfenbarger, 1952 [original description])

Eutrombicula lipovskyi (Brennan and Wharton, 1950) (Kardos, 1954; Loomis, 1956)

Neotrombicula autumnalis (Shaw, 1790) (Kardos, 1954; Loomis, 1956)

Neotrombicula sylvilagi (Brennan and Wharton, 1950) (Kardos, 1954; Loomis, 1956)

Neotrombicula whartoni (Ewing, 1929) (Basolo and Funk, 1974; Kardos, 1954; Loomis, 1956; Mumford and Whitaker, 1982; Whitaker and Loomis, 1979)

Pseudoschongastia hungerfordi Lipovsky, 1951 (Loomis, 1956)

Microtus oeconomus

Laelapidae

Androlaelaps fahrenholzi (Berlese, 1911) (Strandtmann and Wharton, 1958)

Echinonyssus isabellinus (Oudemans, 1913) (Strandtmann and Wharton, 1958)

Eulaelaps stabularis (Koch, 1836) (Strandtmann and Wharton, 1958)

Haemogamasus reidi Ewing, 1925 (Keegan, 1951)

Laelaps kochi Oudemans, 1836 (Strandtmann and Wharton, 1958)

Myobiidae

Radfordia lemnina (Koch, 1841) (Fain and Lukoschus, 1977)

Microtus oregoni
- Glycyphagidae
  - *Dermacarus ondatrae* Rupes and Whitaker, 1968 (Whitaker and Maser, 1984)
  - *Glycyphagus hypudaei* (Koch, 1841) (Whitaker and Maser, 1984)
- Laelapidae
  - *Androlaelaps fahrenholzi* (Berlese, 1911) (Strandtmann, 1949; Whitaker and Maser, 1984)
  - *Eulaelaps stabularis* (Koch, 1836) (Whitaker and Maser, 1984)
  - *Haemogamasus ambulans* (Thorell, 1872) (Keegan, 1951)
  - *Haemogamasus occidentalis* (Keegan, 1951) (Whitaker and Maser, 1984)
  - *Laelaps kochi* Oudemans, 1836 (Whitaker and Maser, 1984)
- Listrophoridae
  - *Listrophorus mexicanus* Fain, 1970 (Whitaker and Maser, 1984)
- Myobiidae
  - *Radfordia hylandi* Fain and Lukoschus, 1977 (Whitaker and Maser, 1984)
- Trombiculidae
  - *Euschoengastia oregonensis* (Ewing, 1929) (Easton, 1975)
  - *Neotrombicula cavicola* (Ewing, 1931) (Brennan and Wharton, 1950; Easton, 1975; Wharton and Fuller, 1952)
  - *Neotrombicula harperi* (Ewing, 1928) (Easton, 1975)

Microtus pennsylvanicus
- Demodicidae
  - *Demodex* sp. (Nutting and Desch, 1979)
- Dermanyssidae
  - *Dermanyssus* sp. (Drummond, 1957)
- Ereynetidae
  - *Speleorodens michigensis* Ford, 1962 (original description and type-host)
- Glycyphagidae
  - *Dermacarus newyorkensis* Fain, 1969 (Fain, 1969*a* [original description and type-host], 1969*b*; Rupes and Whitaker, 1968)
  - *Glycyphagus hypudaei* (Koch, 1841) (Fain, 1969*b*; Mumford and Whitaker, 1982; Rupes and Whitaker, 1968; Whitaker and French, 1982; Whitaker and Wilson, 1968)
  - *Glycyphagus microti* Spicka and OConnor, 1980 (original description)
  - *Orycteroxenus soricis* (Oudemans, 1915) (Fain, 1969*b*)
- Laelapidae
  - *Androlaelaps fahrenholzi* (Berlese, 1911) (Allred and Beck, 1966; Amin, 1973, 1976*b*; Baker, 1946; Drummond, 1957; Florschutz and Darsie, 1960; Genoways and Jones, 1972; Harper, 1961; Jameson, 1947; Judd, 1950, 1953; Lawrence et al., 1965; MacCreary, 1945*a*; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Strandtmann, 1949; Timm, 1972*a*, 1972*b*, 1975; Turner, 1974; Whitaker and French, 1982; Whitaker and Wilson, 1968; Wilson, 1967)
  - *Androlaelaps* sp. (Wright, 1979)
  - *Echinonyssus carnifex* Koch, 1839 (Lawrence et al., 1965)
  - *Echinonyssus isabellinus* (Oudemans, 1913) (Allred and Beck, 1966; Harper, 1961; Herrin, 1970; Timm, 1972*a*, 1972*b*, 1975; Whitaker and French, 1982)

Echinonyssus sp. (Amin, 1976*b*; Genoways and Jones, 1972; Scholten et al., 1962; Wright, 1979)

Eulaelaps stabularis (Koch, 1836) (Drummond, 1957; Genoways and Jones, 1972; Lawrence et al., 1965; Timm, 1975; Wilson, 1967; Wright, 1979)

Haemogamasus ambulans (Thorell, 1872) (Drummond, 1957; Harper, 1956, 1961; Keegan, 1951; Lawrence et al., 1965; Timm, 1975; Whitaker and French, 1982)

Haemogamasus liponyssoides Ewing, 1925 (Drummond, 1957; Keegan, 1951; Lawrence et al., 1965; MacCreary, 1945*a*; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Timm, 1975)

Haemogamasus longitarsus (Banks, 1910) (Ewing, 1925 [described as *H. microti*]; Keegan, 1951)

Laelaps alaskensis Grant, 1947 (Amin, 1973, 1976*b*; Drummond, 1957; Florschutz and Darsie, 1960; Harper, 1956, 1961; Lawrence et al., 1965; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Timm, 1975; Whitaker and French, 1982; Whitaker and Wilson, 1968; Wilson, 1967)

Laelaps kochi Oudemans, 1836 (Allred and Beck, 1966; Amin, 1973, 1976*b*; Baker, 1946; Drummond, 1957; Florschutz and Darsie, 1960; Genoways and Jones, 1972; Harper, 1956, 1961; Jameson, 1947; Judd, 1950, 1953, 1954; Lampe et al., 1974; Lawrence et al., 1965; MacCreary, 1945*a*; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Scholten et al., 1962; Shoemaker and Joy, 1967; Timm, 1972*a*, 1972*b*, 1975; Tipton, 1960; Turner, 1974; Whitaker and French, 1982; Whitaker and Wilson, 1968)

Laelaps multispinosa (Banks, 1910) (Lawrence et al., 1965)

Laelaps muris (Ljungh, 1799) (Judd, 1950, 1953, 1954)

Listrophoridae

Listrophorus mexicanus Fain, 1970 (McDaniel et al., 1967; Mumford and Whitaker, 1982; Whitaker and French, 1982; Whitaker and Wilson, 1968 [reported as *L. leuckarti*])

Listrophorus pitymys Fain and Hyland, 1972 (Fain and Hyland, 1974)

Listrophorus squamiferus Fain and Hyland, 1972 (Fain and Hyland, 1974; McDaniel et al., 1967 [reported as *L. leuckarti*])

Listrophorus sp. (Drummond, 1957)

Macronyssidae

Ornithonyssus bacoti (Hirst, 1913) (Drummond, 1957; Mumford and Whitaker, 1982)

Ornithonyssus bursa (Berlese, 1888) (Drummond, 1957)

Myobiidae

Protomyobia brevisetosa Jameson, 1948 (Whitaker and French, 1982)

Protomyobia claparedei (Poppe, 1896) (Manischewitz, 1966)

Radfordia ensifera (Poppe, 1896) (Manischewitz, 1966)

Radfordia hylandi Fain and Lukoschus, 1977 (Fain and Lukoschus, 1977 [original description]; Mumford and Whitaker, 1982; Whitaker and French, 1982)

Radfordia lemnina (Koch, 1841) (Drummond, 1957; Ewing, 1938; Manischewitz, 1966)

Myocoptidae

Myocoptes japonensis Radford, 1955 (Fain and Hyland, 1970; Fain et al., 1970; Mumford and Whitaker, 1982; Radford, 1955 [originally described as *M. jamesoni*]; Whitaker and French, 1982)

Myocoptes musculinus (Koch, 1844) (Harper, 1956; McDaniel, 1979)

Myocoptes squamosus Fain, Munting, and Lukoschus, 1969 (Fain and Hyland, 1970; Whitaker and French, 1982)

Myocoptes sp. (Drummond, 1957)

Trichoecius tenax (Michael, 1889) (Fain and Hyland, 1970; Fain et al., 1970; Whitaker and French, 1982)

Psorergatidae

Psorergates canadensis Kok, Lukoschus, and Clulow, 1971 (original description and type-host)

Psorergates simplex Tyrrell, 1883 (Lee and Horvath, 1969)

Trombiculidae

Euschoengastia diversa Farrell, 1956 (original description)

Euschoengastia peromysci (Ewing, 1929) (Farrell, 1956; MacCreary, 1945*a* [reported as *Neoschöngastia breviceps*]; Manischewitz, 1966; Mumford and Whitaker, 1982; Whitaker and Loomis, 1979)

Euschoengastia setosa (Ewing, 1937) (Turner, 1974)

Euschoengastia sp. (Drummond, 1957; Wilson, 1967)

Eutrombicula alfreddugesi (Oudemans, 1910) (Ewing, 1944; Jenkins, 1949; MacCreary, 1945*a* [reported as *E. tropica*]; Mumford and Whitaker, 1982; Wharton and Fuller, 1952; Whitaker and Loomis, 1979)

Eutrombicula splendens (Ewing, 1913) (Wharton and Fuller, 1952)

Eutrombicula sp. (Wright, 1979)

Miyatrombicula esoensis (Sasa and Ogata, 1953) (Whitaker and French, 1982)

Neotrombicula autumnalis (Shaw, 1790) (Kardos, 1954; Loomis, 1956)

Neotrombicula bisignata (Ewing, 1929) (Brennan and Wharton, 1950; Ewing, 1929*a* [original description and type-host]; Radford, 1954; Wharton and Fuller, 1952)

Neotrombicula goodpasteri (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description]; Radford, 1954; Wharton and Fuller, 1952)

Neotrombicula harperi (Ewing, 1928) (Brennan and Wharton, 1950; Harper, 1929; Lawrence et al., 1965; Manville, 1949; Timm, pers. observ.; Wharton and Fuller, 1952; Whitaker and French, 1982)

Neotrombicula lipovskyi (Brennan and Wharton, 1950) (Mumford and Whitaker, 1982; Whitaker and Loomis, 1979)

Neotrombicula microti (Ewing, 1928) (Baker, 1946; Brennan and Wharton, 1950; Ewing, 1928; Lawrence et al., 1965; Timm, pers. observ.; Wharton and Fuller, 1952)

Neotrombicula richmondi (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description]; Radford, 1954; Wharton and Fuller, 1952)

Neotrombicula subsignata (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description and type-host]; Genoways and Jones, 1972; Kardos, 1954; Radford, 1954; Wharton and Fuller, 1952)

Neotrombicula whartoni (Ewing, 1929) (Brennan and Wharton, 1950; Drummond, 1957; Farrell, 1956; Kardos, 1954; MacCreary, 1945*a*; Manischewitz, 1966; Mumford and Whitaker, 1982; Wharton and Fuller, 1952; Whitaker and Loomis, 1979)
Neotrombicula sp. (Manville, 1949)
Microtus pinetorum
Cheyletidae
Eucheyletia bishoppi Baker, 1949 (original description)
Glycyphagidae
Dermacarus sp. (Benton, 1955*a*)
Glycyphagus hypudaei (Koch, 1841) (Fain, 1969*b*; Fain and Whitaker, 1973; Mumford and Whitaker, 1982)
Glycyphagus microti Spicka and OConnor, 1980 (original description and type-host)
Orycteroxenus soricis (Oudemans, 1915) (Fain and Whitaker, 1973)
Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Benton, 1955*a*; Drummond, 1957; Ellis, 1955; Hays and Guyton, 1958; Jameson, 1947; Judd, 1950; MacCreary, 1945*a*; Mellott and Connell, 1965; Morlan, 1952; Mumford and Whitaker, 1982; Strandtmann, 1949; Whitaker and Wilson, 1968)
Eulaelaps stabularis (Koch, 1836) (Jameson, 1947; Mumford and Whitaker, 1982; Whitaker and Wilson, 1968)
Haemogamasus ambulans (Thorell, 1872) (Keegan, 1951; Whitaker and Wilson, 1968)
Haemogamasus liponyssoides Ewing, 1925 (Drummond, 1957; Keegan, 1951; Morlan, 1952)
Haemogamasus longitarsus (Banks, 1910) (Drummond, 1957; Keegan, 1951; MacCreary, 1945*a*; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Whitaker and Wilson, 1968; Wilson, 1957)
Laelaps alaskensis Grant, 1947 (Benton, 1955*a*; Mumford and Whitaker, 1982; Whitaker and Wilson, 1968)
Laelaps kochi Oudemans, 1836 (Drummond, 1957; Hamilton, 1938; Hays and Guyton, 1958; Mumford and Whitaker, 1982; Whitaker and Wilson, 1968)
Listrophoridae
Listrophorus pitymys Fain and Hyland, 1972 (Fain and Hyland, 1972 [original description], 1974)
Listrophorus sp. (Drummond, 1957)
Macronyssidae
Ornithonyssus bacoti (Hirst, 1913) (Mumford and Whitaker, 1982)
Myobiidae
Radfordia ensifera (Poppe, 1896) (Manischewitz, 1966)
Radfordia hylandi Fain and Lukoschus, 1977 (Fain and Lukoschus, 1977 [original description]; Mumford and Whitaker, 1982)
Radfordia lemnina (Koch, 1841) (Drummond, 1957; Manischewitz, 1966)
Myocoptidae
Myocoptes canadensis Radford, 1955 (Mumford and Whitaker, 1982)
Myocoptes musculinus (Koch, 1844) (Mumford and Whitaker, 1982)
Myocoptes sp. (Benton, 1955*a*; Drummond, 1957)

Psorergatidae
Psorergates pinetorum Giesen, Lukoschus, Whitaker, and Gettinger, 1983 (original description and type-host)
Trombiculidae
Euschoengastia carolinensis Farrell, 1956 (original description)
Euschoengastia diversa Farrell, 1956 (Loomis, 1956)
Euschoengastia ohioensis Farrell, 1956 (Farrell, 1956 [original description]; Mumford and Whitaker, 1982; Whitaker and Loomis, 1979)
Euschoengastia peromysci (Ewing, 1929) (Farrell, 1956; Manischewitz, 1966; Mumford and Whitaker, 1982; Whitaker and Loomis, 1979)
Eutrombicula alfreddugesi (Oudemans, 1910) (Wolfenbarger, 1952)
Leptotrombidium myotis (Ewing, 1929) (Loomis, 1956; Manischewitz, 1966)
Neotrombicula goodpasteri (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description]; Radford, 1954; Wharton and Fuller, 1952)
Neotrombicula lipovskyi (Brennan and Wharton, 1950) (Kardos, 1954; Loomis, 1956; Mumford and Whitaker, 1982; Whitaker and Loomis, 1979)
Neotrombicula microti (Ewing, 1928) (Kardos, 1954)
Neotrombicula whartoni (Ewing, 1929) (MacCreary, 1945*a*; Manischewitz, 1966)

Microtus richardsoni
Glycyphagidae
Glycyphagus hypudaei (Koch, 1841) (Whitaker and Maser, 1984)
Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Whitaker and Maser, 1984)
Echinonyssus isabellinus (Oudemans, 1913) (Kinsella and Pattie, 1967; Ludwig, 1984; Whitaker and Maser, 1984)
Haemogamasus ambulans (Thorell, 1872) (Kinsella and Pattie, 1967)
Haemogamasus liponyssoides Ewing, 1925 (Kinsella and Pattie, 1967)
Haemogamasus occidentalis (Keegan, 1951) (Whitaker and Maser, 1984)
Haemogamasus reidi Ewing, 1925 (Whitaker and Maser, 1984)
Laelaps alaskensis Grant, 1947 (Kinsella and Pattie, 1967; Ludwig, 1984; Whitaker and Maser, 1984)
Laelaps kochi Oudemans, 1836 (Kinsella and Pattie, 1967)
Listrophoridae
Listrophorus mexicanus Fain, 1970 (Whitaker and Maser, 1984)
Myocoptidae
Myocoptes japonensis Radford, 1955 (Whitaker and Maser, 1984)
Trombiculidae
Neotrombicula microti (Ewing, 1928) (Brennan and Wharton, 1950; Ewing, 1928 [original description and type-host]; Radford, 1954; Wharton and Fuller, 1952)

