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RICHARD S. MILLER
and
RONALD A. WARD

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RICHARD S. MILLER
University of Saskatchewan
and
RONALD A. WARD
Walter Reed Army Medical Center

Four species of pocket gopher occur in Colorado — *Cratogeomys castanops* occupies most of the area south of the Arkansas River in Baca, Prowers and Bent Counties and the eastern part of Otero County; *Geomys bursarius* is found throughout most of the plains north of the Arkansas River and east of the front range of the Rocky Mountains; *Thomomys bottae* occurs in the valleys of the southwest, along the front range as far north as Colorado Springs, and from the front range west to Salida; and *Thomomys talpoides* occupies most of the remaining areas (Miller, unpublished).

The ranges of these four species meet in different combinations of contiguous allopatry at various localities along the Arkansas River and in the vicinity of Colorado Springs, thus offering a unique opportunity for studies of their interrelationships. The purpose of this study was a preliminary survey of the ectoparasites of the pocket gophers of Colorado, with special reference to localities where the ranges of the different pocket gophers meet and where host-specificity would best be shown.

Methods

Collections were made in August 1957 at localities selected on the basis of the distributions outlined above. The pocket gopher specimens were placed in individual plastic bags and stored with dry ice until they could be examined. The parasites were removed within one or two days after the gophers were trapped, and were treated in the manner outlined by Ward (1957a). Lice and a few mites and fleas were also recovered from museum skins in the Warren Collection at Colorado College, the U.S. Fish & Wildlife Service collection at the Denver Federal Center, the Denver Museum of Natural History, and Colorado State University.

We would like to express our appreciation to the following who identified the parasites and provided information about their habits and distributions: Phyllis Johnson (Fleas), G. M. Kohls (Ticks) and Russell Strandtmann (Mites). The lice were identified by Ronald A. Ward.

Results

The numbers of ectoparasites and the host species they were collected from are shown in Table I.

TABLE I.—Ectoparasites collected from pocket gophers in Colorado. Values shown are the numbers of individuals of each parasite species collected from each host species, and the number of individuals of the host species (in parentheses) on which the parasite was found.

Ectoparasite Species	*Thomomys bottae*	*Thomomys talpoides*	*Geomys bursarius*	*Cratogeomys castanops*
ACARINA				
Macrocheles sp.		1(1)	1(1)	
Coprholaspis sp.	1(1)			
Haemogamasus ambulans	1(1)	44(13)		1(1)
Ischryopoda armatus	1(1)			
Hirstionyssus geomydis	2(2)	29(10)	1(1)	
Ornithonyssus sp.		1(1)		
Phytoseidae		1(1)		
Garmania ponorum		1(1)		
Haemolaelaps geomys	20(12)	76(23)	92(13)	2(1)
Aulaelaps stabularis		4(2)		
Ixodes sculptus	10(2)	91(18)	2(1)	
Ixodes kingi	9(2)			
Ixodes sp.[1]	41(2)	1(1)		
Dermacentor sp.	1(1)			
Sarcoptidae		1(1)		
Listrophoridae			1(1)	
MALLOPHAGA				
Geomydoecus thomyus		321(73)		
G. chapini		331(67)		
G. californicus	863(50)		122(7)	
G. minor	655(44)			
G. geomydis				204(5)
G. geomydis-californicus[2]			351(17)	
SIPHONAPTERA				
Foxella ignota	49(16)	192(60)	35(11)	1(1)
Dactylopsylla percernis				8(5)
Thrassis petiolatus	1(1)			

[1] Unidentifiable larvae; probably a mixture of *I. sculptus* and *I. kingi.*

[2] See text for discussion of integradation of *G. geomydis* and *G. californicus.*

A brief account of the habits and host-associations of the ectoparasites is given in the following section:

MITES AND TICKS (ACARINA)

MACROCHELIDAE

Macrochelid mites occur in soil and on vertebrates and invertebrates. They are probably not parasitic (Baker and Wharton, 1952).

Macrocheles sp.—Two females were found on two specimens of *T. talpoides*.

Coprholaspis sp.—One female was found on *T. bottae*.

