EL HORNERO
REVISTA DE ORNITOLOGÍA NEOTROPICAL
Establecida en 1917
ISSN 0073-3407
Publicada por Aves Argentinas/Asociación Ornitológica del Plata
Buenos Aires, Argentina

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2009

Cita: Rodriguez, O. A.; Moya, H.; Matta, N. E. (2009) Avian blood parasites in the National Natural Park Chingaza: high Andes of Colombia. *Hornero* 024 (01) : 001-006

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Universidad de Buenos Aires

AVIAN BLOOD PARASITES IN THE NATIONAL NATURAL PARK CHINGAZA: HIGH ANDES OF COLOMBIA

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ABSTRACT.—Birds from the high Andes in the National Natural Park Chingaza, Colombia, were surveyed for blood parasites in April 2002 and March 2003. Of 136 birds examined, representing 40 species of 14 families, 38 were infected with blood parasites. Parasites of the genera *Leucocytozoon* (21.3% prevalence), *Plasmodium* (8.1%), *Hepatozoon* (2.9%), Microfilariae (2.9%) and *Haemoproteus* (1.5%) were recorded. Twenty five avian species in this survey were examined for blood parasites for the first time and 49 new parasite-host associations were identified. The most striking observation of this study was the high prevalence of *Leucocytozoon* spp. In the Neotropics, the prevalence of *Leucocytozoon* spp. has not been reported to be greater than 0.2% and is closely associated with the presence of migrant birds. Its presence in native avian host suggests a local transmission cycle in the zone.

KEY WORDS: *avian haematozoa, Colombia,* Haemoproteus, Hepatozoon, *high Andes,* Leucocytozoon, *Microfilariae,* Plasmodium.

RESUMEN. PARÁSITOS SANGUÍNEOS DE AVES EN EL PARQUE NACIONAL NATURAL CHINGAZA: ANDES DE COLOMBIA.— Fue analizada la presencia de parásitos sanguíneos en aves de páramo en el Parque Nacional Natural Chingaza (Colombia) en abril de 2002 y marzo de 2003. De las 136 aves examinadas, pertenecientes a 40 especies de 14 familias, 38 estuvieron infectadas con parásitos sanguíneos. Se registraron parásitos de los géneros *Leucocytozoon* (21.3% de prevalencia), *Plasmodium* (8.1%), *Hepatozoon* (2.9%), Microfilariae (2.9%) y *Haemoproteus* (1.5%). A 25 especies de aves se les examinó la presencia de parásitos sanguíneos por primera vez y se identificaron 49 nuevas asociaciones hospedero–parásito. La observación más sobresaliente de este estudio fue la alta prevalencia de *Leucocytozoon* spp., un parásito asociado estrechamente con aves migratorias en el Neotrópico, donde su prevalencia no supera el 0.2%. Su presencia en aves nativas sugiere un ciclo local de transmisión en la zona.

PALABRAS CLAVE: *Colombia,* Haemoproteus, *hematozoarios de aves,* Hepatozoon, Leucocytozoon, *Microfilariae, páramo,* Plasmodium.

Received 1 September 2008, accepted 2 August 2009

Ornithological literature remarks the extremely high avian diversity present in Colombia. The country's geographical position, where both Nearctic and Austral migrant birds come in the September–December period, allows potential inwards or outwards parasite movement (Salaman et al. 2001). In recent years great efforts have been placed on identifying blood parasites from Colombian birds (Rodríguez and Matta 2000, Valkiunas et al. 2003, Matta et al. 2004, Basto et al. 2006). This research program begun in the mid 20th century with the work of Renjifo et al. (1952) and Bennett and Borrero (1976), yet the problem of parasite distribution remains unsolved. Bennett and Borrero (1976) suggested that the avian heamatozoa has a wide altitudinal distribution pattern, recording infected avian hosts from sea level to 2140 masl. We have expanded this research on birds whose distribution reaches higher grounds, above 3000 masl. No other study on avian haematozoa had been carried out before in this ecosystem for Colombia, or in other Neotropical country (Renjifo et al. 1952, Bennett and Borrero 1976, Ayala et al. 1977, Rodríguez and Matta 2000, Valkiunas et al. 2003, Matta et al. 2004, Basto et al. 2006).

The paramos are unique areas of Neotropical mountains, located between 3100–4700 masl (Vargas and Pedraza 2004). These high Andes are distributed from Costa Rica in the north, to northern Peru in the south, and from Colombia in the west to Venezuela in the east (Chaves and Arango 1998). Regionally, Colombia has the largest area of high Andes, both in surface and associated biological diversity. The climate in the tropical high Andes is characterized by low temperatures across the whole year (Guhl 1995), with sunny days with intense solar radiation and very cold and wet nights (Aguilar and Rangel-Ch 1996). It was reported a total of 129 bird species belonging to 84 genera and 31 families, of which 36 are endemic from the high Andes (Chaves and Arango 1998). National Natural Park Chingaza is a unique and privileged area, because in addition to the presence of high Andes, it has three other important ecosystems: tropical rain forest, sub-Andean forest and Andean forest (Vargas and Pedraza 2004). This natural reserve has a wide altitudinal range, with several micro-basins and aquatic ecosystems (Vargas and Pedraza 2004). These unique conditions suggest that host–parasite interactions might vary from those observed in other Neotropical areas.

