Ectoparasites (Acari, Mallophaga, Anoplura, Diptera) of White-Tailed Deer, *Odocoileus virginianus*, from Southern Florida

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ABSTRACT During a 7-yr period (1984–1990), 300 white-tailed deer, *Odocoileus virginianus* (Zimmermann), from 7 localities in Collier, Dade, and Monroe counties in southern Florida were examined for ectoparasites. Eight species were identified: 4 ticks [*Ixodes scapularis* Say, *I. affinis* Neumann, *Amblyomma maculatum* (Koch), and *Dermacentor variabilis* (Say)], 1 chigger mite [*Eutrombicula splendens* (Ewing)], 1 ked (*Lipoptena mazamae* Rondani), 1 chewing louse [*Tricholipeurus lipeuroides* (Megnin)], and 1 sucking louse [*Solenopotes binipilosus* (Fahrenholz)]. The most widely distributed and prevalent species were the deer ked *L. mazamae* and the blacklegged tick *I. scapularis*, both of which occurred in all 7 localities, in all years, and in all age classes of deer. Their overall prevalences were 82 and 22%, respectively. The prevalence of *L. mazamae* varied significantly by month. *L. mazamae* should be considered a core ectoparasite species of white-tailed deer in southern Florida because of its specificity, distribution, and high prevalence.

KEY WORDS ectoparasites, white-tailed deer, Florida

ECTOPARASITES OF WHITE-TAILED deer, *Odocoileus virginianus* (Zimmermann), in North America have been reported in numerous publications. Species lists or reviews have been prepared by Anderson (1962), Walker and Becklund (1970), Samuel et al. (1980), and Strickland et al. (1981). Although several other authors have reported on ectoparasites of white-tailed deer in Florida, most of their data were obtained from animals in northern and central Florida (Harlow and Jones 1965, Kellogg et al. 1971, Davidson et al. 1987). Smith (1977), however, examined ticks from 68 infested deer from 5 counties in southern Florida (Palm Beach, Glades, Highlands, Broward, and Charlotte) and identified 3 species of ticks (*Ixodes scapularis*, *Amblyomma maculatum*, and *Dermacentor variabilis*). There is also 1 report of chigger mites identified as *Eutrombicula* sp. from a white-tailed deer in Collier County in southern Florida (Kellogg et al. 1971).

From 1984 to 1990 a study of white-tailed deer populations in southern Florida was conducted in cooperation with the Florida Game and Fresh Water Fish Commission (FGFWFC) and the National Park Service (NPS). Ectoparasites were collected each year; in the current article we report the identity and prevalence of those parasites, and examine the data for differences based on month, year, and location of collection, and age and gender of host. Some of the data have been mentioned in a different context elsewhere (Forrester 1992), but details, including statistical analyses, were not given.

Materials and Methods

In total, 300 white-tailed deer (240 females and 60 males) collected by FGFWFC and NPS personnel from 1984 through 1990 in 7 localities in Collier (26° 00′ N, 81° 20′ W), Dade (25° 27′ N, 80° 47′ W), and Monroe (25° 45′ N, 81° 00′ W) counties in southern Florida were examined for ectoparasites. Sites in Collier County included the Bear Island and Corn Dance Units of the Big Cypress National Preserve, private land owned by Collier Enterprises, the Florida Panther National Wildlife Refuge, and Fakahatchee Strand State Preserve. The Stairsteps Unit of Big Cypress National Preserve was in Collier and Monroe counties, and Everglades National Park was in Monroe and Dade counties. Two of the sites (Stairsteps Unit and Everglades National Park) were in sawgrass habitats in the Everglades physiographic region, whereas the other 5 sites were made up of various mosaics of cypress swamps, freshwater marshes, hardwood hammocks, pine-oak forests, saw palmetto-wiregrass prairies, and agricultural lands in the Big Cypress physiographic region.

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These areas have been described in more detail by Davis (1943), Duever et al. (1986), and McPherson (1973). Deer were obtained primarily at night by shooting, and were examined 4–12 h later. The age of each deer was determined by the pattern of toothwear and replacement in the lower jaw (Harlow and DeFoor 1962). Age classes were defined as follows: age class 1 was composed of deer ≤12 mo, age class 2 those >12 and ≤24 mo, age class 3 those >24 and ≤36 mo, and age class 4 those >36 mo.

