Surveys for Ectoparasites on Wildlife Associated With *Amblyomma variegatum* (Acari: Ixodidae)-Infested Livestock in St. Croix, U.S. Virgin Islands

JOSEPH L. CORN,[1] PATRICK BERGER,[2] AND JAMES W. MERTINS[3]

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ABSTRACT Surveys in 2001, 2005, and 2006 attempted to determine the role of wildlife in maintenance and dissemination of the tropical bont tick, *Amblyomma variegatum* (F.) (Acari: Ixodidae), in St. Croix, U.S. Virgin Islands. Small mammals; birds; white-tailed deer, *Odocoileus virginianus* (Zimmermann); and feral cattle, *Bos taurus* L., were examined at nine premises, in mountainous rain forest, and in surrounding areas in western St. Croix, an area including and central to all known bont tick-infested premises on the island. Small Asian mongooses, *Herpestes javanicus* (É. Geoffroy Saint-Hilaire), yielded 1,566 ectoparasite specimens, representing five species, and including larvae of a soft tick, *Carios puertoricensis* (Fox); the tropical horse tick, *Anocentor nitens* (Neumann); and the southern cattle tick, *Rhipicephalus* (*Boophilus*) *microplus* (Canestrini). Black rats, *Rattus rattus* L., yielded 144 specimens, representing six ectoparasite species, including *C. puertoricensis*. Of 25 bird species examined, seven yielded 116 ectoparasite specimens representing at least 14 different species of lice and mites, but no ticks. White-tailed deer and feral cattle yielded only various stages of *A. nitens* and *R. microplus* ticks. *A. variegatum* was not encountered on any potential wildlife host sampled, reflecting its low occurrence in St. Croix during the survey period. One collection of chewing lice (Phthiraptera: Philopteridae) from a spotted sandpiper, *Actitis macularia* (L.), and collections of feather mites (Acari: Astigmata: Trouessartiidae) from both bananaquits, *Coereba flaveola* (L.), and black-faced grassquits, *Tiaris bicolor* (L.), may represent new, undescribed species.

KEY WORDS *Amblyomma variegatum*, wildlife, ectoparasites, St. Croix

The tick *Amblyomma variegatum* (F.) (Acari: Ixodidae) is native to Africa (Hoogstraal 1956) and was first introduced into the West Indies on cattle brought from West Africa to Guadeloupe in the 1800s (Curasson 1943). Antigua and Marie Galante also were infested in the 19th century, but further spread in the region was not reported until Martinique became infested in 1948 (Morel 1966). Spread of the tick accelerated after 1948, and it since has occurred on islands from Barbados to Puerto Rico (Barré and Garris 1990). Infestations were declared eradicated in St. Croix in 1970 (Graham and Hourrigan 1977) and in Puerto Rico in 1987 (Garris et al. 1989). More recently, *A. variegatum* was found on a stray bull (*Bos taurus* L.) in St. Croix during August 2000, and a subsequent infestation involving additional livestock was found in March 2001. The recent infestation in St. Croix may be a continuation of the infestation thought eradicated in 1970 or due to a more recent, separate introduction.

A. variegatum is a vector of *Ehrlichia ruminantium* (Cowdry) (Rickettsiales: Ehrlichiaceae), the etiologic agent of heartwater disease (Daubney 1930) that infects domestic livestock in Antigua, Guadeloupe, and Marie Galante (Perreau et al. 1980, Uilenberg et al. 1984, Birnie et al. 1985). This tick also is a vector of African tick-bite fever, a rickettsial zoonosis caused by *Rickettsia africae* (Kelly, Beati, Mason, Matthewman, Roux, and Raoult), and it is found in Guadeloupe (Parola et al. 1999). It also is associated with acute bovine dermatophilosis caused by *Dermatophilus congolensis* (van Sacëghem) Gordon (Actinomycetales: Dermatophilaceae) (Walker and Lloyd 1993), which is found on several islands in the region.

A. variegatum is a three-host tick, and in Africa, wildlife hosts include a wide range of mammals and birds (Hoogstraal 1956, Petney et al. 1987, Cumming 1998). In the Caribbean, wildlife known infested by larvae and nymphs are the black rat (*Rattus rattus* L.), house mouse (*Mus musculus* L.), small Asian

[1] Corresponding author: Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens, Georgia 30602 (e-mail: jcorn@uga.edu).

[2] United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, St. Croix, United States Virgin Islands 00850.

