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Hemosporid (Apicomplexa, Hematozoea, Hemosporida) Community Structure and Pattern in Wintering Wild Turkeys

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ABSTRACT: The hemosporid community of 76 wild turkeys (*Meleagris gallopavo silvestris*) from South Carolina (USA) was examined using thin blood smears collected during January and February 1994. High prevalences and low abundances of hemosporids characterized this community. *Leucocytozoon smithi* and *Haemoproteus meleagridis* occurred in 100% and 54% of the turkeys, respectively; a *Plasmodium* sp. was found in one bird. Prevalence of *H. meleagridis* was significantly higher in juvenile turkeys than adults, but prevalences did not differ significantly among four trap sites or by host sex. Mean (±SE) intensities of *L. smithi*, *H. meleagridis*, and *Plasmodium* sp. were 3.4 ± 0.4, 1.8 ± 0.3, and 3.0 per 10,000 erythrocytes, respectively. Abundances of *L. smithi*, *H. meleagridis*, and *Plasmodium* sp. were 3.4 ± 0.4, 0.9 ± 0.2, and <0.1 ± <0.1 per 10,000 erythrocytes, respectively. Juvenile turkeys had higher rank abundance values of *L. smithi* than adults, whereas no differences were found among trap sites or between sexes. No differences in rank abundances of *H. meleagridis* were found among trap sites, host age, or host sex variables. Collectively, both common hemosporid species varied by host age, reflecting higher abundances in juvenile turkeys. Patterns of hemosporid prevalence appeared similar to patterns found in subtropical regions. Based on our data, we recommend using prevalence and abundance data to analyze the structure and pattern of hemosporid communities at the component community level.

Key words: Eastern wild turkey, *Meleagris gallopavo silvestris*, hemosporids, *Leucocytozoon smithi*, *Haemoproteus meleagridis*, *Plasmodium* sp., component community level, community ecology.

The wild turkey (*Meleagris gallopavo*) is an important game bird in North America. As such, its biology has been the focus of much research, particularly those factors associated with morbidity and mortality. Pathological responses have been reported in wild turkeys infected with *Plasmodium hermani* (Forrester et al., 1980) and *Haemoproteus meleagridis* (Atkinson and Forrester, 1987). Although there have been numerous surveys for hemosporids in wild turkey populations, many workers have attempted to describe host-hemosporid systems using only hemosporid prevalence data and have made generalizations based on data summarized across seasonal and spatial variables or obtained using different collection techniques. Furthermore, models of host-hemosporid systems developed for temperate regions (Herman, 1968) may not be applicable where hemosporid transmission occurs throughout the year (Atkinson, 1991).

We undertook this study to evaluate a hemosporid community in a geographic region where vectors can occur throughout the winter. Our objectives were to determine species composition, prevalence, intensity, and abundance of hemosporids circulating in the peripheral blood of wild turkeys (*M. gallopavo silvestris*) from South Carolina (USA) during late winter, and to evaluate the relationship of host age, host sex, and trapping locality on hemosporids at the component community level.

Turkeys were trapped in January and February 1994 at four sites on the 80,981-ha Savannah River Site, which is operated by the U.S. Department of Energy and located in the upper coastal plain of South Carolina. Three sites (Site 1: 33°22′N, 81°39′W; Site 2: 33°19′N, 81°38′W; Site 3: 33°16′N, 81°35′W) were located in upland habitats and one site (Site 4: 33°7′N, 81°39′W) was in a swamp habitat. Turkeys were classified as juveniles or adults (Larson and Tabor, 1980) and the sex of each bird was determined. Each turkey was

banded and removed from the study area for use in state-sponsored relocation programs.

Two thin smears from each bird were made from blood obtained via brachial vein puncture. All smears were collected between 0600 and 1200 hr. Smears were fixed in 100% methanol and stained with Diff-Quick® (Dade Diagnostics, Inc., Aguada, Puerto Rico). To determine prevalence of hemosporids, both blood smears were examined for 30 min each at ×1,000. For infected birds, 10,000 erythrocytes were counted and examined in 100 replicates of 100 erythrocytes each to provide an estimate of parasite intensity following recommendations of Godfrey et al. (1987). Few workers have quantified *Leucocytozoon* spp. on blood smears (Allan and Mahrt, 1989), possibly from concern over potential pooling of this parasite on the smear (Godfrey et al., 1987). However, based on regression analysis (SAS Institute Inc., 1985a) from a subsample of eight smears, *Leucocytozoon smithi* densities varied concordantly with densities of erythrocytes. Thus, pooling did not appear to be a significant factor.

Hemosporids were identified following the descriptions of Garnham (1966) and Greiner and Forrester (1980). Representative specimens were deposited in the International Reference Centre for Avian Haematozoa, Memorial University, St. John's Newfoundland, Canada (Numbers 144690 and 144691).

