OCCASIONAL PAPERS
THE MUSEUM
TEXAS TECH UNIVERSITY

NUMBER 56 3 NOVEMBER 1978

CIRCULATION OF HELMINTH SPECIES IN A RODENT POPULATION FROM THE HIGH PLAINS OF TEXAS

GEORGE W. RODENBERG AND DANNY B. PENCE

Studies on the helminth fauna of the hispid cotton rat, *Sigmodon hispidus* Say and Ord, from xeric and mesic localities in West Texas (Mollhagen, 1978) and from fresh-water and salt-marsh environments in Florida (Kinsella, 1974) suggest that this host's habitat exerts a considerable influence on the nature and extent of its parasitism by helminths. There also is an indication of considerable variation in the helminth fauna of cotton rats from different geographic regions in North America. However, the above studies did not consider the possible exchange of helminths between cotton rats and other rodent species sharing a particular habitat, a factor that could account for at least part of the variance in helminth faunas from the same host collected in different habitats. Because some overlap in helminth faunas has been reported from various rodents (Harkema, 1936; Doran, 1954*a*, 1954*b*, 1955*a*, 1955*b*), a degree of circulation of helminth species is indicated among different rodents within a particular habitat. Host specificity could also affect the circulation of helminths among various hosts. The present study was initiated to determine the extent of exchange of helminth species between *S. hispidus* and other rodents from one habitat on the High Plains of Texas.

STUDY AREA

Texas Tech University farm, Lubbock County, Texas (one of the xeric areas used by Mollhagen, 1978) was selected as the study area

because easy access and proximity to the laboratory permitted trapping on a daily basis. This site, on the campus of Texas Tech University, consists of approximately one-half section (320 A) of short-grass prairie with second growth honey mesquite, *Prosopis glandulosa*; the area also has been invaded by *Yucca constricta* and various Cactaceae, especially *Opuntia* sp. The habitat has not been grazed for the past three years and was never under cultivation. Predominant rodent species include the hispid cotton rat *Sigmodon hispidus*, thirteen-lined ground squirrel *Spermophilus tridecemlineatus*, house mouse *Mus musculus*, and black-tailed prairie dog *Cynomys ludovicianus*. There are smaller numbers of the deer mouse *Peromyscus maniculatus*, desert cottontail *Sylvilagus audubonii*, and black-tailed jackrabbit *Lepus californicus* as well as feral housecats and dogs. The locality is xeric, with less than 50 centimeters of rainfall per year.

Materials and Methods

Rodents and lagomorphs were trapped from June through August 1977. A small sample of *Sylvilagus audubonii* was included because they frequent prairie dog burrows. Trapping activities were conducted during the warmer months because rodent populations reach their peak reproductive and population levels during this time. Furthermore, ground squirrels and prairie dogs hibernate during the cooler months of the year and otherwise could not have been included in the study.

Animals were transported to the laboratory, killed, and frozen for later necropsy. Nematodes were fixed briefly in glacial acetic acid, stored in a mixture of 70 per cent ethyl alcohol with 5 per cent glycerine by volume, and examined in glycerine wet-mounts after evaporation of the alcohol. Cestodes, trematodes, and acanthocephalans were fixed in AFA and stored in 70 per cent ethyl alcohol. Cestodes and acanthocephalans were stained in Celestine blue B. Trematodes were stained in Semicohn's acetic carmine. These helminths were mounted in Canada balsam.

Faunal diversity was determined by means of Simpson's index (Holmes and Podesta, 1968) and the number of species per sample. An index of similarity comparing helminth faunas among rodent species was calculated according to the methods of Holmes and Podesta (1968), and computations for species overlap indices (Jaccard's coefficients) followed the methods of Neraasen and Holmes (1975). Chi-square analysis of 2×2 contingency tables (Sokal and

TABLE 1.—*Age and sex of predominant rodent and lagomorph species collected in Lubbock County, Texas.*

Host species	♂	♀	Adult	Juvenile
Sigmodon hispidus	19	21	31	9
Spermophilus tridecemlineatus	17	14	23	8
Mus musculus	15	10	15	10
Cynomys ludovicianus	8	7	12	3
Peromyscus maniculatus	4	2	6	0
Sylvilagus audubonii	3	4	4	3

Rohlf, 1969) was used to compare the significance ($P<0.05$) of larval versus adult occurrence of *Mastiphorus muris* in various hosts. Sorenson's similarity index (Greig-Smith, 1964) was used to assess seasonal influence on the helminth fauna of cotton rats by comparing animals taken in warm (this study) and cool months (data from Mollhagen, 1978).