[3] United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services, National Veterinary Services Laboratories, 1800 Dayton Avenue, Ames, Iowa 50010.

Table 1. Status of *A. variegatum*-infested premises in St. Croix during the 2005–2006 wildlife surveys

Estate	Tropical bont ticks first documented	Tropical bont ticks last observed	Domestic animals	Treatment[a]
Carlton	March 2001	Oct. 2003	None	Vacated May 2004
Prosperity	July 2002	Dec. 2004	None	Vacated Dec. 2004
Spratt Hall	Dec. 2002	Sept. 2003	1 horse	Treated since Jan 2003
La Grange	Feb. 2004	Oct. 2006	16 cattle, 30 sheep	Treated since 2002
Jolly Hill	July 2002	Sept. 2002	None	Vacated April 2004
Grove Place	July 2002	July 2003	None	Vacated July 2003
Lower Love I	Dec. 2003	July 2006	2 cattle, 2 horses	Treated since Jan. 2003; Vacated July 2006
Lower Love II	July 2002	Nov. 2006	154 sheep	Treated since July 2002

[a] Treatment means removal of host animals (vacation) or examination for ticks and application of coumaphos.

mongoose [*Herpestes javanicus* (Geoffroy Saint-Hilaire)], black-faced grassquit [*Tiaris bicolor* (L.)], Carib grackle [*Quiscalus lugubris* (Swainson)], cattle egret [*Bubulcus ibis* (L.)], and common ground dove [*Columbina passerina* (L.)] (Garris 1987; Barré et al. 1988; Corn et al. 1993, 1994a). All of these species are present in St. Croix, as are white-tailed deer, *Odocoileus virginianus* (Zimmermann), and feral cattle, both potential hosts for larvae, nymphs, and adults of the tick. Wildlife infested by *A. variegatum* may hinder control or eradication efforts in the Caribbean because they may serve as maintenance hosts for the tick, and they may disseminate the tick within a given island or between islands (Corn et al. 1993, 1996). In our study, we sought first to determine the role of wildlife in the maintenance and dissemination of *A. variegatum* in St. Croix; and second, to document the diversity of ectoparasites occurring on the wildlife species we examined.

Materials and Methods

Study Sites: Small Mammals and Birds. We surveyed small mammals and birds for *A. variegatum* infestations at nine premises in the western area of St. Croix. The United States Department of Agriculture, Animal and Plant Health Inspection Service, Veterinary Services (USDA–APHIS–VS) and the United States Virgin Islands (USVI), Department of Agriculture (VIDOA) conducted the St. Croix *Amblyomma* Eradication Project during 2001–2006 and classified eight of the nine premises as infested with *A. variegatum* (Table 1). We also surveyed wildlife at one additional site, VIDOA lands, adjacent to the two infested Lower Love premises.

Study Sites: White-Tailed Deer and Feral Cattle. We examined white-tailed deer and feral cattle for *A. variegatum* in the mountainous rain forest in the western end of St. Croix and in habitat frequented by white-tailed deer and feral cattle in Estate Mt. Stewart, Estate Prosperity, Estate Oxford, and Estate Annally. This area includes the *A. variegatum*-infested Christensen premises and is central to all of the known infested premises in St. Croix.

Small Mammal Surveys. We examined small Asian mongooses for ticks at the nine identified premises during July–November 2005 and repeated the survey at one premises (Christensen, Estate Prosperity) during April–May 2006. We attempted to capture and examine 60 mongooses per premises during July–November and 30 per premises during April–May, by using live traps (Tomahawk Live Trap Co., Tomahawk, WI). In 2,840 trap-nights (i.e., number of traps × number of trapping nights), we captured and examined 351 mongooses. We either euthanized or immobilized (and later released) the animals as required by the USVI Department of Planning and Natural Resources and the respective landowners. We thoroughly combed and examined the entire body surface of each mongoose visually. We also captured and examined 50 black rats during these surveys. All ectoparasites were collected, stored in 70% ethanol, and subsequently identified at the USDA–APHIS–VS National Veterinary Services Laboratories (NVSL), Ames, IA.

Bird Surveys. We surveyed for ticks on birds at the nine identified premises during July–November 2005, attempting to capture and examine 60 birds per premises. Birds were captured alive via mist nets, a net gun, or hand-made live traps. In 920 mist-net-hours (i.e., number of mist nets × number of hours of operation), we captured 390 birds, examined each via a thorough visual inspection of the entire body surface, and released them. We collected all ectoparasites seen, stored them in 70% ethanol, and subsequently identified them at the NVSL.