The terms prevalence, intensity, and abundance follow Margolis et al. (1982). Common hemosporid species were defined as those with ≥20% prevalence across the collective host sample. A value of 0.5 was arbitrarily assigned to birds that had hemosporid densities <1 per 10,000 erythrocytes to allow their inclusion in statistical analyses. Intensity and abundance data are presented as mean number of hemosporid individuals ± 1 SE per 10,000 erythrocytes.

Frequency data were analyzed with log-linear models (CATMOD; SAS Institute Inc., 1985a) to determine if prevalences of the common hemosporids varied over the main (trapping locality, host age, and host sex) and interactive effects. The frequency distribution of abundance values for each of the common species and the residual errors generated from analysis of variance (ANOVA), were examined with univariate analysis for normality (SAS Institute Inc., 1985b). Because abundance values for each common hemosporid species were overdispersed, the rank transformation procedure of Conover and Iman (1981) was applied to the data. We used a factorial ANOVA, for each of the common species, and a multivariate analysis of variance (MANOVA), for the collective common species, to examine the rank abundances of hemosporids for the main and interactive effects. For significant ANOVAs, means of the main effects were separated using the Tukey-Kramer test, whereas means generated from the interactive effects were separated by the least squares means procedure (SAS Institute Inc., 1985a). Interaction terms involving the independent variable trap locality were not analyzed because some cell sizes had <10 birds per cell.

Three hemosporid species were found in the 76 turkeys examined (Table 1). All turkeys were infected with *L. smithi*. *Haemoproteus meleagridis* was found in 54% of the turkeys; one turkey was infected with a *Plasmodium* sp.

Only *H. meleagridis* prevalence could be evaluated with log-linear analysis. Prevalence of *H. meleagridis* was significantly ($P = 0.02$) higher in juvenile turkeys. Although males tended to have a higher prevalence of *H. meleagridis* than females, no significant differences ($P = 0.53$) were found. Prevalence values between upland trap sites 1 and 3 were the most disparate, yet no significant differences ($P = 0.31$) were detected among the four trap sites. No significant differences ($P = 0.97$) were found for the interactive effect of host age and sex.

Intensities of *L. smithi*, *H. meleagridis*,

TABLE 1. Prevalences (%) of *Leucocytozoon smithi*, *Haemoproteus meleagridis*, and *Plasmodium* sp. found in 76 wild turkeys from South Carolina, January and February 1994.

Species	Locality				Host age		Host sex		Total
	Site 1 (n = 34)	Site 2 (n = 12)	Site 3 (n = 19)	Site 4 (n = 11)	Juvenile (n = 39)	Adult (n = 37)	Male (n = 38)	Female (n = 38)	(n = 76)
L. smithi	34 (100)*	12 (100)	19 (100)	11 (100)	39 (100)	37 (100)	38 (100)	38 (100)	76 (100)
H. meleagridis	15 (44)	7 (58)	14 (74)	5 (45)	26 (67)	15 (41)	23 (61)	18 (47)	41 (54)
Plasmodium sp.	1 (3)	0 (0)	0 (0)	0 (0)	1 (3)	0 (0)	1 (3)	0 (0)	1 (1)

* Number of turkeys with this parasite (percent positive).

and *Plasmodium* sp. ranged from <1 to 16, <1 to 11, and 3 per 10,000 erythrocytes, respectively. Thirteen (17%) of 76 turkeys infected with *L. smithi* and 12 (29%) of 41 turkeys infected with *H. meleagridis* had intensities of <1 per 10,000 erythrocytes. Mean (±SE) intensities of *L. smithi*, *H. meleagridis*, and *Plasmodium* sp. were 3.4 ± 0.4, 1.8 ± 0.3, and 3.0 per 10,000 erythrocytes, respectively.

Significant differences (P = 0.002) in rank abundances occurred for *L. smithi* among host age groups (Table 2); juvenile turkeys had higher abundances than adults (Table 3). Collectively, both common species varied significantly by host age (P = 0.004, Table 2); juvenile turkeys had higher mean (±SE) abundances than adults (6.0 ± 0.7 and 2.6 ± 0.4 per 10,000 erythrocytes, respectively). No differences were found in either of the two common hemosporids, or both species collectively, between trapping locality, host sex, or the interaction variable of host age and sex (Table 2).

TABLE 2. Values of the F statistic generated from factorial ANOVA for the two common hemosporid species and MANOVA (total) for both species collectively of the ranked abundance values among 76 turkeys from South Carolina, 1994.

Variable	*Leucocytozoon smithi*	*Haemoproteus meleagridis*	Total
Locality	1.84	0.73	1.21
Age	9.99*	2.87	5.97*
Sex	0.06	0.32	0.18
Age-sex	0.01	0.04	0.02

* Significant at $P \leq 0.05$.

