BLOOD PARASITES OF BIRDS FROM CHIRIQUI AND PANAMA PROVINCES IN THE REPUBLIC OF PANAMA

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Abstract: Blood smears were examined from 3,715 birds from four areas in the Republic of Panama. Hematozoa were present in at least 142 (50%) of the 281 species examined. An overall prevalence of 18% of the individual birds was noted: *Haemoproteus* 9%, *Plasmodium* 5%, *Leucocytozoon* <1%, *Trypanosoma* 2%, *Atoxoplasma/Lankesterella* <1% and microfilariae 3%. Prevalence in each of the four study areas varied from 13% to 28%. Distribution is analyzed by orders, families and individual species of *Plasmodium* are tabulated. New host records from 170 species of birds are recorded.

INTRODUCTION

A previous report (Galindo and Sousa, 1966) listed the findings of a survey of blood parasites of birds from a single region of Panama. Huff and Wetmore (1967) have added several additional records. Previous records of Hematozoa from birds of the neotropical region were summarized by White, et al. (1978) including the available data from the Republic of Panama. These authors reported on the distribution of blood parasites in the Neotropics on the basis of the avian-host families and the region in which they occur. The present paper summarizes a study of blood parasites of birds from four different areas of the Pacific slope of the Isthmus of Panama.

MATERIALS AND METHODS

Description of the study areas: Specimens for this study were procured from four areas. Two collecting sites, Cuesta de Piedras and La Fortuna, are located in the highlands of Chiriqui Province in western Panama and the other two areas, Juan Mina and Bayano, near sea level in Panama Province just east of the Panama Canal (Fig. 1). The two locations in western Panama are enriched with species predominantly representative of the Central American avifauna. These locations provided a sample of the Panamanian avifauna similar to that found in the Atlantic regions of western Panama. The collecting sites sampled in eastern Panama Province are more influenced by the Colombian (South America) avifauna.

La Fortuna (Area A) is located in the highlands of Chiriqui Province, some 25 km north of Gualaca. The area has been selected as the site of a new hydroelectric project where the Chiriqui River dam will be constructed. The collection area was located approximately 1,000 m above sea level. It is considered a rainy Premontane Life Zone with an annual precipitation of about 4,000 mm. In this area, a total of 209 bird species have been noted (Adames, 1977) with strong representation of species known from the western Atlantic slope and the Costa Rican avifauna.

Cuesta de Piedra (Area B) is a collecting site located on a small farm approximately 1,300 m in elevation just below the town of El Volcan, on the slopes of the Chiriqui Volcano. The area

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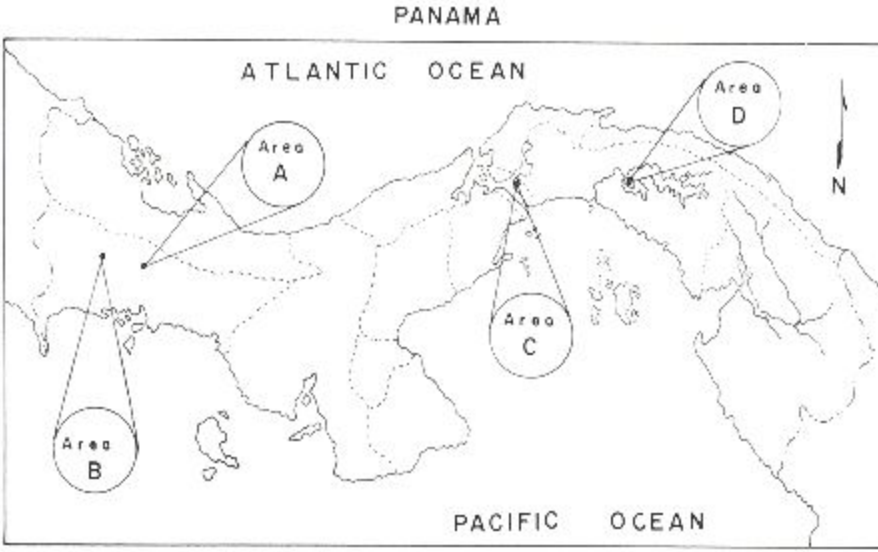

FIGURE 1. Map of the Republic of Panama indicating the general location of collecting sites for birds in La Fortuna, Chiriqui Province (Area A), Cuesta de Piedra, Chiriqui Province (Area B), Juan Mina, Panama Province (Area C) and Bayano, Panama Province (Area D).

used to be, some 25 years ago, under a cover of cloud forest, but it is now completely cleared and utilized mostly as grazing pastures with some cultivation of citrus, plantain, sugar cane and vegetables.

Juan Mina (Area C) has been a mosquito collecting field station for entomologists of the Gorgas Memorial Laboratory for many years. It is located in an old citrus plantation on the south bank of the middle Chagres river, at the old boundary of Panama and the Canal Zone. The plantation has been overgrown for many years by second growth, and some parts have been converted into grazing pastures. Nearby are primary forests of the transitional type approaching the Tropical Moist Forest association.

Bayano (Area D) is located about 70 km east of Panama City and the Panama Canal. It is now an island remaining in the Bayano River Hydroelectric dam reservoir after the recent flooding of the basin. The area corresponds to tropical forest transitional to tropical dry forest. The average rainfall is 2,000 mm corresponding with the Pacific regime of precipitation pattern of the Republic of Panama, with a prolonged wet season from April to November.

