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# A COMPARISON OF PARASITIC HELMINTHS AND ARTHROPODS FROM TWO SUBSPECIES OF FOX SQUIRRELS (*SCIURUS NIGER*) IN FLORIDA

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ABSTRACT: The faunas of parasitic helminths and arthropods of 87 Sherman's fox squirrels (*Sciurus niger shermani*) and 32 Big Cypress fox squirrels (*Sciurus niger avicennia*) collected from Florida (USA) over a 6-yr period (1988 to 1993) were compared. One acanthocephalan, one cestode, nine nematodes, one flea, three sucking lice, three mites, one tick, and one dipteran larva were identified. *Citellinema bifurcatum* and *Physaloptera massino* were new records for Florida and *Gongylonema pulchrum*, *Neotrombicula whartoni*, and *Eushoengastia diversa* were new host records. Three core species of nematodes (distributed widely, highly host specific, and very prevalent) were identified from Sherman's fox squirrels. These included *Strongyloides robustus*, *Heligmodendrium hassalli*, and *C. bifurcatum*, which were higher in prevalence and intensity in Sherman's fox squirrels than in Big Cypress fox squirrels. One core species of cestode (*Raillietina bakeri*) was collected from 32% of Sherman's fox squirrels, but was not observed in Big Cypress fox squirrels. The number of species, prevalences, intensities, and abundances of parasites from Sherman's fox squirrels were greater than those from Big Cypress fox squirrels.

*Key words:* Fox squirrel, parasites, *Sciurus niger shermani*, *Sciurus niger avicennia*.

## INTRODUCTION

The fox squirrel (*Sciurus niger*) is the largest tree squirrel in the western hemisphere and the most vari-colored mammal in North America (Webster et al., 1985). Hall (1981) listed ten subspecies of fox squirrels, two of which are endemic to peninsular Florida (USA). The subspecies with the largest body size is the Sherman's fox squirrel (*S. niger shermani*), which is distributed throughout the mesic and xeric habitats of northern and central Florida (Kantola and Humphrey, 1990). The Big Cypress fox squirrel (*S. niger avicennia*) inhabits the Big Cypress swamp ecosystem of southwestern Florida (Humphrey and Jodice, 1992). The Florida Game and Fresh Water Fish Commission (GFC) lists the Sherman's fox squirrel (SFS) as a "species of special concern" and the Big Cypress fox squirrel (BCFS) as "threatened" (Wood, 1994). Both subspecies are being reviewed currently by the U.S. Fish and Wildlife Service for listing under the Endangered Species Act.

The parasites of many rodents from Florida have been studied, such as the gray squirrel (*Sciurus carolinensis*) (Conti et al., 1984; Wilson et al., 1991), the cotton rat (*Sigmodon hispidus*) (Kinsella, 1974), the rice rat (*Oryzomys palustris*) (Kinsella, 1988) and several species of *Peromyscus* (Forrester, 1992). However, with the exception of a limited survey by Moore (1957), little is known about the parasite fauna of fox squirrels in Florida. Our objective was to determine the internal and external parasite fauna of fox squirrels in Florida, the prevalences and intensities of these parasites, and to assess differences in the abundance and diversity of these parasites with regard to subspecies, sex, and season. In this study, we provide a baseline of information on parasitism in fox squirrels from Florida.

## MATERIALS AND METHODS

Eighty-seven SFS and 32 BCFS were collected from 26 counties in Florida from 1988 through 1993. Sherman's fox squirrels were collected between 30°35′N, 84°40′W and 30°35′N,

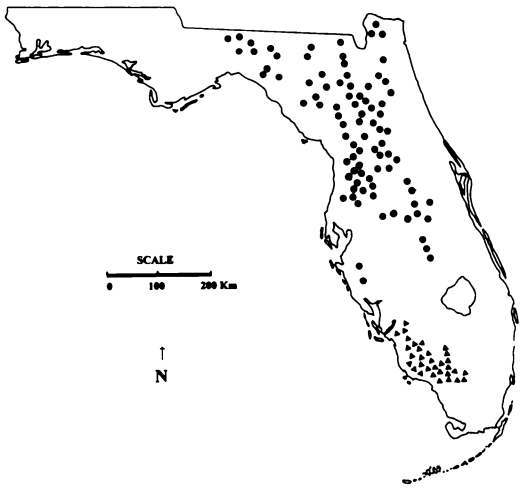


FIGURE 1. Collection sites for Sherman's fox squirrels (●, $n$ = 87) and Big Cypress fox squirrels (▲, $n$ = 32) from Florida, 1988 to 1993.