White-Tailed Deer and Feral Cattle Surveys. We collected white-tailed deer and feral cattle by rifle shot during August–September 2001, September–November 2005, and March–May 2006. Ten deer and 20 feral cows were collected in 2001, seven deer and four cows in 2005, and six deer and eight feral cows in 2006. We examined all animals via a thorough visual inspection of the entire body surface, collected representative samples of all ectoparasites seen in 2001, and all ectoparasites seen in 2005 and 2006. We stored them in 70% ethanol and subsequently identified them at the NVSL.

Sample Size. We determined the requisite sample sizes for mongooses and birds based on the binomial distribution and an assumption of a large, homogeneous population (>400 individuals) (Corn and Nettles 1995). Under these circumstances, negative re-

Table 2. Ectoparasites collected from 351 mongooses in St. Croix, 2005–2006

Parasite	Stage	No. collected	Prevalence[a]	Intensity[b]	Density[c]
Ticks					
Anocentor nitens (Neumann)	Larva	3	2 (0.6)	<0.1	1.5
Rhipicephalus microplus (Canestrini)	Larva	3	3 (0.9)	<0.1	1.0
Carios puertoricensis (Fox)	Larva	1,438	170 (48.4)	4.10	8.5
Mites					
Ornithonyssus bacoti (Hirst)	Female	2	2 (0.6)	<0.1	1.0
Fleas					
Ctenocephalides felis (Bouché)	Male	34	20 (5.7)	0.10	1.7
	Female	85	54 (15.4)	0.2	1.6
	All	119	66 (18.8)	0.3	1.8
Flies					
Culicoides pusillus Lutz	Female	1	1 (0.3)	<0.1	1.0

[a] Number of infested animals (number of infested animals/number of animals examined × 100).
[b] Number of specimens collected/number of animals examined.
[c] Number of specimens collected/number of infested animals.

sults from 29 examined animals indicates an upper limit of parasite infestation in the population of 10% ($P = 0.05$), and negative results from 59 animals indicates an upper limit of infestation of 5% ($P = 0.05$). We could not use these statistics for white-tailed deer or feral cattle sampling in St. Croix because each population probably included <400 animals. We reasonably estimated the number of white-tailed deer in the western end of St. Croix during the survey period at 200 animals. Using hypergeometric probability calculations, negative results from 26 animals examined in a homogeneous population of 200 indicate an upper limit of parasite infestation of 10% ($P = 0.05$). Similarly, we estimated the number of feral cattle in the western end of St. Croix during the survey period at 80; negative results from 24 animals examined in a homogeneous population of 80 indicate an upper limit of infestation of 10% ($P = 0.05$).

Vouchers. Representative voucher specimens for all of the ectoparasites collected in our surveys are deposited in the parasitology reference collection at the NVSL.

Results

Ectoparasites collected from 351 mongooses (Table 2), 50 black rats (Table 3), and 390 birds (Table 4) represent a wide range of species, with 1,566 specimens representing six species on mongooses, 144 specimens representing seven species on black rats, and 116 specimens representing at least 15 species on birds. Although we found three other species of larval ticks on mongooses and one species on rats, we found no *A. variegatum* on small mammals or birds.

We found ectoparasites on 10/10 deer examined during August–September 2001, on six-sevenths ex-

Table 3. Ectoparasites collected from 50 black rats in St. Croix, 2005–2006

Parasite	Stage	No. collected	Prevalence[a]	Intensity[b]	Density[c]
Ticks					
Carios puertoricensis (Fox)	Larva	66	10 (20.0)	1.3	6.6
Mites					
Androlaelaps setosus (Fox)	Female	1	1 (2.0)	<0.1	1.0
Echinolaelaps echidninus (Berlese)	Female	23	10 (20.0)	0.5	2.3
Laelaps nuttalli Hirst	Female	11	8 (16.0)	0.2	1.4
	Nymph	1	1 (2.0)	<0.1	1.0
	All	12	9 (18.0)	0.2	1.3
Listrophoroides cucullatus (Trouessart)[d]	Male	2	2 (4.0)	<0.1	1.0
	Female	2	2 (4.0)	<0.1	1.0
	Nymph	5	3 (6.0)	0.1	1.7
	All	9	4 (8.0)	0.2	2.3
Lice					
Hoplopleura pacifica Ewing	Male	2	2 (4.0)	<0.1	1.0
	Female	9	4 (8.0)	0.2	2.3
	Nymph	10	5 (10.0)	0.2	2.0
	Nit	1	1 (2.0)	<0.1	1.0
	All	22	7 (14.0)	0.4	3.1
Polyplax spinulosa (Burmeister)	Male	2	2 (4.0)	<0.1	1.0
	Female	9	6 (12.0)	0.2	1.5
	Nymph	2	2 (4.0)	<0.1	1.0
	All	13	10 (20.0)	0.3	1.3