Microtus townsendii
Glycyphagidae
Glycyphagus hypudaei (Koch, 1841) (Whitaker and Maser, 1984)
Laelapidae
Androlaelaps fahrenholzi (Berlese, 1911) (Whitaker and Maser, 1984)
Echinonyssus isabellinus (Oudemans, 1913) (Whitaker and Maser, 1984)
Echinonyssus obsoletus Jameson, 1950 (Whitaker and Maser, 1984)

Eubrachylaelaps debilis Jameson, 1950 (Whitaker and Maser, 1984)
Eulaelaps stabularis (Koch, 1836) (Whitaker and Maser, 1984)
Haemogamasus occidentalis (Keegan, 1951) (Keegan, 1951 [original description and type-host]; Whitaker and Maser, 1984)
Haemogamasus reidi Ewing, 1925 (Whitaker and Maser, 1984)
Laelaps kochi Oudemans, 1836 (Whitaker and Maser, 1984)
Listrophoridae
Listrophorus mexicanus Fain, 1970 (Whitaker and Maser, 1984)
Psorergatidae
Psorergates townsendi Giesen, Lukoschus, Whitaker, and Gettinger, 1983 (original description and type-host)
Trombiculidae
Neotrombicula jewetti (Brennan and Wharton, 1950) (Brennan and Wharton, 1950 [original description]; Radford, 1954; Wharton and Fuller, 1952)
Microtus sp. (Mexico)
Laelapidae
Eulaelaps stabularis (Koch, 1836) (de Barrera, 1979)
Echinonyssus breviseta Strandtmann and Morlan, 1953 (de Barrera, 1979)
Echinonyssus utahensis Allred and Beck, 1966 (de Barrera, 1979)
Haemogamasus ambulans (Thorell, 1872) (de Barrera, 1979)
Laelaps kochi Oudemans, 1836 (de Barrera, 1979)

Ticks

All ticks known from *Microtus* belong to the family Ixodidae (hard ticks). The life cycle of a typical ixodid tick includes four stages: egg, nymph, larva, and adult. For the most part, ticks are not strongly host specific, although nymphs and larvae generally feed on small mammals, birds, or reptiles, and adults feed on larger mammals. Larvae, nymphs, and adults all require blood meals for metamorphosis. The entire life cycle may require 1–3 years. The life cycle and natural history of *Dermacentor variabilis*, the American dog tick, is perhaps the best known of all ticks, and is summarized as follows. Eggs hatch in 30–35 days. Newly hatched larvae, called seed ticks, feed on small mammals for 5–12 days, drop from the host, and metamorphose into the nymphal stage. Nymphs feed 6–10 days and drop off to metamorphose into adults. Copulation takes place on the host. Males may copulate with several different females. Females die soon after egglaying. Nymphs and adults can withstand long periods (hundreds of days) without feeding. Unfed adults and larvae are the main overwintering stage. In

Novia Scotia, larvae are active from April through September, nymphs are active from May through August, and adult activity extends from April to mid-August. Also, Garvie et al. (1978:28) found that "The voles *Microtus pennsylvanicus* and *Clethrionomys gapperi* sustained almost 80% of all larvae [*Dermacentor variabilis*] and over 85% of all nymphs collected from mammal hosts."

Ticks are responsible for the transmission of numerous diseases including babesiosis (*Babesia*), Colorado tick-fever virus, relapsing fever, several *Rickettsia* diseases (for example, Q fever and Rocky Mountain spotted fever), tick paralysis, and tularemia. Additionally, exsanguination by a heavy load of ticks may be significant to a mouse. A recent review of tickborne disease is found in Hoogstraal (1981).

Keys for the identification of North American ticks were provided by Clifford et al. (1961), Cooley and Kohls (1945), Gregson (1956), Keirans and Clifford (1978), and Sonenshine (1979). An excellent and comprehensive bibliography to the ticks was provided by Hoogstraal (see *Bibliography of ticks and tickborne diseases from Homer (about 800 B.C.) to 31 December 1981,* NAMRU-3, Cairo; seven volumes have been published as of 1983).

Amblyomma maculatum, the Gulf Coast tick, ranges from southeastern U.S. through Central and South America. The larvae and nymphs are found on small mammals and ground-dwelling birds. The adults generally are found on larger mammals, especially livestock.

Dermacentor andersoni is known as the Rocky Mountain spotted fever tick because it is one of the primary vectors of the *Rickettsia* causing the disease; it is also a vector of tick paralysis, Colorado tick fever, tularemia, and American Q fever. It is one of the most abundant ticks found in the western half of the U.S. and Canada. Small mammals, especially chipmunks, are the primary hosts; larvae, nymphs, and adults are most common on hosts in spring and summer.

Dermacentor occidentalis, the Pacific Coast tick, is common in western California and Oregon. Small mammals are typical hosts for larvae and nymphs, whereas adults are common on deer, cattle, and horses. It is present on hosts during all seasons of the year, but adults generally are most abundant during the rainy season.

Dermacentor variabilis, the American dog tick, is the most abundant tick in the eastern two-thirds of North America, east of the

Rocky Mountains. Larvae and nymphs have been recovered from most species of small mammals, but are especially abundant on cricetines; adults generally feed on dogs, foxes, and other medium-sized carnivores. It is the eastern U.S. counterpart of *D. andersoni*. In southern U.S. it breeds throughout the year; in northern states a distinct seasonality is found. It is the main vector of Rocky Mountain spotted fever in the eastern U.S. Ecological studies on *D. variabilis* were provided by Campbell (1979), Garvie et al. (1978), and Sonenshine (1979). See references in those papers.

Haemaphysalis leporispalustris, the rabbit tick, is found throughout North, Central, and South America. Lagomorphs (both *Lepus* and *Sylvilagus*) are preferred hosts; however, larvae and nymphs are often found on other small mammals and ground-feeding birds. This species is an important vector of Rocky Mountain spotted fever and tularemia.

Ixodes angustus is found throughout North America, and is one of the most common ticks on small mammals. In the Pacific Northwest, Bishopp and Trembley (1945) reported finding adult ticks on small mammals throughout the year, but immatures not later than the end of October. In northeastern Minnesota, Timm (1975) found larvae and nymphs of *I. angustus* on all species of shrews, moles, and cricetines.

Ixodes auritulus is an uncommon species that has been collected primarily from birds along the coast of northwestern North America.

Ixodes californicus is a poorly known and rarely collected species from the far western U.S. It has been taken from both birds and small mammals.

Ixodes cookei is a widely distributed species, although it appears to be most abundant in the east. It has been found on a variety of small mammals and birds. Sonenshine (1979:30) reported that "larvae and nymphs are most abundant on hosts during winter months," and that medium-sized carnivores, especially skunks, raccoons, and foxes, appeared to be preferred hosts.

Ixodes dammini is a widely distributed tick in the eastern U.S. that was described only recently (see Spielman et al., 1979). Adults appear most frequently on white-tailed deer and larvae and nymphs on a wide variety of small mammals. This species was confused for

decades with *I. scapularis* and many of the older records of *scapularis* actually refer to *dammini*. *I. dammini* is the major vector of human babesia, a parasitic protozoan, in the northeastern U.S. Main et al. (1982) reported that both larvae and nymphs were abundant on small mammals in Connecticut from April through October, with peaks of abundance in early and late summer.

Ixodes dentatus is found in the northcentral and eastern U.S., with cottontail rabbits of the genus *Sylvilagus* being the most common hosts. Larvae and nymphs are occasionally found on birds and rodents. Larvae appear to be most abundant on hosts in fall whereas adults are most abundant in spring. This species is a known vector of Rocky Mountain spotted fever.

Ixodes eastoni is a recently recognized species from the Black Hills area of South Dakota and adjacent Wyoming. It has been reported on several species of small mammals, including the genera *Cleth-rionomys, Eutamias, Microtus, Neotoma, Peromyscus,* and *Zapus.* Adults of *I. eastoni* were confused previously with *I. ochotonae* and immature stages with *I. angustus* (Keirans and Clifford, 1983).

Ixodes kingi is called the rotund tick, and is found in the western U.S. and northern Mexico on a variety of mammals. Carnivores seem to be preferred hosts.

Ixodes muris is called the mouse tick, and is restricted to northeastern U.S.; it is generally found on cricetine rodents, although it is found occasionally on shrews. Smith (1944:231) reported that *Microtus* is the most important host and that "adults of the mouse tick do not mate on the host, but on the ground before the females have attached."

Ixodes ochotonae is aptly named the pika tick; most of the records are from *Ochotona.* It is found in the far western U.S. and British Columbia.

Ixodes pacificus is restricted to the Pacific coastal regions of California, Oregon, and Washington. Adults feed primarily on mammals and are most active from fall to spring; larvae and nymphs feed primarily on lizards. Adults are considered a serious pest on dogs, livestock, and man.

Ixodes sculptus is called the black-legged tick and is common in the midwest and western North America. Ground squirrels are the primary hosts, although it has been collected from a wide variety of small mammals and may be a pest on cattle.

Ixodes spinipalpis is an uncommon tick found in northwestern U.S. and adjacent Canada. Lagomorphs seem to be preferred hosts, although it has been collected on other mammals.

The records of ticks parasitizing *Microtus* are as follows:

Microtus breweri
- *Dermacentor variabilis* (Say, 1821) (Spielman and Piesman, 1979)
- *Ixodes dammini* Spielman, Clifford, Piesman, and Corwin, 1979 (original description)
- *Ixodes muris* Bishopp and Smith (Spielman et al., 1979; Winchell, 1977)

Microtus californicus
- *Dermacentor occidentalis* Marx, 1892 (Furman and Loomis, 1984; Holdenried et al., 1951; Mohr et al., 1964)
- *Dermacentor variabilis* (Say, 1821) (Coultrip et al., 1973; Furman and Loomis, 1984)
- *Ixodes angustus* Neumann, 1899 (Cooley and Kohls, 1945; Furman and Loomis, 1984; Holdenried et al., 1951; Mohr et al., 1964)
- *Ixodes pacificus* Cooley and Kohls, 1943 (Arthur and Snow, 1968; Furman and Loomis, 1984; Mohr et al., 1964)
- *Ixodes spinipalpis* Hadwen and Nuttall, 1916 (Furman and Loomis, 1984; Mohr et al., 1964)
- *Ixodes* sp. (Holdenried et al., 1951)

Microtus canicaudus
- *Ixodes angustus* Neumann, 1899 (Easton and Goulding, 1974)

Microtus chrotorrhinus
- *Ixodes angustus* Neumann, 1899 (Kirkland and Jannett, 1982; Timm, 1974, 1975; Timm et al., 1977; Whitaker and French, 1982)
- *Ixodes* sp. (Komarek and Komarek, 1938)

Microtus longicaudus
- *Dermacentor andersoni* Stiles, 1908 (Augustson, 1941*b*; Bacon, 1953; Beck, 1955; Chamberlin, 1937; Clark et al., 1970; Hansen, 1964; Johnson, 1966; Stout, 1979)
- *Dermacentor variabilis* (Say, 1821) (Stout, 1979; Stout et al., 1971)
- *Dermacentor* sp. (Beck, 1955)
- *Ixodes angustus* Neumann, 1899 (Chamberlin, 1937; Cooley and Kohls, 1945; Easton and Goulding, 1974; Furman and Loomis, 1984; Stout, 1979)
- *Ixodes californicus* Banks, 1904 (Chamberlin, 1937)
- *Ixodes eastoni* Keirans and Clifford, 1983 (original description)
- *Ixodes sculptus* Neumann, 1904 (Allred et al., 1960)
- *Ixodes spinipalpis* Hadwen and Nuttall, 1916 (Stout, 1979)
- *Ixodes* sp. (Allred et al., 1960)

Microtus miurus
- *Ixodes angustus* Neumann, 1899 (Rausch, 1964)

Microtus montanus
- *Dermacentor andersoni* Stiles, 1908 (Allred, 1968*b*; Bacon, 1953; Bacon et al., 1959; Bishopp and Trembley, 1945; Hansen, 1964; Harkema, 1936; Hooker et al., 1912 [reported as *D. venustus*])
- *Dermacentor* sp. (Beck, 1955)
- *Ixodes angustus* Neumann, 1899 (Allred et al., 1960; Furman and Loomis, 1984; Seidel and Booth, 1960)

Ixodes kingi Bishopp, 1911 (Allred, 1968*b*)

Ixodes muris Bishopp and Smith, 1937 (Johnson, 1966)

Ixodes sculptus Neumann, 1904 (Allred et al., 1960)

Ixodes sp. (Allred, 1968*b*)

Microtus ochrogaster

Dermacentor andersoni Stiles, 1908 (Cooley, 1938; Parker and Wells, 1917 [reported as *D. venustus*])

Dermacentor variabilis (Say, 1821) (Basolo and Funk, 1974; Buckner and Gleason, 1974; Cooney and Burgdorfer, 1974; Jameson, 1947; Mumford and Whitaker, 1982)

Ixodes sculptus Neumann, 1904 (Jameson, 1947)

Ixodes spinipalpis Hadwen and Nuttall, 1916 (Turner, 1974)

Microtus oeconomus

Ixodes angustus Neumann, 1899 (Fay and Rausch, 1969; Schiller and Rausch, 1956)

Microtus pennsylvanicus

Dermacentor andersoni Stiles, 1908 (Cooley, 1938; Gregson, 1956; Harkema, 1936; Hooker et al., 1912 [reported as *venustus*]; Hunter and Bishopp, 1911 [reported as *D. venustus*]; Turner, 1974)

Dermacentor variabilis (Say, 1821) (Anastos, 1947; Anderson and Magnarelli, 1980; Bequaert, 1945; Bishopp and Smith, 1938; Campbell, 1979; Carey et al., 1980; Clifford et al., 1961; Coher and Shaw, 1951; Cooley, 1938; Dodds et al., 1969; Drummond, 1957; Eddy and Joyce, 1944; Garvie et al., 1978; Gould and Miesse, 1954; Hertig and Smiley, 1937; Knipping et al., 1950*a*; Larrouse et al., 1928; Lawrence et al., 1965; MacCreary, 1945*b*; Magnarelli et al., 1983; McEnroe, 1983; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Parker et al., 1933; Smith et al., 1946; Sonenshine, 1972, 1979; Sonenshine and Atwood, 1967; Sonenshine and Levy, 1972; Sonenshine and Stout, 1968; Sonenshine et al., 1965, 1966; Spielman and Piesman, 1979; Timm, 1972*b*; Wilkinson, 1979; Wilson, 1943; Wilson and Baker, 1972; Wright, 1979)

Haemaphysalis leporispalustris (Packard, 1869) (Lawrence et al., 1965; Martell et al., 1969; Wright, 1979)

Ixodes angustus Neumann, 1899 (Burroughs et al., 1945; Gregson, 1956; Martell et al., 1969; Timm, 1975; Wright, 1979)

Ixodes cookei Packard, 1869 (Clifford et al., 1961)

Ixodes dammini Spielman, Clifford, Piesman, and Corwin, 1979 (Anderson and Magnarelli, 1980; Carey et al., 1980; Main et al., 1982; Spielman and Piesman, 1979; Spielman et al., 1979 [original description]; White and White, 1981)

Ixodes dentatus Marx, 1899 (Bequaert, 1945; MacCreary, 1945*b*; Sonenshine et al., 1965, 1966)

Ixodes eastoni Keirans and Clifford, 1983 (original description)

Ixodes muris Bishopp and Smith, 1937 (Anastos, 1947; Bequaert, 1945; Bishopp and Smith, 1937 [original description and type-host]; Bishopp and Trembley, 1945; Clifford et al., 1961; Cooley and Kohls, 1945; Easton, 1983*b*; Jones and Thomas, 1980; Martell et al., 1969; Smith, 1944; Spielman et al., 1979; Timm, 1975; Wright, 1979)

Ixodes scapularis Say, 1821 (Bequaert, 1945; Cooley and Kohls, 1945)
Ixodes spinipalpis Hadwen and Nuttall, 1916 (Turner, 1974)
Microtus pinetorum
Amblyomma maculatum Koch, 1844 (Bishopp and Hixson, 1936)
Dermacentor variabilis (Say, 1821) (Bequaert, 1945; Bishopp and Smith, 1938; Bishopp and Trembley, 1945; Carey et al., 1980; Clifford et al., 1961; Cooley, 1938; MacCreary, 1940, 1945*b*; Mellott and Connell, 1965; Mumford and Whitaker, 1982; Smith et al., 1946; Sonenshine, 1972, 1979; Sonenshine and Levy, 1972; Sonenshine et al., 1965, 1966; Tugwell and Lancaster, 1962; Wilson and Baker, 1972)
Ixodes dammini Spielman, Clifford, Piesman, and Corwin, 1979 (Carey et al., 1980; Main et al., 1982)
Microtus townsendii
Ixodes angustus Neumann, 1899 (Bishopp and Trembley, 1945; Cooley and Kohls, 1945; Easton and Goulding, 1974)
Microtus sp.
Ixodes auritulus Neumann, 1904 (Gregson, 1956)
Ixodes ochotonae Gregson, 1941 (Gregson, 1956)

Lice

Lice (Anoplura: Hoplopleuridae) of three genera (*Hoplopleura, Neohaematopinus,* and *Polyplax*) are known from North American *Microtus*. American workers commonly recognize two orders of lice, the Anoplura or sucking lice, and the Mallophaga or chewing lice; Europeans generally recognize a single order, Phthiraptera. The Mallophaga are found primarily on birds, although a few genera parasitize mammals; the Anoplura are exclusively parasites of mammals. Anoplurans feed exclusively on blood and have complex, highly specialized mouthparts modified to pierce the skin of the host.

