

## BLOOD PARASITES OF SOME BIRDS FROM SÃO PAULO STATE, BRAZIL

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*A total of 3,449 birds, representing 195 species of 33 families from three areas in São Paulo State, Brazil, were examined for hematozoa during the period 1967-1972. Only 268 birds (7.8%) of 21 families harbored a blood parasite, which were represented by species of Haemoproteus (3.5%), microfilaria (2.6%), Plasmodium (1.8%), Trypanosoma (0.8%) and Leucocytozoon (0.06%). The prevalence was similar in each of the six years of the study but a marked decrease in prevalence was noted in February and June of each year. The prevalence of parasitism was significantly different in each of the three areas sampled.*

A number of studies on the blood parasites of Neotropical birds, summarized by White *et al.*, (1978), have been made over the course of this century, with the more recent studies being concentrated in the northern portion of the continent and in Central America. Despite these studies, however, the blood parasite fauna of the rich and diverse avifauna of the Neotropical region is still poorly known. This is particularly true in Brazil, where, in spite of the studies of Aragão (1908, 1911), Lucena (1941, 1949) and Lanson (1970), there is little information as to the species composition, seasonal distribution, host specificity and prevalence of parasitism in the birds of Brazil. A long term study of the blood parasites of three dissimilar areas in the State of São Paulo in Southeastern Brazil provided the opportunity to assess some of these aspects, and the results are reported herein.

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## MATERIALS AND METHODS

Birds were collected primarily during the years 1967-1972 (with a small sample in 1966) in three areas of the State of São Paulo, viz:

*Itapetininga*: (23°40'S, 48°05'W). An area of open fields; rivers surrounded by gallery forests. Samples collected in both open fields and gallery forests.

*Casa Grande* (23°40'S, 45°55'W). A region covered by extensive primary forest, at an altitude of 800 meters, near the Atlantic Ocean. Area has a high humidity.

*Guaratuba* (23°45'S, 45°55'W). Region covered by extensive primitive forest, sea level. The forests of this region are continuous with those of Casa Grande.

Birds were captured using Japanese mist nets (ATX type with 36mm mesh), and banded for subsequent identification on re-capture. Blood films were air-dried, fixed in 100% methanol and stained with Leishman's, or Giemsa's stain, in São Paulo. The smears were then sent to the International Reference Centre for Avian Haematozoa, St. John's, Newfoundland, for examination and identification of the parasites.

In Tables 1, 3 and 3 a-c, the following abbreviations are used throughout:

Total = total birds examined; +ve = total birds infected with one or more blood parasites each; H. = *Haemoproteus*; P. = *Plasmodium*; T. = *Trypanosoma*; M. = microfilaria; O. = others (*Atoxoplasma*, *Haemogregarina*, *Leucocytozoon*). As some birds harbored more than one blood parasite, the total of the infections in any one table will exceed the total number of infected birds.

## RESULTS AND DISCUSSION

A total of 3,449 birds of 195 species, representing 33 families, were examined for hematozoa. Only 268 (7.8%) birds of 78 species representing 21 families harbored one or more blood parasites variously represented in order of frequency by *Haemoproteus* (3.5%), microfilaria (2.6%), *Plasmodium* (1.8%), *Trypanosoma* (0.8%) and *Leucocytozoon* (0.06%). These data (Table 1) indicate a low prevalence of blood parasites, but represent a prevalence similar to that recorded elsewhere in Central and South America (Bennett & Borrero, 1976; Gabaldon *et al.*, 1974, 1975; White *et al.*, 1978), but far lower than that noted in North America (Greiner *et al.*, 1975). A further indicator of the intensity of parasite attack in the avifauna is the number of multiple infections noted in the infected birds, an indicator conveniently expressed as the *parasite index* — defined as the number of parasite infections / infected bird. In this study, a parasite index of 1.06 was obtained, which compares closely with that obtained for all Neotropical and Southeast Asian birds (Table 2), but is significantly lower than that obtained for Nearctic birds. This parasite index indicates that 10% or less of the infected birds in the Neotropical region harbored more than one blood parasite, while almost one-third of the North American birds had multiple infections. Presumably this indicates a low vector potential in the Neotropical (and Southeast Asian) regions.

