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HEMATOZOA OF COMMON GRACKLES (*QUISCALUS QUISCULA VERSICOLOR*, VIEILLOT) IN CENTRAL ARKANSAS

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ABSTRACT

During the years 1977-84, 118 bronzed grackles, *Quiscalus quiscula versicolor*, Vieillot, of 132 examined were found infected with hematozoa. The eight species of symbionts collected from the infected birds included two microfilarial species (*Chandlerella quiscali* and *Eufilaria hibleri*), five apicomplexans (*Haemoproteus quiscali, Leucocytozoon fringillinarum, Plasmodium matutinum, P. vaughani, P.* sp.) and a flagellate (*Trypanosoma ontarioensis*). *P. matutinum* and *T. ontarioensis* represent new host records and all the protozoans represent new locality records. Comparisons are made of symbiont prevalance and diversity as this relates to seasons of the year, sex and age of the host. Comparisons are also made with previous studies on this subspecies.

INTRODUCTION

The study of avian hematozoa constitutes an intriguing ecological investigation because the symbionts share a common habitat. In some instances the organisms are present in the plasma and in other instances within the blood cells. Microfilaria of nematodes and asexual stages of protozoans constitute the symbionts of this study. Both of these groups rely on the blood as a medium in which they find nutrients and a vehicle through which they are transmitted to the insect intermediate or definitive host. Microfilaria and trypanosomes are solely plasma inhabitants while the species of *Plasmodium, Leucocytozoon* and *Haemoproteus* spend most of their development time within the blood cells. The microfilaria, unlike the protozoans, do not proliferate within the blood but are released from adult fertilized nematodes of either *Chandlerella quiscali* (von Linstow, 1904) in the cerebrum or *Eufilaria hibleri* (Granath, 1981) in the subcutaneous connective tissue. The microfilarial stage is purely the transmission stage as the bird is the definitive host and ceratopogonids the intermediate hosts. In many filarial infections there is a diurnal periodicity of increase in microfilarial numbers in the peripheral blood. Protozoans also have developmental stages in other organs with at least the infective stage being present in the blood. Proliferation of the protozoans occurs in the bird, but the definitive host is an insect in all but one instance. Trypanosomes do not have a known sexual stage and the question of definitive host becomes moot. In this latter case, vegetative proliferation occurs in both the insect and the vertebrate host.

The common grackle, *Quiscalus quiscula,* has been divided into three major subspecies. The bronzed grackle, *Q. q. versicolor* Vieillot, has a breeding range generally extending from the eastern slopes of the Rocky Mountains covering most of Texas to the western slope of the Appalachian Mountains and into New England. The northern boundary reaches far into Canada (Maxwell, 1965). East of the Appalachians, there exists the purple grackle *(Q. q. stonei)* and the coastal Florida grackle *(Q. q. quiscula).*

Substantial hematozoan work has been done on the purple grackle, but few studies have been made concentrating on the hematozoa of the bronzed grackle. There have been more studies in which bronzed grackles have been incidental to a larger study focusing on many species. Bennett, *et al.* (1982) compiled a documentation of bird host-hematozoan associations that enables an investigator to form a list of species of hematozoa from most species of birds. From this source, the following were documented as being present in bronzed grackles: Microfilaria of *C. quiscali;* intracellular apicomplexan species *Leucocytozoon fringillinarum, Plasmodium cathemerium, P. circumflexum, P. elongatum, P. relictum (= P. praecox), P. vaughani (= P. hexamerium); Haemoproteus fringillae/orizivora, H. quiscalus* and the intercellular flagellate, *Trypanosoma avium.* Tables 1 and 2 list the hematozoa recorded above. Table 1 lists the symbionts reported only by genus. Table 2 records those cases in which the symbiont species is identified. The tables also list the genera and species reported since

Table 1. Hematozoa Genera (Species unknown) from Bronzed Grackles

AUTHORS	YEAR	STATE	INF/EX	HAEM	LEUC	PLAS	TRYP	MICR
AL-DABAGH	1964	OH	1/4	1				
BENNETT, CAMERON, WHITE	1975	NB	12/15	4	9	1		
BENNETT, FALLIS	1960	SONT	58/80	7	52		6	16
IMMATURES			13/24		13		1	
NESTLINGS			8/99		8			
CLARKE	1946	ONT	2/3		2			1
COATNEY, WEST	1938	NE	1/1					
IMMATURES			1/1					
FARMER	1960	IA	5/16	1	5	1	1	1
HERMAN	1935	NY		X				
HUFF	1939	IL	63/128	45	4	7	1	X
FLEDGLINGS				3				
NESTLINGS				4	1			
MANWELL	1951	NY	56/75	30	45	8		
ROBINSON	1961	OH	1/2					1
SACHS	1953	IL	3/4	3	3			X
SMITH	1967	OH	23/26	13	16	2		
STABLER, KITZMILLER	1970	CO	4/5	2			1	3