The entire life cycle of lice is spent on the host, and transmission occurs only when hosts are in direct contact, for the lice cannot live independently of the host. Each individual egg, called a nit, is glued to a single hair. There are three nymphal instars and the duration of the life cycle is about a month. The number of lice on an individual host varies greatly; Cook and Beer (1958) reported a range of 1–748 *Hoplopleura acanthopus* per host on *Microtus pennsylvanicus,* with a mean infestation rate for male voles of 25.1 and for females 10.1 lice per infested host. They (1958:651) found a "positive correlation between age and rate of infestation in male meadow voles with the older animals having higher rates than the younger";

no corresponding correlation was found in female voles. Also (p. 649), "over the whole year . . . 72.6% of the male meadow voles harbored lice as opposed to only 60.9% of the females." Rates of infestation varied with the year and season, with peak rates found in December and April. Female lice are more numerous than males on *M. pennsylvanicus,* which Cook and Beer attributed to a shorter life span of males. The main factor controlling louse populations may be the efficiency of the host at mutual and self grooming; molting of hair on the host may be significant in egg loss. Cook and Beer (1958:419) also stated that ". . . in general higher infestations were found on host populations which were stable or declining, and the lower rates were on hosts which were increasing." On *M. arvalis* in the U.S.S.R., Vysotskaia (1950) reported that *H. acanthopus* occurred all over the host's body in spring and summer, but in fall was concentrated anteriorly, especially in the region of the neck and chest up to the ears. In winter, lice were concentrated in the region of the neck. These changes in position on the host's body were attributed to changes in nest temperature. In cold periods, the lice congregated on the warmest parts of the body. Cook and Beer (1955, 1958) provided detailed studies of population dynamics of *Hoplopleura acanthopus* on *Microtus pennsylvanicus* in Minnesota.

It seems probable that reproduction in these lice may be cued to the reproductive cycle of their hosts, as has been demonstrated in the rabbit flea, *Cediopsylla simplex* (Rothschild and Ford, 1964, 1966, 1969). The reproductive steroids of the host presumably trigger the reproductive steroids of the parasite. This remains to be tested in lice, but may prove to be a fruitful area of research. Anoplurans may prove to be important in the transmission of tularemia (*Francisella tularensis*).

Hoplopleura is a worldwide genus of some 117 species that parasitizes rodents. *H. acanthopus* is a true parasite of microtine rodents; it is found on *Clethrionomys, Lemmus, Microtus,* and *Synaptomys.* The species as now defined is Holarctic; however, in reality the microtine *Hoplopleura* is most likely a complex of several closely related species. *H. hesperomydis* is a true parasite of *Peromyscus,* the few records from *Microtus* being either natural transfers or contamination.

Neohaematopinus is a worldwide genus of about 41 species that

parasitizes rodents and insectivores. *N. sciurinus* is a true parasite of tree squirrels of the genus *Sciurus*; the single report from *M. longicaudus* is probably a contaminate.

Polyplax is a worldwide genus of about 76 species, most of which parasitize murid rodents. *P. alaskensis* is a Holarctic species on microtine rodents, especially *Clethrionomys* and *Microtus*. *P. serrata* and *P. spinulosa* are worldwide species whose normal hosts are murid rodents, *Mus* and *Rattus*, respectively.

The records of lice parasitizing *Microtus* are as follows:

Microtus breweri
- *Polyplax alaskensis* Ewing, 1927 (Scanlon and Johnson, 1957; Winchell, 1977)

Microtus californicus
- *Hoplopleura acanthopus* (Burmeister, 1838) (Ferris, 1921; Holdenried et al., 1951; Jameson, 1947; Jellison et al., 1958; Kellogg and Ferris, 1915; Mohr and Stumpf, 1964; Ryckman and Lee, 1958)
- *Polyplax alaskensis* Ewing, 1927 (Ferris, 1916, 1923 [reported as *P. abscisa* and *P. spinulosa*]; Holdenried et al., 1951 [reported as *P. abscisa*]; Mohr and Stumpf, 1964 [reported as *P. abscisa*]; Ryckman and Lee, 1958 [reported as *P. abscisa*]; Scanlon and Johnson, 1957)

Microtus longicaudus
- *Hoplopleura acanthopus* (Burmeister, 1838) (Augustson, 1941*b*; Emerson et al., 1984; Hansen, 1964; Ignoffo, 1956; Morlan and Hoff, 1957; Spencer, 1966)
- *Hoplopleura hesperomydis* (Osborn, 1891) (Morlan and Hoff, 1957)
- *Neohaematopinus sciurinus* (Mjoberg, 1910) (Augustson, 1941*b*)
- *Polyplax alaskensis* Ewing, 1927 (Ignoffo, 1956 [reported as *P. abscisa*]; Kellogg and Ferris, 1915 [reported as *P. spinulosa*])

Microtus mexicanus
- *Hoplopleura acanthopus* (Burmeister, 1838) (Emerson, 1971)
- *Polyplax alaskensis* Ewing, 1927 (Emerson, 1971)

Microtus miurus
- *Polyplax alaskensis* Ewing, 1927 (Quay, 1951)

Microtus montanus
- *Hoplopleura acanthopus* (Burmeister, 1838) (Allred, 1970; Augustson, 1941*b*; Emerson et al., 1984; Hansen, 1964; Jellison et al., 1958, 1959; Kartman et al., 1958*b*; Seidel and Booth, 1960; Spencer, 1966; Stanford, 1934)
- *Polyplax alaskensis* Ewing, 1927 (Allred, 1970 [reported as *P. spinulosa*]; Hansen, 1964 [reported as *P. spinulosa*]; Scanlon and Johnson, 1957)
- *Polyplax serrata* (Burmeister, 1839) (Augustson, 1941*b*)
- *Polyplax spinulosa* (Burmeister, 1839) (Hansen, 1964)

Microtus ochrogaster
- *Hoplopleura acanthopus* (Burmeister, 1838) (Basolo and Funk, 1974; Batson, 1965; Buckner and Gleason, 1974; Ferris, 1951; Jameson, 1947; Mumford and Whitaker, 1982; Turner, 1974)
- *Hoplopleura hesperomydis* (Osborn, 1891) (Buckner and Gleason, 1974)

Microtus oeconomus
- *Polyplax alaskensis* Ewing, 1927 (Quay, 1949, 1951; Scanlon and Johnson, 1957)

Microtus oregoni
Hoplopleura acanthopus (Burmeister, 1838) (Emerson et al., 1984; Spencer, 1966)
Polyplax spinulosa (Burmeister, 1839) (Spencer, 1966)
Microtus pennsylvanicus
Hoplopleura acanthopus (Burmeister, 1838) (Amin, 1976*b*; Cook and Beer, 1955, 1958, 1959; Florschutz and Darsie, 1960; Genoways and Jones, 1972; Harper, 1956, 1961; Ignoffo, 1959; Jameson, 1947; Judd, 1953, 1954; Lampe et al., 1974; Lawrence et al., 1965; MacCreary, 1945*a*; Mathewson and Hyland, 1962; Mumford and Whitaker, 1982; Race, 1956; Scholten et al., 1962; Spencer, 1966; Timm, 1972*b*, 1975; Wilson, 1967)
Hoplopleura erraticus (Osborn, 1896) (original description; probably a misidentification)
Hoplopleura hesperomydis (Osborn, 1891) (Cook and Beer, 1958; Race, 1956)
Neohaematopinus sciurinus (Mjoberg, 1910) (Gyorkos and Hilton, 1982*a*, 1982*b*)
Polyplax alaskensis Ewing, 1927 (Baker, 1946; Ferris, 1942 [reported as *P. abscisa*]; Florschutz and Darsie, 1960; Ignoffo, 1959 [reported as *P. abscisa*]; Mathewson and Hyland, 1962; Race, 1956 [reported as *P. abscisa*]; Scanlon and Johnson, 1957; Whitaker and French, 1982; Wilson, 1943 [reported as *P. spinulosa*])
Polyplax serrata (Burmeister, 1839) (Race, 1956)
Microtus pinetorum
Hoplopleura acanthopus (Burmeister, 1838) (Benton, 1955*a*; Ferris, 1921, 1951; Hamilton, 1938; Mumford and Whitaker, 1982; Race, 1956)
Hoplopleura hesperomydis (Osborn, 1891) (Race, 1956)
Polyplax alaskensis Ewing, 1927 (Morlan, 1952 [reported as *P. spinulosa*]; Race, 1956 [reported as *P. abscisa*])
Microtus townsendii
Hoplopleura acanthopus (Burmeister, 1838) (Spencer, 1966)

Beetles

Leptinidae.—Beetles of the genus *Leptinus* represent one of the few groups of parasitic Coleoptera. *Leptinus* is a Holarctic genus, with three species in the Nearctic and six species in the Palearctic. They are small beetles, usually only 2–3 mm in length, and have greatly reduced or no eyes, and hindwings reduced or absent. All members of the family Leptinidae are parasitic on mammals. In North America two genera are found in addition to *Leptinus: Leptinillus* with one species on beaver (*Castor canadensis*) and one on mountain beaver (*Aplodontia rufa*), and *Platypsyllus* with one species on beaver.

Adults of *Leptinus* are found either on the mammalian host or in the host's nest. Small mammals, especially cricetines, shrews, and moles are typical hosts. Both adults and larvae probably feed on "dead organic matter, such as skin debris, hair fragments, skin-

gland secretions, and excreta" rather than live tissue (Peck, 1982: 1518). Eggs, larvae, and pupae are found in the nest. Adults are more abundant on mammals during winter months. There may be up to three generations per year; adult and larval stages overlap. Little is known about the biology of the North American species and the effect of beetles on their hosts. The absence of *Leptinus* on ground squirrels, pocket gophers, pocket mice, and woodrats is of interest considering its wide distribution on shrews, moles, voles, and deer mice.

A recent revision, including an excellent key, of the *Leptinus* of North America was provided by Peck (1982), who concluded that there are three species in North America: *Leptinus americanus,* restricted to the central United States; *Leptinus occidentamericanus,* found in western North America from California to Alaska; and *Leptinus orientamericanus,* widespread east of the Mississippi River.

The records of *Leptinus* parasitizing *Microtus* are as follows:

Microtus oregoni
  Leptinus occidentamericanus Peck, 1982 (Maser and Hooven, 1971 [reported as *L. testaceus*; Peck, 1982 [original description]; Spencer, 1956 [reported as *L. testaceus*])
Microtus pennsylvanicus
  Leptinus americanus LeConte, 1866 (Peck, 1982)
  Leptinus orientamericanus Peck, 1982 (original description)
Microtus pinetorum
  Leptinus orientamericanus Peck, 1982 (original description)
Microtus townsendii
  Leptinus occidentamericanus Peck, 1982 (original description)

Cryptophagidae.—A single species of cryptophagid or silken fungus beetle, *Cryptophagus bolivari,* has been collected on *Microtus mexicanus* and *Peromyscus melanotis* in México (Barrera and Martinez, 1968). Although little is known of the diet of these beetles, the genus *Cryptophagus* has been found associated with mammals on several occasions; it is likely that they feed on dead skin and scrapings from the hair which might include grains of pollen and smaller soft-bodied arthropods. Nothing is known of the effects of these beetles on their hosts.

Flies

The dipteran family Cuterebridae (bot flies or warbles) is found only in the New World; larvae in all species are subcutaneous, obligate parasites of mammals. The genus *Cuterebra* includes ap-

proximately 36 species, and is distributed widely throughout North America. The primary hosts are sciuromorph and myomorph rodents and lagomorphs. Adults are short-lived and apparently do not feed; they are typical winged flies that resemble bumblebees.

Cuterebrids are not common on *Microtus,* even in areas where they heavily infest *Peromyscus* and sciurids. The highest incidence of *Cuterebra* infestation reported in *Microtus* was on *M. chrotorrhinus* in the Great Smokey Mountains, with 65% of the animals captured carrying one or more bots (Komarek and Komarek, 1938); more typical infestation rates range from 6 to 45% (Maurer and Skaley, 1968). The following discussion of a generalized life cycle for *Cuterebra* is based on other hosts because little has been done to date on *Microtus* parasitized by bots.

Although rarely observed in the field, adult bots emerge, mate, and oviposit during mid-summer. Females probably oviposit along runways and burrows of the hosts, with no direct contact between the gravid female bot fly and the host. Egg-hatching is triggered by a sudden rise in environmental temperature as would occur near a potential host. After hatching, the first-instar larvae assume a "questing position," standing on their caudal ends. They then attach to any object coming in contact with them. It is believed that the larvae crawl over the body of the host and are only able to enter through a natural body orifice. For 7–10 days after entering through the nose or mouth, the larvae migrate dorsally and medially between the skin and muscle layers until the breathing hole is cut, marking the site of warble formation. Larvae are typically located in the posterior third of the abdomen, although they are occasionally found on the neck, back, flank, and between the forelegs. Commonly, one to three larvae are found per host, with similar infestation rates for male and female hosts. Peak infestations occur from mid-August through mid-September. Larval development is completed in 3½ weeks, when the third-instar larvae emerge through the breathing hole, burrow into the soil and pupate, overwintering in the puparium.

The effect of bot flies on their hosts has been a matter of debate for some time. The popular notion in the literature is that bot flies live in the testis and castrate their hosts. In recent reviews of the subject, Timm and Lee (1981, 1982) demonstrated that bot flies are found exclusively in the subcutaneous region between the skin and underlying muscle. They do not consume muscle or reproductive tissue, but rather feed on the tissue debris and exudate pro-

duced. The site of larval development is usually in the posterior third of the host's body, but is unrelated to the gonads. Upon emergence of the mature third-instar larvae, the wound heals rapidly, with few apparent aftereffects. Bot-fly larvae can have a physiological effect upon their hosts. In *Peromyscus,* significantly lower erythrocyte counts, hematocrit percentages, albumin–globulin ratios, and hemoglobin concentrations have been found, whereas the leucocyte number, spleen size, and thymus size were significantly larger (Clough, 1965; see Timm and Cook, 1979, for a review). Timm and Cook (1979) found no significant reduction in reproduction in adult *Peromyscus leucopus* parasitized by *Cuterebra fontinella.* In adult females there was no significant decrease in the number of embryos, corpora lutea, or placental scars; in adult male mice the presence of one or two larvae had no effect on the size of the reproductive organs.

An excellent and recent review of cuterebrid biology was provided by Catts (1982).

The records of bot flies parasitizing *Microtus* are as follows:

Microtus chrotorrhinus
  Cuterebra sp. (Komarek and Komarek, 1938; Martin, 1972)
Microtus oregoni
  Cuterebra sp. (Hunter et al., 1972)
Microtus pennsylvanicus
  Cuterebra fontinella Clark, 1827 (Getz, 1970 [listed as *C. angustifrons*]; Timm, pers. observ.)
  Cuterebra grisea Coquillett, 1904 (Buckner, 1958)
  Cuterebra sp. (Amin, 1973; Clough, 1965; Hensley, 1976; Iverson and Turner, 1968; Jacobsen, 1966; Lawrence et al., 1965; Manville, 1961; Maurer and Skaley, 1968; Seton, 1909; White and White, 1981)
Microtus pinetorum
  Cuterebra sp. (Hamilton, 1930)
Microtus townsendii
  Cuterebra grisea Coquillett, 1904 (Beacham and Krebs, 1980; Boonstra, 1977; Boonstra and Krebs, 1978; Boonstra et al., 1980)
  Wohlfahrtia vigil (Walker, 1849) (Boonstra, 1977; Boonstra and Krebs, 1978)
Microtus sp.
  Cuterebra grisea Coquillett, 1904 (Buckner, 1958)

Fleas

Fleas (Siphonaptera) are obligate parasites that are found on most species of mammals and on a few species of birds. Adults are

active and may be found either on the host or in the nest or burrow. Eggs are generally laid in the nest. The larvae are active and maggot-like, but are not parasitic. They feed on a variety of organic materials, often including the feces of the adults. After two larval molts, the mature larva pupates in a cocoon spun from secretions from the salivary glands. Adult fleas may live for several hundred days and move between various hosts; they feed only on blood. An excellent series on the systematics and distribution of Siphonaptera worldwide was provided by Lewis (1975 and references therein).

