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A Survey of Ectoparasites from Microtus ochrogaster ochrogaster (Wagner), Peromyscus leucopus noveboracensis (Fisher), and Cryptotis parva harlani (Say)

Fred Basolo Jr.
Eastern Illinois University

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A SURVEY OF ECTOPARASITES FROM MICROTUS OCHROGASTER OCHROGASTER (WAGNER), PEROMYSCUS LEUCOPUS NOVEBORACENSIS (FISHER), AND CRYPTOTIS PARVA HARLANI (SAY)

(TITLE)

BY

FRED BASOLO JR.

B. S. in Ed., Eastern Illinois University, 1972

THESIS

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FOR THE DEGREE OF

MASTER OF SCIENCE

IN THE GRADUATE SCHOOL, EASTERN ILLINOIS UNIVERSITY
CHARLESTON, ILLINOIS

1973
YEAR

I HEREBY RECOMMEND THIS THESIS BE ACCEPTED AS FULFILLING
THIS PART OF THE GRADUATE DEGREE CITED ABOVE

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The undersigned, appointed by the head of the Department of Zoology, have examined a thesis entitled

A SURVEY OF ECTOPARASITES FROM MICROTUS OCHROGASTER OCHROGASTER (WAGNER), PEROMYSCUS LEUCOPUS NOVEBORACENSIS (FISHER), AND CRYPTOTIS PARVA HARLANI (SAY)

Presented By

FRED BASOLO JR.

a candidate for the degree of Master of Science and hereby certify that in their opinion it is acceptable.

ABSTRACT

Ectoparasites were taken from 50 white footed deer mice, Peromyscus leucopus noveboracensis (Fisher), 50 prairie voles, Microtus ochrogaster ochrogaster (Wagner), and 11 least shrews, Cryptotis parva harlani (Say), within a five mile radius of Charleston, Illinois from 23 January 1973 through 25 June 1973. A total number of 4,242 ectoparasites were recovered; 2,395 from Microtus ochrogaster, 542 from Peromyscus leucopus, and 1,305 from Cryptotis parva. The major groups of ectoparasites and their percent recovery were: Acari (excl. of Metastigmata) 81.50%, Metastigmata 2.95%, Anoplura 15.50% and Siphonaptera 0.50%. A study of the ectoparasites recovered revealed representatives of 18 families and 31 species of mites, 1 family and 1 species of tick, 1 family and 2 species of lice, and 2 families and 3 species of fleas. The number of ectoparasites recovered from hosts captured alive and dead were compared, and showed a higher yield of most ectoparasite groups from hosts captured alive. The effects of host body size and behavior are correlated with ectoparasite yields. The groups of ectoparasites and their abundance are given by sex of the host, but no apparent differences between sexes were observed.

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INTRODUCTION

Arthropod ectoparasites of man and his domestic animals have been studied in great detail. In recent years there has been an increase in the study of arthropod groups associated with non-domestic animals because of their importance as vectors and reservoirs of diseases, as well as their natural importance as living organisms. Surveys of the ectoparasites of vertebrate groups have revealed an abundance of information on the biology of both ectoparasites and hosts involved. The present survey has intended primarily to identify and tabulate the ectoparasites of Peromyscus leucopus novebora-censis (Fisher), Microtus ochrogaster ochrogaster (Wagner), and Cryptotis parva harlani (Say). Secondarily, ectoparasitic yields of these hosts were studied in regard to age and sex of the host and condition of host when trapped (live versus dead).

LITERATURE REVIEW

In reviewing the literature for a survey of ectoparasites it is necessary to consider the two approaches used by different authors, one emphasizing the parasite group and the other the hosts.

The Ixodidae attracted little attention until in 1889-1890 when Smith and Kilborne (Bequaert, 1945) showed that they played an essential role in the transmission of Texas or Southern Cattle fever. Ticks are one of the most important groups of arthropods concerned in disease transmission to man and animals, and this fact alone has attracted much attention to this group (Philip, 1963). The ixodids of North America did not gain recognition until the beginning of the twentieth century when many workers presented valuable information on classification, host relationships and seasonal history (Banks, 1908; Bishopp, 1911; Hunter and Bishopp, 1911; Hooker, Bishopp and Wood, 1912). The study of the disease Rocky Mountain Spotted Fever has also stimulated the study of ticks in North America (Morgan, 1899; Maver, 1911; Dyer, Badger and Rumreich, 1931; Parker, Philip and Jellison, 1933).

The collecting of ticks from hosts has been conducted throughout the United States. A few early surveys were conducted nation-wide (Hunter and Bishopp, 1911; Hooker, Bishopp and Wood, 1912), however, most are regional in coverage. In Massachusetts, Larrousse, King, and Wolback (1928) found Peromyscus leucopus to serve as a host of Dermacentor variabilis. MacCreary's studies (1940, 1945) have shown Microtus pennsylvanicus to be the preferred host of Dermacentor variabilis in

Delaware. The ticks of Rhode Island were surveyed by Hyland and Mathewson (1961). The studies of ixodids in Illinois have been limited primarily to investigations on the vector of Rocky Mountain Spotted Fever and its distribution (Bishopp and Smith, 1938; Bishopp and Trembley, 1945; Smith, Cole and Gouck, 1946). Ecke and Yeatter (1956) have surveyed the parasites of the cottontail rabbits of Illinois and recorded the tick Ixodes dentatus. The rate of Dermacentor variabilis attachment to white-tailed deer of Pope County, Illinois has been investigated by Montgomery (1968).

