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Antibodies to Vesicular Stomatitis New Jersey Type Virus in White-tailed Deer on Ossabaw Island, Georgia, 1985 to 1989

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ABSTRACT: From 1985 to 1989, 491 serum samples were collected from white-tailed deer (*Odocoileus virginianus*) on Ossabaw Island, Georgia (USA) and were tested for neutralizing antibodies to New Jersey and Indiana type vesicular stomatitis viruses. Prevalence of antibodies to vesicular stomatitis New Jersey (VSNJ) virus in deer for the 5-yr period was 43%. Prevalence of antibodies differed by year ($P < 0.0001$), and was dependent on age class ($P < 0.0001$) and location on the island ($P < 0.0001$). Of 173 deer sampled from other locations in the southeastern United States, only two had VSNJ antibody titers normally considered positive (≥1:32). The positive deer were from Union County, Arkansas (USA) and Wakulla County, Florida (USA). No evidence of exposure to vesicular stomatitis Indiana Virus was observed.

Key Words: Antibodies, *Odocoileus virginianus*, Ossabaw Island, prevalence, southeastern United States, vesicular stomatitis virus, white-tailed deer.

Antibodies to vesicular stomatitis New Jersey type (VSNJ) virus previously have been reported from white-tailed deer (*Odocoileus virginianus*) in the southern United States (Karstad et al., 1956; Jenney, 1967; Trainer and Hanson, 1969: Jenney et al., 1970), and it has been demonstrated that this species represents a good serological indicator of localized areas of VSNJ virus activity (Jenney et al., 1970; Stallknecht and Erickson, 1986). Antibodies to VSNJ virus first were recorded from Ossabaw Island, Georgia, from two white-tailed deer sampled in 1965 (Jenney et al., 1970). Since that time, VSNJ virus neutralizing antibodies have been consistently detected in wildlife and domestic animals sampled from this enzootic focus (Fletcher et al., 1985; Stallknecht et al., 1985), and virus has been isolated from both wild swine (*Sus scrofa*) (Stallknecht et al., 1987) and phlebotomine sand flies (*Lutzomyia shannoni*) (Corn et al., 1990).

Seroconversion to VSNJ virus in swine on Ossabaw Island occurs annually and is extremely localized (Stallknecht et al., 1987). The objective of this study was to evaluate both annual and geographical variation in antibody prevalence in this population of white-tailed deer. As part of a continued effort to delineate foci of VSNJ virus, serologic results from 173 deer from 31 additional locations also are presented.

During October and November 1985 to 1989, blood was collected from hunter-killed white-tailed deer from Ossabaw Island, Georgia (31°47′N, 81°07′W), which is owned and managed by the Georgia Department of Natural Resources (GDNR) (Atlanta, Georgia 30344, USA). Ages of all deer were determined by tooth eruption and wear patterns (Severinghaus, 1949). Because hunters were assigned to specific areas, location data were available for all harvested animals. Samples collected from other southeastern sites were obtained during late-summer herd health checks or from hunter-killed animals.

Sera were tested by microtiter serum neutralization tests (National Veterinary Services Laboratories, 1981) conducted by the National Veterinary Services Laboratories (Science and Technology, Animal and Plant Health Inspection Service, United States Department of Agriculture, Ames, Iowa 50010). All sera were tested for neutralizing antibodies to both the New Jersey and Indiana type vesicular stomatitis vi-

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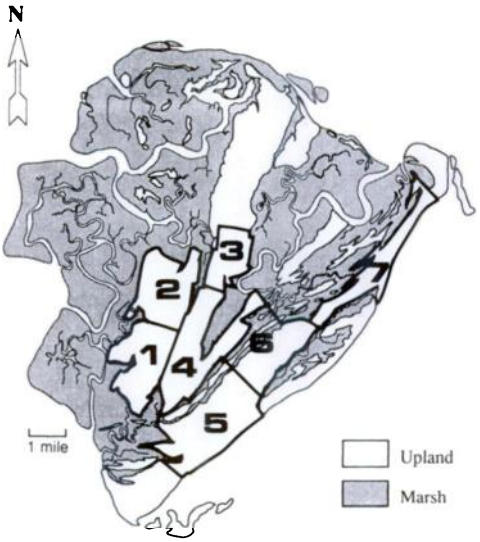


FIGURE 1. White-tailed deer harvest locations on Ossabaw Island, Georgia, 1985 to 1989.