[a] Number of infested animals (number of infested animals/number of animals examined × 100).
[b] Number of specimens collected/number of animals examined.
[c] Number of specimens collected/number of infested animals.
[d] This is probably the first collection record of this mite from St. Croix.

Table 4. Ectoparasites collected from 390 birds in St. Croix, July–November 2005

Parasite	Host (no. examined)	Stage	No. per infested host
Lice: Menoponidae			
Actornithophilus umbrinus (Burmeister)	*Actitis macularia* (L.), spotted sandpiper (2)	Male	1
		Nymph	1
Amyrsidea minuta Emerson	*Pavo cristatus* L., common peafowl (3)	Female	2, 2
Armysidea sp.[a]	*P. cristatus* (3)	Nymph	1
Myrsidea ridulosa (Kellogg & Chapman)	*Dendroica petechia* (L.), yellow warbler (12)	Male	1
		Female	1
Lice: Philopteridae			
Carduiceps sp.[b]	*A. macularia* (2)	Female	1
Columbicula macrourae (Wilson)	*Zenaida aurita* (Temminck), Zenaida dove (121)	Male	1, 1, 1, 1
		Nymph	1
	Zenaida asiatica (L.), white-winged dove (2)	Male	2
		Female	1
		Nymph	4
Columbicula passerinae (Wilson)	*Columbina passerina* (L.), common ground dove (65)	Nymph	1
Goniodes pavonis (L.)	*P. cristatus* (3)	Male	1, 1, 1
		Female	1
		Nymph	1, 2
Goniocotes rectangulatus Nitzsch	*P. cristatus* (3)	Male	1
Physconelloides zenadurae (McGregor)	*Z. aurita* (121)	Male	1
Picicola foedus (Kellogg & Chapman)	*Tyrannus dominicensis* (Gmelin), gray kingbird (13)	Male	2
		Female	1
Saemundssonia platygaster frater (Giebel)	*A. macularia,* (2)	Male	1
		Female	3
		Nymph	1
Unknown genus[c]	*A. macularia,* (2)	Male	3
		Female	4
Mites			
Ornithonyssus bursa (Berlese)	*Seiurus aurocapillus* (L.), ovenbird (1)	Female	1
Trouessartiidae[d]	*Tiaris bicolor* (L.), black-faced grassquit (62)	Nymph	1, 11, 23
		Larva	4, 4
Trouessartiidae[d]	*Coereba flaveola* (L.), bananaquit (116)	Nymph	11, 13

Examined species (*n*) from which ectoparasites were not collected: pearly-eyed thrasher [*Margarops fuscatus* (Vieillot)) (54)], helmeted guineafowl [*Numida meleagris* (L.) (21)]; blackpoll warbler [*Dendroica striata* (Forster) (7)]; black-whiskered vireo [*Vireo altiloquus* (Vieillot) (4)]; hermit thrush [*Catharus guttatus* (Pallas) (3)]; prairie warbler [*Dendroica discolor* (Vieillot) (2)]; yellow-billed cuckoo [*Coccyzus americanus* (L.) (1)], Louisiana water-thrush [*Seiurus motacilla* (Vieillot) (1)]; Caribbean eleana [*Elaenia martinica* (L.) (1)]; mangrove cuckoo [*Coccyzus minor* (Gmelin) (1)]; American kestrel [*Falco sparverius* L.) (1)]; black-and-white warbler [*Mniotilta varia* (L.) (1)]; and smooth-billed ani [*Crotophaga ani* L.) (1)].

[a] Need adult specimens for species identification; two species previously reported from *P. cristatus.*

[b] Need male specimens for species identification; eight species of *Carduiceps* occur on scolopacid birds, but none previously recorded from *A. macularia; Carduiceps zonarius* (Nitzsch) is possible because it occurs on at least 17 other species of scolopacids.