Amphipsylla is a genus of approximately 27 species centered mainly in the Siberian subregion of the Palaearctic; most parasitize rodents, especially microtines. Two species are found on microtines in the northern Nearctic. *A. marikovskii* is a Holarctic species with New World populations recognized as a separate subspecies (*A. m. ewingi*); it is marginally separable from the Siberian populations and is known only from Alaska off *Microtus oeconomus*. *A. sibirica* also is a Holarctic species with several recognized subspecies, two of which occur in North America. *A. s. pollionis* is known from Alaska and northern Canada and is a parasite of microtines, especially *M. pennsylvanicus*.

Atyphloceras is a Holarctic genus containing six species; of these, four are found in the Nearctic. Microtine and cricetine rodents are the primary hosts. *A. bishopi* is found in the eastern U.S. and adjacent Canada, with *Microtus* and *Clethrionomys* being the primary hosts. *A. echis* is found in the western U.S. and is a true parasite of *Neotoma*; the few records from *Microtus californicus* can be considered accidental. *A. multidentatus* is a common winter nest flea found in the western U.S. and British Columbia; the genera *Microtus* and *Peromyscus* are probably the primary hosts, although this species has been taken from *Clethrionomys, Lagurus, Mus, Neotoma, Reithrodontomys, Rattus,* and *Tamiasciurus*. *A. tancitari* is known only from a few higher elevation localities in southcentral Mexico; it has been recorded from *Microtus mexicanus, Peromyscus,* and *Reithrodontomys*.

Catallagia is a genus of 15 species occurring mainly in the Nearctic, but a few representatives occur in the eastern Palaearctic. Microtine rodents appear to be the normal hosts, but accidental hosts often include carnivores and insectivores. *C. borealis* is a winter flea found in the northeastern U.S. and adjacent Canada; *Clethrionomys gapperi* is the normal host, although records from *M. chrotorrhinus*

and *M. pennsylvanicus* are not uncommon. *C. charlottensis* is a common nest flea of *Microtus* and *Peromyscus* found in the late winter and spring in the Pacific Northwest. *C. dacenkoi* is a Holarctic species; the Nearctic populations represent a subspecies (*C. d. fulleri*) distinct from Siberian populations. It has been found only in Alaska, Northwest Territories, and the Yukon, on both *Clethrionomys* and *Microtus*. *C. decipiens* is a widespread and common flea in western North America and is known from a variety of small mammals, including *Clethrionomys, Microtus, Neotoma, Peromyscus, Reithrodontomys,* and sciurids. *C. jellisoni* is known only from Alberta and British Columbia from *Clethrionomys gapperi, Microtus pennsylvanicus,* and *Neotoma cinerea*. *C. mathesoni* is known only from the west coast of the U.S.; most records are from *Peromyscus*. *C. sculleni* occurs in coastal British Columbia, California, Oregon, and Washington on a variety of small mammals, including *Clethrionomys, Microtus, Neotoma,* and *Peromyscus*.

Ctenophthalmus is a genus of approximately 116 species found in all zoogeographic regions, although it is most abundant in the Palaearctic and Ethiopian regions; it includes about 10% of all known fleas. Most are parasites of rodents, although a few are found exclusively on Insectivora. *C. caballeroi* was described from the nest of *Microtus mexicanus mexicanus* and is only known from a few specimens collected in southcentral Mexico. *C. haagi* is known only from a few specimens collected in south-central Mexico; most records are from *M. mexicanus*. *C. pseudagyrtes* is an abundant flea that occurs throughout the year in eastern North America; it has been collected on numerous species of small mammals including most rodents, insectivores, and smaller carnivores.

Delotelis is a northern and western Nearctic genus of two species; their apparent rarity is due to their occurrence in nests. *D. hollandi* is known only from northern California, Oregon, and British Columbia; *Microtus* and *Peromyscus* are the most common hosts. *D. telegoni* appears to be widespread in northwestern North America; *Clethrionomys* and *Microtus* appear to be the most common hosts.

Epitedia is an exclusively Nearctic genus of seven species which primarily parasitize cricetids and insectivores. *E. scapani* is found in the Pacific coastal lowlands of northern California, Oregon, Washington, and adjacent British Columbia; *Microtus* and *Peromyscus* appear to be the most common hosts. *E. stanfordi* is a winter flea found in the Rocky Mountain region of the U.S.; various species

of *Peromyscus* appear to be the primary hosts, although it has been collected on a variety of small mammals. *E. stewarti* is known only from northern California and Oregon; it has been collected on *Microtus californicus, Peromyscus maniculatus,* and *Sorex trowbridgei. E. wenmanni,* a common, transcontinental species throughout North America to northern Mexico, has two recognizable subspecies that intergrade over a broad area of the U.S. (Benton, 1955*b*). *Peromyscus* is the most common host, although it is likely that this species can complete its life cycle on a wide variety of small mammals, including *Microtus.*

Hystrichopsylla is a Holarctic genus of 15 species; six species are found in the Nearctic; most appear to be weakly host specific. *H. dippiei* is a widely distributed and common flea in the midwestern and western Nearctic with four distinctive subspecies; it usually is not abundant on the host itself, suggesting that it is a nest flea. Adults are most commonly collected during fall, winter, and spring. *H. occidentalis* is restricted to far-western North America, from Alaska south to Arizona and California. Campos and Stark (1979) recognized three distinctive subspecies; *Microtus* and *Peromyscus* are the most common hosts. *H. orophila* is known only from southcentral Mexico; the type host is *Microtus mexicanus*; it also has been collected on *Peromyscus maniculatus. H. tahavuana* is restricted to eastern North America; the true hosts are *Condylura cristata, Parascalops breweri,* and *Blarina brevicauda.*

Jellisonia is a poorly known genus of nine species distributed from southwestern U.S. through Mexico and Central America. Most records are from *Peromyscus. J. hayesi* is known only from a few specimens from central Mexico, although Traub (1950) recognized two distinct subspecies. *J. h. breviloba* was described from *M. mexicanus.*

Malaraeus is a Holarctic genus of roughly 12 species; most are parasites of cricetine and microtine rodents. *M. bitterrootensis* is a rare flea found in northwestern U.S. and adjacent Canada; *Ochotona* appears to be the primary host. *M. dobbsi* is known by several specimens, all from only one locality in Oregon off *Microtus oregoni*; repeated attempts to obtain additional specimens of this species have failed. *M. euphorbi* is a poorly known flea found in northwestern U.S. and southwestern Canada; most records are from early spring off *Peromyscus. M. penicilliger* is a widespread and abundant Holarctic species with several described subspecies, two of which occur

in northwestern North America. Microtines are the primary hosts. This species is generally the most abundant flea on the far-northern *Microtus, M. abbreviatus* and *M. oeconomus* (Haas et al., 1978). *M. penicilliger* is often placed in a separate genus, *Amalaraeus,* by Eurasian workers. *M. telchinus* is a widespread and common flea in western North America. *Peromyscus* appears to be the most common host, although it has been collected from numerous mammal species; adults can be collected during all seasons of the year.

Megabothris is a Holarctic genus of 18 species, most of which parasitize microtines. *M. abantis* ranges in western North America from New Mexico north to Alaska; it is found on most species of western and northern microtines. *M. acerbus* is a chipmunk flea found in the northeastern U.S. and adjacent Canada; *Tamias striatus* is the primary host, and the single record from *M. pennsylvanicus* must be considered an accidental occurrence. Two subspecies of *M. asio* are recognized in northern North America, and a single intergrade has been described from southeastern Wisconsin (Amin, 1976*a*). *M. asio asio* is widespread and common in the east and is a true parasite of *Microtus*; it is usually more abundant in the nest than on the host. *M. a. megacolpus* is a western flea parasitizing *Microtus* primarily. *M. calcarifer* is a Holarctic species; Alaskan populations are recognized as a distinct subspecies, *M. c. gregsoni. Microtus* and *Clethrionomys* are the primary hosts. Three subspecies of *M. clantoni* are found in a restricted area of western U.S., and are true parasites of *Lagurus. M. groenlandicus* is a transcontinental Nearctic species occurring only in northern Alaska and Canada; lemmings (both *Dicrostonyx* and *Lemmus*) and *Microtus* are the primary hosts. *M. lucifer* is a rarely collected parasite of *Microtus* from the Rocky Mountain region of Alberta, British Columbia, and western U.S. *M. quirini* is a transcontinental vole flea found throughout the northern tier of states in the U.S. and in adjacent Canada; *Microtus* is the primary host, although *M. quirini* frequently is collected on *Clethrionomys* and *Zapus.*

Monopsyllus is a Holarctic genus of 22 species, 13 of which occur in North America; most species parasitize squirrels, but two species are known only from *Ochotona,* and a few are found on a variety of hosts. Johnson (1961) provided the most recent revision of this group, although now that additional specimens are available, the specific and generic status of several members should be reexamined. *M. ciliatus* has four recognizable subspecies, and occurs

throughout western North America west of the 100th meridian, from Alaska south to Arizona. It is primarily a squirrel flea, with the majority of records coming from *Eutamias, Sciurus, Spermophilus,* and *Tamiasciurus*; the one record from *Microtus longicaudus* can be considered an accidental occurrence. *M. eumolpi* is a true parasite of *Eutamias* with two subspecies found throughout the range of *Eutamias* in the northern midwest and western portions of North America; it has been collected also from a wide variety of small mammals. *M. vison* is a common, northern sciurid flea, but has been collected on a variety of hosts. *M. wagneri* is found from the upper midwest to the west coast of the U.S. and Canada; *Peromyscus* appears to be the primary host although it is taken occasionally from microtines.

Orchopeas is a Nearctic genus of nine species in need of revision. Most of the species are parasites of squirrels; however, a few infest cricetids, especially *Peromyscus* and *Neotoma. O. caedens* is a northern squirrel flea, especially abundant on *Tamiasciurus*; the single record from *Microtus oeconomus* can be considered accidental. *O. howardii* is a true parasite of tree squirrels (*Glaucomys, Sciurus,* and *Tamiasciurus*), and is found from southern Canada south to Venezuela, with three recognized subspecies. It is an abundant flea; adults are present during all months of the year, and are found occasionally on a variety of small mammals. *O. leucopus* is one of the most abundant species of fleas found in North America; it is perhaps a true parasite of *Peromyscus,* although it frequently is found on many other species of mammals, suggesting that it is not an obligate parasite of *Peromyscus. O. sexdentatus* is a true parasite of woodrats and is found throughout North America wherever *Neotoma* occurs; the few records from *Microtus* can be considered accidental.

Peromyscopsylla is a Holarctic genus of 17 species; most are parasites of microtines and murids. Johnson and Traub (1954) provided an excellent revision of the genus. *P. catatina* is found in the northeastern U.S. and adjacent Canada; *Microtus* and *Clethrionomys* are the primary hosts, although it has been recovered from numerous other species during all seasons of the year. *P. ebrighti* is a poorly known species from southern California. *P. hamifer,* a Holarctic species, is widely distributed throughout the northern half of this continent, and is generally most abundant in fall and winter. North American populations are all referred to *P. h. hamifer. P.*

hesperomys is an abundant flea throughout the U.S. and Canada, and extends south to central Mexico; adults occur throughout the year and cricetines, especially *Peromyscus* and *Neotoma,* are the primary hosts. *P. ostsibirica* is a Holarctic species in which both Siberian populations and those in Alaska and adjacent Canada are little differentiated; *Microtus* is the primary host of this summer flea. *P. scotti* is a poorly collected flea from the eastern U.S.; it is apparently a fall and winter flea with *Peromyscus* as the primary host. *P. selenis* is a fall and winter flea parasitizing microtines in the western U.S. and adjacent Canada.

Pleochaetis is a New World genus of 16 species restricted to southwestern U.S., Central America, and northern South America. Most are parasites of cricetid rodents although much remains to be learned about the systematics and host relationships of this group. *P. asetus* is known from the Mogollon Mountains of New Mexico and Cerro Potosi, Nuevo Leon; *Microtus mexicanus* is probably the true host, although this flea also has been collected on *Peromyscus* and *Neotoma. P. sibynus* has a wide distribution in Mexico with two recognized subspecies; specimens are known from *Microtus mexicanus, Neotoma, Peromyscus,* and *Reithrodontomys. P. aztecus, P. mathesoni, P. mundus, P. paramundus,* and *P. parus* are all poorly known species that have been collected on only a few occasions in central Mexico, primarily from *Microtus* and *Peromyscus.*

Rhadinopsylla is a Holarctic complex genus of some 55 species; ten species are known from the Nearctic. Most are found as adults exclusively during winter months, and are nest fleas; they seldom occur on the host per se, but seem to be associated with a wide variety of rodents. Prior to Smit's (1957) revision, all eastern North American specimens of the genus were included within *R. fraterna.* Smit recognized several species within that complex; thus, all older records of *R. fraterna* must now be considered in doubt. *R. fraterna* (sensu stricto) is found in the Rocky Mountain region of the U.S. and adjacent Canada, and is generally considered a true parasite of *Cynomys* and *Spermophilus. R. mexicana* is known only from Mexico and has been collected primarily on *Neotoma* and *Peromyscus. R. orama* is known only from the eastern U.S., and is probably a true parasite of microtines, especially *Microtus. R. sectilis* is a widely distributed flea in western North America, and has been associated with a wide variety of rodents.

Stenoponia is a Holarctic genus of 14 species of which only two are found in North America. The vast majority of taxa are Pa-

laearctic; they occur primarily on murid rodents, usually are nest fleas, and occur as adults mainly in winter months. *S. americana* is a widely distributed and common flea in eastern North America; it has been collected on a wide variety of small mammals, including both rodents and insectivores, and lacks host specificity. *S. ponera* is known only from Mexico and, in addition to *Microtus mexicanus,* has been collected on *Peromyscus* and *Eutamias*; most records are from fall and from elevations of 3,050–3,350 m.

