HELMINTH POPULATION DYNAMICS IN THE COTTON RAT, *SIGMODON HISPIDUS*[1]

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Helminths were collected from Sigmodon hispidus over a two-year period. One or more of five species of helminths were found in 88% of the 130 cotton rats studied. These were the cestodes, Raillietina bakeri, Hymenolepis diminuta, and larval Taenia taeniaeformis, and the nematodes Mastophorus muris ascaroides and Longistriata adunca. There was seasonal variation in number of worms, number of species and number of hosts infected. Intensity was greatest in fall and lightest in the winter. Extent of infestation was greatest in winter-spring and lightest in summer. Ninety-two per cent of male and 84% of female rats were infected. Male rats harbored more worms of each species over the collection period, and more at each season of the year, than did females. The average number of worms was only slightly greater in males in the winter, but two to four times greater than females other seasons of the year.

Small cotton rats had the same number of parasite species as large cotton rats. The average number of worms was greater in large cotton rats, except for the nematode, L. adunca.

No significant differences were seen in number or kind of parasites found in pregnant cotton rats.

Parasites of the cotton rat are well known. Apparently, this is because the rat is abundant in the southern United States, is easily captured, is an important laboratory animal (1), and serves as an experimental animal in the study of echinococcosis (2), filariasis (3), schistosomiasis (4), and trypanosomiasis (5).

Baylis (6) published a list of helminths from this host, while Harkema and Kartman (7) made a study of helminths and ectoparasites from cotton rats from Georgia and central North Carolina. Helminths have been identified in cotton rats from Texas (8, 9, 10), Florida (11, 12), Oklahoma (13), and Georgia (14, 15). Protozoan parasites have been recovered from this host in Florida (16), Central America (17), Georgia (18), and Alabama (19).

This study is the first extensive survey of cotton rat helminth parasites conducted in North Carolina in 25 years and to our knowledge, the first in the coastal area.

The host animal is considered to be *S. hispidus komareki* on the basis of geographical location (20).

MATERIALS AND METHODS

S. hispidus were collected from June, 1970 through May, 1971, and from December, 1971 through March, 1972. Twenty-five live traps (Sherman, SN-40) were set and checked each morning until ten rats were collected for that month. In some months the 750 trap days did not yield ten animals.

The collection site was undeveloped acreage inside the city limits in southwest Greenville, Pitt County, North Carolina. It was a triangular old field plot of about 20 hectares in size.

The animals were chloroformed in the traps in the laboratory. They were measured (snout-vent) and immediately dissected. Standard procedures were used in collecting, fixing, storing, mounting and identifying the worms. The identification of a larval cestode (strobilocercus type) was supported by the successful infection of a laboratory cat and subsequent recovery of the adult worm.

RESULTS

Cotton rats, *S. hispidus*, were captured each month of the year although collections were small in April and May (Table 1). No males were taken in October. Cotton rat population density is known to exhibit an

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TABLE 1. *Total number of parasites from Sigmodon hispidus by sex of host for each month of the year*

Parasite	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Examined	3	9	8	7	6	3	1	2	1	1	5	5	8	5	7	4	3	9	0	11	3	6	15	8	60	70
Infected	3	8	8	6	6	3	1	2	1	0	3	4	6	2	7	4	3	8	0	9	3	5	14	8	55	59
Raillietina baheri	11	29	14	17	29	8	0	6	7	0	32	32	69	18	83	41	98	56	0	54	7	14	45	47	429	322
Hymenolepis diminuta	0	0	5	0	0	0	0	0	0	0	0	0	0	0	9	0	0	0	0	2	0	0	0	0	14	2
Taenia taeniaeformis	4	12	35	5	49	4	0	3	4	0	10	4	1	1	0	0	2	0	0	1	7	1	30	7	142	38
Mastophorus muris ascaroides	12	40	7	3	16	12	1	0	0	0	11	22	41	1	112	10	72	35	0	27	25	25	34	47	331	222
Longistriata adunca	10	40	125	25	100	0	0	15	0	0	0	1	0	0	10	0	100	5	0	110	0	30	115	77	460	303
Total	37	121	186	50	194	24	1	24	11	0	53	59	111	20	214	51	272	96	0	194	39	70	224	178	1342	887

TABLE 2. *Total number and sex of Sigmodon hispidus infected with parasites for each month of the year*

Parasite	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec		Total	
	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F
Examined	3	9	8	7	6	3	1	2	1	1	5	5	8	5	7	4	3	9	0	11	3	6	15	8	60	70
Infected	3	8	8	6	6	3	1	2	1	0	3	4	6	2	7	4	3	8	0	9	3	5	14	8	55	59
Raillietina baheri	2	5	2	3	3	2	0	2	1	1	2	4	5	2	5	2	2	7	0	6	1	3	12	4	35	41
Hymenolepis diminuta	0	0	2	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	2	0	0	0	0	3	2
Taenia taeniaeformis	3	4	7	3	5	3	0	2	1	0	2	2	1	1	0	0	1	0	0	1	1	1	2	3	23	20
Mastophorus muris ascaroides	3	5	4	1	2	1	1	0	0	1	3	2	4	1	7	4	1	3	0	5	2	2	7	4	34	29
Longistriata adunca	1	5	4	0	3	0	1	1	0	0	0	1	0	0	2	1	2	1	0	4	0	2	4	3	17	18

annual cycle with the lowest numbers in spring (21).