Methods. The blood smears which constitute the basis of this report were obtained during a period of eight years (1969 through 1976), as a byproduct of an extensive survey for arthropod-borne viruses in Panama. The procedures followed were described previously (Galindo and Sousa, 1966). Indentification of avian hosts was made by Pedro Galindo and Eustorgio Mendez from the Gorgas Memorial Laboratory and questionable identities were confirmed from study skins submitted to the late Alexander Wetmore of the Smithsonian Institution in Washington, D.C. and Eugene Eisenmann of the American Museum of Natural History. Specimens collected in La Fortuna area were iden-

tified by Robert S. Ridgely of Yale University and R. Hinds from the Gorgas Memorial Laboratory. Species names were used according to Ridgely (1976).

The blood films were fixed with methyl alcohol in the field and treated with Giemsa stain by conventional methods in the laboratory. Each smear was examined under an oil immersion objective (100×) and 6× ocular for at least 10 minutes before discarding as "no parasite found". Most positive smears were examined for longer periods in search of mixed infections or of additional stages which might clarify diagnosis. Representative blood films have been deposited in the International Reference Center for Avian Haematozoa at Memorial University, St. Johns, Newfoundland (Accession Nos. 62219-62238).

RESULTS AND DISCUSSION

Geographical analysis:

Single smears were obtained from a total of 3,715 individuals, representing 281 species, 189 genera, 36 families, and 15 orders. They included 366 birds, representing 80 species, 68 genera, 23 families, and 9 orders from Area A; 221 birds, 49 species, 39 genera, 19 families and 7 orders from Area B; 891 birds, 101 species, 80 genera, 27 families and 11 orders from Area C; and, 2,237 birds, 194 species, 146 genera, 31 families and 11 orders from Area D. Tabulations of findings from each area are presented in Table 1. A total of 661 birds were found infected with at least one type of Hematozoa from all areas of collection, for an overall infection rate of 18%. Birds collected in Juan Mina (Area C) near the Panama Canal showed the highest rate of infection (28%). The lowest rate of infection (13%) was observed in the avifauna examined from Bayano (Area D) in eastern Panama.

Microfilariae were more frequently detected in La Fortuna (Area A) where a 4% prevalence appeared significantly higher than the 2-3% prevalence observed in the other areas. *Leucocytozoon* was not found frequently in the blood of resident birds. Only 20 individuals, <1% of the total sample, were found infected with this parasite. Infections with *Leucocytozoon* were diagnosed mostly (19 of 20 cases) in migrant bird species

TABLE 1. Avian Hematozoa from four areas of the Republic of Panama.

Area	Collection localities	Total No. birds examined	Found Positive No.	%	% Infected with[a] P	H	L	T	Mf	Other
A	La Fortuna, Chiriqui Province	366	68	18.6	3.6	10.9	0.3	0.8	4.4	0.0
B	Cuesta de Piedra, Chiriqui Province	221	57	25.8	4.5	19.5	1.3	1.3	2.3	0.9
C	Juan Mina, Panama Province	891	250	28.0	13.3	12.9	0.0	1.0	2.2	0.6
D	Bayano, Panama Province	2,237	286	12.8	2.5	6.2	0.7	2.6	2.9	0.0
All areas		3,715	661	17.8	5.3	9.0	0.5	2.0	2.9	0.2

[a] P = *Plasmodium*; H = *Haemoproteus*; L = *Leucocytozoon*; T = *Trypanosoma*; Mf = Microfilariae; other: *Atoxoplasma*, *Lankesterella*, etc.

which may have acquired the infections elsewhere. *Haemoproteus* infections were most frequently detected in birds examined from Cuesta de Piedras (Area B). Hemoproteid parasites were demonstrated in 20% of the birds examined from this area. The prevalence of *Plasmodium* was 13% in birds from Area C, ranging from three to five times that of the other areas.

Distribution by Avian Host:

Table 2 shows the distribution of birds according to the avian orders and families included in the sample. The largest proportion of the birds were Passeriformes (3,155 individuals), but Apodiformes (280) and Columbiformes (155) were also well represented. Except for the Piciformes (60) all other orders were represented by smaller samples. *Haemoproteus* was a frequent parasite among Columbiformes, Apodiformes and Passeriformes. *Plasmodium* was seen almost exclusively in Passeriformes. Only two out of 197 birds found infected with this genus were from other avian orders (Caprimulgiformes and Columbiformes).

A total of 3,155 Passeriform birds (205 species, 17 families) were examined for blood parasites. Only two families, Vireolaniidae and Sylviidae, were represented by less than 30 individuals. The sample size varied from 30 to 597 birds examined in the other 15 families.

The prevalence of infection varied markedly among the families. The Icteridae (64%) and Vireolaniidae (100%) showed the highest prevalence of infection with Hematozoa. However, the latter family was represented by only two birds. Other families, such as Pipridae and Hirudinidae, showed the lowest rates of infection. Less than 1% of 320 birds of the family Pipridae and none of 48 individuals from the Hirudinidae were found infected. Within these two extremes, Cotingidae, Vireonidae, Turdidae and Thraupidae showed prevalences from 27 to 48%. The prevalence among other passerine families included in this study varied from 10 to 25%. According to the parasites found: *Plasmodium* was identified in 35% of the positive birds. These malarial parasites were often seen in birds of the Formicariidae, Tyrannidae, Fringillidae, Thraupidae, Turdidae, Vireonidae and Icteridae. *Plasmodium* was infrequent in Cotingidae. Haemoproteid parasites were often observed in most passerine birds (44% of the positives), but were not found in Hirudinidae, Pipridae, and Troglodytidae. *Leucocytozoon* was detected only among Turdidae (23%), Cotingidae (3%) and Parulidae (50%) usually in migratory species. *Atoxoplasma/Lankesterella* parasites were seen only in few instances among Thraupidae (2 of 597 birds), Icteridae (1/44) and Fringillidae (3/545) representing less than 1% of the total birds examined.