81°48′W in the north and 27°10′N, 82°28′W and 27°10′N, 80°40′W in the south (Fig. 1). Big Cypress fox squirrels were collected between 26°40′N, 81°30′W and 26°40′N, 81°00′W in the north and 25°55′N, 81°20′W and 25°45′N, 81°20′W in the south. Animals were collected by shotgun ($n$ = 33) and as road-kills ($n$ = 86). Taxidermists provided some of the carcasses collected by shotgun ($n$ = 27); in these cases the skins had been removed and hence the animals were examined for internal parasites only. Carcasses were frozen until examination.

Ectoparasites were collected by brushing the fur vigorously and removing attached specimens with forceps. Ectoparasites were preserved in 70% ethanol; they were prepared and identified by the techniques of Kim et al. (1986). Representative samples of lice were sent to the Institute of Arthropodology and Parasitology, Statesboro, Georgia (USA), for identification and retention as voucher specimens (Case numbers FS-88-01 through FS-93-02). Mite samples were sent to the National Veterinary Services Laboratory in Ames, Iowa (USA), for identification and retained as voucher specimens (Accession numbers 94-3446 through 94-3451). One larval bot fly was identified to genus (Sabrosky, 1986).

Helminths were collected and identified using techniques described by Conti et al. (1984). Voucher specimens of helminths were deposited in the U.S. National Parasite Collection, Beltsville, Maryland (Accession numbers USNPC 83421 through 83433). Ecological terms were used as defined by Margolis et al. (1982). Winter, spring, summer, and fall were designated as 21 December through 20 March, 21 March through 20 June, 21 June through 20 September, and 21 September through 20 December, respectively. The Statistical Analysis System (SAS Institute, Cary, North Carolina, USA) was used for data analysis. Chi-square analyses were used to compare prevalences between populations. Intensity data were analyzed by logistic regression using the analysis of variance program CATMOD. Levels of significance were set at $P \leq 0.05$.

## RESULTS

Eleven species of helminths were identified from 119 fox squirrels in Florida, including one acanthocephalan, one cestode, and nine nematodes (Table 1). Six (7%) SFS and 24 (75%) BCFS were free of parasitic helminths. The acanthocephalan *Moniliformis clarki* and the cestode *Raillietina bakeri* were collected from SFS only. Nine species of nematodes were identified from SFS and five from BCFS. The most prevalent nematodes collected from all fox squirrels were *Strongyloides robustus* (76%), *Heligmodendrium hassalli* (49%), and *Citellinema bifurcatum* (39%).

New state host records are reported for *H. hassalli, C. bifurcatum, Dipetalonema interstitium, Physaloptera massino, Syphacia thompsoni, Gongylonema pulchrum, Trichostrongylus calcaratus,* and *Bohmiella wilsoni.* The fox squirrel is recorded as a new host in North America for *G. pulchrum.*

Three nematodes occurred in SFS and BCFS most commonly. *Strongyloides robustus* was the most prevalent helminth in fox squirrels from Florida, comprising 62% of all helminths collected. Both prevalence and intensity were greater in SFS than in BCFS ($P < 0.02$), but there was no significant relation to season or host sex. *Heligmodendrium hassalli* was more prevalent and abundant in SFS than in BCFS ($P < 0.05$). Host sex and season of collection were not significantly related to its distribution in Florida; of the 6,122 helminths collected, *H. hassalli* made up 16%, with a total prevalence of 46 (39%) of 119 animals. *Citellinema bifurcatum* was collected from 34 SFS, but from only

TABLE 1. Prevalence, intensity, and abundance of helminths of Sherman's and Big Cypress fox squirrels from Florida, 1988 to 1993.