Of 130 *S. bispidus* examined, 88% were infected with one or more of five species of helminths (Table 1). Multiple infections were common (Table 2). Among 60 males and 70 females, 55 males (92%) and 59 females (84%) were infected.

There was seasonal variation in number of worms, number of worm species and number of infected hosts (Tables 1, 2). Intensity was greatest in the fall (September-October-November) and least in the winter (December-January-February). Five worm species were encountered in fall-winter and four species were recovered in spring-summer. The average number of worms per host was 17, 18, 20, and 24 in winter, spring, summer, and fall, respectively.

The seasonal extent of these infections did not follow the pattern of seasonal intensity (Tables 1, 2). The number of hosts infected was fewest in the summer (76%), higher in fall (88%) and greatest in winter-spring (94% and 93% respectively).

Male cotton rats harbored more worms of each species over the collection period, and more at each season of the year, than did females (Table 1). The average number of worms in each sex was only slightly greater in males in the winter, but ranged between 1.8 and 3.7 times the number in females through the other seasons of the year. A greater number of male hosts were infected with three of the five species (Table 2).

Raillietina bakeri Chandler was the most commonly occurring parasite. It was recovered each month of the year (Table 1). There was a single seasonal peak in numbers of this worm in the fall. Male rats were more heavily infected, but more female hosts than males harbored this worm (Table 2).

Longistriata adunca Chandler was the second most abundant parasite found (Table 1). It appeared there was a sharp increase in numbers to a single seasonal peak in the fall. Very few *L. adunca* were found in spring and summer. Male hosts were more heavily infected than females, and an equal number of male and female hosts were carrying this species (Table 2).

The nematode, *Mastophorus muris ascaroides* (Chitwood), was found during each month of the year except in May when only two rats were captured (Table 1). There was a single seasonal peak of occurrence in male hosts in the fall that declined by winter. Female hosts were not infected as heavily as males. More male than female rats were infected with this worm (Table 2).

Hymenolepis diminuta (Rudolphi), a cosmopolitan parasite of rodents, appeared infrequently and in small numbers (Table 1). Only 16 of these worms were recovered from five hosts. The greatest number was in male hosts.

Taenia taeniaeformis (Batsch) strobilocerci were found in the livers of hosts during all months except August (Table 1), Greatest numbers were found in March after which they declined to low numbers from July through October. More worms were found in male hosts than female (Table 1), and more males were infected (Table 2). To confirm the identification, pieces of liver containing cysts were fed to laboratory cats. One cat received 36 cysts over a three-month period between October and December, 1971. No parasites were recovered. A second cat was fed one cyst on January 5, 1972, and five cysts on February 12. Five adult *T. taeniaeformis* were recovered from this cat on March 17, 1972.

In an attempt to determine the effects of host age on parasite populations in the cotton rat, data were analysed by consideration of host size (Table 3). Each of the parasite species was represented in both small and large rats. Large rats harbored more worms and more worms of each species on the average except for the nematode, *L. adunca.*

A total of 9 of 70 female cotton rats (13%) were found to be carrying litters. There was no great difference in worm burden between pregnant and non-pregnant female cotton rats (Table 4). However, no pregnant females were infected with *L. adunca,* and the worm burdens of the other females was reduced during the time of breeding activity.

TABLE 3. *The relationship of host size to number and species of parasites from Sigmodon hispidus*

Parasite	Host Size					
	8-10 cm			13-15 cm		
	No. Hosts	No. Worms	Ave. Load	No. Hosts	No. Worms	Ave. Load
Raillietina bakeri *Hymenolepis*	15	107	7.1	29	304	10.5
diminuta *Taenia*	2	2	1.0	2	8	4.0
taeniaeformis *Mastophorus*	11	21	1.9	14	97	6.9
muris ascaroides *Longistriata*	15	77	5.1	19	193	10.2
adunca	10	188	18.8	8	131	15.4
TOTAL	33	395	12.6	30	733	24.4

TABLE 4. *The relationship of pregnancy to number and species of parasites from female Sigmodon hispidus*

	Non-Pregnant			Pregnant		
	No. Hosts	No. Worms	Ave. Load	No. Hosts	No. Worms	Ave. Load
Raillietina bakeri	34	263	7.7	5	51	10.2
Hymenolepis diminuta	2	6	3.0	-	--	--
Taenia taeniaeformis	19	27	1.4	3	7	2.3
Mastophorus muris ascaroides	26	195	7.5	2	27	13.5
Longistriata adunca	16	257	16.0	--	--	--
TOTAL	50	748	15.0	9	85	9.4

DISCUSSION

It has been established that certain parasites show seasonal variation. Although dealing mainly with fish parasites, Russian investigators have established principles concerning the relationship of parasitic fauna to the host's life history, ecology, physiology, and behavior (22, 23). These basic ideas were discussed by Kennedy (24).