The frequency of occurrence of the different hematozoan genera in the avifauna is also of interest. In Brazil, 42.3% of the total infections were composed of *Haemoproteus* (Table 2), substantially lower than the 63.8% recorded for this genus in all Neotropical birds, but similar to that observed for Nearctic birds. Substantial differences between the Brazilian (and Neotropical) and North American and Southeast Asian samples were noted in the almost complete absence of *Leucocytozoon* in the former sample. In fact, only two *Leucocytozoon* infections were noted in this study; one in a parulid (*Parula pitayumi*) and one in a fringillid (*Haplospiza unicolor*) (Table 1). Possibly these two individuals acquired their *Leucocytozoon* infections elsewhere and then moved into the study region. However, the conclusion is inevitable that the ornithophilic simuliid vectors of

TABLE 1

Hematozoa of birds collected in three areas of São Paulo State, Brazil, 1966-72.

	Total	+ve*	H.	P.	T.	M.	O.
<b>ACCIPITRIDAE</b>							
<i>Buteo magnirostris</i>	1	0					
<i>Harpagus bidentatus</i>	$\frac{2}{3}$	$\frac{2}{2}$				$\frac{2}{2}$	
Total:	3	2				2	
<b>ALCEDINIDAE</b>							
<i>Chloroceryle aenea</i>	3	0					
<i>Chloroceryle americana</i>	10	0					
<i>Chloroceryle inda</i>	$\frac{2}{15}$	$\frac{0}{0}$					
Total:	15	0					
<b>APODIDAE</b>							
<i>Chaetura cinereiventris</i>	4	0					
<b>ARDEIDAE</b>							
<i>Butorides striatus</i>	1	0					
<b>BUCCONIDAE</b>							
<i>Malacoptila striata</i>	2	1				1	
<i>Nystalus chacuru</i>	$\frac{11}{13}$	$\frac{0}{1}$				$\frac{1}{1}$	
Total:	13	1				1	
<b>CAPRIMULGIDAE</b>							
<i>Hydropsalis brasiliiana</i>	1	0					
<i>Lurocalis semitorquatus</i>	3	0					
<i>Nyctidromus albicollis</i>	1	0					
<i>Nyctiphrynus ocellatus</i>	$\frac{3}{8}$	$\frac{0}{0}$					
Total:	8	0					

\*For abbreviations, see "Materials and Methods".

TABLE 1 (continued)

	Total	+ve:	H.	P.	T.	M.	O.
<b>COLUMBIDAE</b>							
<i>Columbigallina talpacoti</i>	57	14	14				
<i>Geotrygon montana</i>	13	2	2				
<i>Leoptila rufaxilla</i>	2	0					
<i>Leptotila verreauxi</i>	9	0					
Total:	81	16	16				
<b>CONOPOPHAGIDAE</b>							
<i>Conopophaga lineata</i>	92	14		11	4		
<i>Conopophaga melanops</i>	3	0					
Total:	95	14		11	4		
<b>CORVIDAE</b>							
<i>Cyanocorax cristatellus</i>	1	0					
<b>COTINGIDAE</b>							
<i>Attila rufus</i>	8	0					
<i>Pachyramphus marginatus</i>	1	1			1		
<i>Pachyramphus polychropterus</i>	9	3			2	3	
<i>Pachyramphus viridis</i>	1	0					
<i>Platypsaris rufus</i>	3	2	1		1	1	
<i>Pseudattila phoenicurus</i>	4	0					
<i>Rhytipterna simplex</i>	2	0					
Total:	28	6	1		4	4	
<b>CUCULIDAE</b>							
<i>Crotophaga ani</i>	5	0					
<i>Dromococcyx pavoninus</i>	1	0					
<i>Piaya cayana</i>	2	0					
<i>Tapera naevia</i>	1	0					
Total:	9	0					
<b>DENDROCOLAPTIDAE</b>							
<i>Campylorhamphus trochilirostris</i>	11	2	1		1		
<i>Dendrocincla fuliginosa</i>	24	1		1			1
<i>Dendrocolaptes platyrostris</i>	12	1	1				
<i>Lepidocolaptes fuscus</i>	45	0					
<i>Sittasomus griseicapillus</i>	27	1					1
<i>Xiphocolaptes albicollis</i>	5	0					
Total:	124	5	2	1	1		2
<b>FALCONIDAE</b>							
<i>Micrastur ruficollis</i>	5	0					