The Anoplura have long been neglected, for as late as 1910 no critical, comparative study of the group had been made. The North American anoplurans have been dealt with primarily by two authors (Kellogg, 1914; Kellogg and Ferris, 1915; Ferris, 1916, 1951). American anopluran host lists have been given by Kellogg (1914) and by Kellogg and Ferris (1915). The distribution of lice on American rodents has been presented by Jellison (1942). Cook and Beer (1955, 1958) compiled a list of the louse populations of cricetid rodents of northern Minnesota, and Microtus and Peromyscus specimens of southern Minnesota. Other rodent-louse population studies have been conducted in New Jersey (Race, 1956), Rhode Island (Mathewson and Hyland, 1958), Delaware (Florschultz and Darsie, 1960), Texas (Menzies, Eads and Hightower, 1951), California (Mohr and Stumpf, 1964), and in the Great Salt Lake Desert (Ignoffe, 1959). Verts (1960) has presented ecological notes on a few species of lice occurring on the small mammals of Illinois.

The Siphonaptera of North America were revised by Baker (1904), and updated by Ewing and Fox (1943). The fleas of western North America

(Hubbard, 1947) and the eastern United States (Fox, 1940; Fuller, 1943) have also been compiled. Evans and Freeman (1950) and Benton and Cerwonka (1960) investigated the relationships of some mammalian fleas to their hosts. The evolution, classification and host relationships of Siphonaptera have been discussed by Holland (1964).

A flea survey of the wild animals from Bitter Root Valley in Montana was conducted for public health reasons (Dunn and Parker, 1923), and similar surveys were undertaken in Virginia (Hasseltine, 1929), Utah (Stanford, 1931, 1944; Tipton and Allred, 1951), Iowa (Joyce and Eddy, 1943), New Jersey (Burbutis, 1956), New York (Geary, 1959), Kansas (Poorbaugh and Gier, 1961) and Indiana (Whitaker and Corthua, 1967). Illinois records of fleas from mammals have been reported by Layne (1958), and Verts (1961) collected fleas from the small mammals of northwestern Illinois.

The earliest works on Acari in America were those of Banks (1907) and Ewing (1909, 1913, 1923, 1932, 1934). A great number of surveys of acarine parasites on mammalian hosts made throughout the United States have been summarized by Baker et al., (1956). Many parasitic mites have been collected for isolation experiments of viruses, rickettsias, bacteria, spirochaetes, protozoans, and helminths (Audy, 1968). Host specificity in parasitic acarines has been of great interest (Nutting, 1968).

Host lists for chiggers of shrews and rodents were presented by Farrell (1956) and a survey of the myobiid mites from shrews of eastern North America has been published by Jameson (1948). A number of Acari were taken from mammals in Texas during the Texas plague studies (Eads, Menzies, and Miles, 1952). Collections of parasitic mites were taken

in Delaware (Mellott and Connell, 1965), Maryland (Drummond, 1957) and Alabama (Hays and Guyton, 1958). Similar studies were also conducted in Utah (Keegan, 1952; Allred, 1958), Nebraska (Rapp, 1962; Timm, 1972), and Indiana (Whitaker and Wilson, 1968).

Due to the close relationships of mammals to many forms of vegetation they are frequently found to harbor phytophagous mites (Hughes, 1961).

General studies of the ectoparasites of mammals have been conducted in West Virginia (Wilson, 1943), Delaware (MacCreary, 1945; Florschutz and Darsie, 1960; Tindall and Darsie, 1961), Texas (Randolph and Eads, 1946), Florida (Worth, 1950), Georgia (Morlan, 1952), Oklahoma (Ellis, 1955), Arizona (Beer, Cook, and Schwab, 1959), Indiana (Wilson, 1957, 1961), Oregon (Hansen, 1964) and Wyoming (Kinsella and Pattie, 1967).

Surveys of ectoparasites of specific host groups have been referred to by Ewing (1929). Harkema (1936) conducted a survey of both external and internal parasites of rodents in North Carolina. Additional studies of the ectoparasites of rodents have been conducted in Florida (Rumreich and Wynn, 1945), Alabama (Cole and Koepke, 1946), and Georgia (Cole and Koepke, 1947). The abundance and distribution of the ectoparasites of the house mouse, Mus musculus, in Mississippi was presented by Smith (1955). Jameson (1947) has written on the natural history of the prairie vole, Microtus ochrogaster, in Kansas and included an ectoparasitic survey. A biological association between Pyemotes and Dipodomys is discussed in a report of an ectoparasitic survey of Dipodomys ordii in Oklahoma (Reisin and Best, 1973). The ecological relationships of plant communities and ectoparasites of rodents in the Great Salt Basin has been

discussed (Johnson, Parker and Nest, 1970). The food and ectoparasites of the Indiana shrews have been presented (Whitaker and Mumford, 1972) and Jameson (1950) carried out a survey of the parasites of the insectivore Blarina brevicauda in Kansas. Ecke and Yeatter (1956) reported a parasitic survey of the cottontail rabbits of Illinois. The biology of the striped skunk, Mephitis mephitis, of Illinois has been discussed by Verts (1967) in which he lists the ectoparasites of this animal. Further ectoparasitic records from the mammals of Illinois can be found in the collections of the faunistics division of the Illinois Natural History Survey.

