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Ectoparasites of White-Tailed Deer (Artiodactyla: Cervidae) in Southeastern Georgia, USA[1]

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Abstract Ectoparasites were collected from 232 freshly culled white-tailed deer, *Odocoileus virginianus* (Zimmermann), from October through January during 2000–2001, 2001–2002, and 2013–2014 in an 11-county region in southeastern Georgia, USA. Seven species of arthropods were collected: the ticks *Amblyomma americanum* (L.), *Dermacentor albipictus* (Packard), and *Ixodes scapularis* Say (Acari: Ixodidae); the scab mite *Psoroptes equi* (Hering) (Acari: Psoroptidae); the chewing louse *Tricholipeurus lipeuroides* (Mégnin) (Phthiraptera: Trichodectidae); the sucking louse *Solenopotes binipilosus* (Fahrenholz) (Phthiraptera: Linognathidae); and the ked *Lipoptena mazamae* Rondani (Diptera: Hippoboscidae). Prevalence (percentage of deer infested) was significantly higher during the 2013–2014 season for *D. albipictus*, *I. scapularis*, and *P. equi*, and significantly higher during the 2000–2001 season for *T. lipeuroides*. Prevalence and mean intensity (mean per infested deer) for *D. albipictus* were both significantly higher on male versus female deer for each sampling period (hunting season) and for combined data (all seasons combined). Prevalence of *I. scapularis* was significantly higher on male deer during the 2013–2014 season and for combined data. Mean intensity of *L. mazamae* was significantly higher on male deer during the 2001–2002 and 2013–2014 seasons and for combined data.

Key Words ectoparasites, white-tailed deer, Georgia (USA)

The white-tailed deer, *Odocoileus virginianus* (Zimmermann), is common and widespread in the southeastern United States, and the ectoparasites, especially ticks and keds, that parasitize this mammal have been fairly well documented in various parts of North America. Kellogg et al. (1971) recorded 23 species of ectoparasites from *O. virginianus* in the United States, and Kennedy and Newman (1986) reported 11 species from Canada. In the southeastern United States, Forrester et al. (1996) recorded 8 species of ectoparasites (4 ticks, 1 chigger, 2 lice, 1 ked) from white-tailed deer in Florida, and Kellogg et al. (1971) reported 7 species (4 ticks, 3 lice) from this host in Alabama, 11 from Florida (5 ticks, 1 chigger, 4 lice, 1 ked), 14 from Georgia (6 ticks, 1 mange mite, 1 chigger, 1 scab mite, 3 lice, 1 ked, 1 flea), and 11 from South Carolina (6 ticks, 1 scab mite, 3 lice, 1 ked). Although Kellogg et al. (1971) listed the states from which each ectoparasite species was

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recorded from *O. virginianus*, they did not report infestation prevalences or intensities.

In the present study, we document the ectoparasites of white-tailed deer in southeastern Georgia during three hunting seasons (October through January) and, for the first time in Georgia, compare ectoparasite infestation parameters (prevalence and mean intensity) between years and between male and female deer. We hypothesized that infestation parameters would differ for some ectoparasite species among years because of natural population cycles and would be greater on male deer, which tend to have larger home ranges than females and more physical contacts with conspecific hosts (Kollars et al. 1997).

Materials and Methods

Freshly culled deer were examined from 11 counties in southeastern Georgia (Burke, Candler, Emanuel, Jefferson, Jenkins, Johnson, Laurens, Montgomery, Toombs, Treutlen, and Washington) during the 2000–2001, 2001–2002, and 2013–2014 hunting seasons (mid-October through mid-January). Deer were sampled at three deer processing plants located in Emanuel Co. and one processing plant in Montgomery Co. The majority of ectoparasites were removed by combing the dorsal and ventral surfaces of each deer for 30 strokes with a standard flea comb. Ticks were collected by visual inspection of the carcass, primarily the neck and chest region, and removed with forceps. Ectoparasites inside ears were collected on cotton swabs. Parasites from each deer were placed into individually labeled vials containing 70% ethanol. Date, county of harvest, and host sex were recorded for each deer. Ectoparasites were identified using standard guides, including Cooley (1938) and Keirans and Litwak (1989) for ticks, Baker et al. (1956) and Zahler et al. (2000) for parasitic mites, Werneck (1950) for chewing lice, Kim et al. (1986) for sucking lice, and Bequaert (1955) for keds.