Haemoproteus columbae Kruse 1890, the principal blood parasite found among Columbiformes, was particularly prevalent in *Columbina talpacoti* (55%). *Haemoproteus archilochus* Coatney and West 1938 and *H. trochili* White, Bennett and Williams 1979 were the only hematozoan parasites seen in hummingbirds (Apodiformes: Trochilidae). Ten of 24 species of hummingbirds were found infected with these haemoproteids. *Haemoproteus* and *Plasmodium* were widely distributed among Passeriformes. Out of 24 *Haemoproteus* infections found among Cotingidae, 83% were recognized in the black and white becard *(Pachyramphus albogriseus)* and the white-winged becard *(P. polychopterus)*. *Plasmodium* was often seen in the spotted antbird *(Hylophylax naevioides)*, the social flycatcher *(Myiozetetes similis)*, the gray-colored robin *(Turdus grayi)*, the red-eyed vireo *(Vireo olivaceus)*, the crimson-backed tanager *(Ramphocelus dimidiatus)*, the blue-gray tanager *(Thraupis episcopus)*, the yellow-billed cacique *(Amblycercus holosericeus)*, the black-striped sparrow *(Arremonops conirostris)* and the vari-

TABLE 2. Blood parasites found in birds from the Republic of Panama.

Host Species	Total Birds	Infected Birds	Total birds infected with: P	H	L	T	Mf	Other	Area
TINAMIFORMES (Sub-Total)	4	0	0	0	0	0	0	0	
Tinamidae	4	0	0	0	0	0	0	0	
CICONIIFORMES	1	0	0	0	0	0	0	0	
Ardeidae	1	0	0	0	0	0	0	0	
FALCONIFORMES	7	3	0	1	0	0	2	0	
Accipitridae	4	0	0	0	0	0	0	0	
Falconidaae	3	3	0	1	0	0	2	0	
Herpetotheres cachinnans	1	1	0	0	0	0	1*	0	D
Micrastur ruficollis	2	2	0	1	0	0	1*	0	C,D
GALLIFORMES	2	1	0	1	0	0	0	0	
Cracidae	2	1	0	1	0	0	0	0	
Penelope purpurascens	1	1	0	1	0	0	0	0	D
Uninfected species	1	0	0	0	0	0	0	0	
GRUIFORMES	6	1	0	0	0	0	1	0	
Eurypygidae	1	1	0	0	0	1	1	0	
Eurypyga helias	1	1	0	0	0	1*	1*	0	D
Rallidae	5	0	0	0	0	0	0	0	
COLUMBIFORMES	155	60	1	57	0	1	1	0	
Columbidae	155	60	1	57	0	1	1	0	
Claravis pretiosa	36	13	0	13	0	0	0	0	C,D
Columbina talpacoti	78	44	0	43	0	0	1	0	B,C,D
Geotrygon chiriquensis	1	1	0	0	0	1*	0	0	A
Leptotila verreauxi	28	2	1	1	0	0	0	0	B,C,D
Uninfected species	12	0	0	0	0	0	0	0	
PSITTACIFORMES	7	2	0	2	0	0	1		
Psittacidae	7	2	0	1	0	0	1	0	
Brotogeris jugularis	4	1	0	0	0	0	1*	0	C,D
Pionus menstruus	1	1	0	1	0	0	0	0	D
Uninfected species	2	0	0	0	0	0	0	0	
STRIGIFORMES	2	1	0	1	0	0	0	0	
Strigidae	2	1	0	1	0	0	0	0	
Otus choliba	1	1	0	1	0	0	0	0	B
Uninfected species	1	0	0	0	0	0	0	0	

TABLE 2. (continued)

Host Species	Total Birds	Infected Birds	Total birds infected with: P	H	L	T	Mf	Other	Area
CUCULIFORMES	7	0	0	0	0	0	0	0	
CAPRIMULGIFORMES	8	1	1	0	0	0	0	1	
Caprimulgidae	8	1	1	0	0	0	0	1	
Nyctidromus albicollis	8	1	1*	0	0	0	0	1	B,C
APODIFORMES	280	20	0	20	0	0	0	0	
Trochilidae	280	20	0	20	0	0	0	0	
Amazilia amabilis	2	2	0	2*	0	0	0	0	D
Amazilia edward	24	4	0	4	0	0	0	0	B,D
Amazilia tzacatl	8	2	0	2*	0	0	0	0	B,D
Anthracothorax nigricollis	2	1	0	1*	0	0	0	0	D
Chalybura buffoni	10	4	0	4	0	0	0	0	D
Dmophila julie	6	1	0	1*	0	0	0	0	D
Glaucis hirsuta	74	2	0	2	0	0	0	0	A,D
Phaeochroa cuvieri	3	2	0	2*	0	0	0	0	D
Phaethornis anthophilus	23	1	0	1*	0	0	0	0	D
Phaethornis guy	25	1	0	1	0	0	0	0	A
Uninfected species	103	0	0	0	0	0	0	0	
TROGONIFORMES	4	2	0	0	0	0	2	0	
Trogonidae	4	2	0	0	0	0	2	0	
Trogon clathratus	1	1	0	0	0	0	1	0	A
Trogon massena	1	1	0	0	0	0	1*	0	D
CORACIIFORMES	17	2	0	2	0	0	0	0	
Alcedinidae	7	2	0	2	0	0	0	0	D
Chloroceryle aenea	4	2	0	2*	0	0	0	0	C
Uninfected species	3	0	0	0	0	0	0	0	
Momotidae	10	0	0	0	0	0	0	0	
PICIFORMES	60	4	0	2	0	0	2	0	
Bucconidae	24	1	0	1	0	0	0	0	
Notharchus macrorhynchus	1	1	0	1	0	0	0	0	
Uninfected species	23	0	0	0	0	0	0	0	