TABLE 1 (continued)

	Total	+ve	H.	P.	T.	M.	O.
<b>FORMICARIIDAE</b>							
<i>Batara cinerea</i>	1	0					
<i>Dryophila malura</i>	8	0					
<i>Dryophila ochropyga</i>	2	0					
<i>Dryophila squamata</i>	1	0					
<i>Dysithamnus mentalis</i>	40	7	2	2	4		
<i>Dysithamnus xanthopterus</i>	1	0					
<i>Formicarius colma</i>	6	0					
<i>Grallaria ochroleuca</i>	1	1	1				
<i>Grallaria varia</i>	1	0					
<i>Herpsilochmus rufimarginatus</i>	1	0					
<i>Mackenziaena leachii</i>	1	0					
<i>Myrmoderus squamosus</i>	18	0					
<i>Myrmotherula gularis</i>	8	1		1			
<i>Myrmotherula unicolor</i>	4	0					
<i>Pyriglena leucoptera</i>	43	4	1	1	2		
<i>Thamnophilus caerulescens</i>	32	1		1			
<i>Thamnophilus ruficapillus</i>	13	0					
Total:	181	14	4	5	6		
<b>FRINGILLIDAE</b>							
<i>Arremon taciturnus</i>	7	1	1				
<i>Emberizoides herbicola</i>	8	0					
<i>Haplospiza unicolor</i>	20	3	2				1
<i>Myospiza humeralis</i>	7	0					
<i>Pitylus fuliginosus</i>	4	2				2	
<i>Saltator similis</i>	33	6				6	
<i>Sicalis flaveola</i>	1	0					
<i>Spinus magellanicus</i>	17	1		1			
<i>Sporophila caerulescens</i>	35						
<i>Tiaris fuliginosa</i>	8	1		1			
<i>Volatinia jacarina</i>	4	1					
<i>Zonotrichia capensis</i>	163	34	24	7	1	4	
Total:	307	49	27	9	1	12	1
<b>FURNARIIDAE</b>							
<i>Anabazenops fuscus</i>	1	0					
<i>Anabacerthia amaurotis</i>	3	0					
<i>Automolus leucophthalmus</i>	56	3	1		2		
<i>Cichlocolaptes leucophrys</i>	13	0					
<i>Furnarius rufus</i>	10	0					
<i>Heliobletus contaminatus</i>	7	0					
<i>Lochmias nematura</i>	30	2	1			1	
<i>Phacellodomus erythrophthalmus</i>	1	0					

TABLE 1 (continued)

	<i>Total</i>	<i>+ve</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
<i>Philydor atricapillus</i>	8	1	1				
<i>Philydor rufus</i>	3	0					
<i>Sclerurus scansor</i>	8	0					
<i>Synallaxis frontalis</i>	3	0					
<i>Synallaxis ruficapilla</i>	17	0					
<i>Synallaxis spixi</i>	3	0					
<i>Syndactyla rufosuperciliata</i>	41	2	1			1	
<i>Xenops minutus</i>	13	2				2	
<i>Xenops rutilans</i>	2	0					
Total:	219	10	4		2	4	
<b>HIRUNDINIDAE</b>							
<i>Alopochelidon fucata</i>	4	0					
<i>Notiochelidon cyanoleuca</i>	3	0					
<i>Stelgidopteryx ruficollis</i>	21	1					1
Total:	28	1					1
<b>ICTERIDAE</b>							
<i>Cacicus haemorrhous</i>	2	0					
<i>Gnorimopsar chopi</i>	1	0					
<i>Icterus cayanensis</i>	3	1	1				
<i>Molothrus bonariensis</i>	1	0					
Total:	7	1	1				
<b>MIMIDAE</b>							
<i>Mimus saturninus</i>	11	2	2				
<b>PARULIDAE</b>							
<i>Basileuterus culicivorus</i>	10	0					
<i>Basileuterus hypoleucus</i>	24	1		1			
<i>Basileuterus leucoblepharus</i>	15	0					
<i>Basileuterus rivularis</i>	10	0					
* <i>Coereba flaveola</i>	64	0					
<i>Geothlypis aequinoctialis</i>	19	2	1			1	
<i>Parula pitiayumi</i>	5	1					1
Total:	147	4	1			1	1
<b>PICIDAE</b>							
<i>Chrysoptilus melanochloros</i>	2	0					
<i>Colaptes campestris</i>	3	0					
<i>Piculus aurulentus</i>	1	0					