RESULTS

Animals collected were *Sigmodon hispidus* (40 specimens), *Spermophilus tridecemlineatus* (31), *Mus musculus* (25), *Cynomys ludovicianus* (15), *Peromyscus maniculatus* (6), and *Sylvilagus audubonii* (5). Although sample size for the last two species is small, these were included in the following ecological analysis because of their possible contributions to circulation of species within the helminth community. Age and sex characteristics of the above hosts are listed in Table 1.

Seven nematode, six cestode, one trematode, and one acanthocephalan species were collected (Table 2). Of the 15 helminth species recovered, seven were in *S. hispidus*, six in *S. tridecemlineatus*, three in *M. musculus*, one in *C. ludovicianus*, one in *P. maniculatus*, and four in *S. audubonii*. Larvae of *Trichostrongylus* recovered from ground squirrels and desert cottontails were morphologically identical and regarded as the same species; larvae of this species were differentiated easily by caudal structures and spicules from those of *T. texanus* found in prairie dogs.

For comparative purposes, specimens of *Mastiphorus muris* were recorded as adults or larvae. Both stages occurred in cotton rats, ground squirrels, and house mice. However, in terms of frequency of occurrence, reproductively mature worms were found most commonly in cotton rats (38 per cent) and much less frequently in ground

TABLE 2.—*Helminths of rodents and lagomorphs from Lubbock County, Texas. Symbols are C, cecum; I, intestine; L, liver; S, stomach.*

Helminth	N	Per cent infested	Intensity Range	Intensity Mean
Sigmodon hispidus				
Mastiphorus muris (Gmelin, 1790) Chitwood, 1938 adults (S)	15	38	1-22	4
M. muris larvae (S)	5	13	1-151	32
Syphacia sigmodontis Quinton and Kinsella, 1972 (C)	3	8	10-86	58
Plagiorchis muris Tanaka, 1922 (I)	1	3	7	7
Taenia taeniaeformis (Batschi, 1786) Wolffugel, 1863 (L)	2	5	1	1
Raillietina bakeri Chandler, 1942 (I)	24	60	1-41	8
Hymenolepis diminuta Rudolphii, 1819 (I)	5	13	1-7	4
Monoecocestus sigmodontis Chandler and Suttles, 1922 (I)	1	3	2	2
Simpson's index = 0.32				
Spermophilus tridecemlineatus				
Mastiphorus muris adults (S)	2	6	1-14	8
M. muris larvae (S)	17	55	1-65	9
Syphacia sp. larvae (C)	1	3	1	1
Trichostrongylus calcaratus Ransom, 1911 larvae (I)	4	13	1-3	2
Hymenolepis diminuta (I)	3	10	3-7	5
Raillietina bakeri (I)	2	7	1-6	4
Moniliformis clarki (Ward, 1917) Van Cleave, 1924 (I)	6	20	1-8	3
Simpson's index = 0.35				
Mus musculus				
Mastiphorus muris adults (S)	1	4	1	1
M. muris larvae (S)	4	16	1-2	2
Hymenolepis diminuta (I)	2	8	1-5	3
Choanotaenia peromysci (Erickson, 1938) Hansen, 1950 (I)	1	4	20	20
Simpson's index = 0.47				
Cynomys ludovicianus				
Trichostrongylus texanus Dikmans, 1937 (I)	9	60	4-68	24
Simpson's index = 1.00				
Peromyscus maniculatus				
Syphacia sp. larvae (C)	1	17	5	5
Simpson's index = 1.00				

TABLE 2.—*Continued.*

Sylvilagus audubonii				
Trichostrongylus calcaratus (I)	1	20	4	4
T. calcaratus larvae and adults (I)	2	40	4-35	20
Dermatoxys veligera (Rudolphii, 1819) Schneider, 1866 (C)	2	40	5-22	14
Passalurus ambiguus (Rudolphii, 1819) Dujardin, 1845 (C)	1	20	60	60
Raillietina loeweni Bartel and Hensen, 1964 (I)	5	100	2-31	13
Simpson's index = 0.32				

squirrels (7 per cent) and house mice (4 per cent). Conversely, larvae of *M. muris* were most prevalent in ground squirrels (55 per cent) and less frequently unencountered in house mice (16 per cent) and cotton rats (13 per cent). Chi-square analysis revealed a highly significant difference ($P<0.005$) between the presence of adults and larvae in cotton rats and ground squirrels.