The entire carcass of each deer was searched for ectoparasites, with special attention to the ears and head, and the axillary and inguinal regions. Specimens were removed by forceps and preserved in 70% ethanol. No attempt was made to collect all of the ectoparasites present on each deer and therefore information was obtained on prevalence, but not intensity of each species. Voucher samples of the ticks have been deposited in the U.S. National Tick Collection, Georgia Southern University, Statesboro, Georgia (Accession numbers RML 118176-118205 and 119735-119763) and specimens of the other ectoparasites were deposited in the Florida State Collection of Arthropods, Division of Plant Industry, Florida Department of Agriculture and Consumer Services, Gainesville, FL. Data on prevalence were examined using the SAS System (SAS Institute 1988) to determine the effects of various factors. The data were subdivided into 2 sets as follows: deer collected in August, October, March, and June from August 1984 through June 1986 (n = 108) from Bear Island Unit and Corn Dance Unit comprised the 1st data set, and those collected in Fall (October and November) 1984 to 1990 (n = 218) from Bear Island Unit, Corn Dance Unit, plus the 5 other areas, comprised the 2nd set. The latter set contained data from 26 deer also included in the former. The 1st set was analyzed for differences in prevalences by month (March, June, August, October), location (Bear Island Unit, Corn Dance Unit), gender, and age. In addition, the monthly collections were compared collectively for the 1st 2 yr (August 1984 to June 1985 as year 1 and August 1985 to June 1986 as year 2, following McCown et al. [1991]). The 2nd set was analyzed for differences in prevalences related to year, location, gender, and age for deer collected during the Fall of each of the 7 yr of the study.

Screening analyses of variance (ANOVA), in which the response variable (prevalence) was binary (0,1), were performed to identify significant factors. For species with prevalences <20%, the initial models contained only main effects, and those for species with prevalences >20% included main effects and 2-way interactions. An iterative model fitting procedure was then used, in which nonsignificant factors were removed, and the reduced model was fitted. For species without interaction terms, the Fisher exact test was calculated and evaluated. For species with interaction terms, the type IV hypothesis tests were used to determine significance. For each level of factor found significant in the final ANOVA, exact 95% binomial confidence limits were computed; evaluation of significant factors was based on these confidence limits.

Table 1. Prevalences (%) of ectoparasites of white-tailed deer by month and year in southern Florida, 1984–1986

Ectoparasite	Month (n)				Year (n)	
	Mar. (33)	June (26)	Aug. (23)	Oct. (26)	1 (46)	2 (62)
I. scapularis	12	8	9	27	17	11
I. affinis	0	0	9	4	2	3
A. maculatum	0	4	17	0	9	2
E. splendens	3	0	9	8	7	3
L. mazamae	94A	92A	87A	69B	89	84
T. lipeuroides	18	12	4	12	13	11
S. binipilosus	6	0	0	0	2	2

Year 1 = August 1984–June 1985, year 2 = August 1985–June 1986. Values followed by different capital letters are significantly different from each other (Fisher exact test, 2-tailed, $P \leq 0.05$).

Results

Eight species of arthropods were identified: 4 ticks (*Ixodes scapularis* Say, *I. affinis* Neumann, *Amblyomma maculatum* [Koch], and *Dermacentor variabilis* [Say]), 1 chigger mite (*Eutrombicula splendens* [Ewing]), 1 ked (*Lipoptena mazamae* Rondani), 1 chewing louse (*Tricholipeurus lipeuroides* [Megnin]), and 1 sucking louse (*Solenopotes binipilosus* [Fahrenholz]). Results of the monthly collections at Bear Island Unit and Corn Dance Unit from 1984 through 1986 will be presented first, followed by results from the annual Fall collections at all sites from 1984 through 1990.

From August 1984 through October 1986, examination of 108 deer revealed 7 species of ectoparasites (overall prevalences), including 3 species of ticks (*I. scapularis*, 14%; *I. affinis*, 3%; and *A. maculatum*, 5%); 1 chigger mite (*E. splendens*, 5%); 1 ked (*L. mazamae*, 86%); 1 chewing louse (*T. lipeuroides*, 12%); and 1 sucking louse (*S. binipilosus*, 2%).

