Prevalence of Haemosporidians in birds of Northern Michigan

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Abstract

In this study, the prevalence of Haemosporidians in birds of Northern Michigan was investigated with an emphasis on the parasite *Plasmodium* in passerine birds. Birds caught and banded by mist-netters were sampled for blood and recorded by species, net number, sex, age, and swab number. The total prevalence of blood parasites in the samples was 23.8%. Birds caught at the CEMA banding site had the highest prevalence of malarial infection, and the birds of the NOMA banding site had the lowest. Mann-Whitney Tests resulted in two-tailed p-values of 0.001, 0.762, and 0.003 for comparisons of prevalence between NOMA and CEMA, CEMA and SOMA, and NOMA and SOMA, respectively. Kruskal-Wallis Tests regarding bird age, location, and families resulted in p-values of 0.259, 0.004, and 0.009, respectively. Tests for sex showed no significant differences between prevalence of infection in male and female hosts.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Parasites in nonhuman animals offer insight in understanding and treating human parasites, and are thus frequent subjects of scientific study. Avian species of malaria were the first models for studying the biology of the human *Plasmodium* (Slater 2005). In fact, they are so similar that for a long time, there was doubt as to whether the parasites of bird and human malaria were really different (Manwell 1935). Studies by Waters and colleagues (1993) showed that *Plasmodium falciparum*, the most deadly infective agent of human malaria, was more closely related to avian parasites than any other species. Not only are the causative agents similar, but the symptoms of human malaria are also similar to those of bird malarias (Kudo 1971).

Previous studies have also attempted to compare the parasite-host relationship of avian and human malarias, plus evaluate the evolutionary dynamics of a system of many hosts and several multihost parasites (Gandon 2004). Co-evolution between the malaria parasite and its bird hosts have also been of interest. For example, studies of the Hawaiian Honeycreeper suggest that avian parasites do not hinder their hosts' reproductive success possibly because of evolution (Kilpatrick 2006). In addition, another Haemosporidian *Leucocytozoon* in ducks has been studied for its effects on brood size (O'Roke 1934).

However, avian *Plasmodium* in Northern Michigan has not been studied in much depth. Its prevalence in the birds should be between 10 and 30% (Feldman et al. 1995). The current study attempted to examine the possibilities of a trend in the incidence of various species of *Plasmodium* in groupings of birds according to species, age, sex, or size. Furthermore, prevalence of blood parasites in passerine birds were compared to those found in *Mergus merganser* based on previous findings of *Haematozoa* in Michigan (DeJong et al., 2001).

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Methods

Data collection was carried out from July 10 to August 3, 2006 in Emmett County, Michigan. Birds were caught using mist nets, which were arranged in a loop formation with ten nets per loop. There were a total of three sites where birds were captured: NOMA (North Maple River), CEMA (Central Maple River), and SOMA (South Maple River). Data of every bird captured were recorded into organized data sheets, including information such as species name, age, sex, and net number. If blood was taken from a bird, the blood smear number was also recorded. A total of 189 blood samples were taken from a variety of birds; 159 of these were obtained through mist-netting, and the rest were obtained with help of Harvey Blankespoor.

Blood samples were taken from birds' feet using sterile lancets, and then slides pre-cleaned with acid ethanol were held against the small droplet of blood. The blood collected on these slides was smeared with the edge of another slide, then fixed in methanol to be stained later in the lab. Each fixed slide was immersed in Coplin jars containing Giemsa stain for 15 seconds, placed in distilled water for 15 seconds, and finally, rinsed quickly in two more jars of fresh distilled water.

Dried slides were viewed using the 100x power oil immersion lens. Observation of malaria within the blood cells was carried out by manually scanning the surface of the slide for five minutes (roughly 1000 red blood cells).