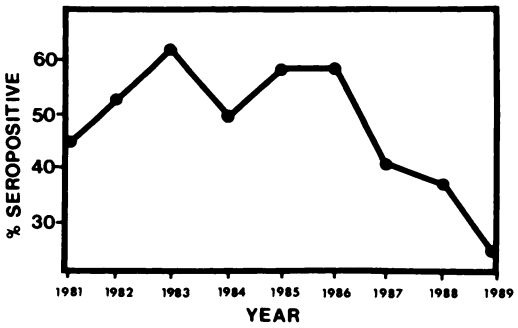


FIGURE 2. Prevalence of serum neutralizing antibodies to vesicular stomatitis New Jersey type virus in white-tailed deer, Ossabaw Island, Georgia, 1981 to 1989. (1981 to 1984 data from Stallknecht and Erickson, 1986).

ruses. Since naturally acquired antibody titers to VSNJ in white-tailed deer can significantly decline within 1 year (Stallknecht and Erickson, 1986), all animals testing positive at dilutions of $\geq$1:8 were included in the statistical analysis. Differences in prevalence of antibodies between years and age classes were tested by Chi Square analysis using the Statistical Analysis System (SAS Institute, Inc., 1985).

In order to evaluate location effects, the hunting area was divided into seven areas based on geographic boundaries, roads, and hunter stands designated by the GDNR (Fig. 1). Geological formation of Ossabaw Island during the Holocene and Pleistocene periods (Hoyt, 1968) has resulted in variation in forest types (Johnson et al., 1974) which allowed comparison of prevalence by geologic type. For this analysis, areas 1 to 4 were grouped as Pleistocene and areas 5 to 7 were grouped as Holocene.

Serum samples were collected from 108, 96, 76, 106, and 105 white-tailed deer on Ossabaw Island during 1985, 1986, 1987, 1988, and 1989, respectively. Prevalence of antibodies differed by year ($P < 0.0001$). Prevalence declined from 58% in 1985 and 1986 to 23% in 1989 (Fig. 2).

Serologic results by year and age class are given in Table 1. For the 5-yr period, antibody prevalence was dependent on age class ($P < 0.0001$) and increased from 15% in the 0.5-yr age class to 61% in the 6.5-yr age class.

Serologic results by year and location are given in Table 2. Overall, prevalence of antibodies was dependent on location ($P < 0.0001$) and was highest for areas 5 (51%) and 6 (67%). On an annual basis, peak antibody prevalence was observed in deer from area 6 during 1985, 1986, and 1988, from area 5 during 1989, and from area 1 in 1987. Annual prevalence of antibodies ranged from 39–61% and from 36–83% in areas 5 and 6, respectively; antibody prevalence in area 1 ranged from 7–100%.

Prevalence of VSNJ antibodies was higher each year in deer from combined areas of Holocene origin (areas 5–7) than in deer collected from Pleistocene areas (areas 1 to 4). Overall, prevalence for the 5-yr period was significantly higher ($P < 0.001$) for deer from Holocene areas (54%) than for deer from Pleistocene areas (36%).

In addition to samples collected from Ossabaw Island, 173 serum samples were tested from 31 other locations in the southeastern United States from 1985 to 1988. Serologic results are presented in Table 3.

Prevalence of antibodies to VSNJ virus in white-tailed deer on Ossabaw Island

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TABLE 1. Prevalence of New Jersey type virus serum neutralizing antibodies to vesicular stomatitis in white-tailed deer by year and age class, Ossabaw Island, Georgia.