MATERIALS AND METHODS

The host mammals yielding the ectoparasites on which this study is based were trapped from 23 January 1973 through 25 June 1973 in Coles County, Illinois. Five trapping areas within a five mile radius of Charleston, Illinois were used. The hosts were identified to species with the help of Dr. J. A. Maya and subspecies names were awarded to each host group based upon their geographical distributions (Hall and Keith, 1959). Fifty standard museum special traps and 20 Sherman live traps were employed for the trapping of the host specimens. Microtus ochrogaster ochrogaster (Wagner) and Peromyscus leucopus noveboracensis (Fisher) specimens were trapped both dead and alive. Each group consisted of 50 trapped individuals, one half of which were trapped alive and one half dead. Only 11 host specimens of Cryptotis parva harlani (Say) were trapped, all from the same field, with the use of the museum special traps. All traps were baited with peanut butter and set flush to the ground, in or near runways. On cold days the Sherman traps were supplied with rags which acted as nesting material to prevent the freezing of the trapped animal. In each field the traps were set in lines of 10 yds. apart. The traps were checked and baited daily, shortly after dawn, and on cold days in the evening as well. All traps were periodically rotated among the five fields.

Upon capture the host specimens were placed in individual, labeled plastic bags to prevent loss of ectoparasites from drop-off, and to prevent host transfer by the ectoparasites (Cook, 1955). Specimens trapped

alive were individually transferred to a one gallon jar, killed with chloroform, and then placed in individual, labeled plastic bags. Each bag was tied shut and labeled according to host, date, field of capture, and type of trap employed. Host specimens were placed in a freezer the day of their capture and left frozen until the time of their examination for ectoparasites.

Prior to the examination for ectoparasites each host was thawed in its plastic bag for approximately two hours. Each host was then weighed and its pelage quality and color noted for approximate age determination (Table 1). The host was then removed from the bag and placed in a 12 oz. jar for washing. The bag was examined for ectoparasites with the aid of a dissecting microscope before the washing of the host.

The host washing process for ectoparasite removal used in this study was taken in part from Lipovsky (1951). A solution containing 95% distilled water and 5% "Liqui-nox" detergent was placed in the jar with the host. The jar was then shaken periodically for approximately 30 minutes. The wash solution was then poured into a 500 ml. graduated cylinder. The host was left in the jar and rinsed by adding distilled water. The jar was again shaken periodically for approximately 30 minutes, after which the rinse water was added to the cylinder containing the wash water. A second rinse then followed using the same procedure. A few drops of 95% ethyl alcohol were added to the cylinder to break down any suds which were present. The wash and rinse solution in the cylinder was then stirred for a uniform concentration of the resultant mixture. The cylinder was then plugged with cotton, and allowed to stand for at least 30 minutes, after which the wash solution was poured into a petri dish and examined for ectoparasites with the aid of a dissecting microscope.

Table 1. The characters of the three age categories of *Microtus ochrogaster* and *Peromyscus leucopus* specimens.

Age category	Characters of* *M. ochrogaster*	Characters of *P. leucopus*
	Less than 21 grams	Less than 19 grams
Juvenile	Entire pelage dull	Entire pelage dull
	Dorsal color black	Dorsal color gray-white
	Between 21-38 grams	Between 19-24 grams
Subadult	Pelage glossy except rump pelage dull	Pelage semi-glossy
	Dorsal color grizzled except on rump	Dorsal color gray-brown
	38 grams or more	25 grams or more
Adult	Entire pelage glossy	Entire pelage glossy
	Dorsal color grizzled	Dorsal color light brown

*The characters of *M. ochrogaster* were taken from Jameson (1947).

Immediately after washing, the host was placed in a petri dish and examined for ectoparasites under a dissecting microscope using a dissecting probe to look through the animal's fur. Special areas of the animal's body, such as on and within the ears, nose, and mouth were also closely examined for ectoparasites. After examination the sex of the animal was determined by dissection and the body discarded.

Ectoparasites were transferred from the bag, the host, and the wash water directly to individual microscope slides for identification, or to vials for storage. Ectoparasites to be stored were placed in 70% ethyl alcohol in 8x25 mm. specimen vials, stoppered with cotton and placed in air tight, labeled, storage jars. Three mounting media were used in this study: Hoyer's, C.M.C. with acid fuchsin, and clear C.M.C. After mounting an ectoparasite the slide was placed on a hot plate for approximately 36 hours to speed drying of the mounting medium. The slides were labeled with both host and ectoparasite data. The ectoparasites were identified with the aid of a compound microscope and a variety of specific taxonomic keys and papers.

RESULTS

A list of the arthropods and their abundance which were recovered from Microtus ochrogaster, Peromyscus leucopus, and Cryptotis parva is presented in Tables 2, 3 and 4 respectively. A summary of the prevalence of the major ectoparasitic groups collected from Microtus ochrogaster and Peromyscus leucopus is recorded in Tables 5 and 6. In both Tables 5 and 6 the number of species of Acari does not include immature "Myocoptes sp." (Tables 2, 3) nor "Acaridae nymphs" (Table 3) because specific identification was not possible. Many of the specimens recorded as "Myocoptes sp." (Tables 2, 3) were adults, but possessed taxonomic characters which did not fit the description of the known species and are not included in the summary tables (Tables 5, 6).