Prevalence of infection was determined by dividing the number of infected passerine birds by the total number of passerine birds examined. Overall prevalence was determined by dividing the number of infected birds by the number of total birds examined. Mann-Whitney and Kruskal-Wallis tests were used to calculate differences of the distribution of avian blood parasites and the intensity of infection between age, gender, and location of the species sampled. These helped to determine any relationship between age or gender and a particular infection and these analyses were done in SPSS 14.0 for Windows.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Results

The total prevalence of blood parasites in the samples was 23.8%. Table 1 summarizes the data of the 14 families of birds that were examined. The family Parulidae was most represented in the sample, but the Anatidae had the highest overall prevalence of infection and prevalence within the family. The family Parulidae also had the highest prevalence of infection within the mist-netted birds (Table 2, Figure 1). At species level, the Baltimore Oriole and Common Grackle had the highest prevalence of parasitic infection, then the Song Sparrow was next highest (Table 3, Figure 2).

Most of the birds caught were in their hatch year age, which also had the highest prevalence excluding the group of five birds which were of unknown or indeterminate ages; no birds of the second year category were found to be infected (Figure 3).

Birds caught at the CEMA banding site had the highest prevalence of malarial infection, and the birds of the NOMA banding site had the lowest (Figure 4). Mann-Whitney Tests resulted in two-tailed p-values of 0.001, 0.762, and 0.003 for comparisons of prevalence between NOMA and CEMA, CEMA and SOMA, and NOMA and SOMA, respectively (Tables 4, 5, and 6).

Kruskal-Wallis Tests regarding bird age, location, and families resulted in p-values of 0.259, 0.004, and 0.009, respectively (Tables 7, 8 and 9). Tests for sex showed no significant differences between male and female.

Table 1. Prevalence of parasitic infection

Family	% represented in the sample	Overall Prevalence	Prevalence within the family
Parulidae	41.0	3.17	7.80
Anatidae	12.0	12.2	100
Turdidae	10.0	1.06	10.5
Emberizidae	9.00	2.65	29.4
Tyrannidae	9.00	0.00	0.00
Paridae	7.00	1.06	15.4
Corvidae	3.00	2.65	100

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Mimidae	3.00	0.00	0.00
Icteridae	2.00	1.06	66.7
Picidae	2.00	0.00	0.00
Cuculidae	1.00	0.00	0.00
Sturnidae	1.00	0.00	0.00
Vireonidae	1.00	0.00	0.00
Sittidae	1.00	0.00	0.00

Table 2. Family, sample size, number infected, and prevalence of infection only in mist-netted birds

Family	N	Number of species infected	Prevalence
Parulidae	77	6	3.8
Turdidae	19	2	1.3
Emberizidae	17	5	3.1
Paridae	13	2	1.3
Icteridae	3	2	1.3
Total	129	17	*10.7

*The overall prevalence based on the total mist-netted birds sampled N=159.

Table 3. Family, species, scientific name, sample size, avian parasite, and prevalence of birds sampled from mist-netting

Family	Species	Scientific name	N	Avian Parasite	Prevalence
Parulidae	Ovenbird	*Seiurus aurocapillus*	21		1.30
Parulidae	Northern Waterthrush	*Seiurus noveboracensis*	2		1.30
Parulidae	Black-and-White Warbler	*Mniotilta varia*	6		1.30
Parulidae	Nashville Warbler	*Vermivora ruficapilla*	10		2.60
Parulidae	American Redstart	*Setophaga ruticilla*	23		1.30
Parulidae	Hermit Thrush	*Catharus guttatus*	10		5.26
Turdidae	Veery	*Catharus fuscescens*	8		5.26
Emberizidae	White-throated Sparrow	*Zonotrichia albicollis*	4		5.88
Emberizidae	Song Sparrow	*Melospiza melodia*	9		23.5

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Paridae	Black-capped Chickadee	*Parus atricapillus*	*13		15.4
Icteridae	Baltimore Oriole	*Icterus galbula*	✦2		33.3
Icteridae	Common Grackle	*Quiscalus quiscula*	✦1		33.3

** The Black-Capped Chickadee was the only bird sampled in the family Paridae.*

✦*The Baltimore Oriole and Common Grackle were the only sampled species in the family Icteridae*