Cotton rats and ground squirrels had nine species of helminths, three of which were shared: *Mastiphorus muris*, *Hymenolepis diminuta*, and *Raillietina bakeri*. The house mouse had three species of helminths, of which two (*M. muris* and *H. diminuta*) were shared with cotton rats and ground squirrels. Desert cottontails contained four helminth species, one of which, *Trichostrongylus calcaratus* (larvae), was shared with ground squirrels. Prairie dogs and deer mice each were infested by one helminth species. *Syphacia* sp. larvae from deer mice and ground squirrels were very similar but differed distinctly from the larvae of S. *sigmodontis* found in cotton rats.

Both *Peromyscus maniculatus* and *Cynomys ludovicianus* harbored a single helminth species and consequently showed no faunal diversity (Simpson's index = 1.00). Simpson's index was low (<0.50) for the helminth faunas of the remaining hosts species, indicating an equability of dispersion (lack of dominance) of helminth species (Table 2).

Indices of species overlap (Jaccard's coefficients) and similarity were calculated and arranged in a trellis diagram (Fig. 1). The similarity index used herein measures the proportion of total worms that are of the same species in two samples (based on a pair-wise comparison of host species). Jaccard's coefficients, measure the proportion of species shared out of the total present in the two

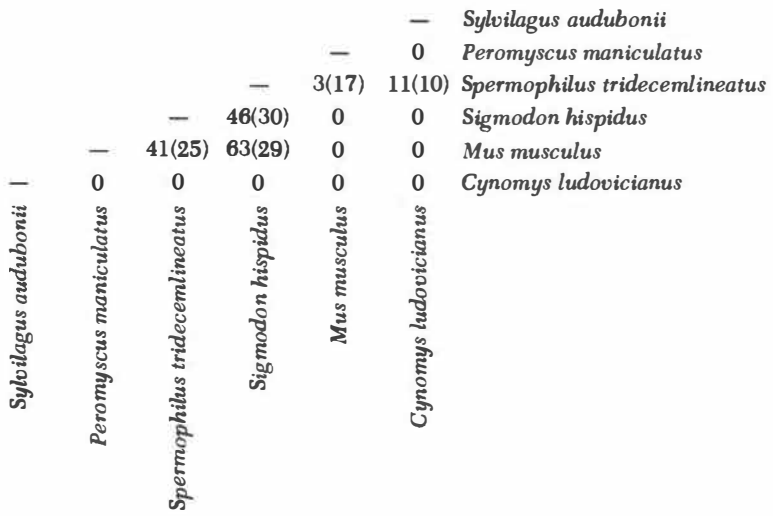

FIG. 1—Trellis diagram of similarity indices between helminth faunas of rodent and lagomorph species in Lubbock, Texas. Jaccard's coefficients of species overlap, when different from the similarity index, are given in parentheses.

samples. These values give objective estimates of the similarity and overlap of the helminth faunas from different species of rodents.

The greatest similarity of helminth faunas was between the ground squirrel and house mouse, but noteworthy similarity also existed between cotton rats and house mice and between cotton rats and ground squirrels. Helminths common to all three hosts are *M. muris* and *H. diminuta*; *Raillietina bakeri* was found in only cotton rats and ground squirrels. Jaccard's coefficients indicated a moderate degree of overlap in composition of the helminth faunas among these three host species. There was a basic dissimilarity and no overlap between the helminth faunas of these three host species and that of prairie dogs, deer mice, and desert cottontails.

Sorenson's similarity index was 72 and indicated some seasonal variation in helminth faunas of cotton rats taken in winter and summer. Chi-square analyses on frequency of occurrence (per cent of hosts infested) of helminth species recovered in winter as opposed to summer indicated significant differences of $P<0.005$ in three species and $P<0.010$ in one. *Raillietina bakeri* occurred more frequently in summer whereas *T. taeniaeformis*, *M. muris*, and S. *sigmodontis* were most abundant in winter.

Discussion

There is some similarity and a moderate degree of overlap between helminth faunas of cotton rats, house mice, and ground squirrels examined from one locality on the High Plains of Texas. At least three common helminth species are shared among two or more of these hosts. The cestodes, *R. bakeri* and *H. diminuta*, reach reproductive maturity in these hosts, which apparently serve as reservoirs. Even though *M. muris* was recovered from all three hosts, it appears that *Sigmodon hispidus* is the principal reservoir and disseminator of this parasite, based on frequency of occurrence of larvae or reproductively immature adults versus reproductively mature worms. For example, although ground squirrels frequently harbored this species, few contained reproductively mature adult worms (7 per cent) and then only in small numbers ($\bar{X}=8$).