Table 2. Hematozoa Species Reported from Bronzed Grackles (Number of Birds Infected)

AUTHORS	YEAR	STATE	PR	PC	PE	PV	TA	HQ	HL/O	LF	CQ	BH
AL-DABAGH	1964	OH						1*				
BENNETT, CAMERON, WHITE	1965	NB							4*	9*		
COATNEY, WEST	1938	NE					1	1				
IMMATURES								1				
FALLIS, BENNETT	1961									1		
FALLIS, BENNETT	1962									1		
GRANATH	1981	IL										86
GRANATH, HUIZINGA	1978	IL									X	
HERMAN	1935	NY		X								
HERMAN	1938	NY		1								
HERMAN(IRCAH)	1982			X								
HUFF	1939	IL	3	2	3							
NESTLINGS			1		1							
IRCAH	1982					X						
MANWELL	1951	NY	1	3								
MANWELL, HERMAN	1935	NY		1								
ODETOYINBO, ULMER	1960	IA									X	
SACHS	1953	IL					1					
STABLER, KITZMILLER	1970	CO					1*					

*Identified by IRCAH after publication.

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the 1982 publication of the *Host-parasite catalog of avian hematozoa*. The following have been added. Granath (1981) described adults and microfilaria of *E. hibleri* from Illinois grackles. Woo and Bartlett (1982) described *T. ontarioensis* from *Corvus brachyrhynchos brachyrhynchos* in Ontario. *Chandlerella quiscali* microfilaria have been reported in the host in Illinois by Granath and Huizinga (1978) and in Iowa by Odetoyinbo and Ulmer (1960). Adults of both microfilarial species have been recorded previously in the birds of this study in Arkansas by Johnson (1984).

No literature is available comparing the hematozoa in male and female hosts. Only a few studies detailed parasitism in immature birds. Coatney and West (1938) described *Haemoproteus quiscali* from a hatching year (HY) bronzed grackle in Nebraska. Huff (1939) reported *Leucocytozoon, Haemoproteus, Plasmodiium relictum* and *P. elongatum* from nestling grackles in Illinois. Farmer (1960) found *Plasmodium* in HY birds in Iowa. Bennett and Fallis (1960) reported hematozoa from adult and immature grackles in Algonquin Provincial Park in Ontario. The following hematozoans were obtained from 58 of the 80 adults they examined: *Trypanosoma, Leucocytozoon, Haemoproteus* and microfilaria. Of the 24 immatures, 13 were infected with *Leucocytozoon* and one of those additionally with *Trypanosoma*. The authors found *Leucocytozoon* infections in eight of 99 nestlings 9-14 days of age suggesting the early onset of parasitism by the latter genus. Multiparasitism in avian hematozoa is apparently widespread but has been only incidentally reported. The immatures above indicate the qualitative compatibility of *Leucocytozoon* and *Trypanosoma* as dual infections. Clarke (1946) indicated an infection of *Leucocytozoon* with microfilaria. Smith (1967) reported dual infections of *Leucocytozoon* with *Haemoproteus* in one case and with *Plasmodium* in another. All of the above suggest a high frequency of dual and perhaps greater multiparasitism.

This study focuses on the migrant and non-migrant bronzed grackles of Arkansas and embraces three seasons: winter, pre-breeding and post-breeding. The first two seasonal samples contain migrants from the north while the third sample contains some migrants from the south as well as Arkansas adults and Arkansas derived juveniles. Since both age and sex are plausible affecting variables, the study has included those distinctions. Earlier studies of the bronzed grackle symbionts have been confined to the northern sections of the United States and southern Canada and there has been little documentation of the hematozoa of wintering and pre-breeding birds. Over an 11-year period the author has banded over 11,000 Arkansas grackles between February 1 and April 15. Recoveries indicate that the migration pattern north from Arkansas is north/northwest or away from the regions in which previous grackle hematozoan studies have been made.