Many workers who have recovered ectoparasites from small mammals have witnessed a higher yield from those mammals which had been captured live (Jameson, 1947; Cole and Koepke, 1947; Reisin and Best, 1973). The major ectoparasitic groups and their abundance recovered from 25 live captured and 25 dead captured Microtus ochrogaster and Peromyscus leucopus specimens are presented in Tables 7 and 8 respectively. The age and sex of the host specimens have been correlated with their ectoparasitic yield. The host specimens of Microtus ochrogaster and Peromyscus leucopus have been assigned to one of three age categories, juvenile, subadult, or adult, and the major ectoparasitic groups for each given (Tables 9, 10). The major ectoparasitic groups and their abundance are given by sexes of Microtus ochrogaster and Peromyscus leucopus in Table 11.

Table 2. Arthropoda recovered from 50 *Microtus ochrogaster* in Coles County, Illinois.

Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Acari				
Astigmata				
Acaridae				
Dermacarus hypudaei	12	24.0	121	2.420
Listrophoridae				
Listrophorus leuckarti	7	14.0	97	1.940
Myocoptidae				
Myocoptes japonensis	21	42.0	52	1.040
Myocoptes musculinus	6	12.0	8	0.160
Myocoptes sp.	34	68.0	541	10.800
Cryptostigmata				
Brachychthoniidae				
Brachychthonius sp.	1	2.0	2	0.040
Oppiidae				
Oribella sp.	1	2.0	1	0.020
Mesostigmata				
Laelapidae				
Androlaelaps fahrenholzi	31	62.0	187	3.740
Laelaps kochi	44	88.0	461	9.200
Metastigmata				
Ixodidae				
Dermacentor variabilis	5	10.0	14	0.280
Prostigmata				
Ereynetidae				
Paraspeleognathopis sp.	2	4.0	2	0.040
Myobiidae				
Radfordia lemnina	25	50.0	140	2.800
Pyemotidae				
Pseudopygmephorus sellnicki	3	6.0	3	0.060
Siteroptes absidatus	2	4.0	3	0.060

Table 2.---Continued.

Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Tarsonemidae				
Tarsonemoides truncatus	4	8.0	45	0.900
Trombiculidae				
Euschongastia peromysci	3	6.0	7	0.140
Trombicula whartoni	7	14.0	38	0.760
Insecta				
Siphonaptera				
Hystrichopsyllidae				
Ctenophthalmus pseudagyrtes	10	20.0	16	0.320
Epitedia wenmanni wenmanni	1	2.0	1	0.020
Anoplura				
Hoplopleuridae				
Hoplopleura acanthopus	37	74.0	595	11.900
Coleoptera				
Carabidae (adults)	2	4.0	2	0.040
Collembola	8	16.0	22	0.440
Total	50	100.0	2,419	48.400

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 3. Arthropoda recovered from 50 *Peromyscus leucopus* in Coles County, Illinois.

Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Acari				
Astigmata				
Acaridae				
Dermacarus hypudaei	1	2.0	1	0.020
Labidophorus soricis	1	2.0	2	0.040
Troupeavia sp.	3	6.0	5	0.100
Tyrophagus sp.	2	4.0	2	0.040
acarid nymphs	1	2.0	3	0.060
Anoetidae				
Prowichmannia spiniferum	1	2.0	2	0.040
Myocoptidae				
Myocoptes japonensis	3	6.0	6	0.120
Myocoptes musculinus	21	42.0	38	0.760
Myocoptes sp.	13	26.0	40	0.800
Saproglyphidae				
Calvolia sp.	1	2.0	1	0.020
Cryptostigmata				
Oribatellidae				
Zygoribatula sp.	1	2.0	1	0.020
Mesostigmata				
Ascidae				
nymph	1	2.0	1	0.020
Laelapidae				
Androlaelaps fahrenholzi	16	32.0	42	0.840
Haemogamasus sp.	1	2.0	1	0.020
Histionyssus arcuatus	7	14.0	21	0.420
Laelaps kochi	4	8.0	5	0.100
Phytoseiidae				
Typhlodromus sp.	1	2.0	1	0.020

Table 3.---Continued.

Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Metastigmata				
Ixodidae				
Dermacentor variabilis	10	20.0	109	2.360
Prostigmata				
Myobiidae				
Radfordia subuliger	20	40.0	69	1.480
Pyemotidae				
Pseudopygmephorus sellnicki	1	2.0	1	0.020
Siteroptes absidatus	3	6.0	21	0.420
pyemotid male	1	2.0	1	0.020
Scutacaridae				
Scutacarus sp.	3	6.0	4	0.080
Tarsonemidae				
Tarsonemoides truncatus	3	6.0	5	0.100
Trombiculidae				
Euschongastia peromysci	11	22.0	83	1.660
Insecta				
Siphonaptera				
Hystrichopsyllidae				
Ctenophthalmus pseudagyrtes	1	2.0	1	0.020
Epitedia wenmanni wenmanni	6	12.0	8	0.160
Ceratophyllidae				
Orchopeas leucopus	3	6.0	5	0.100
Anoplura				
Hoplopleuridae				
Hoplopleura hesperomydis	15	30.0	63	1.260
Coleoptera				
Meloidae (larva)	1	2.0	1	0.020
Nitidulidae (adults)	2	4.0	3	0.060

Table 3.---Continued.

Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Collembola	9	18.0	24	0.480
Diptera (larva)	1	2.0	1	0.020
Homoptera				
Coccidae	1	2.0	1	0.020
Crustacea				
Copepoda				
Cyclopidae	1	2.0	1	0.020
Total	47	94.0	573	11.500

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 4. Arthropoda recovered from 11 *Cryptotis parva* in Coles County, Illinois.

Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Acari				
Astigmata				
Acaridae				
Dermacarus hypudaei	1	9.1	1	0.090
Labidophorus soricis	11	100.0	1,255	114.000
Trophagus sp.	1	9.1	1	0.090
acarid (nymphs)	2	18.2	2	0.180
Mesostigmata				
Laelapidae				
Androlaelaps fahrenholzi	1	9.1	1	0.090
Prostigmata				
Erythraeidae				
Erythraeoidea sp.	1	9.1	1	0.090
Myobiidae				
Blarinobia simplex	4	36.4	26	2.360
Protomyobia claparedei	5	45.5	13	1.180
Pyemotidae				
Pseudopygmephorus sellnicki	3	27.3	5	0.455
Total	11	100.0	1,305	119.000

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 5. A summary of the major ectoparasitic groups recovered from 50 Microtus ochrogaster in Coles County, Illinois.

Taxonomic group	No. of families	No. of species	Total no. of organisms	No. of hosts infested	% of hosts infested	Density*
Acari (excl. of Metastigmata)	11	15	1,769	50	100.0	35.400
Metastigmata	1	1	14	5	10.0	0.280
Anoplura	1	1	595	37	74.0	11.900
Siphonaptera	1	2	17	11	22.0	0.340
Total	14	19	2,395	50	100.0	48.000

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 6. A summary of the major ectoparasitic groups recovered from 50 Peromyscus leucopus in Coles County, Illinois.

Taxonomic group	No. of families	No. of species	Total no. of organisms	No. of hosts infested	% of hosts infested	Density*
Acari (excl. of Metastigmata)	13	22	356	43	86.0	7.000
Metastigmata	1	1	109	10	20.0	2.360
Anoplura	1	1	63	15	30.0	1.260
Siphonaptera	2	3	14	10	20.0	0.280
Total	17	27	542	45	90.0	10.900

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 7. Major ectoparasitic groups from 25 live captured and 25 dead captured Microtus ochrogaster in Coles County, Illinois.

Host condition	Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
dead	Acari (excl. of Metastigmata)	25	100.0	1,058	42.300
	Metastigmata	1	4.0	1	0.040
	Anoplura	18	72.0	480	16.400
	Siphonaptera	4	16.0	5	0.200
	Total	25	100.0	1,472	58.000
live	Acari (excl. of Metastigmata)	25	100.0	723	29.000
	Metastigmata	3	12.0	13	0.520
	Anoplura	19	76.0	187	7.500
	Siphonaptera	7	28.0	12	0.480
	Total	25	100.0	935	37.400

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 8. Major ectoparasitic groups from 25 live captured and 25 dead captured Peromyscus leucopus in Coles County, Illinois.

Host condition	Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
dead	Acari (excl. of Metastigmata)	21	84.0	210	8.400
	Metastigmata	3	12.0	14	0.560
	Anoplura	8	32.0	33	1.320
	Siphonaptera	5	20.0	6	0.240
	Total	23	92.0	263	10.500
live	Acari (excl. of Metastigmata)	22	88.0	132	5.300
	Metastigmata	7	28.0	95	3.800
	Anoplura	8	32.0	26	1.040
	Siphonaptera	5	20.0	8	0.320
	Total	22	88.0	261	10.400

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 9. Major ectoparasitic groups from three age categories of Microtus ochrogaster in Coles County, Illinois.

Age category	No. of hosts examined	Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Juvenile	5	Acari (excl. of Metastigmata)	5	100.0	372	74.100
		Metastigmata	0	0.0	0	0.000
		Anoplura	5	100.0	84	16.800
		Siphonaptera	2	40.0	3	0.600
		Total	5	100.0	459	92.000
Subadult	27	Acari (excl. of Metastigmata)	27	100.0	612	22.600
		Metastigmata	3	11.0	13	0.480
		Anoplura	17	63.0	161	5.950
		Siphonaptera	6	22.0	10	0.370
		Total	27	100.0	796	29.500
Adult	18	Acari (excl. of Metastigmata)	18	100.0	471	26.300
		Metastigmata	1	5.6	1	0.060
		Anoplura	15	83.0	350	19.500
		Siphonaptera	3	16.7	4	0.220
		Total	18	100.0	826	45.800

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 10. Major ectoparasitic groups from three age categories of Peromyscus leucopus in Coles County, Illinois.

Age category	No. of hosts examined	Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
Juvenile	13	Acari (excl. of Metastigmata)	10	77.0	79	6.100
		Metastigmata	3	23.0	10	0.770
		Anoplura	8	61.5	20	1.540
		Siphonaptera	2	15.4	3	0.230
		Total	11	84.5	112	8.600
Subadult	30	Acari (excl. of Metastigmata)	27	90.0	131	4.360
		Metastigmata	5	16.7	37	1.240
		Anoplura	7	23.4	36	1.200
		Siphonaptera	4	13.3	5	0.167
		Total	27	90.0	209	6.980
Adult	8	Acari (excl. of Metastigmata)	7	87.0	60	7.500
		Metastigmata	2	25.0	62	7.700
		Anoplura	2	25.0	3	0.375
		Siphonaptera	4	50.0	6	0.750
		Total	8	100.0	131	16.400

*Density is determined by dividing total number of organisms by the total number of hosts examined.

Table 11. Major ectoparasitic groups from males and females of *Microtus ochrogaster* and *Peromyscus leucopus* in Coles County, Illinois.