Analysis of the helminth fauna of different rodent species in terms of host ecology presents some interesting speculations. Each of the rodent species examined occupies a niche within the habitat, but habitat preferences obviously overlap. The degree of niche overlap is reflected in the number of shared helminth parasites. For example, of the species we examined, cotton rats, ground squirrels, and house mice were the most ecologically similar, all being surface-foraging burrow-frequenting rodents; they shared the greatest number of helminth species. Undoubtedly, the abundance of insects in the diets of these three aforementioned hosts contributes to the common occurrence of helminths such as *M. muris*, *R. bakeri*, and *H. diminuta*. The latter two helminths commonly occur as reproductively mature individuals in both cotton rats and ground squirrels, but *M. muris* is apparently more host specific for cotton rats. Although ground squirrels contact the source of infection frequently (judging from the high frequency of larval stages observed), the worms rarely mature in this host. Thus, repeated exposure to a helminth species does not necessarily imply high levels of patent infestations in a particular host, if host specificity is involved.

When attempting to relate habitat influences on helminth parasitism of a particular host species, circulation of helminths among ecologically related host species in the habitat could be an important factor. Cotton rats from our study area on the High Plains of Texas appear to be the principal reservoir for *M. muris* and the only host for *Syphacia sigmodontis*, *Taenia taeniaeformis*, and *Monoecocestus sigmodontis*. Of the six helminth species found in ground squirrels, only *Moniliformis clarki* was specific to this host. Similarly,

Choanotaenia peromysci was recovered only in the house mouse, but this species has been reported previously from deer mice in other localities (Doran, 1955*b*). Of the remaining hosts examined from this locality, prairie dogs, deer mice, and desert cottontails possessed distinct helminth faunas. Prairie dogs, which were relatively common in the study area, were parasitized by only one helminth species that was not shared with other rodents. The deer mice were uncommon in occurrence and largely free of parasites. Desert cottontails had a helminth fauna distinct from that of rodents and shared only *T. calcaratus* (larval stages) with ground squirrels. Helminths recovered from the desert cottontail in this study have been reported also from black-tailed jackrabbits (Hansen *et al.*, 1965). The latter species inhabits the study area but was not collected as it did not appear to make extensive use of prairie dog burrows for shelter.

Neraasen and Holmes (1975), in a study of circulation of cestodes among three species of geese on the Anderson River delta, Canada, found that the relative abundance of host species, degree of contact between host groups, and degree of host specificity of a particular species of helminth are involved in determining the nature and degree of circulation among hosts. These factors are likewise of importance in the exchange of helminth species among rodent hosts on the High Plains of Texas. There is a greater degree of circulation of helminths among the three most frequently encountered rodent species that have overlaping niches within this habitat.

Seasonality appears to exert a strong influence on the nature and frequency of occurrence of helminths in the rodents examined in this study. Cotton rats collected during the warmer months of the year had a more diverse helminth fauna than did animals collected in winter. Additionally, there was a significant difference in per cent of hosts infected for helminth species found in both winter and summer. This variation probably resulted from diminished sources of infection (arthropod intermediate hosts), decreased circulation of helminth species because of loss of reservoir hosts (hibernation of ground squirrels in winter), and changes in host population dynamics (fewer immunologically tolerant young and juvenile animals in winter). Thus, observed seasonal variation in helminth faunas indicates the importance of examining hosts collected throughout the year in order to obtain a reasonable estimate of the nature and extent of helminth parasitism. However, in many instances this is not possible because of the migratory or hibernating behavior of certain host species.

Helminths of public health and veterinary importance collected in this study include *H. diminuta*, *M. clarki*, and *Plagiorchis muris*. These three species are reported occasionally from humans (Faust, 1970). Cotton rats are the principal intermediate host for the strobilocerci of *T. taeniaeformis*, a parasite of domestic cats.

Acknowledgments

This study was supported in part by funds from the Graduate School, Texas Tech University and the Institute for Museum Research, The Museum of Texas Tech University.

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Addresses of authors: G. W. RODENBERG, *The Museum, Texas Tech University, Lubbock, 79409*; D. B. PENCE, *Department of Pathology, Division of Comparative Pathology, Texas Tech University Health Sciences Centers, and The Museum, Texas Tech University, Lubbock, 79409.* *Received 31 March, accepted 15 May 1978.*

ISSN 0149-175X

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TEXAS TECH UNIVERSITY

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