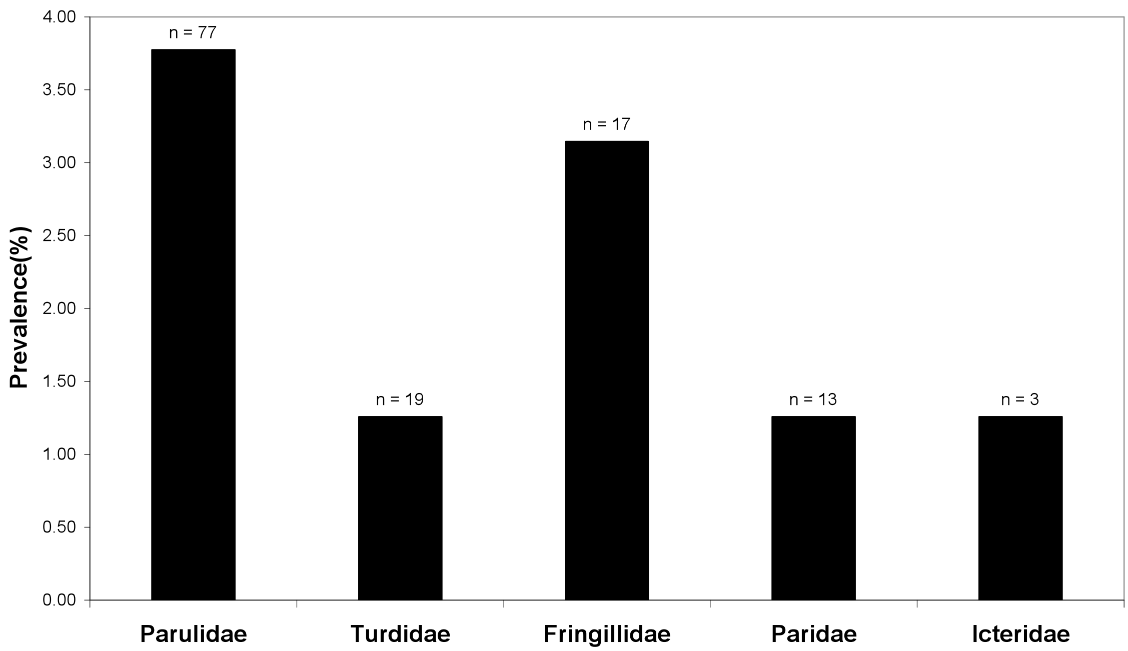

Figure 1. Prevalence of blood parasites in passerine bird families

Correction: Fringillidae should be Emberizidae.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