| Helminth | Sherman's fox squirrel $n = 87$ | | | | Big Cypress fox squirrel $n = 32$ | | | |
|---|---|---|---|---|---|---|---|---|
| | Prevalence (%) | Intensity | | Abundance | Prevalence (%) | Intensity | | Abundance |
| | | Mean | Range | | | Mean | Range | |
| Acanthocephala | | | | | | | | |
| *Moniliformis clarki* | 1 | 7 | 7 | <1 | 0 | 0 | — | 0 |
| Cestoda | | | | | | | | |
| *Raillietina bakeri* | 32 | 5 | 1–16 | 2 | 0 | 0 | — | 0 |
| Nematoda | | | | | | | | |
| *Strongyloides robustus* | 76 | 58 | 1–518 | 44 | 9 | 7 | 6–10 | <1 |
| *Heligmodendrium hassalli*[a] | 49 | 21 | 1–68 | 10 | 9 | 21 | 7–64 | 2 |
| *Citellinema bifurcatum*[a,b] | 39 | 34 | 1–177 | 13 | 3 | 33 | 33 | 1 |
| *Dipetalonema interstitium*[a,d] | 4 | 2 | 1–3 | <1 | 0 | 0 | — | 0 |
| *Physaloptera massino*[a,b] | 3 | 18 | 6–43 | <1 | 0 | 0 | — | 0 |
| *Syphacia thompsoni*[a] | 3 | 4 | 1–6 | <1 | 0 | 0 | — | 0 |
| *Gongylonema pulchrum*[a,c] | 2 | 2 | 2 | <1 | 0 | 0 | — | 0 |
| *Trichostrongylus calcaratus*[a] | 2 | 14 | 1–26 | <1 | 3 | 1 | 1 | <1 |
| *Bohmiella wilsoni*[a] | 1 | 3 | 3 | <1 | 3 | 3 | 3 | <1 |

[a] New host record in Florida.
[b] New Florida record.
[c] New host record in U.S.
[d] Taxidermy specimens could not be examined completely for this parasite.

one BCFS. Male fox squirrels, collected in the fall, had significantly higher intensities of *C. bifurcatum* than either male or female squirrels collected in all other seasons ($P < 0.01$).

Nine species of arthropods were identified (Table 2). The fox squirrel was recorded as a new host for the mites *Neotrombicula whartoni* and *Eushoengastia diversa*.

The squirrel flea (*Orchopeas howardi*) was the only arthropod with prevalences high enough to permit statistical analysis. Fleas were more prevalent ($P < 0.05$) and had significantly higher intensities of infestation ($P < 0.05$) on SFS than on BCFS. None of the 12 female SFS collected in the winter were infested, while all eight female SFS collected in the spring had fleas. No seasonal differences were observed on male animals with regard to flea prevalence, intensity, or abundance.

A larval bot fly was removed from the subcutaneous tissue of one live-trapped SFS. Attempts to rear it in the laboratory were unsuccessful, making identification beyond the genus *Cuterebra* impossible.

## DISCUSSION

Based on prevalence and abundance, there were four important helminths in the parasitic fauna of SFS and three in BCFS. Of the 6,122 helminths collected, *S. robustus, H. hassalli,* and *C. bifurcatum* were common to both subspecies and accounted for 96% of the total number of helminths.

*Strongyloides robustus,* a direct life cycle nematode, is also a common parasite of gray squirrels in Florida (Conti et al., 1984). Parker (1971) reported *S. robustus* to have pathological potential in gray squirrels by localizing at the pyloric sphincter, resulting in perforation of the duodenal mucosa and erosion of intestinal villi. Similar lesions may occur in fox squirrels, although this was not observed in our samples.

The distribution of *H. hassalli* in sciurids is widespread. Chandler (1942) report-

TABLE 2. Prevalence and range of intensity of parasitic arthropods on 54 Sherman's and 32 Big Cypress fox squirrels from Florida, 1988 to 1993.

| Ectoparasite | Sherman's | | Big Cypress | |
|---|---|---|---|---|
| | Prevalence | Intensity range[a] | Prevalence | Intensity range[a] |
| Siphonaptera | | | | |
| *Orchopeas howardi* | 57 | 1–23 | 16 | 1–14 |
| Anoplura | | | | |
| *Neohaematopinus sciurinus* | 13 | 4–26 | 7 | 6–22 |
| *Hoplopleura sciuricola* | 11 | 11–38 | 7 | 3–9 |
| *Enderleinellus longiceps* | 2 | 1 | 0 | — |
| Acari | | | | |
| *Androlaelaps casalis* | 11 | 2–56 | 3 | 1 |
| *Amblyomma americanum* | 7 | 1–4 | 0 | — |
| *Neotrombicula whartoni*[b,c] | 2 | 4 | 0 | — |
| *Euschoengastia diversa*[b,c] | 2 | 1 | 0 | — |
| Diptera | | | | |
| *Cuterebra* sp.[b] | 1 | 1 | 0 | — |

[a] Ranges of intensities only are provided as arthropod parasites may have abandoned road-killed hosts.
[b] New host record in Florida.
[c] New host record in U.S.

ed 100% prevalence in fox squirrels from eastern Texas (USA), while Eckerlin (1993) found 50% prevalence in fox squirrels from Maryland and Virginia (USA). Davidson (1976) considered *H. hassalli* the most common helminth parasite of gray squirrels from the southeastern U.S., excluding Florida.