There were no significant year-to-year or gender differences, but the prevalence of *L. mazamae* was significantly lower ($P \leq 0.05$) in October than any other month, whereas those months did not differ from each other (Table 1). The prevalence of *I. scapularis* was higher ($P \leq 0.05$) at Bear Island Unit than Corn Dance Unit (Table 2). Prevalences of *T. lipeuroides* also varied between the sites, but inversely to the tick, with fewer Bear Island Unit deer being infested compared with Corn Dance Unit deer ($P \leq 0.02$) (Table 2). Prevalences of infestation by the chewing louse also varied by age with age class 1 being significantly higher ($P \leq 0.01$) than the other age classes, which were not significantly different from each other (Table 2).

Table 2. Prevalences (%) of ectoparasites of white-tailed deer by age class and location in southern Florida, 1984–1986

Ectoparasite	Age class (*n*)				Location (*n*)	
	1 (23)	2 (33)	3 (22)	4 (30)	BI (52)	CD (56)
I. scapularis	9	12	18	17	21A	7B
I. affinis	0	3	0	7	6	0
A. maculatum	0	3	5	10	4	5
E. splendens	13	3	0	3	2	7
L. mazamae	74	82	100	90	90	82
T. lipeuroides	30C	12D	0D	7D	2E	21F
S. binipilosus	4	3	0	0	2	2

Values followed by different capital letters are significantly different from each other (Fisher exact test, 2-tailed, $P \leq 0.05$). BI, Bear Island Unit; CD, Corn Dance Unit of Big Cypress National Preserve.

Table 4. Prevalences (%) of ectoparasites in fall collections of white-tailed deer in southern Florida, 1984–1990, by location

Ectoparasite	Location (*n*)						
	BI (49)	CD (40)	CE (33)	ENP (12)	FS (39)	PR (31)	SS (14)
I. scapularis	29	30	6	42	49	13	7
I. affinis	8	5	0	0	26	3	0
A. maculatum	0	18	9	0	28	0	0
D. variabilis	0	0	0	0	3	0	0
E. splendens	0	5	0	0	5	0	0
L. mazamae	80	85	94	8	87	84	50
T. lipeuroides	0	10	3	0	5	0	0
S. binipilosus	0	2	0	0	0	0	0

BI, Bear Island Unit; CD, Corn Dance Unit; CE, Collier Enterprises land; ENP, Everglades National Park; FS, Fakahatchee Strand State Preserve; PR, Florida Panther National Wildlife Refuge; SS, Stairsteps Unit.

In the fall 1984–1990 collections, 1 additional tick, *D. variabilis*, was found, but on only 1 of the 218 deer examined (<1%). Overall prevalences of the other 7 species were as follows: *I. scapularis*, 26%; *I. affinis*, 8%; *A. maculatum*, 10%; *E. splendens*, 2%; *L. mazamae* 79%; *T. lipeuroides*, 3%; and *S. binipilosus*, <1%. Prevalences are presented on an annual basis in Table 3 and by location in Table 4.

The blacklegged tick, *I. scapularis*, was found at all localities, in all years, and in all age classes. Age, year, location, and year–location interactions were significant in the screening ANOVA, although examination of the confidence intervals revealed no clearly significant differences. There was some evidence for possible cyclic patterns at Bear Island Unit and Corn Dance Unit (Fig. 1).

For the ked *L. mazamae*, year, location, and year–location interactions were significant in the screening ANOVA, but there were no clearly significant differences based on examination of the confidence intervals. There was no evidence for cyclic patterns, but no keds were found at Florida Panther National Wildlife Refuge in 1987, nor at Everglades National Park in 1988.

For the less prevalent species, there were no clear differences among the factors, although interpretation of the results was confounded by the small sample sizes and extremely unbalanced data. However, there were some interesting findings, including the high overall prevalence of ticks at Fakahatchee Strand State Preserve (Table 4). The only deer to harbor *D. variabilis* was found at Fakahatchee Strand State Preserve, as were 59% (10/17) of those with *I. affinis*, 52% (11/21) of those with *A. maculatum*, and 33% (19/57) of the deer with *I. scapularis*. That site also yielded 50% (2/4) of the deer with *E. splendens*, and 29% (2/7) of those with *T. lipeuroides*.