The purpose of this study is to use new distributional data in the context of varying space, time and host parameters to glean insights into the relationships between the host and its symbionts and between the symbionts. The presence of the host in Arkansas throughout the year presents an opportunity to study the distribution of hematozoa from bronzed grackles involving several variables. These include geographic location, season of the year, age of the host and sex of the host. In addition the number of different species of hematozoa in the bird provides a useful analytical system in determining the multiparasitism aspects of infections and thus gives information on the interactive synergism or antagonism of the symbionts in the common habitat. Finally, it is possible to ascertain which symbionts are acquired in Arkansas and the relative magnitude of the pre-patent period in the young bird.

MATERIALS AND METHODS

One hundred thirty-two bronzed grackles were examined in Conway, AR (35° 05 'N 92° 27 'W) between 1977 and 1984. Fifteen adult females and 13 adult males were screened from December and January 1982 and 1983. These wintering grackles are designated ARWAHY. Ten adult females and ten adult males were examined during the pre-breeding period, March 1984, and are designated ARPRBAHY. Eighty-four grackles were collected during the post-breeding period (ARPOB) in August-September 1977 (11), June-August 1980 (21) and 1982 (52). The post-breeding collection included 47 juvenile birds and 37 adult birds of both sexes. Sex and age determinations were done by internal examination. The presence of a bursa of Fabricius was used to identify the juvenile birds.

All birds were collected using Glenhaven live traps baited with hen scratch or popcorn. The hosts were dispatched by thoracic constriction and the blood removed immediately from the heart auricles. All examinations were made during the daylight hours. Smears were sent to the International Research Centre for Avian Hematozoa in St. Johns, Newfoundland (IRCAH). Dr. G.F. Bennett and Madonna Bishop supervised fixation, staining and reading of the smears. Their procedure involved looking at 100 fields on each slide using a 40X oil immersion objective.

The following acronyms are used to economize on space. AR = Arkansas, W = Winter, PRB = Pre-breeding, POB = Post-breeding, AHY = Adult (After hatching year), HY = Hatching year, CQ = *Chandlerella quiscali* microfilaria, EH = *Eufilaria hibleri* microfilaria, LF = *Leucocytozoon fringillinarum*, HQ = *Haemoproteus quiscali*, HL/O = *H. fringillae/orizivora*, PV = Plasmodium vaughani, PM = *P. matutinum*, PC = *cathemerium*, PE = *P. elongatum*, PR = *P. relictum*, PN = undetermined species of *Plasmodium* belonging to the Novyella group, TO = *Trypanosoma ontarioensis*, TA = *T. avium*. The acronyms MICR, TRYP, PLAS, LEUC, HAEM stand for microfilaria or genera of the above protozoa. The usual arconyms are used for the states with SONT indicating southern Ontario and NB, New Brunswick. INF always refers to the number infected and PCT to the percent infected. EX indicates the number examined.

DISCUSSION

One hundred eighteen of 132 examined birds were parasitized by at least one of eight hematozoan species. Fifty birds had one symbiont species, 56 birds had two, 11 birds had three and one host had four different parasites.

Arkansas wintering grackles were found to have three diferent hematozoan symbionts: CQ, EH, LF (Table 3). EH was always coupled with the dominant symbiont, CQ, while the LF was so coupled in one case and not the other. Microfilaria predominated in this adult population. Pre-breeding birds housed the same three symbionts but added a fourth:

Table 3. Bronzed Grackle Hematozoa by Season and Age

	W	PRB	POBAHY	POBHY	TOT	PCT
CQ	22	18	30	8	78	59.1
EH	9	7	30	20	66	50.0
HQ	0	0	5	25	30	22.7
LF	2	2	2	0	6	4.5
PV	0	1	1	2	4	3.0
PM	0	0	1	6	7	5.3
PN	0	0	0	2	2	1.5
TO	0	0	1	1	2	1.5
INF	23	19	35	41	118	
NO.	28	20	37	47	132	
PCT	82.1	95.0	94.6	87.2	89.4	

PV. However, the dominant microfilarial species again dwarfed the infections by the protozoans. All the EH were in hosts that also had CQ. Only one of the protozoan infections was a solitary infection.