TABLE 2. (continued)

Picidae	27	1	0	1	0	0	0	0	
Melanerpes rubricapillus	9	1	0	1*	0	0	0	0	B,C
Uninfected species	18	0	0	0	0	0	0	0	
Ramphastidae	9	2	0	0	0	0	2	0	
Aulacorhynchus prasinus	2	2	0	0	0	0	2*	0	A
Uninfected species	7	0	0	0	0	0	0	0	
PASSERIFORMES	3,155	564	195	250	20	71	98	6	
Dendrocolaptidae	114	4	1	1	0	1	1	0	
Campylorhamphus pusillus	1	1	0	0	0	0	1*	0	A
Dendrocincla homochroa	12	2	1*	1*	0	0	0	0	D
Dendrocolaptes certhia	5	1	0	0	0	1*	0	0	A,D
Uninfected species	96	0	0	0	0	0	0	0	
Furnariidae	35	2	0	1	0	1	0	0	
Automolus ochrolaemus	8	2	0	1*	0	1*	0	0	D
Uninfected species	27	0	0	0	0	0	0	0	
Formicariidae	281	30	16	6	0	5	3	0	
Cercomacra tyrannina	21	2	0	2*	0	0	0	0	C,D
Cymbilaimus lineatus	1	1	0	0	0	0	1*	0	D
Formicarius analis	11	1	0	1*	0	0	0	0	C,D
Gymnocichla nudiceps	22	2	1*	0	0	1*	0	0	D
Gymnopithys leucaspis	31	4	3*	1*	0	0	0	0	C,D
Hylophylax naevioides	32	6	6*	0	0	0	0	0	C,D
Myrmeciza immaculata	7	1	0	0	0	1*	0	0	D
Myrmeciza longipes	11	3	0	1*	0	0	2*	0	C,D
Myrmotherula fulviventris	10	1	1*	0	0	0	0	0	D
Phaenostictus mcleannani	19	1	0	0	0	1*	0	0	D
Taraba major	13	1	1*	0	0	0	0	0	C,D
Thamnophilus doliatus	40	4	1	1*	0	2	0	0	C,D
Thamnophilus punctatus	15	3	3*	0	0	0	0	0	C,D
Uninfected species	45	0	0	0	0	0	0	0	
Pipridae	320	3	3	0	0	0	0	0	
Manacus vitellinus	66	2	2	0	0	0	0	0	C,D
Pipra erythrocephala	22	1	1*	0	0	0	0	0	C,D
Uninfected species	232	0	0	0	0	0	0	0	

TABLE 2. (continued)

Host Species	Total Birds	Infected Birds	Total birds infected with: P	H	L	T	Mf	Other	Area
Cotingidae	67	32	1	24	1	11	3	0	
Attila spadiceus	15	3	0	1*	1*	1*	0	0	A,D
Cotinga nattereri	1	1	0	0	0	1*	0	0	D
Lipaugus unirufus	3	2	0	1*	0	1*	0	0	D
Pachyramphus albogriseus	11	2	0	0	0	2*	0	0	B,D
Pachyramphus cinnamomeus	19	11	0	10*	0	5	3	0	D
Pachyramphus polychopterus	14	11	1	10	0	1	0	0	C,D
Platypsaris homochrous	2	1	0	1*	0	0	0	0	D
Rhytipterna holerythra	1	1	0	1*	0	0	0	0	D
Uninfected species	1	0	0	0	0	0	0	0	
Tyrannidae	513	66	20	36	0	10	4	0	
Capsiempsis flaveola	7	2	0	1	0	1*	0	0	C,D
Contopus cinereus	5	1	0	1*	0	0	0	0	C
Contopus sordidulus	6	1	0	1*	0	0	0	0	B,C,D
Contopus sp.	1	1	0	1	0	0	0	0	C
Elaenia chiriquensis	10	2	2*	0	0	0	0	0	B,C
Elaenia flavogaster	42	7	0	6*	0	1*	0	0	B,C,D
Empidonax flaviventris	8	1	1*	0	0	1	0	0	C,D
Empidonax traillii	18	3	0	3	0	0	0	0	C,D
Legatus leucophaius	2	1	0	1*	0	0	0	0	B,C
Mionectes olivaceus	5	1	0	0	0	1*	0	0	A,C
Myiarchus tuberculifer	9	3	3	0	0	1*	0	0	A,B,C
Myiobius atricaudus	8	1	0	0	0	1*	0	0	A,D
Myiodynastes maculatus	10	4	0	3*	0	0	1*	0	A,C,D
Myiopagis gaimardii	3	1	0	0	0	1*	1*	0	D
Myiophobus fasciatus	2	1	0	1*	0	0	0	0	C
Myiozetetes similis	41	7	6*	1	0	0	0	0	B,C,D
Ornithion brunneicapillum	1	1	0	0	0	1*	0	0	D
Phylloscartes flavovirens	2	1	0	1*	0	0	0	0	C
Pipromorpha oleaginea	168	4	1*	2*	0	0	1	0	A,B,C
Platyrinchus coronatus	15	1	0	0	0	0	1*	0	A,C,D
Sublegatus arenarum	5	2	0	2*	0	0	0	0	C