Table 3. Annual prevalences (%) of ectoparasites in fall collections of white-tailed deer in southern Florida, 1984–1990

Ectoparasite	Year (*n*)						
	1984 (12)	1985 (18)	1986 (14)	1987 (29)	1988 (54)	1989 (51)	1990 (40)
I. scapularis	25	39	14	28	11	24	48
I. affinis	8	0	14	7	6	12	8
A. maculatum	0	0	14	17	0	6	28
D. variabilis	0	0	0	0	2	0	0
E. splendens	8	6	7	3	0	0	0
L. mazamae	75	72	93	79	65	76	100
T. lipeuroides	17	6	14	7	0	0	0
S. binipilosus	0	0	0	0	2	0	0

Discussion

Although there are a few published reports based on limited observations, this is the 1st systematic survey of ectoparasites of white-tailed deer in southern Florida. This part of Florida is unique in a number of ways. Its humid subtropical climate is characterized by mild and relatively uniform temperatures compared with other parts of the state. The rainfall patterns result in drier dry seasons and wetter wet seasons than in more northern

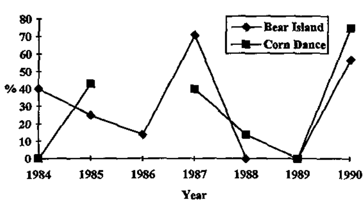

Fig. 1. Prevalences of *I. scapularis* on white-tailed deer in the fall at 2 sites, Bear Island (BI) and Corn Dance (CD) units of the Big Cypress National Preserve in southern Florida, 1984–1990. No deer were collected at Corn Dance Unit in 1986 and therefore there is no line connecting the data points for 1985 and 1987. Values for both Bear Island Unit and Corn Dance Unit were zero for 1989.

sections of Florida (Chen and Gerber 1990). In addition, this area is extremely flat with elevations of only 3 or 4 m above mean sea level (McCown et al. 1991), although slight variations in elevation can greatly affect hydrologic patterns. Elevational differences coupled with varying soil types result in ecologically distinct physiographic regions within southern Florida as mentioned in the *Materials and Methods* section.

Each of the species of ectoparasites has been reported previously from white-tailed deer in Florida (Kellogg et al. 1971, Forrester 1992). The only species that could be considered a core species (highly host specific, widely distributed, and very prevalent [Bush and Holmes 1986]) for white-tailed deer in Florida is the deer ked *L. mazamae*. It was widely distributed, occurred in very high prevalences (overall, 82%), and is known only from white-tailed deer. There is 1 report of *L. mazamae* from a Florida panther, *Felis concolor coryi* Bangs, in Collier County, but this was considered a case of accidental parasitism, the panther probably having been infested while feeding on a deer (Forrester 1992). This ked was reported also to be the most prevalent ectoparasite (64%) of 404 white-tailed deer examined in southern Texas in 1966–1968 (Samuel and Trainer 1972). The chewing louse *T. lipeuroides* and the sucking louse *S. binipilosus* are also fairly host-specific parasites (Strickland et al. 1981) and may be considered core ectoparasite species for white-tailed deer in other parts of its range where they are found in higher prevalences; however, they occurred in such low prevalences in southern Florida as to not be considered as such in this area. The 4 species of ticks and the chigger have been collected from numerous other mammals in Florida. *A. maculatum* and *I. scapularis*, for example, have been reported from 10 and 19 other species of Florida wild mammals, respectively (Forrester 1992), and also occur on domestic mammals (Strickland et al. 1981). Although *D. variabilis* occurs on 21 other species of wild mammals in Florida (Forrester 1992), and may be more common on white-tailed deer in northern Florida (Harlow and Jones 1965, Smith 1977), its presence on only 1 of 300 deer in the current study may mean that the species is an accidental parasite of deer in southern Florida.

The differences seen in prevalences of the various species are likely the result of several interacting factors, some environmental and some biological. The low prevalence of *L. mazamae* on deer collected during October may have been correlated with rainfall and water levels. In southern Florida the great bulk of the rainfall occurs during the rainy season from May to October (Chen and Gerber 1990). The effect of this would be to increase the extent and depth of ground water, resulting in a decrease in the amount of habitat optimal for development and survival of the soil-dwelling puparia. Samuel and Trainer (1972) made a similar observation in southern Texas where low prevalences of *L. mazamae* were correlated with flooding of lowlands following a hurricane in 1968. This same type of reasoning may help explain the extremely low overall prevalence of *L. mazamae* on deer from Everglades National Park, where the deer live in extensive marshlands, the Everglades, where dry land is scarce.