The purpose of this study was to record the prevalence of blood parasites in birds from a paramo ecosystem in the Eastern Cordillera at the National Natural Park Chingaza.

METHODS

The National Natural Park Chingaza is located in the Colombian Eastern Cordillera. This paramo, along with the paramo of Sumapaz, constitutes the largest areas of high Andes ecosystem. Chingaza is under the jurisdiction of Cundinamarca and Meta departments, covering ten municipalities and including the basins of the rivers Negro, Guatiquía, Guavio, Orinoco, and Siecha or Tominé de la Hoya of Magdalena (Inderena 1986). This park covers an area of 76600 hectares. It lies between 800–4020 masl, although most of its territory is above 3000 masl (Vargas and Pedraza 2004). The weather is the result of the interaction between latitude, altitude, and the geographical position of the mountains with respect to the ocean and atmospheric circulation chains. In Chingaza the maximum average temperature ranges between 12–14 °C whereas the minimum recorded temperatures are below 0 °C (Vargas and Pedraza 2004). The region has an average annual rainfall of 1861 mm, with two distinct periods: the first is dry, between November and March, with the lowest rainfall values in January and February, and the second is humid, occurring between April and October with maximum rainfall between June and July. The relative humidity ranges between 80–88% (Inderena 1986).

Avian hosts were collected in the park during the months of April 2002 and March 2003, by mist-netting. Those months have low presence of migratory birds, and in this study there was an exclusive capture of resident birds. The collections were made in three distinct areas: (1) Estación Monterredondo, sendero Suasie (4°38'N, 73°43'W; 3093 masl), (2) Bosque de Encenillo (4°36'N, 73°43'W; 3155 masl), and (3) Valle de los Fraylejones (4°32'N, 73°46'W; 3203 masl). These places are highly cloudy, presenting only 2–3 h of direct insulation.

Three thin smears were made from blood obtained by toenail clip. Smears were immediately air dried and fixed in 100% methanol within 2 h of collection in the field, and stained with Giemsa stain pH 7.2 in the laboratory. In order to determine the prevalence of haematozoa, each smear was scanned double blind in 150–180 fields under low magnification, and at least 100 fields at high magnification, for each slide. The intensity of infection was obtained as a percentage by counting the actual number of parasites per 1000 red blood cells or per 10000 red blood cells if infections were light, as recommended by Godfrey et al. (1987).

Blood parasites were identified according to the methods proposed by Valkiunas (2005). The representative blood films were deposited at The International Reference Centre for Avian Haematozoa, held at the Queensland Museum in Brisbane, Australia.

RESULTS

One hundred thirty six birds belonging to forty species and 14 families were mist netted and surveyed for blood parasites (Table 1). Thirty-eight avian hosts (27.9% overall prevalence), representing 17 species (42.5% of examined species), were found to harbour haematozoa. The most commonly occurring blood parasite genus was *Leucocytozoon* (21.3%), followed by *Plasmodium* (8.1%), *Hepatozoon* (2.9%), Microfilariae (2.9%) and *Haemoproteus* (1.5%) (Table 2). No try-

Table 1. Occurrence of haematozoa in birds from the National Natural Park Chingaza, high Andes of Colombia. Number of examined and infected birds is shown.