Infestation prevalence (percentage of deer infested) and mean intensity (mean per infested deer) were calculated for each ectoparasite species following Bush et al. (1997). These parameters were statistically compared between different years and different sexes of deer. STATISTIX 9 Statistical Software was used to compare prevalences using the chi-square test and untransformed mean intensities using a *t* test. Prevalences and intensities were considered to be significantly different if probability (*P*) values were $\geq$95%.

Results

Seven species of ectoparasites were recorded from white-tailed deer during this study (Tables 1–3). These included the lone star tick, *Amblyomma americanum* (L.); the winter tick, *Dermacentor albipictus* (Packard); the blacklegged tick, *Ixodes scapularis* Say; a psoroptid scab mite, *Psoroptes equi* (Hering); a chewing louse, *Tricholipeurus lipeuroides* (Mégnin); a sucking louse, *Solenopotes binipilosus* (Fahrenholz); and a ked (louse fly), *Lipoptena mazamae* Rondani. We follow Baker et al. (1956) and Zahler et al. (2000) in treating the *Psoroptes* mites of ungulates as *P. equi*.

Table 1. Ectoparasites collected from white-tailed deer during 2000–2001, 2001–2002, and 2013–2014 (October–January) in southeastern Georgia, USA.*

Ectoparasite Species	Total**	2000–2001 (66 Deer)	2001–2002 (100 Deer)	2013–2014 (66 Deer)	Combined Years (232 Deer)
Acari					
Amblyomma americanum	2M, 1F, 1L	0, 0	1.0, 1.0	4.5, 1.0	1.7, 1.0
Dermacentor albipictus	43M, 39F, 63N, 25L	1.5[a], 2.0	9.0[a], 3.4	27.3[a], 7.7	12.1, 6.1
Ixodes scapularis	96M, 133F	4.6[b], 1.0	7.0[b], 2.6	60.6[b], 5.3	21.6, 4.6
Psoroptes equi	4M, 7F	0[c], 0	0[c], 0	4.5[c], 3.7	1.3, 3.7
Phthiraptera					
Solenopotes binipilosus	2F	1.5, 1.0	1.0, 1.0	0, 0	0.9, 1.0
Tricholipeurus lipeuroides	30M, 15F, 38N	22.7[d], 2.5	8.0[d], 2.1	3.0[d], 3.0	12.1, 3.0
Diptera					
Lipoptena mazamae	4,448A†	98.5, 14.8	99.0, 18.7	100, 24.8	99.1, 19.3

* For each entry, pairs of numbers represent prevalence (% of deer infested) and mean intensity (mean per infested host), respectively, for that ectoparasite species, following Bush et al. (1997). Figures on the same row with the same superscript letter indicate significantly different prevalences ($\geq$95% confidence limits) between the 2000–2001, 2001–2002, and 2013–2014 hunting seasons.

** Life stages listed are adults (A), males (M), females (F), nymphs (N), and larvae (L).

† For 2013–2014, 807 males and 831 females of *L. mazamae* were recorded. Sexes were not determined for this species during the 2000–2001 and 2001–2002 seasons.