While much is known about the helminths of cotton rats, their seasonal occurrences are not well studied. Layne (11) studied the seasonal occurrence of the nematode, *Capillaria hepatica*, in three species of rodents of Florida, one of which was *S. bispidus*. Harkema and Kartman (7) showed seasonal data in their study of North Carolina and Georgia cotton rat helminths and ectoparasites. Layne (11) found that *C. hepatica* infections were highest in April and low through the winter in *S. bispidus*. While C. *hepatica* was not recovered from North Carolina cotton rats, April was a month of low incidence of helminths (Table 1). Layne's study is difficult to evaluate since data were not accumulated for each month of the year.

Two fewer species of helminths were found in coastal North Carolina cotton rats, and none that had been found in those of the piedmont (7). The data for helminths found in both studies compare favorably but have many specific differences. A greater percenttage of coastal cotton rats were infected with *R. bakeri* and about an equal percentage with *M. muris ascaroides*. The other three species were found in more

piedmont hosts. The incidence of helminth species was similar only for *R. bakeri* and *T. taeniaeformis* larva. The average numbers of the nematodes and *H. diminuta* per host were five to six times greater in piedmont hosts.

Only *H. diminuta, T. taeniaeformis* larvae and *L. adunca* showed significant differences in seasonal infection in the piedmont (7). On the coast, the extent of infection by *R. bakeri* was similar throughout the year (60%), but the intensity in summer and fall was 2 times greater than spring and winter. *Hymenolepis diminuta* was not recovered during the spring on the coast. It was found only in male hosts in summer and winter, the female hosts in the fall. The larval *T. taeniaeformis* showed lower extensities and intensities in coastal hosts during summer and fall than in winter-spring. The intensities of *M. muris ascaroides* increased from spring through fall on the coast, while the extensity was greatest in summer. The intensity and extensity of *L. adunca* changed appreciably downward only during the summer in coastal hosts.

Among the adult parasites found only *L. adunca* has no intermediate host. Eggs hatch from feces putting the larvae in proximity to the same or another cotton rat. The other species increase their intensities and extensities from spring through fall, which relates, presumably, to an increased number of intermediate hosts during this time of the year.

Taenia taeniaeformis is a larval parasite of the cotton rat. The recruitment period for coastal rats appears to be fall. The greatest intensity and extensity is in the spring. The cat is the definitive host of *T. taeniaeformis*. Eggs are passed in the feces and picked up by the cotton rat in its foraging for food. The onchosphere penetrates the intestine and goes via the bloodstream to the liver, usually appearing within 96 hours. Cysts start to form about day 7, the scolex by day 14, and the strobila around day 48 (25). The lack of success in establishing infections in cats with *T. taeniaeformis* larvae recovered from rats from October through January would seem to indicate that they were not mature and infective before February. Hutchison (26) showed that larvae had to undergo a minimum period of 60 days in the laboratory mouse before becoming infective, so cotton rats at the Greenville site apparently did not acquire this infection before late fall. Since cotton rat populations are low during the spring, it may extend into summer the period before which many cats may pick up the infection. Hutchison (27) reported that the adult worm sheds gravid proglottids between 36-42 days after infection of the cat, so this would seem to make eggs available for cotton rats at the proper time in late fall, when host population densities are high, to complete the life history as indicated by the collection data. An age resistance to infection has been established for laboratory mice (26), so perhaps only rats born in the summer are susceptible to infection.

An attempt was made to group the host animals into age classes to observe the effect of host age on parasite load and parasite-mix. Some workers have used weight as an index of age (28, 11), but Dunaway and Kaye (29) showed that weight is not necessarily indicative of age. We used host body length (snout-vent) as an age index. This measurement is probably not satisfactory. Most animals fell within a narrow range (12-14 cm), although the total range was from 6 to 16 cm. It *was* observed that longer rats had more parasites than shorter rats (Table 3). Cotton rats of low weight have been shown to have the lowest incidence of helminths (7).

Since cotton rats seldom live more than six months in the wild (21) their parasite-mix is representative of only a relatively short-term situation. All species were represented in both the large and the small rats (Table 3). Large rats had more parasites of each species except for the nematode, *L. adunca* (Table 3).

While there is a large difference in parasite prevalence between male and female hosts in this study (Table 1), there appears to be no correlation between incidence and reproductive status of the female hosts (Table 4). Two species, *H. diminuta* and *L. adunca,* were not found in pregnant females. *Hymenolepis diminuta* was of low occurrence in all hosts. *L. adunca* was found in female hosts only during eight months of the year (Table 1). Each species that did occur in pregnant hosts showed a slightly greater prevalence than in non-pregnant females but the increase was not significant

(Table 4). Henry (14) reported similar data for Georgia cotton rats. The review by Schwabe and Kilejian (30) examined the potential role of host hormones on its flatworm parasites. The data are equivocal, but indicate host sex hormones have an effect on worm development and the establishment of some flatworm infections.

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