TABLE 1 (continued)

	Total	+ve	H.	P.	T.	M.	O.
<i>Picumnus temminckii</i>	18	0					
<i>Veniliornis spilogaster</i>	2	0					
Total:	26	0					
<b>PIPRIDAE</b>							
<i>Chiroxiphia caudata</i>	326	3	2			1	
<i>Ilicura militaris</i>	33	0					
<i>Manacus manacus</i>	45	2	1		1		
<i>Neopelma aurifrons</i>	45	1		1			
<i>Schiffornis virescens</i>	62	1			1		
Total:	511	7	3	1	2	1	
<b>PLOCEIDAE</b>							
<i>Passer domesticus</i>	1	0					
<b>RALLIDAE</b>							
<i>Aramides cajanea</i>	1	0					
<i>Micropygia schomburgkii</i>	1	0					
<i>Laterallus melanophaius</i>	1	1				1	
Total:	3	1				1	
<b>RHINOCRYPTIDAE</b>							
<i>Merulaxis ater</i>	1	0					
<b>STRIGIDAE</b>							
<i>Glaucidium brasilianum</i>	1	0					
<i>Otus choliba</i>	3	0					
<i>Speotyto cunicularia</i>	1	0					
Total:	5	0					
<b>THRAUPIDAE</b>							
* <i>Chlorophanes spiza</i>	7	1					
<i>Chlorophonia cyanea</i>	1	0					
* <i>Dacnis cayana</i>	29	3	2			2	
<i>Habia rubica</i>	22	1				1	
<i>Hemithraupis guira</i>	1	0					
<i>Hemithraupis ruficapilla</i>	3	1	1				
<i>Pipraeidea melanonota</i>	5	0					
<i>Ramphocelus bresilius</i>	21	5				5	
<i>Schistochlamys melanopsis</i>	1	0					
<i>Schistochlamys ruficapillus</i>	16	2				2	
<i>Tachyphonus coronatus</i>	180	15		2	2	11	
<i>Tachyphonus cristatus</i>	1	0					

TABLE 1 (continued)

	<i>Total</i>	<i>+ve</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
<i>Euphonia pectoralis</i>	28	1	1				
<i>Euphonia violacea</i>	31	3	3				
<i>Tangara cayana</i>	29	1				1	
<i>Tangara cyanocephala</i>	5	2	2				
<i>Tangara desmaresti</i>	14	4	4				
<i>Tangara seledon</i>	10	5	5			4	
<i>Thraupis cyanoptera</i>	13	1	1				
<i>Thraupis ornata</i>	1	1	1			1	
<i>Thraupis palmarum</i>	4	2	2			1	
<i>Thraupis sayaca</i>	85	13	12			1	
<i>Trichothraupis melanops</i>	<u>86</u>	<u>1</u>	<u>1</u>	<u>2</u>	<u>2</u>	<u>1</u>	
Total:	593	62	34	2	2	30	
TINAMIDAE							
<i>Crypturellus parvirostris</i>	3	1				1	
TROCHILIDAE							
<i>Clytolaema rubricauda</i>	1	0					
TROGLODYTIDAE							
<i>Thryothorus longirostris</i>	8	1				1	
<i>Troglodytes aedon</i>	<u>17</u>	<u>0</u>				<u>1</u>	
Total:	25	1				1	
TURDIDAE							
<i>Platycichla flavipes</i>	42	7	2			5	
<i>Turdus albicollis</i>	96	16	4	1	4	8	
<i>Turdus amaurochalinus</i>	48	8	3	1		4	
<i>Turdus leucomelas</i>	28	5	2	3		1	
<i>Turdus rufiventris</i>	<u>111</u>	<u>11</u>	<u>1</u>	<u>3</u>	<u>4</u>	<u>6</u>	
Total:	325	47	12	8	4	24	
TYRANNIDAE							
<i>Campostoma obsoletum</i>	5	0					
<i>Contopus cinereus</i>	1	0					
<i>Elaenia chiriquensis</i>	28	0					
<i>Elaenia cristata</i>	24	0					
<i>Elaenia flavogaster</i>	14	0					
<i>Elaenia mesoleuca</i>	38	2	2				
<i>Elaenia obscura</i>	55	1				1	
<i>Elaenia parvirostris</i>	3	0					
<i>Elaenia</i> sp.	4	0					
<i>Empidonax euleri</i>	30	1	1				
<i>Empidonomus varius</i>	2	0					