	Examined	Infected
Accipitridae		
Accipiter striatus (Sharp-shinned Hawk)	1	0
Trochilidae		
Coeligena helianthea (Blue-throated Starfrontlet)	2	0
Eriocnemis cupreoventris (Coppery-bellied Puffleg)	4	0
Eriocnemis vestitus (Glowing Puffleg)	14	0
Metallura tyrianthina (Tyrian Metaltail)	1	0
Opisthoprora euryptera (Mountain Avocetbill)	2	1
Oxypogon guerinii (Bearded Helmetcrest)	1	0
Pterophanes cyanopterus (Sapphirewing)	2	0
Trogonidae		
Trogon personatus (Masked Trogon)	1	0
Picidae		
Piculus rivolii (Crimson-mantled Woodpecker)	3	0
Furnariidae		
Margarornis squamiger (Pearled Treerunner)	6	1
Xiphocolaptes promeropirhynchus (Strong-billed Woodcreeper)	1	0
Tyrannidae		
Mecocerculus leucophrys (White-throated Tyrannulet)	11	4
Ochthoeca diadema (Yellow-bellied Chat-tyrant)	4	1
Ochthoeca sp. (Chat-tyrant)	3	0
Pyrrhomyias cinnamomeus (Cinnamon Flycatcher)	1	0
Hirundinidae		
Notiochelidon murina (Brown-bellied Swallow)	5	1
Troglodytidae		
Cinnycerthia unirufa (Rufous Wren)	11	3
Turdidae		
Turdus fuscater (Great Thrush)	12	11
Turdus serranus (Glossy-black Thrush)	1	1
Parulidae		
Basileuterus nigrocristatus (Black-crested Warbler)	1	0
Myioborus ornatus (Golden-fronted Redstart)	1	0
Thraupidae		
Anisognathus igniventris (Scarlet-bellied Mountain-tanager)	2	1
Buthraupis montana (Hooded Mountain-tanager)	3	3
Conirostrum rufum (Rufous-browned Conebill)	2	0
Conirostrum sitticolor (Blue-backed Conebill)	5	0
Diglossa humeralis (Black Flowerpiercer)	1	0
Diglossa lafresnayii (Glossy Flowerpiercer)	10	1
Diglossopis caerulescens (Bluish Flowerpiercer)	1	0
Diglossopis cyanea (Masked Flowerpiercer)	6	3
Dubusia taeniata (Buff-breasted Mountain-tanager)	3	3
Hemispingus verticalis (Black-headed Hemispingus)	3	1
Iridosornis rufivertex (Golden-crowned Tanager)	1	1
Emberizidae		
Atlapetes pallidinucha (Pale-naped Brush-finch)	2	1
Atlapetes schistaceus (Slaty Brush-finch)	1	0
Buarremon brunneinucha (Chestnut-capped Brush-finch)	1	1
Catamenia inornata (Plain-colored Seedeater)	1	0
Zonotrichia capensis (Rufous-collared Sparrow)	3	0
Fringillidae		
Carduelis psaltria (Lesser Goldfinch)	2	0
Icteridae		
Cacicus chrysonotus (Mountain Cacique)	1	0

Table 2. Birds infected with different haematozoa in the National Natural Park Chingaza, high Andes of Colombia. Number of infected birds is shown.

	Leucocytozoon spp.	*Plasmodium* spp.	*Hepatozoon* spp.	*Haemoproteus* spp.	Other
Opisthoprora euryptera	1				
Margarornis squamiger	1				
Mecocerculus leucophrys	3	1			
Ochthoeca diadema					1
Notiochelidon murina			1		
Cinnycerthia unirufa			3		
Turdus fuscater	11	5		2	4
Turdus serranus	1				
Anisognathus igniventris		1			
Buthraupis montana	2	2			
Diglossa lafresnayii		1			
Diglossopis cyanea	3				
Dubusia taeniata	3				
Hemispingus verticalis	1				
Iridosornis rufivertex	1				
Atlapetes pallidinucha	1				
Buarremon brunneinucha	1				

panosome infections were recorded. The intensity of parasitism did not exceed 1% and 11 avian host harboured mixed infections.

Leucocytozoon dubreuili and *Leucocytozoon fringillinarum* were identified on the avian genus *Turdus* (*Turdus fuscater* harboured both species; meanwhile *Turdus serranus* only harboured *Leucocytozoon dubreuili*). Gametocytes resembling *Leucocytozoon thraupis* (based on the description given by Bennett and Squires-Parsons 1992) were recorded on the blood samples of *Buthraupis montana*, *Iridosornis rufivertex* and *Dubusia taeniata*. *Leucocytozoon cambournaci* was identified on the avian host *Buarremon brunneinucha*. Unidentified species of this genus were observed in *Hemispingus verticalis*, *Atlapetes pallidinucha*, *Mecocerculus leucophrys*, *Diglossopis cyanea*, *Margarornis squamiger* and *Opisthoprora euryptera*. No previous data exist on *Leucocytozoon* infection for Trochilidae, Furnariidae, Tyrannidae and Thraupidae, but other blood parasites have been recorded (Galindo and Souza 1966, Bennett et al. 1982, 1987, 1992a, Bennett and Squires-Parsons 1992, Bishop and Bennett 1992, Shurulinkov and Golemansky 2003).

In the blood smears of *Turdus fuscater* and *Buthraupis montana* parasites of the genus *Plasmodium*, belonging to the subgenus *Haemamoeba*, were observed. Different stages of the *Novyella* subgenus of *Plasmodium* were also observed. Additionally, *Plasmodium* parasites on different developmental stages were found on the blood smears of *Diglossa lafresnayii*, *Anisognathus igniventris* and *Mecocerculus leucophrys*, but further identification was not possible.