Host and Sex	No. of hosts examined	Taxonomic group	No. of hosts infested	% of hosts infested	Total no. of organisms	Density*
M. ochrogaster male	30	Acari (excl. of Metastigmata)	30	100.0	979	32.600
		Metastigmata	3	10.0	13	0.434
		Anoplura	21	70.0	345	11.500
		Siphonaptera	7	23.4	13	0.434
		Total	30	100.0	1,350	45.000
M. ochrogaster female	20	Acari (excl. of Metastigmata)	20	100.0	803	40.300
		Metastigmata	1	5.0	1	0.050
		Anoplura	16	80.0	250	12.500
		Siphonaptera	4	20.0	4	0.200
		Total	20	100.0	1,058	52.900
P. leucopus male	32	Acari (excl. of Metastigmata)	26	81.0	146	4.550
		Metastigmata	8	25.0	79	2.470
		Anoplura	12	37.5	50	1.570
		Siphonaptera	6	18.8	9	0.282
		Total	27	84.0	284	8.850
P. leucopus female	18	Acari (excl. of Metastigmata)	16	89.0	136	7.550
		Metastigmata	3	16.3	30	1.670
		Anoplura	4	22.3	9	0.500
		Siphonaptera	4	22.3	4	0.223
		Total	17	94.5	179	9.900

*Density is determined by dividing total number of organisms by the total number of hosts examined.

DISCUSSION

Few animal groups illustrate the enormous diversity in form, habitat and behavior seen in the Acari. Every terrestrial vertebrate group has its complex of external acarine parasites. Therefore, it is not surprising that 84 percent of the ectoparasites recovered in the present study were mites. Acarine parasites of animals occur in all but the suborder Cryptostigmata, which includes primarily fugivorous, algivorous, or saprophagous mites (Krantz, 1970). Four cryptostigmatic mites were recovered in this survey and their presence may be attributed to the association of small mammals with vegetation in the form of stored food, nesting materials and runways.

The astigmatic mites are cosmopolitan and have achieved success in many forms of existence. Members of the Acaridia are generally phytophagous as adults, but as immature forms (deutonymphs or hypopi) they exhibit a phoretic relationship with other animals including small mammals. Phoretic mites are free living mites which utilize other animals as a means of dispersal. The hypopi of Dermacarus hypudaei and Labidophorous soricis have been found attached to the hairs of small mammals (Whitaker and Wilson, 1968). In this study Dermacarus hypudaei was found associated mainly with Microtus ochrogaster (Table 2), and Labidophorus soricis was common on Cryptotis parva (Table 4). The occurrence of these mites on species other than their usual host can be attributed to the fact that these hosts occupy the same general

habitat, and utilize the same runways. Hypopi of the genus Labidophorous have seldom been reported from North America because they are so tiny, and they cling tenaciously to individual hairs (Krantz, 1970). These characteristics of Labidophorus hypopi account for the inaccurate density reported for this group in many surveys as well as in the present (Table 4). More accurate counts would be obtained only if the technique of digesting the host was used to recover the parasites (Hilton, 1970). Other phoretic Acaridia taken in this survey but considered to be phoretic upon insects by Krantz (1970) include Prowichmannia spiniferum and Calvolia sp. taken from Peromyscus leucopus (Table 3).

Six adult Troupeavia and two adult Tyrophagus of the Acaridae were recovered, and their presence must also be considered accidental as they are not phoretic. Representatives of the psoroptidian mite families Listrophoridae and Myocoptidae were recovered in this study. Listrophorus leuckarti, collected only from Microtus ochrogaster (Table 2), was also taken from Microtus pennsylvanicus by Whitaker and Wilson (1968). Myocoptes musculinus was recovered from Microtus ochrogaster and Peromyscus leucopus in this study and by Whitaker and Wilson (1968). In addition, Myocoptes japonensis and a number of Myocoptes species, were also collected from both hosts. The percent infestation and density of these two species of Myocoptes on Microtus ochrogaster and Peromyscus leucopus illustrate a degree of host specificity (Tables 2, 3). Although it has been shown by Dubinina (1969) that two or more species of a single genus may coexist on the same host the collection of two species and essentially intermediate forms from the same host in this investigation suggests the need for additional taxonomic work on the genus Myocoptes.

Mesostigmatic mites are mainly predators, but many are external or internal parasites of vertebrates and invertebrates. The mesostigmatic

mites recovered in this survey were primarily Laelapidae, a family containing many external parasites of small mammals. However, one female Typhlodromus sp. and one nymphal ascid mite, both of which prey on phytophagous mites (Krantz, 1970), were also recovered. Of the laelapids collected, the cosmopolitan mite Androlaelaps fahrenholzi has been found to parasitise a variety of hosts (Baker et al., 1956), and was found on all three species of host examined in this survey. Another mite of this group, Laelaps kochi, was recovered from Microtus ochrogaster and Peromyscus leucopus. The percent of infestation of Laelaps kochi on Microtus ochrogaster is 11 times greater than on Peromyscus leucopus clearly illustrating a preference for Microtus as reported by Allred and Beck (1966). Many species of small mammals are parasitised by members of the genus Haemogamasus (Kinsella and Pattie, 1967; Whitaker and Wilson, 1968). In the present survey only one specimen of Haemogamasus was recovered and was found on Peromyscus leucopus. Peromyscus leucopus was also parasitised by Hirstionyssus arcuatus, this same species was recorded from Peromyscus by Whitaker and Wilson (1968) as Hirstionyssus talpae.