Age (yr)	Number seropositive*/number samples (% seropositive)						Range (%) (positive)
	1985	1986	1987	1988	1989	Total	
0.5	2/12 (17%)	3/7 (43%)	1/12 (8%)	3/21 (14%)	1/17 (6%)	10/69 (15%)	6–43%
1.5	18/27 (67%)	5/15 (33%)	3/10 (30%)	1/18 (6%)	6/25 (24%)	33/95 (35%)	6–67%
2.5	12/23 (52%)	13/24 (54%)	7/15 (47%)	11/19 (58%)	5/23 (22%)	48/104 (46%)	22–58%
3.5	15/23 (65%)	19/29 (66%)	6/15 (40%)	8/18 (44%)	2/20 (10%)	50/105 (48%)	10–66%
4.5	6/7 (86%)	4/5 (80%)	8/15 (53%)	1/4 (25%)	5/9 (56%)	24/40 (60%)	25–86%
5.5	3/3 (100%)	4/6 (67%)	1/3 (33%)	7/13 (54%)	1/4 (25%)	16/29 (55%)	25–100%
6.5+	7/13 (54%)	8/10 (80%)	4/6 (67%)	7/13 (54%)	4/7 (57%)	30/49 (61%)	54–80%
Total	63/108 (58%)	56/96 (58%)	30/76 (40%)	38/106 (36%)	24/105 (23%)	211/491 (43%)	23–58%

* Includes positive results at ≥1:8 dilution.

TABLE 2. Prevalence of New Jersey type virus serum neutralizing antibodies to vesicular stomatitis in white-tailed deer by year and location, Ossabaw Island, Georgia.

Area	Number seropositive*/number samples (% seropositive)						Range (%) (positive)
	1985	1986	1987	1988	1989	Total	
1	7/11 (64%)	5/12 (42%)	10/10 (100%)	2/9 (22%)	1/15 (7%)	25/57 (44%)	7–100%
2	10/14 (71%)	3/11 (27%)	6/13 (46%)	8/19 (42%)	2/22 (9%)	29/79 (37%)	9–71%
3	8/18 (44%)	5/8 (63%)	0/12 (0%)	2/16 (13%)	0/13 (0)	15/67 (22%)	0–63%
4	8/16 (50%)	10/15 (67%)	2/13 (15%)	8/24 (33%)	7/22 (33%)	35/90 (39%)	15–67%
5	13/25 (52%)	11/18 (61%)	6/11 (55%)	7/18 (39%)	5/10 (50%)	42/82 (51%)	39–61%
6	11/14 (79%)	16/20 (80%)	6/13 (46%)	10/12 (83%)	4/11 (36%)	47/70 (67%)	36–83%
7	6/10 (60%)	6/12 (50%)	0/4 (0%)	1/8 (13%)	5/12 (42%)	18/46 (39%)	0–60%
Total	63/108 (58%)	56/96 (58%)	30/76 (40%)	38/106 (36%)	24/105 (23%)	211/491 (43%)	23–58%

* Includes positive results at ≥1:8 dilution.

TABLE 3. Serum neutralizing antibodies to vesicular stomatitis New Jersey type virus in white-tailed deer from the southeastern United States.

State	Year	Location	County or parish	Number tested	Serologic results
Alabama	1986	Eufaula NWR[a]	Barbour	5	Neg[b,c]
	1988	Lee Haven	Sumter	5	Neg
Arkansas	1985	Felsenthal NWR	Union	6	4 Neg 1 Pos[d] @ 1:8 1 Pos @ 1:128
	1985	Lafayette WMA[e]	Lafayette	5	4 Neg 1 Pos @ 1:16
	1985	St. Francis Forest WMA	Lee	5	4 Neg 1 Pos @ 1:8
	1988	Overflow NWR	Ashley	5	Neg
Florida	1984	Eglin Air Force Base	Walton	3	Neg
	1985	Eglin Air Force Base	Walton	12	Neg
	1985	St. Marks NWR	Wakulla	5	4 Neg 1 Pos @ 1:128
	1986	Corbett WMA	Palm Beach	5	Neg
	1987	Deseret Ranch	Osceola	5	Neg
	1987	St. Marks NWR	Wakulla	5	4 Neg 1 Pos @ 1:16
	1988	Lower Suwanee NWR	Levy	5	Neg
Georgia	1987	Bullard Creek WMA	Jeff Davis	2	Neg
	1987	Effingham County	Effingham	5	Neg
	1988	Chickasawhatchee WMA	Dougherty	4	Neg
	1988	Kings Bay	Camden	5	Neg
Louisiana	1985	Boeuf River WMA	Caldwell	5	Neg
	1985	Delta NWR	Plaquemines	5	Neg
	1985	Lacassine NWR	Cameron	4	Neg
	1985	Pass A Loutre	Plaquemines	2	Neg
	1985	Tensas River NWR	Madison	5	4 Neg 1 Pos @ 1:16
	1986	Tenmile WMA	Union	5	Neg
	1988	Beechgrove Plantation	E. Feliciana	5	Neg
	1988	Big Thicket	Jackson	5	Neg
	1988	D'Arbonne NWR	Union	5	Neg
	1988	Red Dirt WMA	Natchitoches	5	Neg
	1988	Tensas River NWR	Madison	5	Neg
Mississippi	1986	Yazoo NWR	Washington	5	Neg
North Carolina	1985	Alligator River NWR	Dare	6	Neg
	1985	Pungo NWR	Hyde	10	Neg
South Carolina	1985	Santee NWR	Clarendon	5	Neg
	1986	Pickney Island NWR	Beaufort	4	Neg
Virginia	1985	Front Royal	Warren	5	Neg
			Total	173	