[c] Possible new louse genus and species.

[d] Need adult specimens for species identification; no previous reports of feather mites from *T. bicolor* or *C. flaveola;* probably undescribed.

amined during September–November 2005, and on six-sixths examined during March–May 2006 (Tables 5 and 6). All collected ectoparasites were ticks, including 2,518 specimens of the southern cattle tick, *Rhipicephalus* (*Boophilus*) *microplus* (Canestrini), and 1,224 specimens of the tropical horse tick, *Anocentor nitens* (Neumann), but no *A. variegatum.*

We found ectoparasites on 20/20 feral cows examined during August–September 2001, on two-fourths examined during September–November 2005, and on six-eighths examined during March–May 2006 (Tables 5 and 6). All collected ectoparasites were ticks, including 3,337 specimens of *R.* (*B.*) *microplus*, and 28 *A. nitens*, but no *A. variegatum.*

Discussion

The absence of *A. variegatum* on small mammals, ground-feeding birds, white-tailed deer, and feral cattle examined in St. Croix suggests a low local abundance of *A. variegatum* at the time the surveys were conducted. Previous studies in Guadeloupe, Antigua, and Puerto Rico revealed infestations of both small mammals and birds, but populations of ticks on these islands, gauged by abundance of adult *A. variegatum* on cattle, were higher than in St. Croix. In Guadeloupe, where the concurrent mean intensity was 43 adult bont ticks per cow, *A. variegatum* was collected from 65/124 mongooses, 21/80 cattle egrets, 29/62 Carib grackles, 1/14 common ground doves, and 1/20 black-faced grassquits (Barré et al. 1988). A later study in Guadeloupe (Corn et al. 1994b) found the prevalence of *A. variegatum* on mongooses was as high as 52% in some areas, but mean bont tick intensities on mongooses decreased when cattle were treated with acaricides. In Antigua, where mean bont tick intensities were three to 16 adults per cow, larvae of *A. variegatum* were collected from 40/540 mongooses, 5/212 cattle egrets, and 3/60 Carib grackles, and nymphs were collected from 4/540 mongooses, 1/212 cattle egrets, and 1/1 feral cat (Corn et al. 1993, 1994a). In Puerto Rico, where mean bont tick intensity was 20 adults per cow, larvae were found on 1/64 mongooses, 2/539 house mice, and 1/183 black rats

Table 5. Infestation of white-tailed deer and feral cattle by *Rhipicephalus* (*Boophilus*) *microplus* in St. Croix, 2001–2006

Host	Yr	Statistic	Male	Female	Nymph	Larva	All ticks
Deer	2001	Prevalence[a]	9/10 (90.0)	10/10 (100.0)	9/10 (90.0)	5/10 (50.0)	10/10 (100.0)
		No. ticks	48	147	84	12	291
		Intensity[b]	4.8	14.7	8.4	1.2	29.1
		Density[c]	5.3	14.7	9.3	2.4	29.1
	2005–2006	Prevalence	11/13 (84.6)	12/13 (92.3)	12/13 (92.3)	9/13 (69.2)	12/13 (92.3)
		No. ticks	433	551	817	426	2,227
		Intensity	33.3	42.4	62.8	32.8	171.3
		Density	39.4	45.9	68.1	47.3	185.6
Feral cattle	2001	Prevalence	20/20 (100.0)	20/20 (100.0)	16/20 (80.0)	9/20 (45.0)	20/20 (100.0)
		No. ticks	388	866	410	14	1,678
		Intensity	19.4	43.3	20.5	0.7	83.9
		Density	19.4	43.3	25.6	1.6	83.9
	2005–2006	Prevalence	8/12 (66.7)	8/12 (66.7)	8/12 (66.7)	5/12 (41.7)	8/12 (66.7)
		No. ticks	432	662	536	29	1,659
		Intensity	36.0	55.2	44.7	2.4	138.3
		Density	54.0	82.8	67.0	5.8	207.4

[a] Number of infested animals/number of animals examined (percentage infested).
[b] Number of ticks collected/number of animals examined.
[c] Number of ticks collected/number of infested animals.

(Garris 1987). If mongooses, rats, or birds were infested in St. Croix during our survey period, the prevalence was below a level detectable with the sample sizes used. Any such infestations probably were insignificant and reflective of the low abundance of *A. variegatum* in St. Croix, but even incidental infestations might allow small numbers of ticks to survive on wildlife in isolated areas (Corn et al. 1996).