TABLE 2. (continued)

Terenotriccus erythrurus	11	1	0	0	0	1*	0	0	C,D
Tyranniscus villissimus	3	1	1	0	0	0	0	0	D
Tyrannus melancholicus	36	17	6	11	0	0	0	0	A,B,C
Flycatcher (unidentified)	1	1	0	1	0	1	0	0	D
Uninfected species	94	0	0	0	0	0	0	0	
Hirundinidae	48	0	0	0	0	0	0	0	
Troglodytidae	140	5	2	0	0	0	3	0	
Henicorhina leucophrys	27	3	1*	0	0	0	2*	0	A
Thryothorus modestus	12	1	0	0	0	0	1*	0	A,C
Troglodytes musculus	45	1	1*	0	0	0	0	0	A,B,D
Uninfected species	56	0	0	0	0	0	0	0	
Turdidade	174	47	24	9	11	0	7	0	
Catharus fuscater	11	7	6*	0	0	0	2*	0	A
Catharus minimus	16	2	0	0	2	0	0	0	D
Catharus ustulatus	69	13	4	0	9	0	1	0	A,B,C
Myadestes melanops	12	2	2*	0	0	0	0	0	A
Turdus albicollis	1	1	0	1	0	0	0	0	B
Turdus grayi	55	19	12	6	0	0	3	0	A,B,C,D
Turdus obsoletus	3	2	0	1*	0	0	1*	0	A
Turdus plebejus	1	1	0	1*	0	0	0	0	A
Uninfected species	6	0	0	0	0	0	0	0	
Sylviidae	11	1	0	1	0	0	0	0	
Rhamphocaenus rufiventris	10	1	0	1*	0	0	0	0	A,D
Uninfected species	1	0	0	0	0	0	0	0	
Vireolaniidae	2	2	0	1	0	0	1	0	
Smaragdolanius pulchellus	2	2	0	1*	0	0	1*	0	C,D
Vireonidae	92	36	12	21	0	6	4	0	
Hylophilus flavipes	22	7	1*	3*	0	2*	1*	0	B,C
Vireo flavoviridis	14	10	2*	6*	0	2*	3*	0	B,C,D
Vireo olivaceus	48	19	9	12	0	2	0	0	B,C,D
Uninfected species	8	0	0	0	0	0	0	0	
Parulidae	142	16	7	6	8	3	1	0	
Dendroica castanea	34	9	2*	5*	4*	3*	1*	0	A,D
Dendroica petechia	2	1	0	1	0	0	0	0	D
Protonotaria citrea	2	1	1*	0	0	0	0	0	

TABLE 2. (continued)

Host Species	Total Birds	Infected Birds	Total birds infected with: P	H	L	T	Mf	Other	Area
Seiurus motacilla	1	1	1*	0	0	0	0	0	D
Seiurus noveboracensis	18	2	2	0	2	0	0	0	C,D
Vermivora peregrina	43	2	1*	0	2*	0	0	0	A,D
Uninfected species	42	0	0	0	0	0	0	0	
Thraupidae	597	160	48	83	0	20	26	2	
Chlorospingus ophthalmicus	5	3	2*	1*	0	0	0	0	A
Chlorospingus pileatus	1	1	0	1*	0	0	0	0	A
Eucometis penicillata	29	6	0	4*	0	2*	0	0	C,D
Euphonia anneae	10	1	0	0	0	0	1*	0	A
Euphonia laniirostris	47	3	0	2	0	1*	1*	0	A,C,D
Habia fuscicauda	5	2	1*	1*	0	0	0	0	C,D
Piranga olivacea	3	2	0	1	0	1*	0	0	D
Piranga rubra	12	9	1	8	0	1	0	0	A,D
Ramphocelus dimidiatus	70	24	14*	4*	0	2*	5*	0	C,D
Ramphocelus passerinii	14	12	1	12	0	0	0	1*	B
Ramphocelus icteronotus	47	18	7*	8*	0	2*	6*	0	C,D
Rhodinocichla rosea	4	2	2*	0	0	0	0	0	C
Tachyphonus rufus	12	4	1	2*	0	0	1	0	C,D
Tachyphonus luctuosus	35	20	3*	18*	0	4*	0	0	C,D
Tangara icterocephala	17	13	0	13*	0	0	1*	0	A
Tangara inornata	17	6	1*	1*	0	1*	4	0	A,C,D
Tangara larvata	20	5	0	2*	0	0	3*	0	B,C,D
Thraupis episcopus	207	26	13*	4	0	6	4	1*	A,B,C
Thraupis palmarum	22	3	2*	1	0	0	0	0	C,D
Uninfected species	20	0	0	0	0	0	0	0	
Coerebidae	30	4	1	1	0	1	2	0	
Coereba flaveola	24	2	1*	0	0	1*	1*	0	B,D
Dacnis cayana	5	2	0	1*	0	0	1*	0	C,D
Uninfected species	1	0	0	0	0	0	0	0	
Icteridae	44	28	10	11	0	4	9	1	
Amblycercus holosericeus	11	10	10*	0	0	0	0	1*	C,D
Cacicus cela	11	4	0	1	0	0	3*	0	D

TABLE 2. (continued)