Strepsylla is a poorly known Nearctic genus of eight recognized species ranging from Guatemala north to central Mexico. Most records are from *Peromyscus,* but very little is known of the biology of this group. *S. mina* was described from *Microtus mexicanus phaeus*; it is known only from a few higher-elevation localities in southcentral Mexico; it also has been taken on *Neotomodon alstoni* and *Peromyscus melanotis.*

Many other species of fleas have been taken from *Microtus,* which in our present state of knowledge are assumed to be accidental. These include: *Anomiopsyllus falsicalifornicus, A. nudatus-princei* (complex), *Callistopsyllus deuterus, Carteretta carteri, Cediopsylla inaequalis, Ceratophyllus niger, Corrodopsylla curvata, Corypsylla kohlsi, C. ornata, Dactylopsylla bluei, D. rara, Dasypsullus gallinulae, Diamanus montanus, Doratopsylla blarinae, Echidnophaga gallinacea, Foxella ignota, Hoplopsylla anomalus, Leptopsylla segnis, Megarthroglossus bisetis, M. divisus, Meringis cummingi, M. hubbardi, M. parkeri, M. shannoni, Nearctopsylla hyrtaci, Neopsylla inopina, Nosopsyllus fasciatus, Opisocrostis bruneri, Opisodasys keeni, O. pseudarctomys, Oropsylla arctomys, O. idahoensis, Pulex irritans, P. simulans, Thrassis spenceri, T. bacchi,* and *Xenopsylla cheopis.*

The records of fleas parasitizing *Microtus* are as follows:

Microtus abbreviatus

Malaraeus penicilliger (Grube, 1851) (Holland, 1963; Rausch and Rausch, 1968)

Megabothris groenlandicus (Wahlgren, 1903) (Rausch and Rausch, 1968)

Microtus breweri

Epitedia wenmanni (Rothschild, 1904) (Fox, 1940*a*; Main, 1970; Winchell, 1977)

Microtus californicus

Anomiopsyllus falsicalifornicus C. Fox, 1929 (Barnes et al., 1977; Linsdale and Davis, 1956 [reported as *A. congruens*])

Atyphloceras echis Jordan and Rothschild, 1915 (Jellison and Senger, 1976; Linsdale and Davis, 1956 [reported as *A. longipalpus*])

Atyphloceras multidentatus (C. Fox, 1909*b*) (Augustson, 1943 [reported as *A. artius*]; Augustson and Wood, 1953; Burroughs, 1944; Coultrip et al., 1973; Fox, 1909*b* [original description]; Hopkins and Rothschild, 1962; Hubbard, 1947 [reported as *A. felix*]; Jellison and Senger, 1976; Kartman,

1958, 1960; Kartman and Prince, 1956; Kartman et al., 1958*a*, 1958*d*; Linsdale and Davis, 1956; Macchiavello, 1954; Miles et al., 1957; Mitzmain, 1909; Murray, 1957; Stark and Miles, 1962; Stewart, 1940 [reported as *A. felix*])

Carteretta carteri Fox, 1927 (Augustson, 1943; Macchiavello, 1954)

Catallagia charlottensis (Baker, 1898) (Fox, 1909*a*; Macchiavello, 1954)

Catallagia sculleni Hubbard, 1940 (Burroughs, 1944 [reported as *C. vonbloekeri*])

Catallagia wymani (Fox, 1909) (Fox, 1909*c* [original description and type-host]; Kartman, 1958, 1960; Kartman et al., 1958*a*, 1958*d*; Macchiavello, 1954; Miles et al., 1957; Murray, 1957; Stark and Miles, 1962)

Cediopsylla inaequalis (Baker, 1895) (Linsdale and Davis, 1956)

Ceratophyllus niger C. Fox, 1908 (Murray, 1957)

Corrodopsylla curvata (Rothschild, 1915) (Miles et al., 1957)

Corypsylla ornata C. Fox, 1908 (Murray, 1957)

Dactylopsylla bluei C. Fox, 1909 (Hubbard, 1947; Macchiavello, 1954)

Diamanus montanus (Baker, 1895) (Kartman et al., 1958*d*; Linsdale and Davis, 1956; Miles et al., 1957)

Echidnophaga gallinacea (Westwood, 1875) (Augustson, 1943; Linsdale and Davis, 1956)

Epitedia stewarti Hubbard, 1940 (Hopkins and Rothschild, 1962)

Foxella ignota (Baker, 1895) (Murray, 1957)

Hoplopsyllus anomalus (Baker, 1904) (Holdenried et al., 1951; Linsdale and Davis, 1956; Rutledge et al., 1979)

Hystrichopsylla dippiei (Rothschild, 1902) (Burroughs, 1944; Macchiavello, 1954; Mitzmain, 1909)

Hystrichopsylla gigas (Kirby, 1837) (Holdenried et al., 1951) (questionable identification)

Hystrichopsylla occidentalis Holland, 1949 (Campos and Stark, 1979; Coultrip et al., 1973; Holland, 1957; Hopkins and Rothschild, 1962; Kartman et al., 1958*a*, 1958*c*, 1958*d*, 1960; Miles et al., 1957; Quan et al., 1960*a*, 1960*b*; Schwan, 1975; Stark and Kinney, 1962; Stark and Miles, 1962)

Leptopsylla segnis (Schonherr, 1811) (Fox, 1909*a* [reported as *Ctenopsyllus musculi* (Duges)]; Hardy et al., 1974; Kartman et al., 1958*d*; Macchiavello, 1954; Miles et al., 1957; Mitzmain, 1909 [reported as *C. musculi*]; Murray, 1957; Schwan, 1975)

Malareus telchinus (Rothschild, 1905) (Augustson, 1943; Augustson and Wood, 1953; Burroughs, 1944; Burroughs et al., 1945; Coultrip et al., 1973; Fox, 1909*a*; Jellison and Senger, 1976; Kartman et al., 1958*a*, 1958*d*, 1960; Lidicker, 1973; Linsdale and Davis, 1956; Macchiavello, 1954; Miles et al., 1957; Mitzmain, 1909; Murray, 1957; Quan et al., 1960*a*; Rutledge et al., 1979; Schwan, 1975; Stark and Kinney, 1962; Stark and Miles, 1962; Wagner, 1936*b*)

Meringis cummingi (C. Fox, 1926) (Holdenried et al., 1951)

Monopsyllus wagneri (Baker, 1904) (Kartman et al., 1958*d*; Linsdale and Davis, 1956; Miles et al., 1957; Rutledge et al., 1979)

Nosopsyllus fasciatus (Bosc, 1801) (Adams et al., 1970; Doane, 1908; Kartman et al., 1958*a*, 1958*d*; Lidicker, 1973; Macchiavello, 1954; Miles et al., 1957; Stark and Miles, 1962)

Opisodasys keeni (Baker, 1896) (Augustson, 1955; Holdenried et al., 1951 [re-

ported as *O. nesiotus*]; Kartman et al., 1958*a*, 1958*d*; Miles et al., 1957; Murray, 1957; Quan et al., 1960*a*; Stark and Miles, 1962)

Orchopeas sexdentatus (Baker, 1904) (Holdenried et al., 1951; Linsdale and Davis, 1956; Macchiavello, 1954)

Peromyscopsylla ebrighti (C. Fox, 1926) (Burroughs, 1944)

Peromyscopsylla hesperomys (Baker, 1904) (Linsdale and Davis, 1956; Macchiavello, 1954; Stewart, 1940)

Peromyscopsylla selenis (Rothschild, 1906) (Hubbard, 1947; Jellison and Senger, 1976; Johnson and Traub, 1954)

Xenopsylla cheopis (Rothschild, 1903) (Kartman et al., 1958*d*; Miles et al., 1957)

Microtus canicaudus

Atyphloceras multidentatus (C. Fox, 1909) (Easton, 1983*a*; Faulkenberry and Robbins, 1980; Hubbard, 1941*a*, 1947; Robbins, 1983; Robbins and Faulkenberry, 1982)

Catallagia charlottensis (Baker, 1898) (Faulkenberry and Robbins, 1980; Hubbard, 1941*a*, 1947; Robbins, 1983; Robbins and Faulkenberry, 1982)

Catallagia sculleni Hubbard, 1940 (Easton, 1983*a*; Hubbard, 1941*a*, 1947 [reported as *C. chamberlini*])

Corrodopsylla curvata (Rothschild, 1915) (Faulkenberry and Robbins, 1980; Robbins, 1983)

Epitedia scapani (Wagner, 1936) (Hubbard, 1941*a*, 1947 [reported as *E. jordani*])

Hystrichopsylla dippiei Rothschild, 1902 (Hubbard, 1941*a*, 1947)

Hystrichopsylla occidentalis Holland, 1949 (Faulkenberry and Robbins, 1980; Robbins, 1983)

Megabothris abantis (Rothschild, 1905) (Hubbard, 1947)

Monopsyllus wagneri (Baker, 1904) (Faulkenberry and Robbins, 1980; Robbins, 1983)

Nosopsyllus fasciatus (Bosc, 1801) (Faulkenberry and Robbins, 1980; Robbins, 1983)

Opisodasys keeni (Baker, 1896) (Hubbard, 1941*a*)

Peromyscopsylla selenis (Rothschild, 1906) (Faulkenberry and Robbins, 1980; Hubbard, 1941*a*, 1947; Robbins, 1983)

Rhadinopsylla sectilis (Jordan and Rothschild, 1923) (Hubbard, 1941*a*, 1941*b*, 1947 [reported as *Micropsylla goodi*])

Microtus chrotorrhinus

Atyphloceras bishopi Jordan, 1933 (Benton and Kelly, 1975; Benton and Smiley, 1963; Martin, 1972)

Catallagia borealis Ewing, 1929 (Benton and Kelly, 1975; Benton and Smiley, 1963; Martin, 1972; Whitaker and French, 1982)

Ctenophthalmus pseudagyrtes Baker, 1904 (Benton and Cerwonka, 1964; Benton and Kelly, 1975; Benton et al., 1969; Brown, 1968; Geary, 1959; Jameson, 1943*a*; Linzey and Linzey, 1973; Lovejoy and Gaughan, 1975; Martin, 1972; Whitaker and French, 1982)

Epitedia wenmanni (Rothschild, 1904) (Benton and Kelly, 1975; Martin, 1972; Whitaker and French, 1982)

Megabothris asio (Baker, 1904) (Benton, 1980; Benton and Cerwonka, 1964; Benton and Kelly, 1975; Benton et al., 1969; Martin, 1972)

Megabothris quirini (Rothschild, 1905) (Benton, 1980; Benton and Cerwonka,

1964; Benton and Kelly, 1975; Benton and Timm, 1980; Benton et al., 1969; Brown, 1968; Main, 1970; Martin, 1972; Osgood, 1964; Timm, 1974, 1975; Whitaker and French, 1982)

Orchopeas leucopus (Baker, 1904) (Martin, 1972)

Peromyscopsylla catatina (Jordan, 1928) (Benton, 1980; Benton and Cerwonka, 1964; Benton and Kelly, 1975; Benton and Smiley, 1963; Benton and Timm, 1980; Benton et al., 1969; Brown, 1968; Johnson and Traub, 1954; Martin, 1972; Timm, 1974, 1975; Whitaker and French, 1982)

Peromyscopsylla hesperomys (Baker, 1904) (Benton and Kelly, 1975)

Microtus longicaudus

Anomiopsyllus nudatus-A. princei complex (Haas et al., 1973)

Atyphloceras multidentatus (C. Fox, 1909) (Hopkins and Rothschild, 1962; Hubbard, 1941*a*)

Callistopsyllus deuterus Jordan, 1937 (Augustson, 1941*b*)

Catallagia charlottensis (Baker, 1898) (Holland, 1949*b*; Hubbard, 1947 [reported as *C. motei*])

Catallagia decipiens Rothschild, 1915 (Beck, 1955; Egoscue, 1966, 1976; Haas et al., 1973; Hansen, 1964; Holland, 1949*b*; Hopkins and Rothschild, 1962; Hubbard, 1947; Morlan, 1955)

Catallagia sculleni Hubbard, 1940 (Jameson and Brennan, 1957)

Corrodopsylla curvata (Rothschild, 1915) (Hopkins and Rothschild, 1966)

Delotelis hollandi Smit, 1952 (Jameson and Brennan, 1957; Smit, 1952)

Delotelis telegoni (Rothschild, 1905) (Holland, 1949*b*; Jellison and Senger, 1973; Morlan, 1955; Stark, 1959)

Epitedia scapani (Wagner, 1936) (Hopkins and Rothschild, 1962; Hubbard, 1941*a*, 1947 [reported as *E. jordani*])

Epitedia stanfordi Traub, 1944 (Egoscue, 1966, 1976)

Epitedia wenmanni (Rothschild, 1904) (Easton, 1982; Jameson and Brennan, 1957)

Hystrichopsylla dippiei Rothschild, 1902 (Egoscue, 1966; Haas et al., 1973; Hansen, 1964; Holland, 1949*a*, 1949*b*, 1957; Hopkins and Rothschild, 1962; Hubbard, 1947; Morlan, 1955)

Hystrichopsylla occidentalis Holland, 1949 (Campos and Stark, 1979; Holland, 1957)

Malaraeus telchinus (Rothschild, 1905) (Dunn and Parker, 1923; Egoscue 1966, 1976; Haas, 1973; Hansen, 1964; Holland, 1949*b*; Hubbard, 1947; Jameson and Brennan, 1957; Morlan, 1955; Wagner, 1936*a*)

Megabothris abantis (Rothschild, 1905) (Allred, 1952; Augustson, 1941*b*; Beck, 1955; Burroughs, 1947, 1953; Egoscue, 1966, 1976; Haas et al., 1973; Hansen, 1964; Holland, 1949*b*, 1958; Hubbard, 1941*a*, 1947; Jellison and Senger, 1973; Morlan, 1955; Tipton, 1950)

Megabothris asio (Baker, 1904) (Hubbard, 1940*a*, 1947)

Megabothris quirini (Rothschild, 1905) (Hubbard, 1947; Wiseman, 1955)

Megarthroglossus bisetis Jordan and Rothschild, 1915 (Haas et al., 1973)

Megarthroglossus divisus (Baker, 1895) (Holland, 1949*b*)

Meringis hubbardi Kohls, 1938 (Egoscue, 1966)

Meringis parkeri Jordan, 1937 (Stark, 1959)

Monopsyllus ciliatus Baker, 1904 (Hubbard, 1941*a*, 1947)

Monopsyllus eumolpi (Rothschild, 1905) (Egoscue, 1966; Morlan, 1955)
Monopsyllus wagneri (Baker, 1904) (Augustson, 1941*b*; Beck, 1955; Egoscue, 1966, 1976; Haas et al., 1973; Hansen, 1964; Holland, 1949*b*; Hubbard, 1947; Jameson and Brennan, 1957; Morlan, 1955)
Neopsylla inopina Rothschild, 1915 (Hansen, 1964; Svihla, 1941)
Opisodasys keeni (Baker, 1896) (Egoscue, 1976; Hubbard, 1947)
Orchopeas leucopus (Baker, 1904) (Egoscue, 1976)
Oropsylla idahoensis (Baker, 1904) (Haas et al., 1973; Hubbard, 1947)
Peromyscopsylla hamifer (Rothschild, 1906) (Egoscue, 1976; Haas, 1973; Haas et al., 1973; Holdenried and Morlan, 1956; Hopkins and Rothschild, 1971; Morlan, 1955)
Peromyscopsylla hesperomys (Baker, 1904) (Haas et al., 1973; Hubbard, 1947)
Peromyscopsylla selenis (Rothschild, 1906) (Augustson, 1941*b*; Egoscue, 1966, 1976; Haas, 1973; Haas et al., 1973; Hansen, 1964; Holland, 1949*b*; Hopkins and Rothschild, 1971; Jameson and Brennan, 1957; Jellison and Senger, 1973; Johnson and Traub, 1954; Morlan, 1955; Tipton, 1950)
Rhadinopsylla sectilis Jordan and Rothschild, 1923 (Hubbard, 1947)

Microtus mexicanus
Atyphloceras tancitari Traub and Johnson, 1952 (Traub and Johnson, 1952)
Catallagia sp. (Barrera, 1968)
Ctenophthalmus caballeroi Barrera and Machado, 1960 (Barrera, 1968; Barrera and Machado, 1960 [original description])
Ctenophthalmus haagi Traub, 1950 (Hopkins and Rothschild, 1966; Traub, 1950 [original description; from *M. mexicanus phaeus*])
Ctenophthalmus pseudagyrtes Baker, 1904 (Barrera, 1968; Tipton and Mendez, 1968)
Epitedia wenmanni (Rothschild, 1904) (Tipton and Mendez, 1968)
Hystrichopsylla orophila Barrera, 1952 (Barrera, 1952 [original description], 1968)
Jellisonia hayesi Traub, 1950 (Barrera, 1968; Traub, 1950 [original description])
Pleochaetis asetus Traub, 1950 (Barrera, 1968; Tipton and Machado-Allison, 1972; Tipton and Mendez, 1968; Traub, 1950 [original description])
Pleochaetis aztecus Barrera, 1954 (Barrera, 1968)
Pleochaetis mathesoni Traub, 1950 (Barrera, 1968)
Pleochaetis mundus (Jordan and Rothschild, 1922) (Barrera, 1968)
Pleochaetis paramundus Traub, 1950 (Barrera, 1968)
Pleochaetis parus Traub, 1950 (Barrera, 1968)
Pleochaetis sibynus Jordan, 1925 (Barrera, 1968; Fox, 1939*b*; Tipton and Mendez, 1968; Traub, 1950)
Pulex simulans Baker, 1895 (Tipton and Mendez, 1968)
Rhadinopsylla mexicana (Barrera, 1952) (Barrera, 1968; Tipton and Mendez, 1968)
Stenoponia ponera Traub and Johnson, 1952 (Tipton and Mendez, 1968)
Strepsylla mina Traub, 1950 (Hopkins and Rothschild, 1962; Traub, 1950 [original description; from *M. mexicanus phaeus*])

Microtus miurus
Corrodopsylla curvata (Rothschild, 1915) (Hopla, 1965*b*)
Malaraeus penicilliger (Grube, 1851) (Hopla, 1965*b*; Rausch, 1964)

Megabothris calcarifer (Wagner, 1913) (Hopla, 1965*b*; Hubbard, 1960; Rausch, 1964)
Megabothris groenlandicus (Wahlgren, 1903) (Hopla, 1965*b*; Hubbard, 1960; Jellison and Senger, 1976; Rausch, 1964)
Megabothris quirini (Rothschild, 1905) (Hopla, 1965*b*)
Peromyscopsylla ostsibirica (Scalon, 1936) (Rausch, 1964)