[a] NWR, National Wildlife Refuge.
[b] Neg, negative.
[c] Neg, 1:8 dilution.
[d] Pos, positive.
[e] WMA, Wildlife Management Area.

show a decreasing trend since 1983. However, the presence of seropositive deer each year in the 0.5-yr age class indicates that deer have been infected with VSNJ annually.

Prevalence of VSNJ antibodies in deer on Ossabaw was consistently high in areas 5 and 6 (36–83%). This correlates with locations of VSNJ virus isolations from Ossabaw Island swine during 1983 and 1988

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(Stallknecht et al., 1985; Corn et al., 1990). In 1983, virus was isolated from one wild swine from area 6 and from one wild swine caught in area 4 (Stallknecht et al., 1985). Virus isolations in 1988 were from two wild swine from area 5 and two wild swine from area 6 (Corn et al., 1990). Also in 1988, virus was isolated from pooled samples of sand flies (*L. shannoni*) collected from areas 4, 5, and 6.

The Holocene portions of Ossabaw, which include areas 5 and 6, are characterized by climax maritime forest dominated by large, uniform stands of live-oak (*Quercus virginianus*) (Johnson et al., 1974). In contrast, many areas of Pleistocene origin on the island were cleared for agriculture at one time, and are now predominately pine (*Pinus* spp.) and mixed hardwoods (Johnson et al., 1974).

These differences in forest types may explain antibody prevalence variation between areas since hollow trees provide important diurnal resting sites for *L. shannoni* (Rozeboom, 1944; Rosabal and Miller, 1970). In a survey of sandflies in Louisiana, *L. shannoni* were most frequently found in deep clefts or hollow interiors of living hardwoods, but not pines (Rosabal and Miller, 1970). Isolations of VSNJ virus from *L. shannoni* on Ossabaw Island (Corn et al., 1990) and subsequent laboratory demonstration of VSNJ virus replication, transovarial transmission, and bite transmission (Comer et al., 1990) strongly implicate *L. shannoni* as a biological vector and/or reservoir of this virus. The higher antibody prevalence seen in white-tailed deer from areas of Holocene origin may reflect past land-use practices and soil conditions which favored the old growth hardwood forests which provide the necessary habitat for *L. shannoni*. These observations are consistent with past epidemiologic studies of VSNJ in the southeastern United States, which have correlated VSNJ with river and stream courses (Clower and Mikel, 1953; Schoening, 1954). Such areas in the southeastern United States were and are characterized by bottomland hardwood forests.

Of 173 serum samples from other southeastern locations, 166 were negative for VSNJ virus neutralizing antibodies at the 1:8 dilution (Table 3). Seven deer from five locations were positive ($\geq$1:8); however, only one deer from Felsenthal National Wildlife Refuge (NWR), Union County, Arkansas (1:128) and one deer from St. Marks NWR, Wakulla County, Florida (1:128) had titers normally considered positive ($\geq$1:32). Antibody titers to VSNJ virus in deer have not been previously reported from these areas, but both have a history of seropositive results from feral swine (Stallknecht et al., 1986). It is interesting to note that *L. shannoni* have been collected at or near all locations where VSNJ seropositive deer have been reported (Jenney et al., 1970; Young and Perkins, 1984; Stallknecht and Erickson, 1986; Stallknecht et al., 1987).

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