The Metastigmata are ectoparasites which feed primarily on the blood of terrestrial vertebrates in all of their life stages (Krantz, 1970). The immature stages engorge mainly on small rodents (Bishopp and Smith, 1938; Bishopp and Trembley, 1945) and in the present survey the only ticks recovered were nymphs of Dermacentor variabilis (Tables 2, 3). This tick was found parasitising twice as many specimens of Peromyscus leucopus and Microtus ochrogaster, a condition which is the opposite of results of previous investigations (Larrousse, King, and Wolback, 1928; MacCreary, 1940; Bequaert, 1945; Bishopp and Trembley,

1945). The absence of ticks on Cryptotis parva may be attributed to the small size of the shrew.

The greatest number of mite species recovered in this survey belong to the suborder Prostigmata. This group of mites is cosmopolitan in distribution, and virtually unlimited in habitat (Krantz, 1970). Two members of the family Pyemotidae (Pseudopygmephorus sellnicki and Siteroptes absidatus) were recovered in this study. Pseudopygmephorus sellnicki was taken from all of the host species in small numbers (Tables 2, 3 and 4). The habits of this mite are not known, but it has been recorded from various small rodents and insectivores, soil, and lily bulbs (Cross, 1965). Siteroptes absidatus which occurred on Microtus ochrogaster and Peromyscus leucopus (Tables 2, 3) are phytophagous mites in the nests of small mammals (Hughes, 1961) and their presence on the hosts may be considered accidental. Specimens of the predatory Tarsonemoides trucatus (Tarsonemidae) were recovered from Microtus ochrogaster and Peromyscus leucopus and should also be considered accidental. The Erythraeoidea are predators of small arthropods (Krantz, 1970) but one individual was recovered from Cryptotis parva (Table 4). Paraspeleognathopsis mites, two of which were taken from Microtus ochrogaster (Table 2), are common nasal mites of rodents and not usually collected during surveys of ectoparasites.

The members of the family Myobiidae are ectoparasites of rodents, marsupials, bats and insectivores (Krantz, 1970) and show a high degree of host specificity. Microtus ochrogaster was found to harbor only Radfordia lemnina, while Radfordia subuliger was found exclusively on Peromyscus leucopus. These same associations were found in other surveys (Drummond, 1957; Whitaker and Wilson, 1968). Cryptotis parva was

was parasitised by two species of myobiids (Table 4). Protomyobia claparedei has not only been taken from Cryptotis parva, but seems to occur on most of the members of Soricidae (Jameson, 1948; Whitaker and Wilson, 1968; Whitaker and Mumford, 1971). Blarinobia simplex has exhibited a high percent of infestation and density for Cryptotis parva in this survey, although this mite is considered to be restricted to the shrew Blarina brevicauda (Jameson, 1948; Whitaker and Mumford, 1971).

The family Trombiculidae which was represented in this study by Euschongastia peromysci and Trombicula whartoni (Tables 2, 3) are parasitic as larvae (chiggers) on all classes of terrestrial vertebrates. These chiggers were most often found deep in the ear conch of their host, the normal microclimatical habitat for these species. Farrell (1956) described Euschongastia peromysci in detail and gave an extensive host list of shrews and rodents. This survey supports other studies (Drummond, 1957; Tindall and Darsie, 1961) because even though this mite is found to infest many small mammals it is most frequently found on species of the genus Peromyscus. Trombicula whartoni was taken only from Microtus ochrogaster (Table 2), however this mite has been recovered from a number of other small mammals including Peromyscus (Kardos, 1954; Loomis, 1956).

The major ectoparasitic group with the second greatest number of representatives recovered in this study was Anoplura. This group constituted 15.50 percent of the total number of arthropods taken. Anoplurans are, for the most part, restricted as parasites of mammals inhabiting these organisms throughout their life cycle. Due to the fact that anoplurans show a high degree of host specificity, two host groups in

this study were found infested with their own specific anopluran (Tables 2, 3). It has been shown in other surveys that Hoplopleura acanthopus prefers Microtus while Hoplopleura hesperomydis prefers hosts of genus Peromyscus (Kellogg and Ferris, 1915; Hopkins, 1949; Cook and Beer, 1955, 1958). Jameson (1947) found that Microtus ochrogaster supported only Hoplopleura acanthopus, while Cook and Beer (1955) in large samples of rodents collected in Minnesota, did not find Hoplopleura acanthopus on Peromyscus nor Hoplopleura hesperomydis on Microtus. A high percentage of the small mammals which have been examined are not known to support lice, or when they do, to support them in localized areas and with low infestations (Mohr and Stumpf, 1964), therefore, the absence of anoplurans on Cryptotis parva may be attributed to their small body size.

The Siphonaptera make up the remaining 0.50 percent of ectoparasites recovered in the present survey. These organisms are found on birds and mammals only as adults. They are most commonly found on rodents which construct nests in which the flea larvae develop (Ewing, 1929). Because most flea activity usually occurs within the den or nest of the host animal, and since fleas seldom oviposit on their host, but instead within the confines of its nest, it was not surprising that few fleas were collected. Ctenophthalmus pseudagyrtes is the most common flea of small mammals and at the same time the least host specific (Benton and Cerwonka, 1960). This flea has been recovered from both Microtus ochrogaster and Peromyscus leucopus in this (Tables 2, 3) and a number of other surveys (Jameson, 1947; Layne, 1958; Verts, 1961; Poorbaugh and Gier, 1961; Whitaker and Corthua, 1967). The recovery of Epitedia wenmanni, found here in large numbers on Peromyscus

leucopus, supports other surveys (Layne, 1958; Verts, 1961; Poorbaugh and Gier, 1961; Whitaker and Corthua, 1967). The flea Orchopeas leucopus shows a much stronger host preference for Peromyscus leucopus than does any other flea. One hundred and three Orchopeas leucopus were recovered from small mammals in Illinois by Verts (1961) of which 99 were obtained from Peromyscus. Layne (1958) has reported 110 specimens of this flea in Illinois, all of which were recovered from Peromyscus. Although no siphonapterans were taken from Cryptotis parva in this survey, there have been reports of a number of different fleas recorded from this host with Corrodopsylla hamiltoni being the most common (Poorbaugh and Gier, 1961; Whitaker and Corthua, 1967; Whitaker and Mumford, 1972).