The tapeworm *R. bakeri* was collected from 28 (32%) of 87 SFS, but was not observed in 32 BCFS (Table 1). Factors limiting the distribution of *R. bakeri* are not known, but many parasites with indirect life cycles are limited by the distribution of an essential intermediate host. Other members of this genus use coprophagous beetles as intermediate hosts (Levine, 1980) and some of these may be absent from the range of BCFS. Other rodents may be reservoir hosts for the parasite. Conti et al. (1984) collected *R. bakeri* from 33% of gray squirrels examined in northern Florida. Kinsella (1974, unpublished 1987 data cited in Forrester, 1992) reported this parasite in cotton rats, Florida mice (*Podomys floridanus*), and golden mice (*Ochrotomys nutalli*) from northern and central Florida. Layne (1974) reported that fewer species of rodents are found in southern Florida than in other regions of the state and that Florida mice and golden mice were absent from southwestern Florida. Rodent population density is also lower in southern than in northern and central Florida (Layne, 1974) and decreased reservoir host interactions may account for the absence of *R. bakeri* in BCFS.

The remainder of the helminths had prevalences of <5% and were considered incidental parasites, although some local populations may have high prevalences and intensities of certain parasites. Moore (1957) reported *Moniliformis clarki* in four (17%) of 24 fox squirrels from Putnam County, Florida, but we identified the parasite in only one squirrel from our sample. The higher prevalences of this parasite in Putnam County could have been the result of a local phenomenon, such as higher fox squirrel densities or the presence of other infected hosts.

Bush and Holmes (1986) examined parasite communities in lesser scaup (*Aythya affinis*) and divided the helminth fauna

into core and satellite species. Core species were defined as having high prevalences (≥70%) and high intensities, and satellite species as having lower prevalences (<70%) and intensities. This concept has been applied to other host species, most of which have high densities and live in aquatic habitats (Forrester et al., 1987). Kinsella (1991) compared the helminths of three species of mice from southern Florida and suggested that the definition of core species of parasites be modified for terrestrial hosts which are present in low densities. He recommended that parasites with high host specificity, wide distribution, but with prevalences below 70% be considered core species. Fox squirrels in Florida are found in low densities (Humphrey and Jodice, 1992) and, following the proposal of Kinsella (1991), we believe four species of helminths may be considered core species of SFS. These include the nematodes *S. robustus, H. hassalli,* and *C. bifurcatum,* which have direct life cycles, and the tapeworm (*R. bakeri*) which probably requires an arthropod intermediate host. Prevalence is probably dependent upon habitat, host density, and distribution of other rodents species. The number of hosts in a limited habitat could directly influence transmission by increased interaction between animals and overlap of range. These parasites have all been reported in gray squirrels from the southeastern U.S. (Davidson, 1976; Conti et al., 1984). Gray squirrels or other sympatric hosts may share common habitat with fox squirrels and interaction could increase the probability of infection. Soil type, vegetation, and climatic conditions may affect the survival of eggs and larvae also.

Female fox squirrels have offspring in the winter and reproductive factors, such as hormonal changes or extended time spent in the nest, may make them more susceptible to infestation by fleas in the spring. *Orchopeas howardi* has been reported from gray squirrels in northern Florida (Wilson et al., 1991) and southern Florida (Layne, 1971). The distribution of these sympatric hosts may influence the prevalence of fleas in fox squirrels.

Many arthropod parasites have a high degree of host specificity (Kim et al., 1986). The prevalences of many of the species we collected from fox squirrels were low, which may indicate that they are accidental parasites, normally found on other wild mammals, or that some of the ectoparasites may have abandoned the host post mortem.

As might be expected from two closely related hosts, the similarities in parasite faunas are as striking as the differences. Both subspecies of fox squirrels shared three of four core helminths and the most prevalent arthropod parasite. The BCFS is confined to the southernmost range of *S. niger* where many vertebrate species (Layne, 1974), as well as the parasites in this study seem to be absent or uncommon.

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## LITERATURE CITED

BUSH, A. O., AND J. C. HOLMES. 1986. Intestinal helminths of lesser scaup ducks: Patterns of association. Canadian Journal of Zoology 64: 132–141.

CHANDLER, A. C. 1942. Helminths of tree squirrels in southeast Texas. The Journal of Parasitology 28: 135–140.