We did not detect *A. variegatum* on white-tailed deer or feral cows in St. Croix; thus, we have no evidence that these potential hosts were factors in the maintenance or dissemination of *A. variegatum* in St. Croix during our surveys. White-tailed deer were examined previously for *A. variegatum* in the Caribbean Region on two occasions; none was found on 18 white-tailed deer examined in St. Croix in 1967–1968 (Hourrigan et al. 1969) or on five white-tailed deer examined in Culebra, PR, in 1989 (J.L.C., unpublished data). However, tick-infested stray cattle significantly hinder control and eradication programs on some islands (Pegram et al. 2004), and the initial finding of *A. variegatum* in St. Croix in 2000 was on a stray bull. The absence of *A. variegatum* on deer and feral cattle in our surveys does not rule out deer or feral cattle as sylvatic hosts if *A. variegatum* becomes more abundant in St. Croix nor does it rule out the possibility that current infestations of deer or feral cattle exist at prevalences too low to detect. In fact, we were unable to acquire the requisite sample sizes of 26 white-tailed deer and 24 feral cattle necessary to unequivocally ensure that the prevalence of bont ticks on these animals was <10%. Therefore, perhaps 10% or slightly more of St. Croix deer and feral cattle may be infested, possibly in isolated pockets and at a low prevalence that might allow sylvatic survival of *A. variegatum*, at least for periods of several years.

Notwithstanding the absence of *A. variegatum* in our surveys, we found abundant ticks and/or a diversity of other arthropod ectoparasites on all groups of host animals examined. As expected, the greatest di-

Table 6. Infestation of white-tailed deer and feral cattle by *A. nitens* in St. Croix, 2001–2006

Host	Yr	Statistic	Male	Female	Nymph	Larva	All ticks
Deer	2001	Prevalence[a]	1/10 (10.0)	1/10 (10.0)	3/10 (30.0)	4/10 (40.0)	5/10 (50.0)
		No. ticks	1	1	17	203	222
		Intensity[b]	0.1	0.1	1.7	20.3	22.2
		Density[c]	1.0	1.0	5.7	50.8	44.4
	2005–2006	Prevalence	6/13 (46.2)	5/13 (38.5)	7/13 (53.9)	6/13 (46.2)	7/13 (53.9)
		No. ticks	79	59	603	261	1002
		Intensity	6.1	4.5	46.4	20.1	77.1
		Density	13.2	11.8	86.1	43.5	143.1
Feral cattle	2001	Prevalence		2/20 (10.0)	1/20 (5.0)	5/20 (25.0)	6/20 (30.0)
		No. ticks	0	10	1	17	28
		Inensity		0.5	0.1	0.9	1.4
		Density		5.0	1.0	3.4	4.7
	2005–2006	Prevalence					
		No. ticks	0	0	0	0	0
		Intensity					
		Density					

[a] Number of infested animals/number of animals examined (percentage infested).
[b] Number of ticks collected/number of animals examined.
[c] Number of ticks collected/number of infested animals.

versity occurred on avian hosts among the chewing lice (Phthiraptera: Menoponidae, Philopteridae), where most species are monophagous or oligophagous (Price et al. 2003). We sampled 25 bird species and found a cumulative total of at least 12 species of chewing lice on seven of them; conversely, 18 examined avian species yielded no lice. Nearly all the observed louse–bird host relationships were documented previously (Price et al. 2003). Four bird species bore only one kind of louse each, but spotted sandpipers, *Actitis macularia* (L.), yielded four species of louse parasites; peafowl, *Pavo cristatus* L., yielded three species; and Zenaida doves, *Zenaida aurita* (Temminck), had two species. One louse species occurred on both white-winged doves, *Z. asiatica* (L.), and Zenaida doves.

Two other findings are of particular interest. One of the lice on a spotted sandpiper was identifiable only to family level (i.e., Philopteridae), despite the presence of both male and female specimens. The seven specimens on one bird, all with food in their guts, suggest that these were not stragglers, but we could not identify them with any known sandpiper associate or, indeed, place them in any known louse genus, by using the most recent checklist and keys (Price et al. 2003). They may represent a new genus and species and are retained as voucher specimens. Two passerine bird hosts, the bananaquit, *Coereba flaveola* (L.), and the black-faced grassquit, *T. bicolor*, each provided samples of immature feather mites (Acari: Astigmata: Trouessartiidae) that probably represent new species, as well. No feather mites are described previously from either bird.