Microtus montanus
Amphipsylla sibirica (Wagner, 1898) (Allred, 1968*a*; Eads et al., 1979)
Callistopsyllus deuterus Jordan, 1937 (Augustson, 1941*b*)
Catallagia decipiens Rothschild, 1915 (Allred, 1952; Beck, 1955; Haas et al., 1973; Hansen, 1964; Holland, 1949*b*; Hopkins and Rothschild, 1962; Stark, 1959)
Catallagia mathesoni Jameson, 1950 (original description)
Catallagia sculleni Hubbard, 1940 (Augustson, 1941*a* [described as *C. rutherfordi* from *M. montanus dutcheri*]; Stark and Kinney, 1969)
Corrodopsylla curvata (Rothschild, 1915) (Haas et al., 1973; Hansen, 1964)
Dactylopsylla rara I. Fox, 1940 (Haas et al., 1973)
Delotelis hollandi Smit, 1952 (original description)
Epitedia stanfordi Traub, 1944 (Stark, 1959)
Epitedia wenmanni (Rothschild, 1904) (Allred, 1952; Beck, 1955; Stark, 1959; Tipton, 1950)
Hoplopsyllus anomalus (Baker, 1904) (Allred, 1952; Beck, 1955)
Hystrichopsylla dippiei Rothschild, 1902 (Beck, 1955, Haas et al., 1973; Holland, 1949*b*, 1957; Tipton, 1950)
Malaraeus bitterrootensis (Dunn, 1923) (Wiseman, 1955)
Malaraeus euphorbi (Rothschild, 1905) (Allred, 1968*a*)
Malaraeus telchinus (Rothschild, 1905) (Allred, 1952, 1968*a*; Beck, 1955; Haas et al., 1973; Hansen, 1964; Hartwell et al., 1958; Seidel and Booth, 1960; Stark, 1959; Tipton, 1950)
Megabothris abantis (Rothschild, 1905) (Allred, 1952; Augustson, 1941*b*; Beck, 1955; Haas et al., 1973; Hansen, 1964; Hubbard, 1947, 1949*c*; Jellison and Senger, 1973; Kartman and Prince, 1956; Kinsella and Pattie, 1967; Stark, 1959)
Megabothris asio (Baker, 1904) (Hansen, 1964; Holland, 1950; Hubbard, 1949*c*)
Megabothris clantoni Hubbard, 1949 (Hansen, 1964; Hubbard, 1949*b*)
Megabothris lucifer (Rothschild, 1905) (Holland, 1941, 1949*a*, 1949*b*; Jellison and Senger, 1976; Wagner, 1936*b*)
Meringis hubbardi Kohls, 1938 (Hansen, 1964)
Meringis parkeri Jordan, 1937 (Allred, 1968*a*)
Meringis shannoni (Jordan, 1929) (Bacon, 1953)
Monopsyllus eumolpi (Rothschild, 1905) (Allred, 1952; Beck, 1955; Hansen, 1964; Stark, 1959)
Monopsyllus wagneri (Baker, 1904) (Allred, 1952, 1968*a*; Bacon, 1953; Beck, 1955; Haas et al., 1973; Hansen, 1964; Stark, 1959)
Nosopsyllus fasciatus (Bosc, 1801) (Allred, 1952; Beck, 1955)
Opisodasys keeni (Baker, 1896) (Stark, 1959; Stark and Kinney, 1969)
Oropsylla idahoensis (Baker, 1904) (Haas et al., 1973)

Peromyscopsylla hamifer (Rothschild, 1906) (Haas et al., 1973; Johnson and Traub, 1954; Stark, 1959)

Peromyscopsylla selenis (Rothschild, 1906) (Augustson, 1941*b*; Haas, 1973; Haas et al., 1973; Hansen, 1964; Hopkins and Rothschild, 1971; Hubbard, 1947, 1949*c*; Johnson and Traub, 1954; Stark, 1959; Stark and Kinney, 1969)

Thrassis bacchi (Rothschild, 1905) (Allred, 1968*a*)

Microtus ochrogaster

Ctenophthalmus pseudagyrtes Baker, 1904 (Basolo and Funk, 1974; Batson, 1965; Buckner and Gleason, 1974; Hopkins and Rothschild, 1966; Jameson, 1947; Jellison and Senger, 1973; Layne, 1958; Mumford and Whitaker, 1982; Poorbaugh and Gier, 1961; Senger, 1966; Verts, 1961; Whitaker and Corthum, 1967)

Epitedia wenmanni (Rothschild, 1904) (Basolo and Funk, 1974; Buckner and Gleason, 1974; Hopkins and Rothschild, 1962; Jameson, 1947; Poorbaugh and Gier, 1961; Verts, 1961; Whitaker and Corthum, 1967; Wilson, 1957)

Hystrichopsylla dippiei Rothschild, 1902 (Hopkins and Rothschild, 1962)

Malaraeus euphorbi (Rothschild, 1905) (Senger, 1966)

Megabothris asio (Baker, 1904) (Verts, 1961)

Monopsyllus wagneri (Baker, 1904) (Turner, 1974)

Nearctopsylla hyrtaci (Rothschild, 1904) (Jellison and Senger, 1973; Senger, 1966)

Nosopsyllus fasciatus (Bosc, 1801) (El-Wailly, 1967; Jameson, 1947)

Orchopeas howardii (Baker, 1895) (Jameson, 1947)

Orchopeas leucopus (Baker, 1904) (Buckner and Gleason, 1974; Easton, 1982; El-Wailly, 1967; Jameson, 1947; Jellison and Senger, 1973; Lampe et al., 1974; Poorbaugh and Gier, 1961; Rapp and Gates, 1957; Turner, 1974; Verts, 1961)

Orchopeas sexdentatus (Baker, 1904) (Rapp and Gates, 1957)

Peromyscopsylla scotti I. Fox, 1939 (Buckner and Gleason, 1974)

Rhadinopsylla sectilis Jordan and Rothschild, 1923 (Senger, 1966)

Stenoponia americana (Baker, 1899) (Buckner and Gleason, 1974; Hopkins and Rothschild, 1962; Poorbaugh and Gier, 1961; Verts, 1961; Whitaker and Corthum, 1967; Wilson, 1957)

Microtus oeconomus

Amphipsylla marikovskii Ioff and Tiflov, 1939 (Fox, 1940*b* [reported as *A. ewingi*]; Holland, 1963; Hopkins and Rothschild, 1971; Hopla, 1965*a*, 1965*b*)

Catallagia dacenkoi Ioff, 1940 (Hopkins and Rothschild, 1962; Hopla, 1965*a*, 1965*b*; Hubbard, 1960; Jellison and Senger, 1976)

Ceratophyllus garei Rothschild, 1902 (Hopla, 1965*b*)

Corrodopsylla curvata (Rothschild, 1915) (Haas et al., 1982; Hopla, 1965*b*)

Epitedia wenmanni (Rothschild, 1904)(Haas et al., 1979; Hubbard, 1960)

Hystrichopsylla occidentalis Holland, 1949 (Campos and Stark, 1979; Haas et al., 1979; Holland, 1957)

Malaraeus penicilliger (Grube, 1851) (Haas et al., 1979, Haas et al., 1982; Holland, 1958, 1963; Hopla, 1965*a*, 1965*b*, 1980; Hubbard, 1960; Rausch et al., 1969)

Megabothris abantis (Rothschild, 1905) (Haas et al., 1979, 1982; Rausch et al., 1969; Schiller and Rausch, 1956)
Megabothris calcarifer (Wagner, 1913) (Haas et al., 1979, 1982; Holland, 1958, 1963; Hopla, 1965*a*, 1965*b*, 1980; Hubbard, 1960)
Megabothris groenlandicus (Wahlgren, 1903) (Hubbard, 1960)
Megabothris quirini (Rothschild, 1905) (Hopla, 1965*a*, 1965*b*, 1980)
Monopsyllus vison (Baker, 1904) (Hopla, 1965*b*)
Orchopeas caedens (Jordan, 1925) (Hopla, 1965*b*)
Peromyscopsylla hamifer (Rothschild, 1906) (Quay, 1951)
Peromyscopsylla ostsibirica (Scalon, 1936) (Haas et al., 1982; Holland, 1958, 1963; Hopkins and Rothschild, 1971; Hopla, 1965*a*, 1965*b*, 1980; Hubbard, 1960; Jellison and Senger, 1976; Rausch et al., 1969)

Microtus oregoni
Atyphloceras multidentatus (C. Fox, 1909) (Holland, 1949*b*,; Hopkins and Rothschild, 1962; Hubbard, 1941*a*, 1947)
Catallagia charlottensis (Baker, 1898) (Holland, 1949*b*; Hubbard, 1941*a*, 1947)
Corrodopsylla curvata (Rothschild, 1915) (Holland, 1949*b*; Hubbard, 1941*a*, 1947 [reported as *Doratopsylla jellisoni* Hubbard])
Corypsylla ornata C. Fox, 1908 (Holland, 1949*b*; Hopkins and Rothschild, 1962)
Delotelis hollandi Smit, 1952 (Hopkins and Rothschild, 1962; Smit, 1952)
Delotelis telegoni (Rothschild, 1905) (Holland, 1949*b*)
Epitedia scapani (Wagner, 1936) (Hopkins and Rothschild, 1962; Hubbard, 1941*a*, 1947 [reported as *E. jordani*])
Hystrichopsylla dippiei Rothschild, 1902 (Hubbard, 1941*a*, 1947)
Hystrichopsylla occidentalis Holland, 1949 (Campos and Stark, 1979; Holland, 1957; Hopkins and Rothschild, 1962)
Malaraeus dobbsi Hubbard, 1940 (Hubbard, 1940*b* [original description], 1941*a*; Jellison and Senger, 1976)
Megabothris abantis (Rothschild, 1905) (Holland, 1949*b*, Hubbard, 1941*a*, 1947; Wagner, 1936*a*)
Megabothris quirini (Rothschild, 1905) (Hubbard, 1947)
Opisodasys keeni (Baker, 1896) (Holland, 1949*b*)
Peromyscopsylla hesperomys (Baker, 1904) (Hubbard, 1947; Johnson and Traub, 1954)
Peromyscopsylla selenis (Rothschild, 1906) (Holland, 1949*b*; Hubbard, 1941*a*)
Rhadinopsylla sectilis (Jordan and Rothschild, 1923) (Holland, 1949*b*)

Microtus pennsylvanicus
Amphipsylla marikovskii Ioff and Tiflov, 1939 (Hopla, 1965*a*)
Amphipsylla sibirica (Wagner, 1898) (Brown, 1944; Hopkins and Rothschild, 1971; Jordan and Rothschild, 1913; Rothschild, 1905 [reported as *Ceratophyllus pollionis*]; Wagner, 1936*a*)
Atyphloceras bishopi Jordan, 1933 (Baker, 1946; Benton, 1980; Benton and Cerwonka, 1960; Benton and Kelly, 1971, 1975; Benton and Smiley, 1963; Buckner and Blasko, 1969; Burbutis, 1956; Cressey, 1961; Fox, 1940*a*; Geary, 1959; Holland, 1949*a*, 1958; Holland and Benton, 1968; Hopkins and Rothschild, 1962; Jameson, 1943*a*; Jordan, 1933; Lawrence et al., 1965; Main, 1970; Mathewson and Hyland, 1964; Miller and Benton, 1973; Scharf and Stewart, 1980)

Catallagia borealis Ewing, 1929 (Benton, 1980; Ewing, 1929*b* [original description and type-host]; Fox, 1940*a*; Fuller, 1943*a*, 1943*b*; Holland and Benton, 1968; Hopkins and Rothschild, 1962; Main, 1970)

Catallagia charlottensis (Baker, 1898) (Holland, 1949*b*)

Catallagia dacenkoi Ioff, 1940 (Holland, 1951; Hopkins and Rothschild, 1962; Hopla, 1965*a*)

Catallagia decipiens Rothschild, 1915 (Easton, 1982; Holland, 1949*b*; Hopkins and Rothschild, 1962)

Catallagia jellisoni Holland, 1954 (Hopkins and Rothschild, 1962)

Corrodopsylla curvata (Rothschild, 1915) (Robert and Bergeron, 1977; Verts, 1961)

Ctenophthalmus pseudagyrtes Baker, 1904 (Amin, 1973, 1976*a*; Baker, 1946; Batson, 1965; Bell and Chalgren, 1943, Benton, 1966; Benton and Kelly, 1969, 1975; Benton and Krug, 1956; Benton and Timm, 1980; Benton et al., 1969; Brimley, 1938; Brown, 1944; Brown, 1968; Burbutis, 1956; Connor, 1960; Cressey, 1961; Cummings, 1954; Erickson, 1938*a*; Fox, 1940*a*; Fuller, 1943*a*, 1943*b*; Gates, 1945; Geary, 1959; Gyorkos and Hilton, 1982*b*; Holland and Benton, 1968; Hopkins and Rothschild, 1966; Hubbard, 1949*a*; Jameson, 1943*b*; Jordan, 1928; Joyce and Eddy, 1944; Judd, 1950; Knipping et al., 1950*b*; Lawrence et al., 1965; Lovejoy and Gaughan, 1975; MacCreary, 1945*a*; Main, 1970, 1983; Main et al., 1979; Mathewson and Hyland, 1964; Miller and Benton, 1973; Osgood, 1964; Quackenbush, 1971; Rapp and Gates, 1957; Robert, 1962; Robert and Bergeron, 1977; Rothschild, 1904; Scharf and Stewart, 1980; Stewart, 1928, 1933; Timm, 1975; Tindall and Darsie, 1961; Verts, 1961; Whitaker and Corthum, 1967; White and White, 1981; Woods and Larson, 1971; Wright, 1979)

Delotelis telegoni (Rothschild, 1905) (Brown, 1944; Holland, 1949*b*, Hopkins and Rothschild, 1962; Rothschild, 1905 [original description and cotype host]; Tiraboschi, 1907)

Doratopsylla blarinae C. Fox, 1914 (Benton, 1966; Fox, 1940*a*; Main, 1970)

Epitedia stanfordi Traub, 1944 (Hopkins and Rothschild, 1962)

Epitedia wenmanni (Rothschild, 1904) (Allred, 1952; Baker, 1946; Beck, 1955; Benton and Kelly, 1971, 1975; Benton and Timm, 1980; Burbutis, 1956; Connor, 1960; Cressey, 1961; Fox, 1940*a*; Fuller, 1943*a*; Gabbutt, 1961; Geary, 1959; Holland, 1949*b*; Holland and Benton, 1968; Hopkins and Rothschild, 1962; Joyce and Eddy, 1944; Knipping et al., 1950*b*; Lawrence et al., 1965; Main, 1970, 1983; Main et al., 1979; Mathewson and Hyland, 1964; Mumford and Whitaker, 1982; Osgood, 1964; Stark, 1959; Timm, 1972*b*; Tindall and Darsie, 1961; Verts, 1961; Whitaker and Corthum, 1967; Wright, 1979)

Hoplopsyllus anomalus (Baker, 1904) (Allred, 1952; Beck, 1955)

Hystrichopsylla dippiei Rothschild, 1902 (Easton, 1981; Fox, 1940*a*; Holland, 1957; Jordan, 1929; Timm, 1975)

Hystrichopsylla occidentalis Holland, 1949 (Campos and Stark, 1979; Egoscue, 1966)

Hystrichopsylla tahavuana Jordan, 1929 (Benton, 1966; Benton and Kelly, 1975; Benton et al., 1969; Geary, 1959; Hopkins and Rothschild, 1962; Jordan,

1929 [original description]; Main, 1970; Osgood, 1964; Quackenbush, 1971)

Malaraeus penicilliger (Grube, 1851) (Holland, 1952b; Hopla, 1965*a*)

Megabothris abantis (Rothschild, 1905) (Holland, 1949*b*; Rothschild, 1905 [original description and type host])

Megabothris acerbus (Jordan, 1925) (Benton and Kelly, 1975)

Megabothris asio (Baker, 1904) (Amin, 1976*a*; Baker, 1946; Benton, 1966, 1980; Benton and Kelly, 1975; Benton and Krug, 1956; Benton and Timm, 1980; Benton et al., 1969, 1971; Brown, 1968; Burbutis, 1956; Connor, 1960; Cressey, 1961; Cummings, 1954; Florschutz and Darsie, 1960; Fox, 1939*a*, 1940*a*; Fuller, 1943*a*; Gabbutt, 1961; Geary, 1959; Gyorkos and Hilton, 1982*b*; Harper, 1956, 1961; Holland, 1949*a*, 1949*b*, 1950, 1958; Holland and Benton, 1968; Jellison and Senger, 1973; Jordan, 1929 [described as *Ceratophyllus megacolpus*, 1933]; Knipping et al., 1950*b*; Lawrence et al., 1965; Lovejoy and Gaughan, 1975; MacCreary, 1945*a*; Main, 1970; Main et al., 1979; Mathewson and Hyland, 1964; Miller and Benton, 1973; Mumford and Whitaker, 1982; Osgood, 1964; Quackenbush, 1971; Robert, 1962; Robert and Bergeron, 1977; Scharf and Stewart, 1980; Scholten et al., 1962; Timm, 1975; Tindall and Darsie, 1961; Verts, 1961; Wagner, 1936*a* [reported as *M. megacolpus*]; Woods and Larson, 1969; Wright, 1979)