HAEMOGAMASSIDAE

These mites are common parasites of small mammals throughout the world, which suggests that they may be important in the transmission of plague, typhus, tularemia, and perhaps other diseases (Baker and Wharton, 1952). They attach to the host only to feed; non-feeding time is spent in the nest of the host.

Haemogamasus ambulans (Thors.)—This genus is restricted to small, burrowing rodents and insectivores (Ewing, 1929). *H. ambulans* was common on *T. talpoides* and single specimens were collected from *T. bottae* and *C. castanops*.

Ischryopoda armatus Keegan.—Only two species of this genus are known. *I. armatus* was described from *Thomomys bottae* in California and has also been found in *Dipodomys, Perognathus* and *Peromyscus* from California, New Mexico and Colorado. One specimen was collected from *T. bottae* in this study.

DERMANYSSIDAE

Dermanyssid mites are thought to be relatively specific and the family contains several species of medical and veterinary importance (Baker and Wharton, 1952).

Hirstionyssus geomydis (Keegan).—This genus is almost entirely restricted to rodents (Baker and Wharton, 1952), living in the host nest and attaching to the host only to feed. *H. geomydis* was common on *T. talpoides* and was also present on *T. bottae* and *G. bursarius*.

Ornithonyssus sp.—Members of this genus are true parasites of birds, mammals and reptiles. One specimen was found on *T. talpoides*.

PHYTOSEIDAE

Members of this family are frequently found on plants as predators of plant-feeding invertebrates. One unidentified specimen was found on *T. talpoides*.

Garmania ponorum (Ouds.).—Since members of this genus are non-parasitic, this mite would probably occur on small mammals by accident, or as a predator of other small arthropods. One specimen was found on *T. talpoides*.

LAELAPTIDAE

Laelaptid mites are common, relatively specific, ectoparasites of mammals.

Haemolaelaps geomys Strandtmann.—The genus *Haemolaelaps* occurs on birds and mammals and some species of the genus are apparently restricted to a single genus or family of mammals. *H. geomys* is found only on geomyids and occurs throughout the host range. This species was found on all four species of pocket gophers examined.

Eulaelaps stabularis (Koch).—This species was found on only two specimens of *T. talpoides*. It is associated with various small mammals in Europe and North America. Jameson (1950) found it commonly on *Blarina brevicauda* in California.

IXODIDAE

Ixodes sculptus Neumann.—This tick is common on ground squirrels and their predators throughout the central and western United States and Canada (Gregson, 1956) and was the most common tick found in this study. Tryon (1947) found *Ixodes* sp. common on *T. talpoides* in Montana, but Howard and Childs (unpublished) found no ticks on *T. bottae* in California, even though a careful search was made for them. *I. sculptus* was especially common on *T. talpoides* in this study, but was also found on *T. bottae* and *G. bursarius*. Male *Ixodes* remain on the host only during mating, but females oviposit on the host for several weeks, or even months. No males were collected.

Ixodes kingi Bishop.—This tick is also a common parasite of ground squirrels and their predators in the prairies of the United States and Canada. It was found only on *T. bottae*.

Dermacentor sp.—A single, unidentifiable, larva was collected from *T. bottae*. Species of this genus are not separable at the larval stage, but the larva was either *D. parumapterus* or the Rocky Mountain wood tick, *D. andersoni*. These ticks feed on any of a wide range of hosts and often require a new host for each instar (Gregson, 1956).

SARCOPTIDAE

Sarcoptid mites are skin parasites of warm-blooded animals. The family includes the scabies mite, *Sarcoptes scabiei*, and several other species responsible for sarcoptic mange. One unidentified sarcoptid was found on *T. talpoides*.

LISTROPHORIDAE

Members of this family occur in the hair of small to medium-sized mammals. They apparently feed on sebaceous secretions (Trouessart, 1918). One female, probably *Mycoptes* sp., was found on a specimen of *G. bursarius*.