TABLE 1 (continued)

	Total	+ve	H.	P.	T.	M.	O.
<i>Gubernetes yetapa</i>	2	0					
<i>Hemitriccus diops</i>	6	0					
<i>Idioptilon nidipendulum</i>	3	0					
<i>Idioptilon orbitatum</i>	1	0					
<i>Leptopogon amaurocephalus</i>	12	0					
<i>Muscipipra vetula</i>	1	0					
<i>Muscivora tyrannus</i>	1	1	1				
<i>Myiarchus swainsoni</i>	2	0					
<i>Myiarchus tyrannulus</i>	7	0					
<i>Myiobius atricaudus</i>	20	1					1
<i>Myiodynastes maculatus</i>	2	0					
<i>Myiophobus fasciatus</i>	26	0					
<i>Myiozetetes cayanensis</i>	10	0					
<i>Myiozetetes similis</i>	1	1				1	
<i>Phyllomyias fasciatus</i>	12	1					
<i>Phyllomyias griseocapilla</i>	2	0					
<i>Phylloscartes ventralis</i>	4	0					
<i>Pipromorpha rufiventris</i>	171	1			1		
<i>Platyrrinchus leucoryphus</i>	1	0					
<i>Platyrrinchus mystaceus</i>	62	2	1		1		
<i>Platyrrinchus platyrhynchus</i>	1	0					
<i>Pitangus sulphuratus</i>	8	0					
<i>Platyrrinchus sp.</i>	1	0					
<i>Pyrocephalus rubinus</i>	1	0					
<i>Satrapa icterophrys</i>	1	0					
<i>Serpophaga subcristata</i>	7	0					
<i>Sublegatus modestus</i>	1	0					
<i>Todirostrum plumbeiceps</i>	2	0					
<i>Todirostrum poliocephalum</i>	1	0					
<i>Tolmomyias sulphurescens</i>	10	0					
<i>Tyrannus melancholicus</i>	8	1	1				
<i>Xanthomyias virescens</i>	14	0					
<i>Xolmis cinerea</i>	1	0					
Total:	606	12	7		2	2	1
VIREONIDAE							
** <i>Cyclarhis gujanensis</i>	14	5		1		4	
** <i>Cyclarhis ochrocephala</i>	1	0					
<i>Hylophilus poicilotis</i>	29	0					
<i>Vireo olivaceus</i>	18	7	6	1	1	1	
Total:	62	12	6	2	1	5	

TABLE 1 (continued)

	Total	+ve	H.	P.	T.	M.	O.
GRAND TOTAL:	3.449	268	120	40	29	89	6
Percent infected:		7.8	3.5	1.8	0.8	2.6	0.18

\**Coereba flaveola* is considered by some authors to be in the family Coerebidae; it is here considered to be a member of the Parulidae. *Dacnis cayana* and *Chlorophanes spiza* are also considered by some authors to be in the Coerebidae, but are here considered as members of the Thraupidae.

\*\*Some authors place both *Cyclarhis gujanensis* and *C. ochrocephala* in the separate family Cyclarhidae.

TABLE 2

Comparison of the prevalence and parasite frequency of avian hematozoa in four regions of the world. Data obtained as follows: Brazil, this study; Neotropical, White *et al.* (1978); Nearctic, Greiner *et al.* (1975); Southeast Asia, McClure *et al.* (1978).