Megabothris calcarifer (Wagner, 1913) (Holland, 1950, 1958; Hopla, 1965*a*)

Megabothris groenlandicus (Wahlgren, 1903) (Holland, 1952*a*)

Megabothris lucifer (Rothschild, 1905) (Brown, 1944; Genoways and Jones, 1972; Holland, 1949*b*; Rothschild, 1905 [original description and cotype-host]; Woods and Larson, 1971)

Megabothris quirini (Rothschild, 1905) (Benton, 1966; Benton and Kelly, 1975; Benton and Timm, 1980; Benton et al., 1969, 1971; Buckner, 1964; Fox, 1940*a*; Fuller, 1943*a*; Gabbutt, 1961; Geary, 1959; Gyorkos and Hilton, 1982*b*; Harper, 1956; Holland, 1949*b*; Hopla, 1965*a*, 1980; Hubbard, 1947; Jordan, 1932; Knipping et al., 1950*b*; Lawrence et al., 1965; Lovejoy and Gaughan, 1975; Quackenbush, 1971; Robert, 1962; Timm, 1975; Wagner, 1936*a*; Whitaker and French, 1982; Woods and Larson, 1969; Wright, 1979)

Monopsyllus eumolopi (Rothschild, 1905) (Jordan, 1932)

Monopsyllus vison (Baker, 1904) (Robert, 1962)

Monopsyllus wagneri (Baker, 1904) (Beck, 1955; Benton and Timm, 1980; Easton, 1982; Genoways and Jones, 1972; Timm, 1972*b*; Verts, 1961)

Nosopsyllus fasciatus (Bosc, 1801) (Allred, 1952; Baker, 1946; Beck, 1955; Fuller, 1943*a*; Geary, 1959; Holland and Benton, 1968; Jameson, 1943*a*)

Opisocrostis bruneri (Baker, 1895) (Amin, 1973, 1976*a*; Benton et al., 1971; Benton and Timm, 1980; Woods and Larson, 1969)

Opisodasys pseudarctomys (Baker, 1904) (Holland and Benton, 1968)

Orchopeas howardii (Baker, 1895) (Main et al., 1979; Mathewson and Hyland, 1964; White and White, 1981)

Orchopeas leucopus (Baker, 1904) (Amin, 1973, 1976*a*; Benton and Kelly, 1975; Buckner, 1964; Cressey, 1961; Fox, 1940*a*; Fuller, 1943*a*; Gates, 1945; Geary, 1959; Genoways and Jones, 1972; Holland and Benton, 1968;

Joyce and Eddy, 1944; Knipping et al., 1950*b*; Lawrence et al., 1965; Main, 1970; Main et al., 1979; Mathewson and Hyland, 1964; Robert, 1962; Timm, 1975; Verts, 1961; Whitaker and Corthum, 1967)

Oropsylla arctomys (Baker, 1904) (Verts, 1961)

Peromyscopsylla catatina (Jordan, 1928) (Baker, 1946; Benton and Kelly, 1975; Benton and Krug, 1956; Benton and Timm, 1980; Benton et al., 1969; Buckner, 1964; Buckner and Blasko, 1969; Easton, 1981, 1982; Fox, 1940*a*; Fuller, 1943*a*; Geary, 1959; Harper, 1956; Holland and Benton, 1968; Hopkins and Rothschild, 1971; Jordan, 1929; Lawrence et al., 1965; Lovejoy and Gaughan, 1975; Mathewson and Hyland, 1964; Stewart, 1933; Timm, 1975)

Peromyscopsylla hamifer (Rothschild, 1906) (Benton, 1980; Benton and Miller, 1970; Benton and Timm, 1980; Cressey, 1961; Haas and Wilson, 1973; Holland, 1958; Holland and Benton, 1968; Hopkins and Rothschild, 1971; Hubbard, 1949*a*; Johnson and Traub, 1954; Knipping et al., 1950*b* [originally reported as *P. catatina*]; Lawrence et al., 1965; Lovejoy and Gaughan, 1975; Main, 1970, 1983; Main et al., 1979; Miller and Benton, 1973; Mumford and Whitaker, 1982; Timm, 1975; Whitaker and Corthum, 1967)

Peromyscopsylla hesperomys (Baker, 1904) (Benton and Kelly, 1975; Johnson and Traub, 1954)

Peromyscopsylla ostsibirica (Scalon, 1936) (Haas et al., 1982; Hopla, 1965*a*)

Peromyscopsylla scotti I. Fox, 1939 (Benton and Kelly, 1975)

Peromyscopsylla selenis (Rothschild, 1906) (Hopkins and Rothschild, 1971; Johnson and Traub, 1954; Rothschild, 1906; Wagner, 1936*a* [reported as *Ctenopsylla selenis*])

Rhadinopsylla fraterna (Baker, 1895) (Hopkins and Rothschild, 1962; Smit, 1957)

Rhadinopsylla orama Smit, 1957 (Benton, 1980; Fox 1940*a* [questionable identification]; Fuller, 1943*a*; Miller and Benton, 1973; Smit, 1957 [original description; type collected in nest])

Stenoponia americana (Baker, 1899) (Benton and Kelly, 1971, 1975; Fox, 1940*a*; Fuller, 1943*a*; Hopkins and Rothschild, 1962; MacCreary, 1945*a*; Main, 1983; Main et al., 1979; Miller and Benton, 1973; Quackenbush, 1971; Tindall and Darsie, 1961)

Thrassis bacchi (Rothschild, 1905) (Easton, 1982)

Microtus pinetorum

Atyphloceras bishopi Jordan, 1933 (Benton and Kelly, 1975; Main et al., 1979)

Ctenophthalmus pseudagyrtes Baker, 1904 (Benton, 1955*a*; Benton and Kelly, 1969, 1975; Benton and Krug, 1956; Benton et al., 1969; Burbutis, 1956; Cressey, 1961; Fox, 1940*a*; Harlan and Palmer, 1974; Holland and Benton, 1968; Hopkins and Rothschild, 1966; Jameson, 1943*b*, 1947; Jordan, 1928; Layne, 1958; MacCreary, 1945*a*; Main, 1970, 1983; Main et al., 1979; Mathewson and Hyland, 1964; Miller and Benton, 1973; Morlan, 1952; Mumford and Whitaker, 1982; Palmer and Wingo, 1972; Sanford and Hays, 1974; Schiefer and Lancaster, 1970; Tindall and Darsie, 1961; Whitaker and Corthum, 1967)

Doratopsylla blarinae C. Fox, 1914 (Benton, 1955*a*; Benton and Kelly, 1975; Burbutis, 1956; Miller and Benton, 1973)

Epitedia wenmanni (Rothschild, 1904) (Burbutis, 1956)
Hystrichopsylla tahavuana Jordan, 1929 (Benton and Kelly, 1975; Benton and Smiley, 1963; Holland, 1949*a*, 1957)
Megabothris asio (Baker, 1904) (Miller and Benton, 1973)
Opisodasys pseudarctomys (Baker, 1904) (Holland and Benton, 1968)
Orchopeas howardii (Baker, 1895) (Morlan, 1952)
Orchopeas leucopus (Baker, 1904) (Benton and Kelly, 1975; Benton et al., 1969; Ellis, 1955; Holland and Benton, 1968; Jameson, 1947; MacCreary, 1945*a*; Main et al., 1979; Tindall and Darsie, 1961)
Peromyscopsylla catatina (Jordan, 1928) (Benton et al., 1969; Holland and Benton, 1968)
Peromyscopsylla hamifer (Rothschild, 1906) (Main et al., 1979)
Peromyscopsylla hesperomys (Baker, 1904) (Main, 1983)
Rhadinopsylla orama Smit, 1957 (Benton, 1980; Benton and Kelly, 1975; Holland and Benton, 1968; Hopkins and Rothschild, 1962; Miller and Benton, 1973; Smit, 1957)
Stenoponia americana (Baker, 1899) (Benton and Kelly, 1975; Benton and Smiley, 1963; Burbutis, 1956; Hopkins and Rothschild, 1962; MacCreary, 1945*a*; Main et al., 1979; Palmer and Wingo, 1972; Sanford and Hays, 1974; Tindall and Darsie, 1961; Wilson, 1957)

Microtus richardsoni
Catallagia charlottensis (Baker, 1898) (Hubbard, 1947)
Catallagia sculleni Hubbard, 1940 (Holland, 1949*b*)
Hystrichopsylla dippiei Rothschild, 1902 (Hubbard, 1947; Jellison and Senger, 1973; Senger, 1966)
Megabothris abantis (Rothschild, 1905) (Egoscue, 1966; Hubbard, 1947; Jellison and Senger, 1973; Kinsella and Pattie, 1967; Ludwig, 1984)
Megabothris asio (Baker, 1904) (Ludwig, 1984)
Monopsyllus eumolpi (Rothschild, 1905) (Ludwig, 1984)
Monopsyllus wagneri (Baker, 1904) (Allred, 1952)
Nearctopsylla hyrtaci (Rothschild, 1904) (Ludwig, 1984)
Opisodasys keeni (Baker, 1896) (Stark, 1959)
Peromyscopsylla hamifer (Rothschild, 1906) (Ludwig, 1984)
Peromyscopsylla hesperomys (Baker, 1904) (Hubbard, 1947)
Peromyscopsylla selenis (Rothschild, 1906) (Gresbrink and Hopkins, 1982; Hopkins and Rothschild, 1971; Hubbard, 1947; Ludwig, 1984)
Stenoponia americana (Baker, 1899) (Hopkins and Rothschild, 1962)
Thrassis alpinus Stark, 1957 (Senger, 1966)

Microtus townsendii
Atyphloceras multidentatus (C. Fox, 1909) (Holland, 1949*b*; Hoplins and Rothschild, 1962; Hubbard, 1947; Macchiavello, 1954)
Catallagia charlottensis (Baker, 1898) (Holland, 1949*b*; Hopkins and Rothschild, 1962; Hubbard, 1947; Macchiavello, 1954; Svihla, 1941)
Catallagia sculleni Hubbard, 1940 (Hopkins and Rothschild, 1962)
Corrodopsylla curvata (Rothschild, 1915) (Hubbard, 1947; Macchiavello, 1954)
Corypsylla ornata C. Fox, 1908 (Holland, 1949*b*)
Corypsylla kohlsi Hubbard, 1940 (Fox, 1940*c* [described as *Corypsylloides spinata*]; Macchiavello, 1954)

Delotelis hollandi Smit, 1952 (Hopkins and Rothschild, 1962; Smit, 1952 [original description and type-host])
Delotelis telegoni (Rothschild, 1905) (Holland, 1949*b*; Hubbard, 1947; Jellison and Senger, 1976; Macchiavello, 1954)
Epitedia scapani (Wagner, 1936) (Hopkins and Rothschild, 1962; Hubbard, 1947; Macchiavello, 1954)
Hystrichopsylla dippiei Rothschild, 1902 (Hubbard, 1947; Macchiavello, 1954; Svihla, 1941)
Hystrichopsylla occidentalis Holland, 1949 (Holland, 1957; Hopkins and Rothschild, 1962)
Megabothris abantis (Rothschild, 1905) (Hubbard, 1947; Macchiavello, 1954; Svihla, 1941; Wagner, 1936*a*)
Megabothris quirini (Rothschild, 1905) (Hubbard, 1947)
Monopsyllus wagneri (Baker, 1904) (Hubbard, 1947; Macchiavello, 1954)
Opisodasys keeni (Baker, 1896) (Holland, 1949*b*; Macchiavello, 1954)
Peromyscopsylla hesperomys (Baker, 1904) (Hubbard, 1947; Macchiavello, 1954)
Peromyscopsylla selenis (Rothschild, 1906) (Hopkins and Rothschild, 1971; Svihla, 1941)
Rhadinopsylla sectilis Jordan and Rothschild, 1923 (Hopkins and Rothschild, 1962; Hubbard, 1941*b*, 1947 [reported as *Micropsylla goodi*]; Macchiavello, 1954)

Directions for Future Research

A review of the literature on parasites of North American *Microtus* contains over 485 primary references covering the 91-year period from 1894 to 1984. Most of these papers deal with the taxonomy of the various groups of parasites and their distribution on the hosts. Surprisingly, with this wealth of literature, we actually know very little about the biology of parasites on *Microtus*. Future research on systematic problems of many of the groups of parasites is needed, most especially of the mites, the most diverse and poorly known of the parasitic groups.

One of the most productive areas for future research will be exploring aspects of the biology of hosts and parasites from an evolutionary perspective. Future research should address co-evolution in the broadest sense between hosts and parasites, including co-accommodation, co-adaptation, and co-speciation. One of the most challenging, yet most fruitful directions will be in statistical quantification of the cost of parasitism. Hopefully, future studies will be able to directly or indirectly measure increased or decreased reproductive success by both host and parasites. Such questions might include: 1) What are the selective forces exerted by the host on the

parasites, and conversely, what are the selective forces exerted by the parasites on the host? 2) What is the cost of parasitism to the host? 3) How are the reproductive cycles of the parasites cued to the reproductive cycle of the host? 4) What is the role of parasites in the epidemiology of diseases among hosts? 5) Can parasites affect the behavior of the host? 6) Is there a genetic basis for resistance to parasitic infections by the host, and can this be selected for? 7) Can parasites play a role in regulating host populations? and 8) Can parasites or the diseases transmitted by them be responsible for delineating geographic ranges of species? Certainly we would expect massive infestations of parasites to alter the behavior or reproductive cycle of the host, but given lower "normal" levels of infestation, can the host be altered in more subtle ways through hormonal imbalance, odors, etc? The rapidly expanding field of biogeography has provided interesting and potentially productive directions for future studies in parasitology. The application of island biogeography theory to host–parasite systems leads to questions such as: Can an individual host, a population, or entire species be viewed as an island for parasites?

The study of parasites has been a part of both our basic and applied sciences for decades, yet it is still an extremely fruitful area of future research. There remains much to learn about the biology of *Microtus* with respect to its parasites and about the biology of those parasites.