A number of organisms recovered in this study are not ectoparasites (Tables 2, 3) and are considered to be accidental inhabitants of Microtus and Peromyscus. The majority of these organisms belong to the class Insecta and include Collembola, Coleoptera and Diptera. One member of the class Crustacea was taken belonging to the family Cyclopidae (Table 3). These organisms are inhabitants of aquatic environments, and their accidental presence on mammals may be a result of the flooding of the trapping areas by nearby streams.

In addition to listing the organisms recovered from the three species of small mammals certain characteristics of the mammals were also observed to determine their effect, if any, on presence of the ectoparasites. In the present survey the ectoparasitic yield from live captured hosts was compared to that of dead captured hosts (Tables 7, 8). Trapping techniques and time of removal of host organisms from traps must be consistent if ectoparasite counts from two samples are

to be comparable, because some ectoparasites leave the host when it dies. Cole and Koepke (1947) found the mean number of each major group of ectoparasites was higher on rats, Rattus rattus, captured live than on those captured dead. Specimens of Microtus ochrogaster (Table 7) collected alive in the present study showed a higher percent infestation by all the groups of ectoparasites except for the Acari (excl. of Metastigmata) which were present on all living and dead animals. Siphonaptera are the ectoparasites least often found on dead captured mammals. Jameson (1947) found twice as many fleas on live captured Microtus ochrogaster specimens than on dead ones. Reisen and Best (1973) found the frequency of occurrence and absolute index of Siphonaptera and Anoplura to be lower than they had expected and attributed this to the use of snap traps which kill the host. Peromyscus leucopus captured alive in this survey show a higher percent infestation for the Acari than do those captured dead. In a number of cases the percent of infestation increased in hosts captured alive while the density decreased, and in such instances one offsets the other and no apparent difference in ectoparasitic yields may be determined. Obvious differences in this survey for both host groups were exhibited only by the Siphonaptera and Metastigmata.

The age categories of small mammals is reflected in the body size and behavior of the host, and both of these factors have been found to affect the ectoparasitic yields of the host (Smith, Cole, and Gouck, 1946; Milne, 1949; Mohr, 1961; Mohr and Stumpf, 1962; Phillips, 1966). Ectoparasitic yields were compared among age categories of the host specimens Microtus ochrogaster and Peromyscus leucopus (Tables 9, 10). Within the Acari (excl. of Metastigmata)

few differences have been reported except on large hosts which generally harbor more trombiculids (Mohr, 1956). In the present study the Acari (excl. of Metastigmata) showed no apparent difference among the age categories of either host. It has been observed during studies of ticks by Milne (1949) that the proportion of hosts infested became less with decreased body size, and the animals which covered the most ground (adults have larger areas of activity) came in contact with the most ticks. According to Milne (1949) the smaller the animal, the less the breadth of its front and generally the less the distance traveled, hence the less area of ground swept in any unit of time. Smith, Cole and Gouck (1946) have stated that larval and nymphal ticks tend to accumulate along runways. Therefore, one might suggest that of all potential small mammals hosts, those individuals with the largest available surface area would have greatest probability of contact with waiting ticks as they move through their runways. The Metastigmata recovered from Peromyscus leucopus in this study show an increase in density with an increase in body size of the host (Table 10). An opposing trend of tick infestation was encountered by Mohr and Stumpf (1964) where they found younger, smaller, individuals of Microtus to be most often infested with ticks, and they concluded that younger, smaller individuals are less efficient self-cleaners than the large, adult individuals. Such conflicting results indicates a need of additional investigation of host size and incidence of parasitism.

Anoplurans are discriminate in their selection of hosts, therefore incident of infestation is not related to host size, however there may be a relationship between size of host and number of lice supported (Phillips, 1966). Lice are found to inhabit all parts of a host's body,

therefore it seems logical that the larger the host the more lice it may support, however just the opposite condition has been illustrated for Peromyscus leucopus in this study (Table 10). These results for lice populations on Peromyscus leucopus may be explained by suggesting more efficient grooming activities by the larger animals as Mohr and Stumpf (1964) concluded for tick populations on Microtus. The Siphonaptera have also been found in greater numbers on the larger specimens of a given species of host (Milne, 1949; Phillips, 1966). From these data recovered in this survey the body size of the host did not affect the number of fleas encountered.

The sex of the host also can influence the abundance of the ectoparasites. Cook and Beer (1955) reported that male Peromyscus in Minnesota had over twice the incidence of Anoplura as that of females, while Mohr and Stumpf (1964) found a similar situation in meadow mice (Microtus). These results may be attributed to the fighting and mating activities of the male that increase his contact with other animals. In the present study no noticeable differences were observed between the number of ectoparasites found on males and females of either Microtus ochrogaster or Peromyscus leucopus.

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