	Brazil	Neotropic.	Nearct.	SE. Asia
Total birds examined	3.449	35.555	57.026	55.289
Total infected birds	268	3.743	21.048	9.026
Percent prevalence	7.8	10.5	36.9	16.3
Total parasite infections	284	4.107	27.771	9.827
Parasite index	1.06	1.10	1.32	1.10
Percent parasite frequency of total parasite infections:				
<i>Haemoproteus.</i>	42.3	63.8	40.0	63.2
<i>Leucocytozoon.</i>	0.01	0.01	36.3	14.9
microfilaria	31.3	10.7	6.4	10.2
<i>Plasmodium.</i>	14.1	16.3	7.9	4.3
<i>Trypanosoma.</i>	10.2	4.8	8.1	1.2

*Leucocytozoon* are virtually absent in the study area, and extremely rare in the Neotropical region. On the other hand, the proportion of microfilaria infections in the sample is exceptionally high (Table 2), substantially higher than in any other region, a feature that applies also to the *Trypanosoma*. In as much as blood films are a poor diagnostic technique for these two parasites (Bennett, 1962), the high proportion of the total parasite infections represented by these two groups is indeed significant. Why such a high proportion of these two parasite groups occurs in the avifauna of Brazil (even as compared to the Neotropical region) is not known.

Blood parasites occurred with greater frequency in certain families of birds than others (Table 1). The Columbidae (20% with *H. mcallumi*) were the most frequently parasitized family, followed by the Vireonidae (19.3%, with a variety of parasite species), the Fringillidae (15.9%, primarily with *H. fringillae* and *P. vaughani*), Conopophagidae

(14.7%, primarily with *P. vaughani*), Turdidae (14.5%, primarily with *H. fallisi* and microfilaria), the Thraupidae (10.4%, primarily with an undescribed haemoproteid). A number of families were not found to harbor hematozoa, but these families are usually represented by small samples. A number of families, with samples of 100 or more birds (Table 1), however, still showed a low parasite prevalence. These include the Dendrocolaptidae, Formicariidae, Fumariidae, Parulidae, Pipridae and Tyrannidae.

The families with the highest prevalences are the same families recorded with high prevalences in North America (Greiner et al., 1975), Africa (Bennett & Herman, 1976; Bennett et al., 1974) and Southeast Asia (McClure et al., 1978). It would appear that some aspect of these birds enhances parasitism by hemosporozoans. This could be interpreted as meaning that birds of these families are inherently more susceptible to infection by blood parasites. It could also be interpreted as meaning that birds of these families have behavior patterns (i.e. nesting sites, roosting sites, etc.), which bring them into more frequent contact with vectors.

Prevalence of blood parasites differed in each of the three study areas. The highest prevalence was experienced in Guaratuba (11.5%) while the lowest was at Casa Grande (3.8%); Itapetininga was intermediate (8.3%) (Tables 3, 3 a-c). The differences were significant, the prevalence at Casa Grande significantly lower at the P. 01 level, while that of Itapetininga was significantly lower at the P. 05 level. These differences could be explained either on the basis of a different avifauna in each area (and hence differing prevalences due to host-related factors such as susceptibility) or on the basis of different habitats (and hence differing prevalences due to habitat-related factors such as nesting sites, presence or absence of vectors, etc) or a combination of both.

TABLE 3

Prevalence of avian hematozoa in three regions of São Paulo State, Brazil, 1966-1972

<i>Region</i>	<i>Total</i>	<i>+ve*</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
Guaratuba	706	81	32	3	8	46	2
Percent infected		11.5	4.5	0.4	1.1	6.5	0.3
Casa Grande	916	35	15	4	8	7	2
Percent infected		3.8	1.6	0.4	0.9	0.8	0.2
Itapetininga	1.827	152	73	33	13	36	2
Percent infected		8.3	3.9	1.8	0.7	2.1	0.1
Grand Total	3.449	268	120	40	29	89	6

\*For abbreviations, see "Materials and Methods".

TABLE 3a

Prevalence of hematozoa in birds from Casa Grande, State of São Paulo, Brazil.