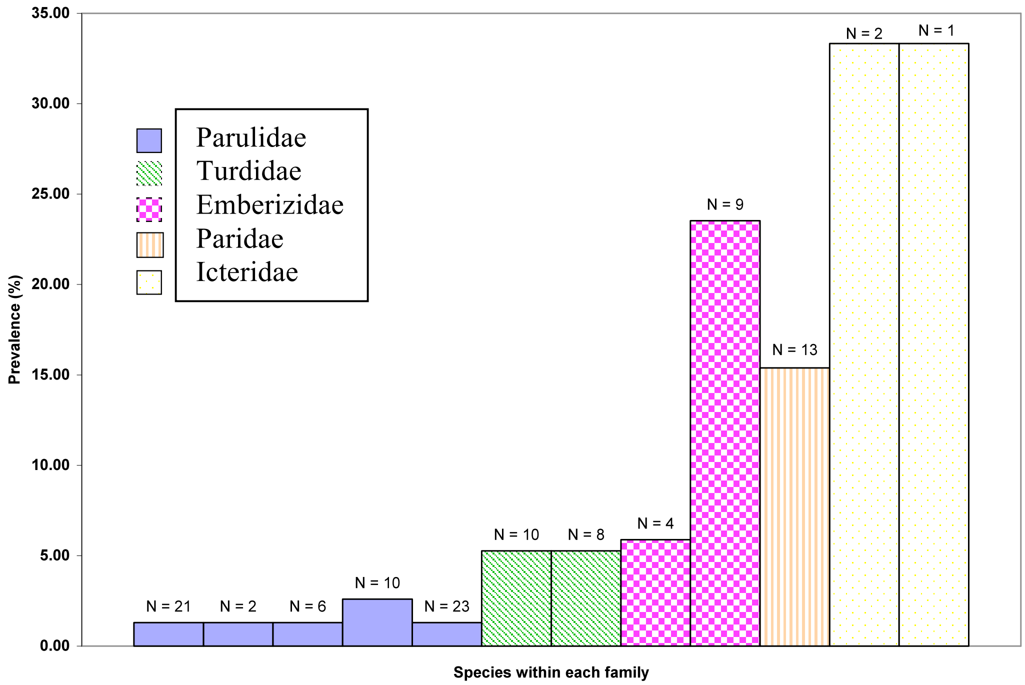

Figure 2. Prevalence of parasitic infection in host species grouped by families. From left to right: in the Parulidae family, species are Ovenbird, Northern Waterthrush, Black and White Warbler, Nashville Warbler, and American Redstart; Turdidae include Hermit Thrush and Veery; Emberizidae include the White-throated Sparrow and Song Sparrow; Black-capped Chickadee is the sole representative of Paridae; and the Icteridae include the Baltimore Oriole and Common Grackle.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