Table 2. Comparison of ectoparasite infestation data between male and female white-tailed deer during 2000–2001 and 2001–2002 (October–January) in southeastern Georgia, USA.*

	2000–2001		2001–2002	
Ectoparasite Species	**Male Deer ($n = 26$)**	**Female Deer ($n = 40$)**	**Male Deer ($n = 58$)**	**Female Deer ($n = 42$)**
Acari				
Amblyomma americanum	0, 0	0, 0	1.7, 1.0	0, 0
Dermacentor albipictus	3.9, 2.0	0, 0	15.5[a], 3.4[b]	0[a], 0[b]
Ixodes scapularis	3.9, 1.0	5.0, 1.0	10.3, 2.7	2.4, 2.0
Phthiraptera				
Solenopotes binipilosus	3.9, 1.0	0, 0	1.7, 1.0	0, 0
Tricholipeurus lipeuroides	30.8, 2.9	17.5, 2.0	12.9, 2.3	2.4, 1.0
Diptera				
Lipoptena mazamae	100, 18.9	97.5, 12.0	98.3, 25.2[c]	100, 9.9[c]

* Pairs of numbers list prevalence (% of deer infested) and mean intensity (mean per infested host), respectively, for each ectoparasite species, following Bush et al. (1997). Figures on the same row with the same superscript letter indicate significantly different prevalences and/or mean intensities (≥95% confidence limits) between male and female hosts for that sampling period.

Prevalence was significantly higher during the 2013–2014 season for *D. albipictus*, *I. scapularis*, and *P. equi*, and significantly higher during the 2000–2001 season for *T. lipeuroides* (Table 1). Prevalence and mean intensity for *D. albipictus* were both significantly higher on male versus female deer for each sampling period and for combined data (all samples combined) (Tables 2, 3). Prevalence of *I. scapularis* was significantly higher on male deer during the 2013–2014 season and for combined data (Table 3). Mean intensity of *L. mazamae* was significantly higher on male deer during the 2001–2002 and 2013–2014 seasons and for combined data (Tables 2, 3).

Discussion

Because entire deer were not examined for ectoparasites in this study, the reported infestation parameters listed in Tables 1–3 should be considered as minimum prevalences and mean intensities, respectively. However, the uniform nature in which each deer was sampled for ectoparasites permits reliable comparisons between years and host sexes.

All of the ectoparasites recorded in this study have previously been reported from white-tailed deer in the southeastern United States (Forrester et al. 1996, Kellogg et al. 1971), although Kellogg et al. (1971) did not identify the *Psoroptes* scab mites to species in their study. However, we report infestation parameters

Table 3. Comparison of ectoparasite infestation data between male and female white-tailed deer during 2013–2014 and combined years (2000–2001, 2001–2002, and 2013–2014) (October–January) in southeastern Georgia, USA.*

	2013–2014		Combined Years	
Ectoparasite Species	**Male Deer ($n = 48$)**	**Female Deer ($n = 18$)**	**Male Deer ($n = 132$)**	**Female Deer ($n = 100$)**
Acari				
Amblyomma americanum	4.2, 1.0	5.5, 1.0	2.3, 1.0	1.0, 1.0
Dermacentor albipictus	37.5[a], 7.7[b]	0[a], 0[b]	21.2[c], 6.1[d]	0[c], 0[d]
Ixodes scapularis	72.9[e], 5.5	27.8[e], 3.4	31.8[f], 5.0	8.0[f], 2.6
Psoroptes equi	6.3, 3.7	0, 0	2.3[g], 3.7	0[g], 0
Phthiraptera				
Solenopotes binipilosus	0, 0	0, 0	0.9, 1.0	0, 0
Tricholipeurus lipeuroides	4.2, 3.0	0, 0	13.6, 3.1	10.0, 2.2
Diptera				
Lipoptena mazamae	100, 28.0[h]	100, 16.2[h]	99.2, 25.0[i]	99.0, 11.9[i]

* Pairs of numbers list prevalence (% of deer infested) and mean intensity (mean per infested host), respectively, for each ectoparasite species, following Bush et al. (1997). Numbers on the same row with the same superscript letter indicate significantly different prevalences and/or mean intensities ($\geq$95% confidence limits) between male and female hosts for that sampling period.