Black rats and mongooses share the same haunts in St. Croix and some of the same ectoparasites as well (Webb 1980). Indeed, mongooses were introduced to St. Croix in 1872 in a misguided attempt to control rat populations (Hinton and Dunn 1967). We found two tropical rat mites, *Ornithonyssus bacoti* (Hirst), on our mongooses and three other parasitic mite species typical of rats on our black rats, but larvae of the soft tick, *Carios puertoricensis* (Fox), were the only parasites shared in our survey by both hosts. Prevalence of this tick on St. Croix mongooses was generally comparable with those occurrences on the same host recently seen in Antigua (Corn et al. 1994a), although mean intensity was a bit lower. In the 1970s, Webb (1980) found much lower tick occurrences and two instances of adults on St. Croix mongooses. Although Fox (1947) first found *C. puertoricensis* on domestic rats, we and Corn et al. (1994a) collected the larvae with greater frequency and abundance on mongooses than on rats. The small numbers of larval tropical horse ticks and southern cattle ticks we found on mongooses were all flat (unfed), and like those found on mongooses in Antigua (Corn et al. 1994a), they were incidental stragglers of negligible importance.

The presence of *R. microplus* and *A. nitens* on surveyed white-tailed deer has more veterinary significance, and both have been found previously on deer in St. Croix (Beatty 1944, Hourrigan et al. 1969, Kistner and Hayes 1970). Kistner and Hayes (1970) thought tick-infested deer were a factor in a failed early *R. microplus* eradication attempt, but their later experiments with small numbers of penned white-tailed deer and cattle demonstrated that routine dipping of cattle, under the given numbers of animals and ratios of cattle to deer, alone could eradicate *R. microplus* from areas shared by both hosts. We found high prevalences and intensities of both *R. microplus* and *A. nitens* on surveyed white-tailed deer and very abundant *R. microplus* on feral cattle (Tables 5 and 6), suggesting that these hosts still may represent a complicating factor in control programs for any livestock tick species in the Caribbean Region.

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References Cited

Barré, N., and G. I. Garris. 1990. Biology and ecology of *Amblyomma variegatum* (Acari: Ixodidae) in the Caribbean: implications for a regional eradication program. J. Agric. Entomol. 7: 1–9.

Barré, N., G. I. Garris, G. Borel, and E. Camus. 1988. Host and population dynamics of *Amblyomma variegatum* (Acari: Ixodidae) on Guadeloupe, French West Indies. J. Med. Entomol. 25: 111–115.

Beatty, H. A. 1944. The Arachnida of St. Croix, V.I. J. Agric. Univ. Puerto Rico 28: 111–113.

Birnie, E. F., M. J. Burridge, E. Camus, and N. Barré. 1985. Heartwater in the Caribbean: isolation of *Cowdria ruminantium* from Antigua. Vet. Record 116: 121–123.

Corn, J. L., N. Barré, B. Thiebot, T. E. Creekmore, G. I. Garris, and V. F. Nettles. 1993. Potential role of cattle egrets, *Bubulcus ibis* (Ciconiformes: Ardeidae), in the dissemination of *Amblyomma variegatum* (Acari: Ixodidae) in the Eastern Caribbean. J. Med. Entomol. 30: 1029–1037.

Corn, J. L., D. M. Kavanaugh, T. E. Creekmore, and J. L. Robinson. 1994a. Wildlife as hosts for ticks (Acari) in Antigua, West Indies. J. Med. Entomol. 31: 57–61.

Corn, J. L., B. D. Snyder, N. Barré, and G. I. Garris. 1994b. Effect of acaricide treatment of cattle on *Amblyomma variegatum* (Acari: Ixodidae) infestation of mongooses (Carnivora: Viverridae: *Herpestes auropunctatus*) in Guadeloupe, French West Indies. J. Med. Entomol. 31: 490–495.

Corn, J. L., and V. F. Nettles. 1995. Disinfection and wildlife. Rev. Sci. Tech. Off. Int. Epiz. 14: 455–468.

Corn, J. L., N. Barré, G. I. Garris, and V. F. Nettles. 1996. Potential impact of wildlife on the tropical bont tick eradication program in the Caribbean. Ann. N.Y. Acad. Sci. 791: 77–84.

Cumming, G. S. 1998. Host preference in African ticks (Acari: Ixodidae): a quantitative data set. Bull. Entomol. Res. 88: 379–406.