LICE (MALLOPHAGA)

Since lice spend their entire life cycle on the host, they have been free to evolve a high degree of host specificity. Hopkins (1949) examined 50 species of wild mammals and found only six instances of the same trichodectid on two host species. In each case, closely allied species of the same genus of mammal were involved. This close association between lice and their hosts has also allowed the lice to evolve with their hosts, so that the origins of the host genera and families, and the history of their subsequent distributions, determine whether they are hosts to Anoplura or Mallophaga (Jellison, 1942). The Geomyidae are hosts to Mallophaga but not Anoplura.

TRICHODECTIDAE

Trichodectid lice are common parasites of mammals and usually show a high degree of host-specificity (Hopkins, 1949).

Geomydoecus californicus (Chapman).—Hopkins (1949) lists *Thomomys bottae* as the true host of this species, although it has also been recorded from *Geomys arenarius* and *T. baileyi*. It seems to be a common parasite of *T. bottae* throughout its range in Colorado, and was also collected from *Geomys bursarius* in the vicinity of Colorado Springs and Canon City, where the ranges of *G. bursarius* and *T. bottae* meet.

Geomydoecus chapini Werneck.—The only previous record of this species is from a specimen of *Geomys personatus* from Tabasco, Mexico (Hopkins and Clay, 1952). On the basis of fresh specimens and museum skins examined during this study, this species appears to be generally distributed in Colorado as a parasite of *T. talpoides*. The northern limit of its range is not known. The

junior author examined a large series of museum skins of pocket gophers from Utah and *Geomydoecus chapini* was not found. This may be a species of Mexican origin which has followed the Rocky Mountain chain northward.

Geodmydoecus geomydis (Osborn).—Hopkins (1949) lists *Geomys bursarius* as the true host of this species. There are several records of this louse from *Cratogeomys castanops* however, and it is the only louse known to occur on this genus of pocket gophers. *Geomydoecus geomydis* was not collected from *Geomys bursarius* during this study, but it occurred on all of the *Cratogeomys castanops* examined.

Geomydoecus minor Werneck.—Hopkins (1949) lists *Thomomys baileyi* as the host of *Geomydoecus minor*. It was common on the *T. bottae* specimens examined and seems to occur on this gopher throughout its range.

Geomydoecus thomyus (McGregor).—Hopkins (1949) lists *Thomomys talpoides* as the true host of this species, but it has also been recorded from *Thomomys bottae* and from *Thomomys monticola* in Oregon. This louse is widely distributed throughout the range of *T. talpoides* in the United States and Canada.

Geomydoecus geomydis-californicus.—Geomys bursarius is considered to be the true host of *Geomydoecus geomydis* and *Thomomys bottae* the true host of *Geomydoecus californicus* (Hopkins, 1949). None of the *Geomys bursarius* collected during this study were hosts of *Geomydoecus geomydis,* which occurred,

TABLE II.—Relative host specificities of ectoparasites of pocket gophers

	Primarily restricted to Geomyidae	General rodent parasites	Non-parasitic or accidental
MITES	*Hirstionyssus geomydis*	*Haemogamasus ambulans*	*Macrocheles* sp.
	Haemolaelaps geomys	*Ischryopoda armatus*	*Coprholaspis* sp.
		Eulaelaps stabularis	*Garmania panorum*
		Ornithonyssus sp.	
TICKS		*Ixodes sculptus*	
		I. kingi	
		Dermacentor sp.	
LICE	*Geomydoecus californicus*		
	G. chapini		
	G. geomydis		
	G. minor		
	G. thomyus		
FLEAS	*Foxella ignota*	*Thrassis petiolatus*	
	Dactylopsylla percernis		

instead, on *Cratogeomys castanops*. Specimens of *Geomys bursarius* collected in the vicinity of Colorado Springs and Canon City, near the range of *T. bottae*, were hosts to typical *Geomydoecus californicus*. Specimens collected north of these localities, along the front range of the Rocky Mountains, had lice which appeared to be intergrades between *Geomydoecus geomydis* and *Geomydoecus californicus*. These localities represent the western limit of the range of *Geomys bursarius*, and the lice that were collected probably represent a case of introgression.