Parasites of the genus *Hepatozoon* were only found in two bird species, *Cinnycerthia unirufa* and *Notiochelidon murina*. For the last host, the parasites resembled those redescribed by Bennett and Peirce (1989) for *Hepatozoon atticorae*; however, in the same blood samples other morphotypes different from the typically recorded U-form (Bennett and Peirce 1989) were found. This result suggests a double *Hepatozoon* infection; alternatively, it could be that polymorphic forms for this parasite are present in the study area.

Finally, *Haemoproteus fallisi* gametocytes and Microfilariae were found on the blood smears of *Turdus fuscater*, and undetermined blood parasites were found on *Ochthoeca diadema*.

DISCUSSION

Twenty five bird species (more than half of those recorded) were examined for haematozoa for the first time during the present study, and almost every blood parasite found was not pre-

viously related with its avian host (49 of 52 hosts-parasite associations), according to Bennett et al. (1982), Bishop and Bennett (1992), Valkiunas et al. (2003), Valkiunas (2005) and Basto et al. (2006). Our results clearly stress the huge gaps in avian haematozoan knowledge on high Andean ecosystems, especially the paramo.

It was remarkable the high prevalence of *Leucocytozoon* parasites, inasmuch for the Neotropics it has been found in low prevalence (0.2%) or complete absence, in contrast to records in the avifauna of Nearctic (17.7%) (Greiner et al. 1975, White et al. 1978, Valkiunas 2005). The ecological peculiarities responsible for the low prevalence of hemoparasites in Neotropical birds are not completely understood, although Bennett et al. (1980) suggested that it could be due to a paucity of suitable vectors species. *Leucocytozoon* species are mainly transmitted by black flies (Desser and Bennet 1993). The life cycle of this arthropod vector depends on well oxygenated running waters, commonly found on mountainous landscapes, like the Rocky Mountains of North America (Greiner et al. 1975) and the paramo ecosystem. The high prevalence of *Leucocytozoon* found in native birds from National the Natural Park Chingaza suggests the existence of suitable vectors, and possibly a local cycle of transmission.

The prevalence recorded by Bennett and Borrero (1976), Rodríguez and Matta (2000), and Valkiunas et al. (2003) for Colombia were similar to those observed for the whole Neotropical area by White et al. (1978), where the avian haematozoa prevalence is clearly lower (10.2%) than that reported by Greiner et al. (1975) for other Wallacean life zones like the Nearctic (36.9%). All of these studies have been made in lowland and warmer localities. Despite many of them are protected areas and have clean rivers and water flows (which could also allow the development of potential Simuliidae vectors), the records of *Leucocytozoon* are limited to migratory birds. The overall prevalence of blood parasites found in this study (27.9%) was similar to those previously obtained by Renjifo et al. (1952), and Basto et al. (2006) for Villavicencio (26.7%) and the National Natural Park Macarena (24%), respectively. However, in the present study become apparent differences in host–parasite relationships: despite National Natural Park Chingaza is located in a Neotropical country, it possesses ecological niches that have allowed a change in the relative frequency of each parasite in the bird populations; for example, the high prevalence found for *Leucocytozoon*. Another peculiar finding was for the genus *Hepatozoon*; its prevalence may be related with the natural history of host–species, especially for the Brown-bellied Swallow, *Notiochelidon murina*, which develops colonial behaviour probably allowing parasite transmission by fleas or louse as previously suggested for other swallow species (Bennett et al. 1992b). In the same sense, the Rufous Wren, *Cinnycerthia unirufa*, has developed familiar flock's behaviour patterns (Hilty and Brown 1986), which could be related with an increase of potential vector contact.

The transmission pattern for most of avian hemoparasites and the host's susceptibility are still unknown in the Neotropical region, especially for those avian species related with a tropical origin, like Trochilidae, Furnariidae or Tyrannidae. To better understand the high Andes ecosystem it is necessary to promote research in order to evaluate the trophic relationships between its components (Vargas and Pedraza 2004). Undoubtedly, the results of basic research will generate knowledge of the biodiversity of parasites in unique ecosystems in Neotropical countries and will allow a better understanding of the dynamics of host–parasite–vector transmission, generating new trends in the epizootiology of hemoparasites of birds in Colombia and the Andean countries. Within this perspective, it is important to investigate if the *Leucocytozoon* species found in paramo avian host are regularly introduced there by migrant birds or if there is an active and isolated transmission ground among the Neotropical high Andean birds.

ACKNOWLEDGEMENTS

We thank C. Lora and the staff of National Natural Park System for providing access to sampling location; CJ Marinkelle, FG Stiles and EC Greiner for their professional assistance; R Gutiérrez and the avian haematozoan study group who assisted us during collection work; LF Cadavid for manuscript revision. This study was funded by División de Investigación Bogotá, Universidad Nacional de Colombia, and Idea Wild.

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