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Appendix A. Endoparasites

Acanthocephalans

Microtus ochrogaster

Moniliformis clarki (Ward, 1917) (Fish, 1972)

Microtus pennslyvanicus
Moniliformis clarki (Ward, 1917) (Benton, 1954; Fish, 1972)
Polymorphus paradoxus Connell and Corner, 1957 (Platt, 1978)
Microtus pinetorum
Moniliformis clarki (Ward, 1917) (Benton, 1954, 1955*a*; Fish, 1972; Van Cleave, 1953)

Cestodes

Microtus abbreviatus
Andrya arctica Rausch, 1952 (Rausch and Rausch, 1968)
Andrya macrocephala Douthitt, 1915 (Rausch and Rausch, 1968)
Paranoplocephala infrequens (Douthitt, 1915) (Rausch and Rausch, 1968) (=*Anoplocephaloides* sp.; *A. infrequens* as presently understood is restricted to pocket gophers; at least two species of morphologically similar cestodes of the genus *Anoplocephaloides* occur in voles in the Arctic [R. L. Rausch, pers. comm.])
Paranoplocephala omphalodes (Hermann, 1783) (Rausch, 1976; Rausch and Rausch, 1968)
Taenia crassiceps (Zeder, 1800) (Rausch and Rausch, 1968) (larval stage)
Microtus breweri
Andrya macrocephala Douthitt, 1915 (Winchell, 1977)
Microtus californicus
Andrya macrocephala Douthitt, 1915 (Rausch, 1952*b*; Voge, 1948 [reported as *A. kirbyi*])
Microtus chrotorrhinus
Andrya macrocephala Douthitt, 1915 (Martin, 1972; Schad, 1954)
Hymenolepis horrida (von Linstow, 1901) (Schiller, 1952a)
Taenia crassiceps (Zeder, 1800) (Martin, 1972) (larval stage)
Microtus longicaudus
Andrya communis Douthitt, 1915 (Rankin, 1945) (=*A. primordialis* Douthitt, 1915)
Hymenolepis diminuta (Rudolphi, 1819) (Rankin, 1945)
Hymenolepis horrida (von Linstow, 1901) (Kinsella, 1967; Kuns and Rausch, 1950; Schiller, 1952*a*)
Paranoplocephala infrequens (Douthitt, 1915) (Kinsella, 1967; Kuns and Rausch, 1950) (=*Anoplocephaloides troeschi* Rausch, 1946)
Taenia mustelae Gmelin, 1790 (Kinsella, 1967) (larval stage)
Microtus mexicanus
Paranoplocephala infrequens (Douthitt, 1915) (Rausch, 1952*a*)(=*A. troeschi*)
Microtus miurus
Andrya arctica Rausch, 1952 (Rausch, 1952a [original description])
Hymenolepis horrida (von Linstow, 1901) (Schiller, 1952*a*)
Paranoplocephala infrequens (Douthitt, 1915) (Rausch, 1952*a*) (=*Anoplocephaloides* sp.)
Paranoplocephala omphalodes (Hermann, 1783) (Rausch, 1952*a*, 1976)
Taenia tenuicollis Rudolphi, 1809 (Rausch, 1952*a*) (=*T. mustelae*) (larval stage)
Microtus montanus
Andrya communis Douthitt, 1915 (Rankin, 1945) (=*A. primordialis* Douthitt, 1915)
Andrya macrocephala Douthitt, 1915 (Kinsella, 1967; Kuns and Rausch, 1950)

Andrya primordialis Douthitt, 1915 (Kuns and Rausch, 1950)
Hymenolepis horrida (von Linstow, 1901) (Kuns and Rausch, 1950; Schiller, 1952*a*)
Paranoplocephala infrequens (Douthitt, 1915) (Kinsella, 1967; Kuns and Rausch, 1950; Rausch, 1952*a*, 1976) (=*A. troeschi*)

Microtus ochrogaster
Andrya macrocephala Douthitt, 1915 (Hansen, 1947 [reported as *A. microti*, 1950]; Lubinsky, 1957)
Choanotaenia nebraskensis Hansen, 1950 (original description)
Choanotaenia sp. (Rausch and Tiner, 1949)
Hymenolepis horrida (von Linstow, 1901) (Schiller, 1952*a*)
Hymenolepis sp. (Rausch and Tiner, 1949)
Paranoplocephala borealis (Douthitt, 1915) (Rausch, 1952*a*) (=*Anoplocephaloides* sp.)
Paranoplocephala infrequens (Douthitt, 1915) (Hansen, 1950; Whitaker and Adalis, 1971) (=*A. troeschi*)
Paranoplocephala troeschi Rausch, 1946 (Whitaker and Adalis, 1971) (=*A. troeschi*)
Paranoplocephala sp. (Rausch and Tiner, 1949) (=*Anoplocephaloides* sp.)
Taenia mustelae Gmelin, 1790 (Lubinsky, 1957 (larval stage)
Taenia taeniaeformis (Batsch, 1786) (Rausch and Tiner, 1949; Whitaker and Adalis, 1971) (larval stage)

Microtus oeconomus
Andrya macrocephala Douthitt, 1915 (Rausch, 1952*a*)
Echinococcus granulosus (Batsch, 1786) (Rausch and Schiller, 1951) (=*E. multilocularis*; larval stage)
Echinococcus multilocularis Leuckart, 1863 (Ohbayashi, 1971; Vogel, 1957) (larval stage)
Echinococcus sibiricensis Rausch and Schiller, 1954 (Rausch and Schiller, 1954 [original description], 1956) (=*E. multilocularis*; larval stage)
Echinococcus sp. (Rausch, 1952*a*; Rausch and Schiller, 1951) (=*E. multilocularis*; larval stage)
Paranoplocephala infrequens (Douthitt, 1915) (Rausch, 1952*a*, 1957) (=*Anoplocephaloides* sp.)
Paranoplocephala omphalodes (Hermann, 1783) (Rausch, 1976)
Taenia polyacantha Leuckart, 1856 (Schiller, 1953) (larval stage)
Taenia twitchelli Schwartz, 1924 (Rausch, 1977) (larval stage)

Microtus pennsylvanicus
Andrya communis Douthitt, 1915 (Douthitt, 1915 [original description]; Lubinsky, 1957) (=*A. primordialis*)
Andrya macrocephala Douthitt, 1915 (Hall and Sonnenberg, 1955; Kuns and Rausch, 1950; Lubinsky, 1957; Mumford and Whitaker, 1982; Schad, 1954; Whitaker and Adalis, 1971)
Andrya primordialis Douthitt, 1915 (Kuns and Rausch, 1950; Meggitt, 1924)
Andrya sp. (Erickson, 1938*b*; Hall and Sonnenberg, 1955)
Cladotaenia globifera (Batsch, 1786) (Baron, 1971) (larval stage)
Cladotaenia sp. (Whitaker and Adalis, 1971)
Echinococcus multilocularis Leuckart, 1863 (Hnatiuk, 1966; Leiby, 1965; Leiby et al., 1970; Rausch and Richards, 1971) (larval stage)

Hymenolepis evaginata Barker and Andrews, 1915 (Rausch and Tiner, 1949)
Hymenolepis fraterna Stiles, 1906 (Rausch and Tiner, 1949)
Hymenolepis horrida (von Linstow, 1901) (Kinsella, 1967; Lubinsky, 1957; Schiller, 1952*a*)
Hymenolepis johnsoni Schiller, 1952 (Rausch, 1952*a*; Schiller, 1952*b* [original description and type-host])
Paranoplocephala borealis (Douthitt, 1915) (Rausch, 1952*a*) (=*Anoplocephaloides* sp.)
Paranoplocephala infrequens (Douthitt, 1915) (Hall and Sonnenberg, 1955; Kinsella, 1967; Kuns and Rausch, 1950; Lubinsky, 1957; Mumford and Whitaker, 1982; Rausch, 1946, 1952*a*; Rausch and Schiller, 1949; Schad, 1954) (=*A. troeschi*)
Paranoplocephala troeschi Rausch, 1946 (Mumford and Whitaker, 1982; Rausch, 1946 [original description and type-host], 1976; Rausch and Tiner, 1949) (=*A. troeschi*)
Paranoplocephala variabilis (Douthitt, 1915) (Kinsella, 1967; Lubinsky, 1957; Schad, 1954) (=*A. variabilis*)
Paranoplocephala sp. (Erickson, 1938*a*; Rausch and Tiner, 1949) (=*Anoplocephaloides*)
Paruterina candelabraria (Goeze, 1782) (Baron, 1971) (larval stage)
Taenia crassiceps (Zeder, 1800) (Freeman, 1954, 1962; Leiby and Whittaker, 1966) (larval stage)
Taenia mustelae Gmelin, 1790 (Lubinsky, 1957) (larval stage)
Taenia taeniaeformis (Batsch, 1786) (Erickson, 1938*b*; Kinsella, 1967; McBee, 1977; Rausch and Tiner, 1949) (larval stage)
Taenia tenuicollis Rudolphi, 1809 (Schad, 1954) (=*T. mustelae*)

Microtus pinetorum
Hymenolepis pitymi Yarkinsky, 1952 (original description)
Taenia taeniaeformis (Batsch, 1786) (Lochmiller et al., 1982*b*) (larval stage)
Taenia sp. (Erickson, 1938*b*; Lochmiller et al., 1982*b*; Whitaker and Adalis, 1971) (larval stage)

Microtus richardsoni
Andrya macrocephala Douthitt, 1915 (Kuns and Rausch, 1950)
Andrya primordialis Douthitt, 1915 (Kuns and Rausch, 1950)
Andrya sp. (Kuns and Rausch, 1950)
Hymenolepis horrida (von Linstow, 1901) (Kuns and Rausch, 1950; Schiller, 1952*a*)
Paranoplocephala infrequens (Douthitt, 1915) (Kuns and Rausch, 1950; Rausch, 1952*a*) (=*A. troeschi*)

Microtus xanthognathus
Taenia martis americana Wahl, 1967 (Rausch, 1977) (larval stage)

Nematodes

Microtus abbreviatus
Heligmosomoides bullosus matthewensis Durette-Desset, 1967 (Durette-Desset, 1968)
Heligmosomum nearcticum Durette-Desset, 1967 (Durette-Desset, 1968)
Heligmosomum sp. (Rausch and Rausch, 1968)

Microtus californicus
- *Heligmosomoides montanus* Durette-Desset, 1967 (Durette-Desset et al., 1972)
- *Pelodera* sp. (Poinar, 1965) (larval stage in eyes)

Microtus chrotorrhinus
- *Capillaria hepatica* (Bancroft, 1893) (Fisher, 1963)
- *Cheiropteranema* sp. (Komarek and Komarek, 1938)
- *Nematospiroides dubius* Baylis, 1926 (Schad, 1954)

Microtus longicaudus
- *Aspiculuris tetraptera* (Nitzsch, 1821) (Kinsella, 1967)
- *Heligmosomoides microti* (Kuns and Rausch, 1950) (Kinsella, 1967)
- *Heligmosomoides montanus* Durette-Desset, 1967 (Durette-Desset, 1968)
- *Heligmosomum costellatum* (Dujardin, 1845) (Kinsella, 1967)
- *Mastophorus* sp. (Kinsella, 1967) (=*Protospirura* sp.)
- *Nematospiroides longispiculatus* Dikmans, 1940 (Rausch, 1952*a*) (=*Heligmosomoides longispiculatus*)
- *Pelodera* sp. (Kinsella, 1967) (larval stage in eyes)
- *Syphacia obvelata* (Rudolphi, 1802) (Kinsella, 1967; Rankin, 1945) (Quentin [1971] concluded that *Syphacia nigeriana* Baylis, 1928, is the only species of *Syphacia* parasitizing *Microtus* in North America; *S. obvelata* is restricted in occurrence to *Rattus* and perhaps other murids.)

Microtus mexicanus
- *Syphacia nigeriana* Baylis, 1928 (Quentin, 1971)

Microtus miurus
- *Heligmosomum nearcticum* Durette-Desset, 1967 (Durette-Desset, 1968)
- *Rictularia microti* McPherson and Tiner, 1952 (McPherson and Tiner, 1952 [original description]; Quentin, 1971) (=*Pterygodermatites microti*)
- *Rictularia* sp. (Rausch, 1952*a*)
- *Trichinella spiralis* (Owen, 1835) (Rausch et al., 1956) (=*T. nativa* Britov and Boev, 1972)

Microtus montanus
- *Nematospiroides microti* Kuns and Rausch, 1950 (Kinsella, 1967; Kuns and Rausch, 1950 [original description]) (=*Heligmosomoides microti*)
- *Syphacia obvelata* (Rudolphi, 1802) (Kinsella, 1967; Kuns and Rausch, 1950; Leiby, 1962; Rankin, 1945) (=*S. nigeriana* ?)

Microtus ochrogaster
- *Boreostrongylus dikmansi* Durette-Desset, 1974 (original description)
- *Capillaria* sp. (Dunaway et al., 1968)
- *Longistriata carolinensis* Dikmans, 1935 (original description) (=*B. carolinensis*)
- *Syphacia obvelata* (Rudolphi, 1802) (Rausch and Tiner, 1949) (=*S. nigeriana* ?)
- *Trichuris* sp. (Rausch and Tiner, 1949)

Microtus oeconomus
- *Heligmosomoides bullosus bullosus* Durette-Desset, 1967 (Durette-Desset, 1968)
- *Heligmosomum nearcticum* Durette-Desset, 1967 (Durette-Desset, 1968)
- *Pterygodermatites microti* (McPherson and Tiner, 1952) (Quentin, 1971)
- *Rictularia microti* McPherson and Tiner, 1952 (original description) (=*P. microti*)
- *Sobolevingylus microti* Rausch and Rausch, 1969 (original description and type-host)
- *Syphacia nigeriana* Baylis, 1928 (Quentin, 1971)

Microtus pennsylvanicus
- *Capillaria hepatica* (Bancroft, 1893) (Freeman and Wright, 1960; Lubinsky et al., 1971)
- *Capillaria muris-sylvatici* (Diesing, 1851) (Rausch and Tiner, 1949)
- *Dictyocaulus viviparus* (Bloch, 1782) (Rausch and Tiner, 1949)
- *Heligmosomoides longispiculatus* (Dikmans, 1940) (Durette-Desset et al., 1972)
- *Heligmosomoides wisconsinensis* Durette-Desset, 1967 (Durette-Desset, 1968; Durette-Desset et al., 1972)
- *Heligmosomum costellatum* (Dujardin, 1845) (Kinsella, 1967)
- *Heligmosomum microti* (Kuns and Rausch, 1950) (Kinsella, 1967; Kuns and Rausch, 1950) (=*Heligmosomoides microti*)
- *Heligmosomum nearcticum* Durette-Desset, 1967 (Durette-Desset, 1968)
- *Longistriata dalrympei* Dikmans, 1935 (Dikmans, 1935 [original description]; Lichtenfels and Haley, 1968; Rausch and Tiner, 1949)
- *Mastophorus muris* (Gmelin, 1790) (Rausch and Tiner, 1949) (=*Protospirura muris*)
- *Nematospira turgida* Walton, 1923 (original description and type-host)
- *Nematospiroides longispiculatus* Dikmans, 1940 (original description) (=*Heligmosomoides longispiculatus*)
- *Nematospiroides* sp. (Hall and Sonnenberg, 1955; Rausch and Tiner, 1949) (=*Heligmosomoides* sp.)
- *Oxyuris* sp. (Stiles and Hassall, 1894)
- *Rictularia coloradensis* Hall, 1916 (Lubinsky, 1957) (=*Pterygodermatites coloradensis*)
- *Syphacia nigeriana* Baylis, 1928 (Quentin, 1971)
- *Syphacia obvelata* (Rudolphi, 1802) (Erickson, 1938*a*, 1938*b*; Kinsella, 1967; Kuns and Rausch, 1950; Rausch and Tiner, 1949; Schad, 1954) (=*S. nigeriana* ?)
- *Syphacia* sp. (Hall and Sonnenberg, 1955; Lichtenfels and Haley, 1968)
- *Trichinella spiralis* (Owen, 1835) (Holliman and Meade, 1980)
- *Trichuris opaca* Barker and Noyes, 1915 (Hall and Sonnenberg, 1955; Lichtenfels and Haley, 1968; Rausch and Tiner, 1949)
- *Trichuris* sp. (Hall and Sonnenberg, 1955)

Microtus pinetorum
- *Capillaria gastrica* (Baylis, 1926) (Lochmiller et al., 1982*a*)
- *Oxyuris* sp. (Stiles and Hassall, 1894)
- *Trichinella spiralis* (Owen, 1835) (Zimmermann, 1971)
- *Trichuris opaca* Barker and Noyes, 1915 (Hall and Sonnenberg, 1955)
- *Trichuris* sp. (Benton, 1955*a*)

Microtus richardsoni
- *Nematospiroides microti* Kuns and Rausch, 1950 (original description)
- *Syphacia obvelata* (Rudolphi, 1802) (Kuns and Rausch, 1950) (=*S. nigeriana* ?)
- *Trichuris opaca* Barker and Noyes, 1915 (Kuns and Rausch, 1950)

Trematodes

Microtus miurus
- *Brachylaima rauschi* McIntosh, 1951 (Rausch, 1952*a*)

Microtus montanus
Quinqueserialis hassalli (McIntosh and McIntosh, 1934) (Kuns and Rausch, 1950) (=*Q. quinqueserialis*; Barker and Laughlin, 1911)
Microtus oeconomus
Quinqueserialis quinqueserialis (Barker and Laughlin, 1911) (Rausch, 1952*a*)
Microtus pennsylvanicus
Brachylaima sp. (Rausch, 1952*a*)
Entosiphonus thompsoni Sinitsin, 1931 (Rausch and Tiner, 1949)
Mediogonimus ovilacus Woodhead and Malewitz, 1936 (Rausch and Tiner, 1949; Woodhead and Malewitz, 1936 [original description])
Monostomum sp. (Stiles and Hassall, 1894)
Plagiorchis muris Tanabe, 1922 (Kinsella, 1967; Schad, 1954)
Quinqueserialis hassalli (McIntosh and McIntosh, 1934) (Harwood, 1939; Kuns and Rausch, 1950; McIntosh and McIntosh, 1934 [original description and type-host]; Rausch, 1952*a*; Rausch and Tiner, 1949) (=*Q. quinqueserialis*)
Quinqueserialis quinqueserialis (Barker and Laughlin, 1911) (Edwards, 1949; Harrah, 1922; Kinsella, 1967; Rausch, 1952*a*; Schad, 1954)
Schistosomatium douthitti (Cort, 1915) (Price, 1931; Zajac and Williams, 1980, 1981)