FLEAS (SIPHONAPTERA)

CERATOPHYLLIDAE

Foxella ignota (Baker).—Fleas of this genus are true parasites of pocket gophers, although they also occur on pocket gopher predators and rodents which are closely associated with pocket gophers and use their abandoned burrows. *Foxella ignota* is widely distributed in the United States, Canada and Mexico, wherever pocket gophers occur, and has also been recorded from ground squirrels, weasels, burrowing owls, pocket mice, prairie dogs and deer mice (Hubbard, 1947). It occurred on all of the species examined in this study.

Dactylopsylla percernis Eads and Menzies.—Fleas of this genus, the "giant fleas of pocket gophers" (Hubbard, 1943), are restricted primarily to the Geomyidae. *D. percernis* was found only on *Cratogeomys castanops* during this study, but this species of flea is relatively rare and individuals generally occur singly or in pairs on the host (Hubbard, 1947). The range of the genus broadly overlaps that of *Foxella*, but *Dactylopsylla* populations are more scattered and less common.

Thrassis petiolatus (Baker).—One specimen was collected from *Thomomys bottae*. This flea is primarily associated with ground squirrels of the genus *Citellus* (Holland, 1949), but has also been collected from woodrats, marmots, cottontails and tree squirrels (Holland, 1949).

On the basis of the data in Table I and the foregoing accounts of the known associations of the ectoparasites collected, the relative host specificities of the ectoparasites are shown in Table II. Two mites, five lice and two fleas are primarily restricted to pocket gophers. Four mites, three ticks and a flea occur on pocket gophers but are known to be general rodent parasites. Three of the mites are considered to be non-parasitic and their occurrence on pocket gophers may have been accidental.

A close correlation was found between adult louse and flea population sizes and the body weights of their hosts, possibly indicating close host-parasite associations (Ward, 1957b). The product-moment correlation coefficients for these relationships are shown in Table III. The correlation coefficient r was computed as explained by Ward (1957b), using the formula:

$$r = \frac{\Sigma xy - \bar{x}\Sigma y}{\sqrt{(\Sigma x^2 - \bar{x}\Sigma x)(\Sigma y^2 - \bar{y}\Sigma y)}}$$

The higher correlation between lice and their hosts than between fleas and their hosts may be attributed to a closer parasitic relationship between the former.

TABLE III.—Product-moment correlations between host body weights and adult population sizes of lice and fleas

Host species	Mallophaga		Siphonaptera	
	n	r	n	r
T. bottae	22	0.78	22	0.69
T. talpoides	56	0.60	79	0.59
G. bursarius	12	0.77	12	0.57
C. castanops	6	0.95	6	0.76

DISCUSSION

Various degrees of host-specificity are shown in the ectoparasite fauna of pocket gophers. None of the ectoparasites collected during this study is restricted throughout its range to a single host species, although four species of lice were confined to single hosts during this study. The flea, *Dactylopsylla percernis,* was only collected from *C. castanops,* but is known also from *T. talpoides* and *T. bottae* and the senior author has observed it on other species in Colorado. The fact that it was only recorded on *C. castanops* during this study is probably due to its general scarcity and the short period of time covered by the collections. Thus two mites, five lice and two fleas are primarily restricted to the Geomyidae, but none is restricted to a single species of pocket gopher.

Most of the general rodent parasites were relatively scarce on pocket gophers and occurred on only one or two host species. This was not the case, however, with the mite, *Haemogamasus ambulans,* or the tick, *Ixodes sculptus.* The genus *Haemogamasus* is restricted to burrowing rodents and insectivores, but little is known of the species *H. ambulans.* During this study it was abundant on *T. talpoides* and occurred also on *T. bottae* and *C. castanops. Ixodes sculptus,* a common parasite of ground squirrels, was relatively abundant on *T. bottae* and *T. talpoides* and was also found on *G. bursarius.* In view of their relative abundance on pocket gophers and their host associations during this study, both of these species should probably be considered as common ectoparasites of pocket gophers, even though not primarily restricted to pocket gophers.