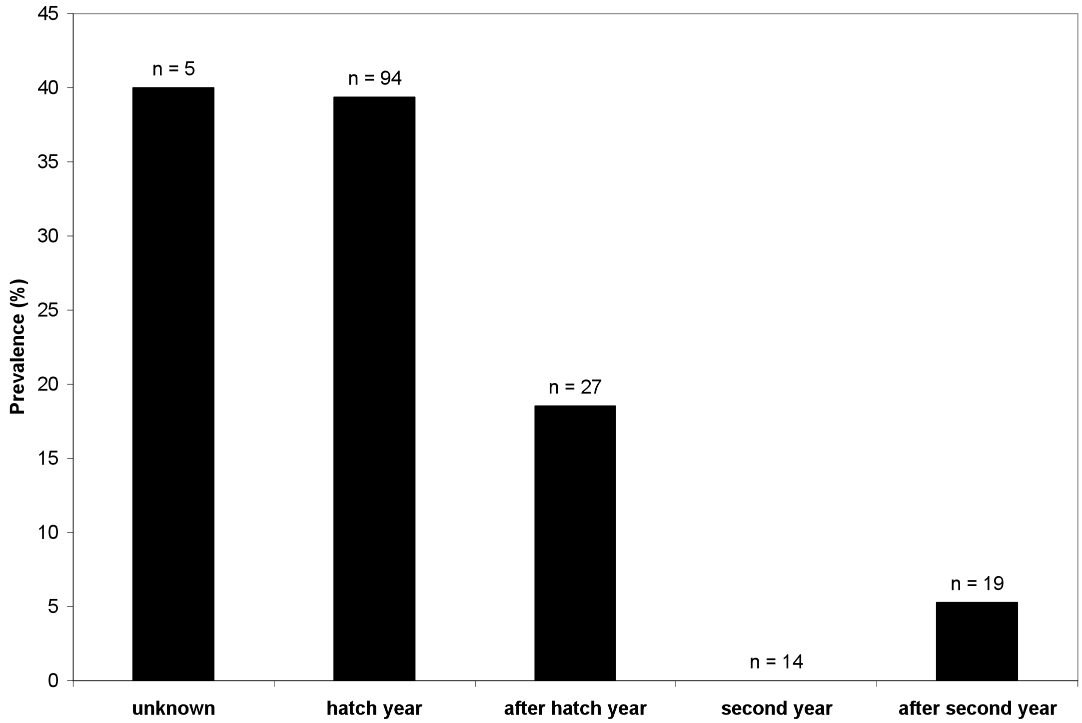

Figure 3. Prevalence of parasitic infection by host age

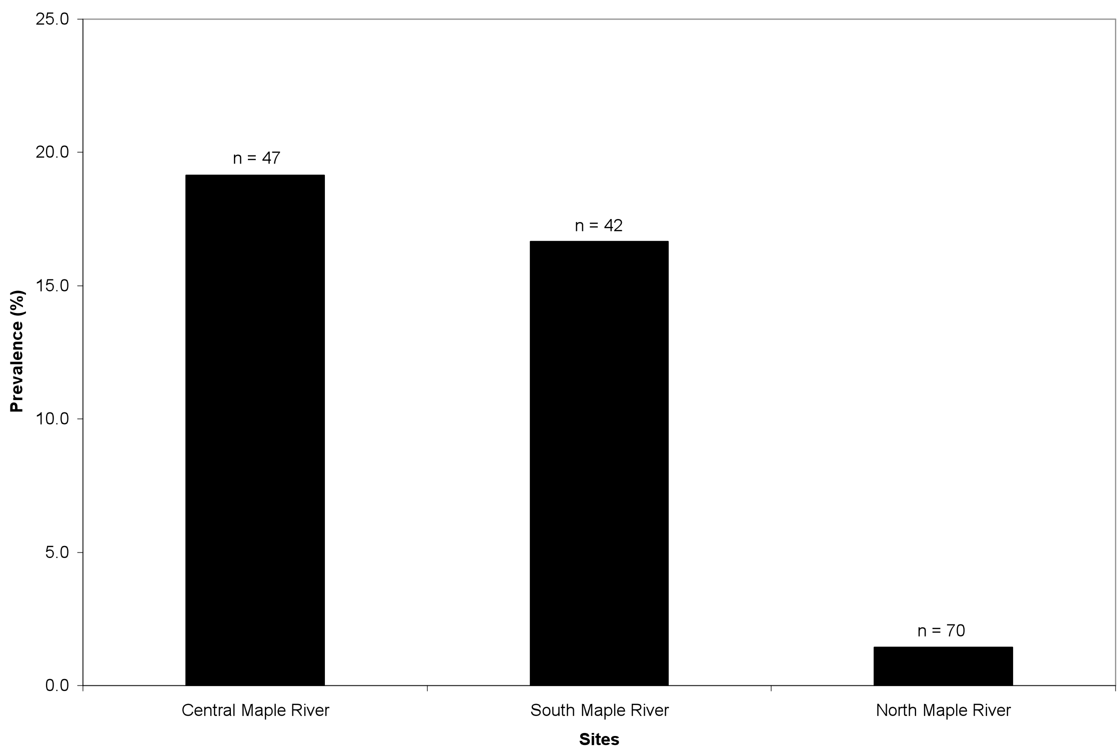

Figure 4. Prevalence of malarial infection by banding site

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Table 4. Result of Mann-Whitney Test for the prevalence of infection between central and north Maple River

	Lcode	N	Mean Rank	Sum of Ranks
Infection	Central Maple River	47	65.20	3064.50
	North Maple River	70	54.84	3838.50
	Total	117		

a.

	Infection
Mann-Whitney U	1353.500
Wilcoxon W	3838.500
Z	-3.347
Asymp. Sig. (2-tailed)	.001

b.

Table 5. Results of Mann-Whitney Test for the prevalence of infection between central and south Maple River

	Lcode	N	Mean Rank	Sum of Ranks
Infection	Central Maple River	47	45.52	2139.50
	South Maple River	42	44.42	1865.50
	Total	89		

a.

	Infection
Mann-Whitney U	962.500
Wilcoxon W	1865.500
Z	-.303
Asymp. Sig. (2-tailed)	.762

b.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Table 6. Result of Mann-Whitney Test for the prevalence of infection between north and south Maple River

	Lcode	N	Mean Rank	Sum of Ranks
Infection	North Maple River	70	53.30	3731.00
	South Maple River	42	61.83	2597.00
	Total	112		

a.