	<i>Total</i>	<i>+ve*</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
COLUMBIDAE	12	1	1				
CONOPOPHAGIDAE	28	3		1	2		
COTINGIDAE	8	0					
DENDROCOLAPTIDAE	62	0					
FALCONIDAE	4	0					
FORMICARIIDAE	76	5	2	2	1		
FRINGILLIDAE	22	2	1				1
FURNARIIDAE	53	0					
PARULIDAE	11	0					
PICIDAE	2	0					
PIPRIDAE	258	3	2	1			
RHINOCRYPTIDAE	1	0					
THRAUPIDAE	124	5	4			1	
TROCHILIDAE	1	0					
TURDIDAE	81	11	3		3	6	
TYRANNIDAE	162	5	2		2		1
VIREONIDAE	11	0					
TOTAL:	916	35	15	4	8	7	2
percent infected		3.8	1.6	0.4	0.9	0.8	0.2

\* For abbreviations, see "Materials and Methods".

TABLE 3b

Prevalence of hematozoa in birds from Guaratuba, State of São Paulo, Brazil.

	<i>Total</i>	<i>+ve*</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
ACCIPITRIDAE	2	2				2	
ALCEDINIDAE	9	0					
APODIDAE	4	0					
BUCCONIDAE	2	1				1	
CAPRIMULGIDAE	3	0					
COLUMBIDAE	4	0					
CONOPOPHAGIDAE	2	0					
COTINGIDAE	14	5	1		3	3	
CUCULIDAE	4	0					
DENDROCOLAPTIDAE	34	2	1	1			1
FORMICARIIDAE	26	1			1		

TABLE 3b (continued)

	<i>Total</i>	<i>+ve</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
FRINGILLIDAE	19	3	2	1			
FURNARIIDAE	23	3	1			2	
HIRUNDINIDAE	12	1					1
ICTERIDAE	2	0					
PARULIDAE	63	0					
PICIDAE	5	0					
PIPRIDAE	79	3	1		1	1	
THRAUPIDAE	214	38	18		2	24	
TROGLODYTIDAE	13	1				1	
TURDIDAE	85	15	3	1		11	
TYRANNIDAE	81	2	1			1	
VIREONIDAE	6	4	4		1		
TOTAL:	706	81	32	3	8	46	2
percent infected		11.5	4.5	0.4	1.1	6.5	0.3

\*For abbreviations, see "Materials and Methods".

TABLE 3c

Prevalence of hematozoa in birds from Itapetininga, State of São Paulo, Brazil.

	<i>Total</i>	<i>+ve*</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
ACCIPITRIDAE	1	0					
ALCEDINIDAE	6	0					
ARDEIDAE	1	0					
BUCCONIDAE	11	0					
CAPRIMULGIDAE	5	0					
COLUMBIDAE	65	15	15				
CONOPOPHAGIDAE	65	11		10	2		
CORVIDAE	1	0					
COTINGIDAE	6	1			1	1	
CUCULIDAE	5	0					
DENDROCOLAPTIDAE	28	3	1		1		1
FALCONIDAE	1	0					
FORMICARIIDAE	79	8	2	3	4		
FRIGILLIDAE	265	44	25	8	1	12	
FURNARIIDAE	143	7	3		2	2	
HIRUNDINIDAE	16	0					
ICTERIDAE	5	1	1				

TABLE 3c (continued)

	<i>Total</i>	<i>+ve*</i>	<i>H.</i>	<i>P.</i>	<i>T.</i>	<i>M.</i>	<i>O.</i>
MIMIDAE	11	2	2				
PARULIDAE	73	4	1	1			1
PICIDAE	19	0					
PIPRIDAE	167	1			1		
PLOCEIDAE	1	0					
RALLIDAE	3	1				1	
STRIGIDAE	5	0					
THRAUPIDAE	263	19	11	2		6	
TINAMIDAE	3	1				1	
TROGLODYTIDAE	12	0					
TURDIDAE	159	21	6	7	1	8	
TYRANNIDAE	363	5	4			1	
VIREONIDAE	45	8	2	2		4	
TOTAL:	1.827	152	73	33	13	36	2
percent infected		8.3	4.0	1.8	0.7	2.0	0.1

\*For abbreviations, see "Materials and Methods".