Workers describing host-hemosporid systems in temperate regions often report a seasonal aspect in transmission related to vector abundance (Allan and Mahrt, 1989). Typically, latent periods occur when vector populations are low or absent and represent periods in the host when hemosporid prevalence and intensity are low (Herman, 1968; Beaudoin et al., 1971). Alternatively, Atkinson et al. (1988) reported high (50 to 100%) prevalences and continual transmission of *H. meleagridis* throughout the year in southern Florida (USA) using domestic sentinel turkeys. Their findings were attributed to sufficient vector populations occurring throughout the year as a result of the subtropical climate. We found high prevalences and low intensities of the two common hemosporids during late winter, which is evidence that chronic infections probably resulted from continual hemosporid transmission.

Mild winter temperatures on our study area (National Oceanic and Atmospheric Administration, 1994), resulting from a southern maritime climatological influence, are capable of supporting vector populations. Jones and Richey (1956) found breeding populations of *Simulium slossonae* and *S. congareenarum* in early February in Jasper County, South Carolina. Noblet et al. (1975) found *L. smithi* was transmitted throughout the winter in the Coastal Plain and Sandhill regions of South Carolina. Unfortunately, annual abundance patterns of culicine mosquitoes (vectors of *Plasmodium* spp.), and of ceratopogonid and hippoboscid flies (vectors of *Haemoproteus* spp.) have not been ex-

amined within our study area or adjacent regions.

Host age clearly was related to the structure and pattern of the hemosporid community. Prevalence of *H. meleagridis* and abundance of *L. smithi* consistently were higher in juvenile turkeys. Age-specific host immunological status and physiological condition have been proposed as important factors in other host-hemosporid systems (Godfrey et al., 1990) and may have been a factor in our study. Turkeys tend to segregate unto unisex flocks for extended periods (Healy, 1992), which could represent different exposure probabilities to vectors if habitat preferences were sex-specific. We found no differences in hemosporid prevalence or abundance between trapping locality (representing upland and swamp habitat types) or host sex variables.

We found one turkey infected with a *Plasmodium* sp. Apparently, this is the first record of a *Plasmodium* sp. in wild turkeys from South Carolina (Forrester, 1991). We were unable to determine the species, but it appeared similar to *Plasmodium* (*Novyella*) sp. reported by Castle et al. (1988). Sufficient differences were found in erythrocytic stages of this parasite to exclude either *P. hermani* or *P. lophurae*, which have been reported in wild turkeys from Florida and Wisconsin (USA), respectively (Forrester, 1991). Although subinoculation techniques were beyond the scope of this study, it is likely that more turkeys were positive for *Plasmodium* sp. than we observed.

Prevalence data often has been used as the exclusive means to describe hemosporid communities. However, our results provide strong evidence for using both prevalence and abundance data. For example, overall abundance of *L. smithi* was about three times higher than that found for *H. meleagridis*. Prevalences of *L. smithi* were similar across the biotic and spatial variables that we examined; yet juvenile turkeys had twice as many *L. smithi* than were found in adults. Also, the collective

TABLE 3. Abundances of *Leucocytozoon smithi*, *Haemoproteus meleagridis*, and *Plasmodium* sp. found in 76 wild turkeys from South Carolina, 1994.

Species	Locality				Host age		Host sex		Total (n = 76)
	Site 1 (n = 34)	Site 2 (n = 12)	Site 3 (n = 19)	Site 4 (n = 11)	Juvenile (n = 39)	Adult (n = 37)	Male (n = 38)	Female (n = 38)	
L. smithi	3.5 ± 0.5[a]	1.9 ± 0.4	4.9 ± 0.9	1.9 ± 0.4	4.6 ± 0.5	2.1 ± 0.3	3.8 ± 0.5	3.0 ± 0.5	3.4 ± 0.4
H. meleagridis	0.7 ± 0.2	0.7 ± 0.2	1.6 ± 0.6	0.6 ± 0.3	1.4 ± 0.3	0.5 ± 0.1	1.4 ± 0.4	0.5 ± 0.1	0.9 ± 0.2
Plasmodium sp.	0.1 ± 0.1	0[b]	0[b]	0[b]	0.1 ± 0.1	0[b]	0.1 ± 0.1	0[b]	<0.1 ± <0.1

[a] Mean ± SE number of hemosporids per 10,000 erythrocytes.
[b] None found.

abundances of both common hemosporids were two times higher in juvenile turkeys than adults. Particular host subpopulations in which gametocytes are concentrated represent an important component in the maintenance of the host-hemosporid-vector cycle. Clearly, abundance data provides important information about the structure of hemosporid communities at the component community level and also provides insight about possible ecological relationships between hosts and their parasites, which could not be ascertained using only prevalence data.