Icterus aurocapillus	5	1	0	1*	0	1*	0	0	D
Icterus chrysater	10	10	0	8*	0	3*	4*	0	D
Icterus mesomelas	4	2	0	0	0	0	2*	0	C,D
Zarhynchus wagleri	2	1	0	1*	0	0	0	0	D
Uninfected species	1	0	0	0	0	0	0	0	
Fringillidae	545	128	50	49	0	9	34	3	
Arremon aurantiirostris	28	6	6	0	0	0	0	0	C,D
Arremonops conirostris	49	20	14	3	0	1*	6	2*	A,B,C,D
Atlapetes branneinucha	24	16	0	15	0	0	2*	0	A
Cyanocompsa cyanoides	67	18	8	2*	0	6*	4	0	C,D
Oryzoborus funereus	39	6	4*	1	0	0	1*	0	C,D
Pitylus grossus	4	1	0	0	0	0	1	0	D
Saltator albicollis	54	2	1	1*	0	0	1*	0	A,B,C,D
Saltator atriceps	6	1	0	1*	0	0	0	0	C
Saltator maximus	38	10	0	0	0	0	10*	0	A,B,C
Sporophila aurita	164	38	12	24	0	2*	5	1*	A,B,C,D
Sporophila schistacea	4	1	0	1*	0	0	0	0	D
Tiaris olivacea	36	6	3*	0	0	0	4*	0	A,B,C,D
Volatinia jacarina	25	3	2	1	0	0	0	0	B,D
Uninfected species	7	0	0	0	0	0	0	0	
Total	3,715	661	197	335	20	73	107	7	
Percent		17.8	5.3	9.0	0.5	2.0	2.9	0.2	

*New host records (based on White, et al., 1979).
P = *Plasmodium;* H = *Haemoproteus;* L = *Leucocytozoon;* T = *Trypanosoma;* Mf = Microfilaria; Other = *Atoxoplasma/Lankesterella* types.

NOTE: No parasites were found in the following birds. The number after the species indicates number of birds examined: the letter indicates area where collected.

TINAMIFORMES: Tinamidae, *Crypturellus soui* 4C. CICONIIFORMES: Ardeidae, *Florida caerulea* 1C. FALCONIFORMES: Accipitridae, *Accipiter bicolor* 1D, *Buteo platypterus* 2AD, *Leucopternis albicollis* 1D. GALLIFORMES: Cracidae, *Ortalis cinereiceps* 1D. GRUIFORMES: Rallidae, *Gallinula chloropus* 2C, *Laterallus albigularis* 1C, *Porphyrula martinica* 2C. COLUMBIFORMES: Columbidae, *Columba nigrirostris* 2D, *Columbina minuta* 1D, *Leptotila cassinii* 9CD. PSITTACIFORMES: Psittacidae, *Forpus conspicillatus* 1D, *Pyrrhura hoffmanni* 1D. STRIGIFORMES: Strigidae, *Otus guatemalae* 1A. CUCULIFORMES: Cuculidae, *Crotophaga ani* 2CD, *Coccyzus minor* 1D, *Piaya cayana* 2D, *Tapera naevia* 1D. APODIFORMES: Trochilidae, *Campylopterus hemileucurus* 6A, *Colibri thalassinus* 1A, *Chalybura urochrysia* 2D, *Chlorostilbon*

(continued on page 216)

TABLE 2. (continued)