The high prevalence of *I. scapularis* at Bear Island Unit compared with Corn Dance Unit during the monthly collections of 1984–1986 were probably related to habitat differences and densities of deer populations. The Bear Island Unit habitat was on fairly fertile and productive soils, and consisted of cypress domes and strands, pine forests, oak hammocks, freshwater marshes, and prairies of palmettos and grasses, whereas the Corn Dance Unit area consisted mostly of stunted cypress growing on shallow infertile soils with scattered cypress domes and strands and a few pine/palmetto associations (McCown et al. 1991). Deer densities were higher at Bear Island Unit (1 deer per 26 ha) than at Corn Dance Unit (1 deer per 91 ha) (Schortemeyer and McCown 1986). The more diverse habitat and higher deer density at Bear Island Unit may have been more optimal for the survival, development, and host finding by *I. scapularis* than the less diverse habitat and lower deer densities at Corn Dance Unit. The apparent cyclic pattern in the prevalence of *I. scapularis* on deer at Bear Island Unit and Corn Dance Unit over the 7-yr period may be related to rainfall during the year before each collection year. For example, the low prevalences of 1988 and 1989 were preceded by years in which total rainfall was 12.85 and 18.79 (5.06 and 7.40 in) below average, and the high prevalences for 1990 were preceded by a year in which total rainfall was 32.75 cm (12.89 in) above normal (NOAA 1983–1990). Subadult stages of *I. scapularis* are prone to desiccation (Stafford 1994) and during years of decreased rainfall, populations of adult ticks on deer may be reduced.

The deer from Fakahatchee Strand State Preserve were hosts for the highest number of species of ectoparasites and also the highest prevalences of ticks compared to other areas. This may have been related to the high plant species richness of that area. The Fakahatchee Strand State Preserve habitat is composed of a complex mosaic of plant communities that includes some endemic species most closely allied with tropical species, and other endemics more closely related to temperate species (Austin et al. 1990).

Burning and grazing can influence the distribution of suitable habitat for ticks while they are off their hosts, as can annual variation in temperature and rainfall (Minshull and Norval 1982, Spickett et al. 1992, Davidson et al. 1994). During the period of this study there were prescribed fires and lightning fires in some of the areas (Schortemeyer and McCown 1986) and these may have resulted in reduced tick populations.

Host factors, including immunity and behavioral changes, may have caused the higher prevalences of *T. lipeuroides* in deer ≤12 mo of age compared with older deer. A similar observation was made in southern Texas (Samuel and Trainer 1971) with white-tailed deer infested by a closely related species of chewing louse, *T. parallelus*. Several of these factors, and others such as reproductive and nutritional status, concurrent infections with other diseases or parasites, and deer densities, most likely interact to determine the ectoparasites found on individual deer at any particular time and location.

None of these ectoparasites is known to be a vector of other parasites or disease agents of white-tailed deer in southern Florida (Forrester 1992). One exception might be the ked *L. mazamae*. Strickland et al. (1981) pointed out that other species of keds serve as vectors of trypanosomes in domestic sheep and goats and suggested that *L. mazamae* could be a vector of the deer trypanosome *Trypanosoma cervi*, although this has not been investigated. If this is true, it would help explain the high prevalence of *T. cervi* (93%) in white-tailed deer in southern Florida (Telford et al. 1991) which parallels the high prevalence of *L. mazamae*, although the extremely low prevalence of *L. mazamae* in deer from Everglades National Park where *T. cervi* is common, would tend to contradict that idea. In addition, white-tailed deer serve as excellent hosts for adult *I. scapularis* and may serve to support or increase the overall population of this tick. The nymphal stages of *I. scapularis* may acquire *Borrelia burgdorferi*, the etiologic agent of Lyme disease, after feeding on infected small rodents in deer habitat. The cotton rat, *Sigmodon hispidus*, is widespread in Florida, occurs in most white-tailed deer habitat, is a known host for immature stages of *I. scapularis*, and has been found recently to harbor natural infections of *B. burgdorferi* in the northeastern part of the state (Forrester 1992, Oliver et al. 1995).

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