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LITERATURE CITED

ALLAN, R. A., AND J. L. MAHRT. 1989. Influence of transmission period on primary and relapse patterns of infection of *Leucocytozoon* spp. and *Haemoproteus mansoni*. The American Midland Naturalist 121: 341–349.

ATKINSON, C. T. 1991. Vectors, epizootiology, and pathogenicity of avian species of *Haemoproteus* (Haemosporina: Haemoproteidae). Bulletin of the Society for Vector Ecology 16: 109–126.

———, AND D. J. FORRESTER. 1987. Myopathy associated with megaloschizonts of *Haemoproteus meleagridis* in a wild turkey from Florida. Journal of Wildlife Diseases 23: 495–498.

———, ———, AND E. C. GREINER. 1988. Epizootiology of *Haemoproteus meleagridis* (Protozoa: Haemosporina) in Florida: Seasonal transmission and vector abundance. Journal of Medical Entomology 25: 45–51.

BEAUDOIN, R. L., J. E. APPLEGATE, D. E. DAVIS, AND R. G. MCLEAN. 1971. A model for the ecology of avian malaria. Journal of Wildlife Diseases 7: 5–13.

CASTLE, M. D., B. M. CHRISTENSEN, AND T. E. ROCKE. 1988. Hematozoan parasites of Rio Grande wild turkeys from southern Texas. Journal of Wildlife Diseases 24: 88–96.

CONOVER, W. J., AND R. L. IMAN. 1981. Rank transformations as a bridge between parametric and nonparametric statistics. The American Statistician 35: 124–129.

FORRESTER, D. J. 1991. The ecology and epizootiology of avian pox and malaria in wild turkeys. Bulletin of the Society for Vector Ecology 16: 127–148.

———, P. P. HUMPHREY, S. R. TELFORD, JR., AND L. E. WILLIAMS, JR. 1980. Effects of blood-induced infections of *Plasmodium hermani* on domestic and wild turkey poults. Journal of Wildlife Diseases 16: 237–244.

GARNHAM, P. C. C. 1966. Malaria parasites and other Haemosporidia. Blackwell Scientific Publications, Oxford, England, 1,114 pp.

GODFREY, R. D., JR., A. M. FEDYNICH, AND D. B. PENCE. 1987. Quantification of hematozoa in blood smears. Journal of Wildlife Diseases 23: 558–565.

———, D. B. PENCE, AND A. M. FEDYNICH. 1990. Effects of host and spatial factors on a haemoproteid community in mourning doves from western Texas. Journal of Wildlife Diseases 26: 435–441.

GREINER, E. C., AND D. J. FORRESTER. 1980. *Haemoproteus meleagridis* Levine 1961: Redescription and developmental morphology of the gametocytes in turkeys. The Journal of Parasitology 66: 652–658.

HEALY, W. 1992. Behavior. *In* Wild turkey biology and management, J. G. Dickson (ed.). Stackpole Books, Harrisburg, Pennsylvania, pp. 46–65.

HERMAN, C. M. 1968. Blood parasites of North American waterfowl. Transactions of the North American Wildlife and Natural Resources Conference 33: 348–359.

JONES, C. M., AND D. J. RICHEY. 1956. Biology of the black flies in Jasper County, South Carolina, and some relationships to a *Leucocytozoon* disease of turkeys. Journal of Economic Entomology 49: 121–123.

LARSON, J. S., AND R. D. TABOR. 1980. Criteria of sex and age. *In* Wildlife management techniques manual, 4th ed., S. D. Schemnitz (ed.). The Wildlife Society, Washington, D.C., pp. 143–202.

MARGOLIS, L., G. W. ESCH, J. C. HOLMES, A. M. KURIS, AND G. A. SCHAD. 1982. The use of ecological terms in parasitology (report of an ad hoc committee of the American Society of Parasitologists). The Journal of Parasitology 68: 131–133.

NATIONAL OCEANIC AND ATMOSPHERIC ADMINIS-

TRATION. 1994. Climatological data: South Carolina, monthly summaries (January and February). National Climatic Center, Asheville, North Carolina.

NOBLET, R., J. B. KISSAM, AND T. R. ADKINS, JR. 1975. *Leucocytozoon smithi*: Incidence of transmission by black flies in South Carolina (Diptera: Simuliidae). Journal of Medical Entomology 12: 111–114.

SAS INSTITUTE INC. 1985a. SAS user's guide: Statistics, Version 5 ed. SAS Institute, Inc., Cary, North Carolina, 956 pp.

———. 1985b. SAS user's guide: Basics, Version 5 ed. SAS Institute, Inc., Cary, North Carolina, 1,290 pp.

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