assimilis 1D, *Elvira chionura* 1A, *Eutoxeres aquila* 6A, *Florisuga mellivora* 1B, *Heliodoxa jacula* 26A, *Heliomaster longirostris* 1D, *Heliotryx barroti* 1D, *Lampornis castaneoventris* 2A, *Phaethornis longuemareus* 2D, *Phaethornis superciliosus* 46D, *Threnetes ruckeri* 7D. TROGONIFORMES: Trogonidae, *Trogon rufus* 1D, *Trogon violaceus* 1D. CORACIIFORMES: Alcedinidae, *Ceryle torquata* 1B, *Chloroceryle amazona* 1B, *Chloroceryle americana* 1A: Momotidae, *Momotus momota* 10BCD. PICIFORMES: Bucconidae, *Malacoptila panamensis* 13D, *Monasa morphoeus* 2D, *Nonnula frontalis* 8D; Picidae, *Campephilus melanoleucos* 8D, *Melanerpes formicivorus* 1A, *Melanerpes pucherani* 8D, *Picumnus olivaceus* 1D; Ramphastidae, *Pteroglossus torquatus* 6D, *Ramphastos sulfuratus* 1D. PASSERIFORMES: Dendrocolaptidae, *Campylorhamphus trochilirostris* 5D, *Deconychura longicauda* 17AD, *Dendrocincla fuliginosa* 23CD, *Dendrocolaptes picumnus* 1D, *Glyphorynchus spirurus* 14AD, *Lepidocolaptes souleyetii* 4BD, *Sittasomus griseicapillus* 3A, *Xiphorhynchus erythropygius* 3A, *Xiphorhynchus guttatus* 17CD, *Xiphorhynchus lachrymosus* 9D; Furnariidae, *Anabacerthia variegaticeps* 2A, *Cranioleuca erythrops* 1A, *Margarornis rubiginosus* 1D, *Sclerurus albigularis* 1A, *Sclerurus guatemalensis* 6AD, *Synallaxis brachyura* 1B, *Syndactyla subalaris* 3A, *Xenops minutus* 12CD; Formicariidae, *Dysithamnus mentalis* 3A, *Dysithamnus puncticeps* 1C, *Formicarius rufipectus* 1C, *Myrmeciza exsul* 13D, *Myrmotherula axillaris* 9CD, *Myrmotherula surinamensis* 11D, *Thamnistes anabatinus* 1D, *Thamnophilus nigriceps* 6D; Pipridae, *Corapipo altera* 3A, *Chloropipo holochlora* 20D, *Pipra coronata* 2C, *Pipra mentalis* 194D. *Schiffornis turdinus* 13D; Cotingidae, *Pachyramphus rufus* 1D; Tyrannidae, *Aphanothriccus audax* 1D, *Camptostoma obsoletum* 3CD, *Cnipodectes subbrunneus* 2D, *Colonia colonus* 3D, *Contopus virens* 1B, *Empidonax virescens* 3CD, *Leptopogon superciliaris* 1A, *Lophotriccus pileatus* 2A, *Mitrephanes phaeocercus* 2A, *Myiarchus panamensis* 2C, *Myiobius sulphureipygius* 5D, *Myiodynastes luteiventris* 1B, *Myiodynastes hemichrysus* 1D, *Myiozetetes cayanensis* 6CD, *Myiozetetes granadensis* 10B, *Oncostoma olivaceum* 1D, *Onychorhynchus mexicanus* 17CD, *Pitangus sulphuratus* 1C, *Platyrinchus mystaceus* 3A, *Rhynchocyclus olivaceus* 11CD, *Sayornis nigricans* 6A, *Serpophaga cinerea* 3A, *Todirostrum cinereum* 3CD, *Todirostrum sylvia* 1C, *Tolmomyias sulphurescens* 2D, *Tyrannulus elatus* 3CD; Hirundinidae, *Hirundo rustica* 3D, *Pygochelidon cyanoleuca* 12A, *Stelgidopteryx ruficollis* 33 ABCD; Troglodytidae, *Campylorhynchus albobrunneus* 1D, *Cyphorhinus phaeocephalus* 11CD, *Henicorhina leucosticta* 24D, *Microcerculus marginatus* 4D, *Thryothorus atrogularis* 1C, *Thryothorus fasciatoventris* 11D, *Thryothorus rufalbus* 4A; Turdidae, *Catharus fuscescens* 6D; Sylviidae, *Polioptila plumbea* 1D; Vireonidae, *Hylophilus aurantiifrons* 1D, *Hylophilus decurtatus* 2BD, *Hylophilus ochraceiceps* 5D; Parulidae, *Basileuterus culicivorus* 1A, *Basileuterus delattrei* 1B, *Basileuterus fulvicauda* 5AD, *Dendroica pensylvanica* 1D, *Mniotilta varia* 2A, *Myioborus miniatus* 12A, *Oporornis formosus* 6AD, *Parula pitiayumi* 1B, *Wilsonia canadensis* 12AD, *Wilsonia pusilla* 1B; Thraupidae, *Euphonia fulvicrissa* 10D, *Habia rubica* 9C, *Tangara gyrola* 1B; Coerebidae, *Cyanerpes cyaneus* 1C; Icteridae, *Icterus galbula* 1D; Fringillidae, *Atlapetes gutturalis* 3A, *Pheucticus ludovicianus* 2D, *Sporophila nigricollis* 2B.

able seedeater (*Sporophila aurita*). It is possible that some of the low level infections identified as *Haemoproteus* may actually represent *Plasmodium* cases with only gametocytes circulating in the blood of the naturally infected avian host at the time of sampling.

A total of 170 new host-parasite records are included in the findings of this survey (Table 2).

IDENTIFICATION: Most of the infections produced parasitemias of less than one parasite per 10,000 red blood cells. Specific identity in a single smear survey must be based exclusively on morphological characteristics of a limited number of visible forms. Many overlapping characteristics in the currently accepted classification of these parasites make diagnosis precarious. For example, the finding of very few elongate gametocytes and a single schizont containing four merozoites could be interpreted as an early stage of several species of *Plasmodium*. All the infections with *Leucocytozoon* contained round gametocytes and were often too few in numbers to justify specific assignment. Only, *L. dubreuili* of the Turdidae could be recognized. With the exception of *Haemoproteus columbae*, *H. trochili* and *H. archilochus* cited above, which were sufficiently numerous and characteristic to leave little doubt as to their identity, all other haemoproteid infections had such a low parasitemia that species identification was not plausible. Types 2 and 4 of Greiner et al. (1977) were the gametocyte forms usually observed. The trypanosomes, which are characteristically pleomorphic, were scarce when found in the individual blood preparations and no attempt was made to classify them to species.

The identity of the *Plasmodium* species are tabulated in Table 3. The authors are well aware of the fact that with further material and/or isolation and study in experimental hosts these designations might prove in error and that even some of the infections herein reported as *Haemoproteus* might prove to be *Plasmodium* instead. We have attempted to designate species on the basis of closest attainments (Greiner et al., 1975a) to major characteristics of the species assigned and hope this approach will aid future investigators in the clarification of this problem and toward a more exact interpretation of the distribution of species of *Plasmodium* prevalent in avian hosts.

CONCLUSIONS

The prevalence of Hematozoa in the neotropical avifauna is substantially lower than that of the Nearctic (White et al., 1978). Birds in the nearctic region of the Western Hemisphere have been found to harbor at least one type of hematozoan parasite in 75% of the species examined (Greiner et al., 1975b) in contrast to neotropical birds which have been found infected with hematozoa in only 53% of the species examined (White et al., 1978). The present study of the avian Hematozoa in the birds of the Republic of Panama has shown at least 142 (50%) out of a total of 282 species harbored at least one hematozoan parasite. This is comparable to findings for the Neotropic, but much lower than indicated for the Nearctic. The prevalence of Hematozoa in 3,715 birds of the Republic of Panama examined during the present study was 18%, identical with the 18% rate of infection reported by White et al. (1978) for 20,880 birds previously examined for blood parasites in the neotropical regions. This is, however, much lower than the 27% prevalence recorded for Central American birds by the same authors. A comparison of our findings with previous data is summarized in Table 4.