	Infection
Mann-Whitney U	1246.000
Wilcoxon W	3731.000
Z	-3.018
Asymp. Sig. (2-tailed)	.003

b.

Table 7. Kruskal-Wallis Test by Age

	age	N	Mean Rank
Infection	after hatch year	27	84.26
	hatch year	94	76.55
	second year	14	70.00
	after second year	19	78.11
	Total	154	

a.

	Infection
Chi-Square	4.026
df	3
Asymp. Sig.	.259

b.

Table 8. Kruskal-Wallis Test by Location

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

	Lcode	N	Mean Rank
Infection	Central Maple River	47	86.72
	North Maple River	70	72.64
	South Maple River	42	84.75
	Total	159	

a.

	Infection
Chi-Square	11.310
df	2
Asymp. Sig.	.004

b.

Table 9. Kruskal-Wallis Test by Family

	Fcode	N	Mean Rank
Infection	Fringillidae	17	75.47
	Icteridae	3	99.50
	Paridae	13	66.42
	Parulidae	77	61.53
	Turdidae	19	63.29
	Total	129	

a.

	Infection
Chi-Square	13.436
df	4
Asymp. Sig.	.009

b.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Discussion

The data from this study show that prevalence of avian malaria in Northern Michigan was statistically significant. The prevalence of infection in all of the samples collected was 23.8% and the prevalence in only passerine birds was 10.7%, which supports previous research that blood smears demonstrate infection rates between 10 and 30% (Feldman et al. 1995).

Haemoproteus and *Leucocytozoon* are host-specific and are found within related species of a particular family (Fallis et al. 1974), but species of the genus *Plasmodium* are not as family-specific (Bennett et al. 1982). Results from the current study showed that *Plasmodium* was represented in five families. Birds of the family Anatidae had the highest prevalence of haemosporidian infection, but this is because of the ubiquitous nature of *Leucocytozoon* in that family of birds. The family Corvidae also had a high prevalence of 100%.

Prevalence among species also varied dramatically. One factor that may explain the variance is habitat preference of infected bird species. Mosquitoes are found much more often near standing water, which suggests that birds nesting and breeding near standing water should be more susceptible to avian malaria. The Ovenbirds of the family Parulidae are common in all woods with dry floor; the Northern Waterthrushes are mainly in conifer bogs, wooden swamps, and along streams in heavily shaded ravines; the Black-and-White Warblers are common in conifer bogs; the Nashville Warblers are common in moist conifer woods and bogs or open, dry woods; the American Redstarts are common in deciduous woods. The Hermit Thrush of the family Turdidae are common in semi-open woods, and the Veeries are common in densely shaded, often moist woods. The White-throated Sparrows of the family Emberizidae are common in the shrubby edges of conifer bogs and heavily shaded coniferous-deciduous woods, and the Song Sparrows are common in brushy areas. Black-Capped Chickadees of the Paridae family are commonly found in wooded areas. The Baltimore Oriole of the family Icteridae is common at the edges of open deciduous woods, and the Common Grackle is common near lakes and streams,

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

particularly where there are pines and other conifers. (Pettingill 1974). Overall, some of the infected bird species prefer habitats that are potentially mosquito-dense while others do not.

There was a propensity for prevalence of infection to decrease with bird age except for birds in their second year (Figure 3). These data were inconsistent with previous findings which showed juveniles to be more susceptible to infection than adult birds (Atkinson and Van Riper 1991). Birds should be highly vulnerable to insect bites during the two weeks until they leave the nest because of their bare, feather-less skin, allowing an opportunity for them to be infected by *Plasmodium.* The small sample size of this study most likely limited the accuracy of the data; with a larger, more thorough sample, one would be able to better interpret the relationship of host age and haematozoan infection. Prevalence of infection was also high in the group of birds with unknown age, since only two out of only five birds were infected.