Curasson, G. 1943. Traité de protozoologie vétérinaire et comparée, tome I. Trypanosomes. Vigot Frères, Paris, France.

Daubney, R. 1930. Natural transmission of heartwater of sheep by *Amblyomma variegatum* (Fabricius 1794). Parasitology 22: 260–267.

Fox, I. 1947. Ornithodoros puertoricensis, a new tick from rats in Puerto Rico. J. Parasitol. 33: 253–259.

Garris, G. I. 1987. *Amblyomma variegatum* (Acari: Ixodidae): population dynamics and hosts used during an eradication program in Puerto Rico. J. Med. Entomol. 24: 82–86.

Garris, G. I., B. H. Bokma, R. K. Strickland, and G. P. Coombs. 1989. Evaluation of the eradication program for *Amblyomma variegatum* (Acari: Ixodidae) on Puerto Rico. Exp. Appl. Acarol. 6: 67–76.

Graham, O. H., and J. L. Hourrigan. 1977. Eradication programs for the arthropod parasites of livestock. J. Med. Entomol. 6: 629–658.

Hinton, H. E., and A.M.S. Dunn. 1967. Mongooses: their natural history and behaviour. University of California Press, Berkeley, CA.

Hoogstraal, H. 1956. African Ixodoidea, vol. I. Ticks of the Sudan (with special reference to Equatoria Province and with preliminary reviews of the genera *Boophilus, Margaropus,* and *Hyalomma*). Research Report NM 005 050.29-07, United States Department of the Navy, Bureau of Medicine and Surgery, Washington, DC.

Hourrigan, J. L., R. K. Strickland, O. L. Kelsey, B. E. Knisely, C. C. Crago, S. Whittaker, and D. J. Gilhooly. 1969. Eradication effort against tropical bont tick, Amblyomma variegatum, in the Virgin Islands. J. Am. Vet. Med. Assoc. 154: 540–545.

Kistner, T. P., and F. A. Hayes. 1970. White-tailed deer as hosts of cattle fever ticks. J. Wildl. Dis. 6: 437–440.

Morel, P. C. 1966. Étude sur les tiques du bétail en Guadeloupe et Martinique. I. Les tiques et leur distribution (Acariens, Ixodoidea). Rev. Élev. Méd. Vét. Pays Trop. 19: 307–321.

Parola, P., G. Vestris, D. Martinez, B. Brochier, V. Roux, and D. Raoult. 1999. Tick-borne rickettsiosis in Guadeloupe, the French West Indies: isolation of *Rickettsia africae* from *Amblyomma variegatum* ticks and serosurvey in humans, cattle, and goats. Am. J. Trop. Med. Hyg. 60: 888–893.

Pegram, R., L. Indar, C. Eddi, and J. George. 2004. The Caribbean *Amblyomma* Program: some ecologic factors affecting its success. Ann. N.Y. Acad. Sci. 1026: 302–311.

Perreau, P., P. C. Morel, N. Barré, and P. Durand. 1980. Existence de la cowdriose (heartwater) à *Cowdria ruminantium,* chez les petits ruminants des Antilles françaises (la Guadeloupe) et des Mascareignes (la Reunion et île Maurice). Rev. Élev. Méd. Vét. Pays Trop. 33: 21–22.

Petney, T. N., I. G. Horak, and Y. Rechav. 1987. The ecology of the African vectors of heartwater, with particular reference to *Amblyomma hebraeum* and *Amblyomma variegatum.* Onderst. J. Vet. Res. 54: 381–395.

Price, R. D., R. A. Hellenthal, R. L. Palma, K. P. Johnson, and D. H. Clayton. 2003. The chewing lice: a world checklist and biological overview. Illinois Nat. Hist. Surv. Spec. Publ. 24: 1–501.

Uilenberg, G., N. Barré, E. Camus, M. J. Burridge, and G. I. Garris. 1984. Heartwater in the Caribbean. Prev. Vet. Med. 2: 255–267.

Walker, A. R., and C. M. Lloyd. 1993. Experiments on the relationship between feeding of the tick *Amblyomma variegatum* (Acari: Ixodidae) and dermatophilosis skin disease in sheep. J. Med. Entomol. 30: 136–143.

Webb, J. W. 1980. Parasites of small Indian mongoose on St. Croix, Virgin Islands. J. Parasitol. 66: 176–178.

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