The post-breeding population presented opportunities to look at the role of age, sex and year as well as season in relation to species distribution. When the years 1977, 1980 and 1982 are compared (Table 4) as

Table 4. Number of Hematozoa Species in ARPOB Birds

YEAR	0	1	2	3	4	TOTAL
1977	1	5	4	1	0	11
1980	2	6	9	3	1	21
1982	4	17	24	6	1	52
TOTALS	7	28	37	10	2	84
PERCENT	8.3	33.3	44.0	11.9	2.4	

to number of species per bird it is apparent that the variation over the years is minor and that the usual number of symbionts per host is one or two. When the same group is separated by sex and by age (Table 5) no difference appears concerning the sex of the host and the number

Table 5. Hematozoa of ARPOB Grackles

Percentage of number of species vs age and sex					
	0	1	2	3	4
HY(N=47)	12.8	44.7	29.8	12.8	0.0
AHY(N=37)	5.4	13.5	67.6	10.8	2.7
MALE(N=36)	8.3	30.6	47.2	13.9	0.0
FEMALE(N=48)	10.4	31.3	45.8	10.4	2.1

of species of hematozoa. The post-breeding adults and juveniles each have seven species of symbionts in the samples. However, the number of different symbiont species per host is greater in the adults than the juveniles. This is a seasonal event since the adults enter the breeding season with a parasitic legacy. As juvenile birds progress through the summer the initial high frequency of HQ decreases as EH frequency increases and CQ begins to appear (Table 6). Since all the juveniles were hatched in Arkansas, the seven symbiont species found in that age group were contracted in the state. The adults suggest an immunity to HQ since this frequency is low throughout the summer while both EH and CQ frequencies are high (Table 7). The low CQ frequency in the young birds suggests a longer pre-patent period for that species compared to the other microfilarial species.

If the data from the tables are consolidated to show the compatibility of the eight symbionts toward one another in a common host, it is

Table 6. Juvenile Infection Numbers by Month

	JUNE	JULY	AUG	SEPT
NUMBER	14	13	13	7
EH	1	9	7	3
CQ	1	2	3	2
HQ	9	9	3	4
PM	2	2	2	0
PN	1	0	1	0
PV	0	1	0	1
LF	0	0	0	0
TO	0	0	1	0

Table 7. Adult Grackle Infection Numbers by Month

	JUNE	JULY	AUG	SEPT
NUMBER	11	12	12	2
EH	9	11	10	0
CQ	9	8	12	1
HQ	2	2	0	1
PM	0	0	1	0
PN	0	0	0	0
PV	0	0	1	0
LF	1	1	0	0
TO	1	0	0	0

seen that the dominant symbionts CQ, HQ and EH were found in hosts with each of the other seven. The other five species only showed one other association (PM-PV), but since the frequency of other cases of infection was small the likelihood of dual infections would be expected to be rare. There is no evidence for antagonistic effects between any

of the symbionts. Of the 27 possible dual combinations between the eight hematozoans, 22 were recorded. Those not seen would be predicted to be low probability events. The high frequency with which EH and CQ are found together indicates no antagonism and perhaps even a synergism in which ontogenetically EH enhances infections with CQ.

This study has produced new locality records for four protozoan hematozoans in juveniles and five in adult Arkansas bronzed grackles. *T. ontarioensis* and *P. matutinum* comprise new host records. The dominant hematozoan symbionts in Arkansas adult grackles are the microfilaria of *Chandlerella quiscali* and *Eufilaria hibleri*. The dominant symbiont in the immature birds is *Haemoproteus quiscali*. The prevalence of infection in the other protozoan species is low. *E. hibleri* develops during the summer more rapidly than *Chandlerella quiscali*. As the year progresses the number of hematozoan species per bird increases and that is also true as the bird continues to age. However, in a seven-year-old banded and recovered bird only CQ was present. The breeding season is associated with greater insect activity (simuliids, culicids, hippoboscids, ceratopogonids) and thus the opportunity for transmission of all the hematozoans mentioned in this paper. Sex of the host apparently is not a determining factor in the prevalence and diversity of infections.

Bennett and Fallis (1960), referring collectively to many species of birds in Algonquin Park, Canada, state, "*Leucocytozoon, Trypanosoma,* and *Haemoproteus* were more prevalent among immature birds during June and July, and more birds had high parasitemias during the same period, than in August and September." In bronzed grackles specifically they found a high prevalence of *Leucocytozoon* in all ages of birds with all 13 immature birds examined infected. A very early onset of this infection is documented in the natural infections in eight nestlings. In Arkansas *Haemoproteus,* prevalence is high while the *Leucocytozoon* prevalence is low in the young birds. The simuliid vectors of *Leucocytozoon* are probably less abundant in Arkansas than in Ontario. Conversely, the ceratopogonid vectors of *Haemoproteus, Eufilaria* and *Chandlerella* may be abundant in Arkansas. Bennett and Fallis (1960) correlated insect abundance with prevalence of hematozoan infection in Algonquin Provincial Park. Huff (1939) also found *Haemoproteus* infections in young grackles in Illinois, suggesting a similar vector situation in that state.

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