The prevalence of infection at the three banding locations differed from one another, and was statistically significant. This could be a result of birds having varying degrees of exposure to the mosquito vector. Birds caught in mist nets near water should show a higher prevalence of infection than those caught elsewhere. Possibly, the CEMA and SOMA locations had more mosquito-rich areas in it, and as a result reflected a higher prevalence of bird malaria in the data.

Tests for different prevalence in sex showed no significance, which is a result of inadequate data. Many of the birds caught in the mist nets could not be characterized for sex, because they were too young and juveniles are difficult to assess gender even with the expertise of collaborators of this project.

Prevalence of Haemosporidian infection throughout the birds of Northern Michigan varied significantly by host family, species, age, and location. There are many possible factors that could contribute to this: bird behavior, habitat, concentration of mosquito vectors, climate, or co-evolution (Atkinson and Van Riper 1991). Further studies that look into this would be useful in comparison to distribution patterns of *Plasmodium* species that infect humans. No conclusions could be made about the effect of Haemosporidians on the bird populations of Northern Michigan,

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

but continued pursuit of this question could supplement data and make more accurate analyses possible.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Acknowledgements

Keely Dinse deserves the most credit in this project for allowing the authors to join her in collecting birds and for giving them all of the needed bird identification data. I would like to acknowledge Harvey Blankespoor for giving his assistance in identifying the parasites, Mike Akresh for helping data collection and data analysis, Dave Gonthier for data collection and assistance in parasite identification, Paula Furey for her assistance in using the camera microscope. Lastly, the University of Michigan Biological Station deserves credit for making this project possible.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

Literature Cited

Atkinson, C. T., and C. Van Riper III. 1991. Pathogenicity and epizootiology of avian Haematozoa: *Plasmodium*, *Leukocytozoon*, and *Haemoproteus*. *In* Bird-Parasite interaction. J. T. Loye and M. Zuk (eds.). Oxford University Press, Oxford, U.K., p. 19-48.

Bennett, G.F., Whiteway, M., and C. Woodworth-Lynas. 1982. A host-parasite catalogue of the avian haematozoa. Memorial University of Newfoundland Occasional Papers in Biology. No. 5.

DeJong, R.J., Reimink, R.L., and H.D. Blankespoor. 2001. Hematozoa of hatch-year common mergansers from Michigan. Journal of Wildlife Diseases. 37(2): 403-407.

Fallis, A.M., Desser, S.S., and R.A. Khan. 1974. On species of *Leucocytozoon*. Advances in Parasitology. 12: 1-67.

Gandon, S. 2004. Evolution of multihost parasites. Evolution 58(3): 455–469.

Kilpatrick, A. M., LaPointe, D. A., Atkinson C. T., Woodworth, B. L., Lease, J. K. Reither, M. E. and K. Gross. 2006. Effects of chronic avian malaria (*Plasmodium relictum*) infection on reproductive success of Hawaii Amakihi (*Hemignathus virens*). The Auk 123(3): 764-774.

Kudo, Richard R. 1971. Protozoology 5th Edition. Charles C. Thomas Publisher, Springfield, Illinois, 735-738 pp

Manwell, R. D. 1935. How many species of avian malaria parasites are there. The American Journal of Tropical Medicine. Vol. 15(3): 265-283.

O'Roke, E. C. 1934. A malaria-like disease of ducks, caused by *Leucocytozoon anatis* Wickware. In Bulletin (University of Michigan. School of Forestry and Conservation) ; no. 4.

Pettingill, O. S. 1974. Ornithology at The University of Michigan Biological Station

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan

and The Birds of The Region. Beimer Printing Co., Kalamazoo, Michigan.

Slater, L. B. 2005. Bird Malaria. Bull. Hist. Med. 79: 261–294.

Waters, A.P, Higgins, D.G., and T.F. McCutchan. 1993. Evolutionary relatedness of some primate models. Mol. Biol. Evol. 10(4): 914-923.

Michigan Corpus of Upper-level Student Papers. Version 1.0 Ann Arbor, MI. Copyright (c) 2009 Regents of the University of Michigan