Ectoparasite populations would appear to provide excellent material for an evaluation of the role of interspecific competition in animal communities. A fairly wide variety of species is available to the ectoparasite community, the environment is more or less uniform, and the necessary conditions for competition are often present. The evaluation of competition between species has largely been focused upon closely related species of the same genus which might tend to displace one another with respect to a particular ecological niche. Of the fourteen genera of ectoparasite recorded by Jameson (1950) from *Blarina brevicauda,* none was monotypic although six were represented locally by only one species. It was theoretically possible

for the remaining eight genera to have more than one species per genus parasitic on the short-tailed shrews of Jameson's study. However, Jameson (*op. cit.*) concluded that the species within a given family differ in occurrence or in habits, and that they compete on only a limited scale or not at all. In a study of the fleas parasitic on *Apodemus sylvaticus* and *Clethrionomys glareolus,* Evans and Freeman (1950) found as many as four species of flea on an individual host. *Ctenophthalmus agyrtes* and *Malaraeus penicilliger* occurred in sufficient numbers for their associations to be analyzed and were considered to be potential competitors. They showed a strong negative association on *Apodemus* and a moderate positive association on *Clethrionomys.* The authors concluded that the somewhat longer and coarser fur on *Clethrionomys* allowed these two species of flea to live side by side on that host and to avoid the direct competition that might occur on *Apodemus.* When two closely related species are found together on the same host it is often assumed, as in this study by Evans and Freeman (1950), that they occupy different niches and that competition is thus alleviated. Lice have been shown to occupy different ecological niches on birds (Hopkins, 1949; Ward, 1957b), but direct evidence for mammals is lacking. Multiple infestations of lice are common among hyraxes, for example, but it has not been shown that the different genera and species found on these animals prefer different parts of the body.

In the present study only ticks and lice were represented by more than one species of the same genus on a single host. The tick, *Ixodes kingi,* occurred with *l. sculptus* or not at all; although *l. sculptus,* the more abundant of the two, was frequently present when *l. kingi* was absent. There was no apparent tendency for the two species to exclude each other, nor was there any evidence that they occupied different parts of the host.

The lice *Geomydoecus thomyus* and *G. chapini* occurred together on 52.2 per cent of the 92 specimens of *Thomomys talpoides* examined. *G. californicus* and *G. minor* occurred together on 82.7 per cent of the 51 specimens of *T. bottae* examined. The fact that these ectoparasites were not mutually exclusive was also demonstrated by correlations between the numbers of each on a single host individual. The correlation between the numbers of *G. thomomyus* and *G. chapini* on individual *T. talpoides* was 0.46 ($P = .001$). The corresponding correlation for *G. californicus* and *G. minor* on *T. bottae* was 0.63 ($P = .001$). If the members of these species pairs tended to exclude one another, one would expect negative correlations.

The data presented in this study are incomplete with respect to a number of important variables. They are based on collections in selected areas during only one season, and an extended study would show seasonal differences in abundance and distribution of the parasite species, would probably increase the list of ectoparasites known to occur on pocket gophers in Colorado, and might reduce the degree of host specificity shown locally by some species. The extent to which

these data apply to the question of interspecific competition, or lack of it, between closely related species would not be much affected however. There is no doubt that these species exhibit seasonal differences in abundance and have differences in habits — this much can be assumed, *a priori,* from the fact that they are different species. Nevertheless, when an opportunity for competition exists, there is no evidence to show that they exclude each other, or that they occupy niches which are different enough to preclude competition between them.

SUMMARY

A study was made of the ectoparasites of the four species of pocket gopher that occur in Colorado.

Of the ectoparasites collected, two mites, five lice and two fleas are primarily restricted to pocket gophers; four mites, three ticks and one flea are general rodent parasites; and three mites are non-parasitic and may have been accidentals.

Most of the general rodent parasites occurred in small numbers on only one or two host species; but the abundance and host associations of the mite, *Haemogamasus ambulans,* and the tick, *Ixodes sculptus,* suggest that they are common pocket gopher parasites.

Four species of lice were the only ectoparasites that were host-specific, although each of the lice has also been recorded from other hosts in other parts of its range.

There were two examples among the lice and one among the ticks of closely related species of the same genus occurring on the same host. The data showed that these species pairs were not mutually exclusive and there was no evidence that they occupied different ecological niches.

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