(prevalences and mean intensities) of ectoparasites on white-tailed-deer in Georgia for the first time. In Georgia, Kellogg et al. (1971) recorded seven additional ectoparasite species from white-tailed deer: the Gulf Coast tick, *Amblyomma maculatum* (Koch); the American dog tick, *Dermacentor variabilis* (Say); the tick *Ixodes affinis* Neumann (no common name); a demodicid mange mite, *Demodex* sp.; a chigger mite, *Neotrombicula whartoni* (Ewing); an additional species of chewing louse, *Tricholipeurus parallelus* (Osborn); and the rabbit flea, *Cediopsylla simplex* (Baker). Chiggers, *Eutrombicula splendens* (Ewing), were also recorded from white-tailed deer in Florida by Forrester et al. (1996). Some of the ectoparasites recorded from Georgia white-tailed deer by Kellogg et al. (1971), such as *D. variabilis* and *C. simplex*, should be considered as accidental ectoparasites of deer, so it is not surprising that we did not record them in this survey. Similarly, demodicid mites which are subdermal parasites, and chiggers, may not have been removed by our sampling technique. However, the ticks *A. maculatum* and *I. affinis* are both typical ectoparasites of white-tailed deer in some southeastern states, including Georgia (Durden and Keirans 1996, Durden et al. 1991, Forrester et al. 1996, Lavender and Oliver 1996). Adults of these ticks usually parasitize white-tailed deer during the warmer months (Demarais et al. 1987,

Durden et al. 1991, Forrester et al. 1996, Lavender and Oliver 1996), and we probably would have recorded both species if deer had been sampled outside of our sampling months (October–January). Similarly, we would have expected to record larger numbers of *A. americanum* if deer had been sampled during the warmer months.

Nemeth et al. (2014) also reported *Demodex* sp. itch mites (*Chorioptes texanus* Hirst), chiggers, ticks (*A. americanum* and *A. maculatum*), chewing lice (*Tricholipeurus* spp.), and keds (*Lipoptena cervi* (L.)) from white-tailed deer from a region that encompassed Georgia, Louisiana, Maryland, South Carolina, Tennessee, and Virginia.

The deer ked, *L. mazamae*, was the most abundant ectoparasite collected in this study, with 230 of the 232 examined deer being infested with this ectoparasite. This ked has previously been collected from white-tailed deer in Georgia and other southeastern states (Kellogg et. al. 1971, Reeves et al. 2006). In the northeastern United States, *L. mazamae* is replaced in many areas by the introduced Palearctic species *L. cervi* as detailed by Bequaert (1955). This is the first study to demonstrate significantly higher numbers (mean intensities) of *L. mazamae* on male versus female deer (Tables 2, 3). The larger number of keds we recorded on male deer may be related to the larger home ranges of male deer and their increased movement during the mating season (the rut) (Kollars et al. 1997). By increased movement within their environment, male deer may have more opportunities for exposure to deer keds after adult flies emerge from puparia in the soil. Keds feed on host blood and are known to carry *Bartonella* spp. bacteria that are pathogenic to ruminants (Halos et al. 2004) or are closely related to species of veterinary or zoonotic concern (Reeves et al. 2006). Although *L. mazamae* primarily parasitizes the white-tailed deer, it has been recorded from other mammals including cattle (Drummond 1966).

Ticks were the second most commonly recorded group of ectoparasites in this study. The significantly higher infestation prevalences that we recorded during the 2013–2014 season for two species of ticks, *D. albipictus* and *I. scapularis*, on white-tailed deer (Table 1) could have been due to natural population dynamics of these ectoparasites between years which could be influenced by host abundance, host immunity, and/or climate. Male deer also had significantly higher infestation prevalences than females for these two species of ticks in most years and for all years combined (Tables 2, 3). Further, mean intensity of *D. albipictus* was significantly higher on male deer in two of the three years and for combined data (Tables 2, 3). In fact, no female deer were infested with *D. albipictus* in this study. A higher intensity of infestation of male deer by *D. albipictus* has been previously reported (Kollars et. al. 1997). Because these ticks search (quest) for hosts from vegetation, the larger home ranges of male deer presumably account for these differences. Also, white-tailed deer secrete interdigital substances that are used in trail and territorial marking and which also serve as kairomones for aiding host location by ticks (Carroll 2001, Carroll et al. 1996). The dispersal of the interdigital gland substance and the increased movement during the deer breeding season may bring breeding-age male deer into contact with more questing ticks. It should be noted that *D. albipictus* is a one-host tick (Cooley 1938) and, therefore, only the larvae of this species quest for ungulate hosts such as deer. Two color varieties have been documented for this tick (Cooley 1938); specimens recorded in the

present study were of the darker *nigrolineatus* morph. Because *D. albipictus* is a one-host tick, we recorded all three life stages (larva, nymph, and adult) during this study, sometimes on the same individual deer.