Similarity of the avifauna at the familial level in the three study areas was tested with Coefficient of Community (CC) analyses, employing the protocols of Williams & Bennett (1978), viz:

$$CC = 200 S_{xy} / S_x + S_y,$$

where  $S_{xy}$  is the number of families common to both samples and  $S_x$  and  $S_y$  are the number of families in samples X and Y respectively. The limits of the coefficient are  $0 \leq CC \leq 100$ , with the values expressed as percent similarity. When the two samples have no families in common, then  $CC = 0$ ; when the two samples have identical families, then  $CC = 100$ . Using this test, it was noted that the avifauna of Casa Grande was least similar to the other regions, having a 65.2% similarity with Itapetininga and a 70% similarity with Guaratuba, while Guaratuba had a higher shared faunal relationship with Itapetininga, showing an 80.8% shared familial fauna. While the three regions do show differences in degree of shared fauna, they all have a good commonality of families. On the other hand, the three areas are known to differ environmental composition. Therefore, as the families of birds in the three areas are similar, presumably habitat-related factors are responsible for the differing prevalences noted. Particularly it would appear that the environment of Casa Grande is not suitable for the *Culicoides* vectors of *Haemoproteus*.

An examination of the overall prevalence of blood parasites on a yearly basis throughout the period 1967-72 (Table 4) indicated little variation from year to year. Individual parasite genera fluctuated somewhat more, but the variation was not considered to be significant. The data were re-analysed with respect to the prevalence of blood parasites throughout the year (Table 5). The prevalence of parasites is essentially similar in each month with the exception of February and June, in which months prevalence of parasitism is significantly lower. Presumably this lowered prevalence is due either to the appearance of nestlings (February) or to a climatic sequence (dry-cold season) which has reduced the vector potential (June).

TABLE 4

Yearly distribution of avian hematozoa in three regions of São Paulo State, 1967-1972

Year	Total	+ve	%+ve	Haemoproteus		Plasmodium		Trypanosoma		Microfilaria	
				No	%	No	%	No	%	No	%
1967	231	18	7.8	6	2.6	3	1.3	2	0.9	9	3.9
1968	978	66	6.7	25	2.6	17	1.7	3	0.3	24	2.5
1969	523	36	6.9	18	3.4	3	0.6	2	0.4	16	3.1
1970	639	54	8.5	30	4.7	9	1.4	4	0.6	11	1.7
1971	116	10	8.6	8	6.9	1	0.9	1	0.9	1	0.9
1972	931	79	8.5	31	3.3	8	0.9	16	1.7	28	3.0
Totals:	3,418	263	7.7	118	3.5	41	1.2	28	0.8	89	2.7

*Note:* The small sample of 31 birds collected in 1966 are not included in this summary as they represent a sample size statistically not comparable with the samples from the other years. The "other" category was also excluded as the numbers are too small to be of significance.

TABLE 5

Monthly distribution of avian hematozoa in three regions of São Paulo state, Brazil, 1966-1972.

Month	Total	+ve	%+ve	<i>Haemoproteus</i>		<i>Plasmodium</i>		<i>Trypanosoma</i>		<i>Microfilaria</i>	
				Nº	%	Nº	%	Nº	%	Nº	%
January	272	33	12.1	22	8.1	3	1.1	1	0.4	4	1.5
February	391	18	4.6	5	1.3	10	2.6	2	0.5	3	0.8
March	388	30	7.7	13	3.4	4	1.0	8	2.1	6	1.5
April	445	38	8.5	16	3.6	4	0.9	3	0.7	18	4.0
May	386	37	9.6	7	1.8	5	1.3	4	1.0	11	2.8
June	261	11	4.2	5	1.9	2	0.9	3	1.1	2	0.8
July	407	33	8.1	13	3.2	3	0.7	1	0.2	22	5.4
August	273	23	8.4	12	4.4	5	1.8	2	0.7	5	1.8
September	266	19	7.1	12	4.5	2	0.8	1	0.4	9	3.4
October	206	13	6.3	7	3.4	2	1.0	2	1.0	4	1.9
November	37	3	8.1	2	5.4			1	2.7	1	2.7
December	117	10	8.5	6	5.1					4	3.4
Totals:	3.449	268	7.8	120	3.5	40	1.8	28	0.8	89	2.6

Note: Although the "Other" category is omitted from the table, the monthly totals do include these infected birds.



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