CONTI, J. A., D. J. FORRESTER, R. K. FROHLICH, G. L. HOFF, AND W. J. BIGLER. 1984. Helminths of urban gray squirrels in Florida. The Journal of Parasitology 70: 143–144.

DAVIDSON, W. R. 1976. Endoparasites of selected populations of gray squirrels (*Sciurus carolinensis*) in the southeastern United States. Proceedings of the Helminthological Society of Washington 43: 211–217.

ECKERLIN, R. P. 1993. Helminth parasites from two populations of the Delmarva fox squirrel (*Sciurus niger cinereus*) in Maryland and Virginia. *In* Proceedings of the Second Symposium on Southeastern Fox Squirrels, *Sciurus niger*, N. D. Moncrief, J. W. Edwards, and P. A. Tappe (eds.), Special Publication Number 1, Virginia Museum of Natural History, Martinsville, Virginia, pp. 53–56.

FORRESTER, D. J. 1992. Parasites and diseases of wild mammals in Florida. University Press of Florida, Gainesville, Florida, 459 pp.

———, D. B. PENCE, A. O. BUSH, D. M. LEE, AND N. R. HOLLER. 1987. Ecological analysis of the helminths of round-tailed muskrats (*Neofiber alleni* True) in southern Florida. Canadian Journal of Zoology 65: 2976–2979.

HALL, E. R. 1981. The mammals of North America, 2nd ed. John Wiley and Sons, New York, New York, 1175 pp.

HUMPHREY, S. R., AND P. G. R. JODICE. 1992. Big Cypress fox squirrel. *Sciurus niger avicennia*. Rare and endangered biota of Florida. Vol. I. Mammals. University Press of Florida, Gainesville, Florida, pp. 224–233.

KANTOLA, A. T., AND S. R. HUMPHREY. 1990. Habitat use by Sherman's fox squirrel (*Sciurus niger shermani*) in Florida. Journal of Mammalogy 71: 411–419.

KIM, K. C., H. D. PRATT, AND C. J. STOJANOVICH. 1986. The sucking lice of North America. An illustrated manual for identification. Pennsylvania State Press, University Park, Pennsylvania, 241 pp.

KINSELLA, J. M. 1974. Comparison of helminth parasites of the cotton rat, *Sigmodon hispidus*, from several habitats in Florida. American Museum Novitates 2540: 1–12.

———. 1988. Comparison of helminths of rice rats, *Oryzomys palustrus*, from freshwater and saltwater marshes in Florida. Proceedings of the Helminthological Society of Washington 55: 275–280.

———. 1991. Comparison of helminths of three species of mice, *Podomys floridanus*, *Peromyscus gossypinus*, and *Peromyscus polionotus*, from southern Florida. Canadian Journal of Zoology 69: 3078–3083.

LAYNE, J. N. 1971. Fleas (Siphonaptera) of Florida. The Florida Entomologist 54: 35–51.

———. 1974. The land mammals of south Florida. *In* Environments of south Florida: Present and past, P. J. Gleason (ed.). Memoir 2, Miami Geological Society, Miami, Florida, pp. 386–413.

LEVINE, N. D. 1980. Nematode parasites of domestic animals and man, 2nd ed. Burgess, Minneapolis, Minnesota, 477 pp.

MARGOLIS, L., G. W. ESCH, J. C. HOLMES, A. M. KURIS, AND G. A. SCHAD. 1982. The use of ecological terms in parasitology. The Journal of Parasitology 68: 131–133.

MOORE, J. C. 1957. The natural history of the fox squirrel, *Sciurus niger shermani*. Bulletin of the American Museum of Natural History 113: 1–71.

PARKER, J. C. 1971. Protozoan, helminth and arthropod parasites of the gray squirrel in southwestern Virginia. Ph.D. Dissertation. Virginia Polytechnic Institute, Blacksburg, Virginia, 262 pp.

SABROSKY, C. W. 1986. North American species of *Cuterebra*, the rabbit and rodent bot flies (Diptera: Cuterebridae). Entomological Society of America, College Park, Maryland, 240 pp.

WEBSTER, W. D., J. F. PARNELL, AND W. C. BIGGS, JR. 1985. Mammals of the Carolinas, Virginia, and Maryland. University of North Carolina Press, Chapel Hill, North Carolina, 255 pp.

WILSON, N. A., S. R. TELFORD, JR., AND D. J. FORRESTER. 1991. Ectoparasites of a population of urban gray squirrels in northern Florida. Journal of Medical Entomology 28: 461–464.

WOOD, D. A. 1994. Official lists of endangered and potentially endangered fauna and flora in Florida. Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, 19 pp.

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