All three tick species we recorded from deer in this study are of medical and/or veterinary importance. *Ixodes scapularis* is a vector of several pathogens, including deer tick virus (a variant of Powassan virus), *Borrelia burgdorferi* Johnson, Schmid, Steigerwalt, and Brenner, causative agent of Lyme disease; *Anaplasma phagocytophilum* (Foggie), causative agent of human granulocytic anaplasmosis; and *Babesia microti* (Franca), an agent of babesiosis (Nicholson et al. 2009). *Amblyomma americanum* is a vector of *Ehrlichia chaffeensis* Anderson, Dawson, Jones, and Wilson, *Ehrlichia ewingii* Anderson, Greene, Jones, and Dawson, and at least one additional species of *Ehrlichia*, all of which are causative agents of ehrlichiosis, *Francisella tularensis* (McCoy and Chapin), which causes tularemia, and *Borrelia lonestari* Barbour, Maupin, Teltow, Carter, and Piesman, and *Candidatus* Rickettsia amblyommii, which are putative causative agents of Southern Tick Associated Rash Illness (Nicholson et al. 2009). *Dermacentor albipictus* parasitizes various species of ungulates in addition to deer (Cooley 1938) and can occur in numbers large enough to cause hair loss (via intense host grooming) and anemia (Nicholson et al. 2009).

Prevalence of the chewing louse *T. lipeuroides* was significantly greater during the 2000–2001 season and lowest during the 2013–2014 season (Table 1). However, there were no statistical differences between prevalences or mean intensities on male versus female deer for this ectoparasite in any of the hunting seasons or for combined data (Tables 2, 3). As with keds and ticks, the different prevalences between sampling periods could be related to louse population dynamics, host population densities, host immunity, climate, or other factors. However, unlike keds and ticks, lice spend their entire life cycle on the host (Durden 2001), so population dynamics of lice are presumably largely related to on-host factors. Although we recorded one species of chewing louse (*T. lipeuroides*) and one species of sucking louse (*S. binipilosus*) on white-tailed deer during this survey, at least three additional species of lice are known to parasitize this host in the United States: the chewing louse *L. parallelus*, a presumably invasive chewing louse belonging to the Eurasian genus *Damalinia*, and the sucking louse *Solenopotes ferrisi* (Fahrenholz) (Kellogg et al. 1971, Kim et al. 1986, L.A.D. unpubl.). Except for the *Damilinia* sp. louse, large populations of which can cause deer hair loss syndrome (Bildfell et al. 2004), none of these lice appear to cause major health issues in wild deer (Durden 2001).

Although we recorded only 11 specimens of *P. equi* in this study (Table 1), the infestation prevalence of this scab mite was significantly higher during 2013–2014 (Table 1) (none were recorded in 2000–2001 or 2001–2002). *Psoroptes* spp. mites are of veterinary importance for certain domestic animals and wildlife because they can cause auditory problems such as exudate accumulation inside ears of deer (Kellogg et al. 1971) and fur loss with scabby lesions on other parts of the body in various ungulates (Baker et al. 1956, Zahler et al. 2000).

Overall, we document significant year-to-year differences between infestation parameters of certain ectoparasite species (ticks, scab mites, and chewing lice) on white-tailed deer in southeastern Georgia. We also highlight significant differences in infestation parameters for ticks, scab mites, and keds between male and female

hosts. The relevance of this study is based on the fact that deer are an important game animal in the region and are parasitized by arthropods that can cause deleterious health issues in these hosts; some of these ectoparasites (especially ticks) can also parasitize humans and transmit zoonotic pathogens.

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