Present findings on the hematozoan parasites of birds collected in four areas of the pacific slopes of the Republic of Panama have shown that the prevalence of infection varies from 13% in eastern

TABLE 3. Frequency of *Plasmodium* infections in birds from the Republic of Panama.

Host	Area	No. Exam.	No. Inf.	Plasmodium*							
				Re	Po	Ci	Pi	Nu	He	Va	Ro
Leptotila verreauxi	C	9	1		1						
Nyctidromus albicollis	C	8	1					1			
Dendrocincla homochroa	D	12	1							1	
Gymnocichla nudiceps	D	22	1							1	
Gymnopithys leucaspis	D	30	3							3	
Hylophylax naevioides	C,D	32	6	2						6	
Myrmotherula fulviventris	D	10	1							1	
Taraba major	C	6	1							1	
Thamnophilus doliatus	C	15	1				1				
Thamnophilus punctatus	C,D	15	3	2						1	
Manacus vitellinus	C	19	2					2			
Pipra erythrocephala	C	18	1					1			
Pachyramphus polychopterus	C	7	1					1			
Empidonax flaviventris	C	1	1					1			
Elaenia chiriquensis	C	9	2					2			
Myiarchus tuberculifer	C,D	5	3					2		1	
Myiozetetes similis	C	27	6					6			
Pipromorpha oleaginea	C	7	1					1			
Tyranniscus vilissimus	D	3	1					1			
Tyrannus melancholicus	C	21	6					6			
Henicorhina leucophrys	A	27	1							1	
Troglodytes musculus	D	40	1	1							
Catharus fascater	A	11	6	2						6	
Catharus ustulatus	B,D	65	4							4	
Myadestes melanops	A	12	2			1				1	
Turdus grayi	A,B,C	52	12	2						11	
Hylophilus flavipes	C	20	1					1			
Vireo flavoviridis	C	2	2					2			
Vireo olivaceus	B,C,D	48	9	1		2		3		4	
Dendroica castanea	D	33	2							2	
Protonotaria citrea	D	2	1							1	
Seiurus motacilla	D	1	1		1						

TABLE 3. (continued)

Seiurus noveboracensis	D	17	2	2							
Vermivora peregrina	D	33	1		1						
Chlorospingus ophthalmicus	A	5	2	1						2	
Habia fuscicauda	C	4	1					1			
Piranga rubra	D	10	1							1	
Ramphocelus dimidiatus	C,D	70	14	2				2		9	
Ramphocelus icteronotus	C	12	7	1				3	1	3	
Ramphocelus passerinii	B	14	1	1							
Rodinocichla rosea	C	4	2					2			
Tachyphonus rufus	C	11	1	1							
Tachyphonus luctuosus	D	34	3	3							
Tangara inornata	C	1	1					1			
Thraupis episcopus	C	184	13					12		1	
Thraupis palmarum	C,D	22	2	1				1			
Coereba flaveola	D	22	1							1	
Amblycercus holosericeus	C	10	10		2					8	
Arremon aurantiirostris	C,D	28	6	4						4	
Arremonops conirostris	C,D	41	14	3						12	
Cyanocompsa cyanoides	C,D	67	8	3	1					4	
Oryzoborus funereus	C	31	4					1		3	
Saltator albicollis	C	47	1								1
Sporophila aurita	A,B,C	86	12							12	
Tiaris olivacea	D	25	3	3							
Volatinia jacarina	B,D	25	2							1	1
Total birds infected with *Plasmodium*		1,392	197	35	6	3	1	53	1	106	2
Percent of total birds infected with *Plasmodium*			14.1	2.5	0.4	0.2	0.07	3.8	0.07	7.6	0.14
Percent of *Plasmodium* infections				17.8	3.0	1.5	0.5	26.9	0.5	53.8	1.0

*Re = *relictum*, Po = *polare*, Ci = *circumflexum*, Pi = *pinotti*, Nu = *nucleophilum*, He = *hexamerium*, Va = *vaughani*, Ro = *rouxi*.

Table 4. Comparison of blood parasites of birds in Panama with findings in Central America.

	Panama avifauna (Present work)	Central America (White et al., 1978)
Total no. birds examined	4,715	5,335
Total no. found infected	661	1,446
Percent infected	17.8	27.1
Prevalence of infection (percent) with		
Haemoproteus	9.0	19.9
Plasmodium	5.3	7.5
Leucocytozoon	0.5	0.8
Microfilariae	2.9	5.4
Other	0.2	1.0

Panama (Bayano, Area D) to 28% in central Panama (Juan Mina, Area C) close to the old Canal Zone. Such differences might be due to sample size, seasonal changes, the species of birds and ecological conditions of the collection site, more than the result of simple geographical separation. Distribution and density of vector species probably also play an important role. The prevalence of Hematozoa among passerine birds of Almirante, Bocas del Toro Province (Gallindo and Sousa, 1966), La Fortuna and Cuesta de Piedras, Chiriqui Province, and Juan Mina, in Panama Province varied slightly (22 to 28%) in contrast to the much lower rate of infection (13%) among passerines of the Bayano area in eastern Panama Province.

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