

Prevalence of hemoparasites in avian species of coastal and upland sites of Marinduque Island, MIMAROPA, Philippines

Michael S. Sanchez^{1*}, Vachel Gay V. Paller²

¹Forestry Development Center, College of Forestry and Natural Resources, University of the Philippines Los Baños, College, Laguna, Philippines;

*Email: mssanchez2@up.edu.ph

²Institute of Biological Sciences, College of Arts and Sciences, University of the Philippines Los Baños, College, Laguna, Philippines

ABSTRACT. Interaction between birds and blood parasites may provide signs of the environment's health status and thus, help decision-making. Avian species in the coastal (0-7 m asl) and mountain (110–770 m asl) areas of the island of Marinduque were captured to determine the prevalence and test the difference of blood parasites between these sites. One hundred thirty-two resident wild birds and 60 individuals of free-range domestic chicken were sampled and screened for blood parasites through peripheral blood smear microscopy. *Plasmodium*, *Hemoproteus*, and *Aegyptianella* were observed in 21% of captured birds and 17.7% of all sampled, including free-range domestic chicken. *Plasmodium* occurred the highest (6.77%), followed by *Aegyptianella* (5.72%), while *Hemoproteus* was the lowest (5.20%). Out of the burrow, tree cavity, mound, and open cup nester avian species captured in this study, five open cup nesters and only one burrow nester were infected. Two species of these birds prefer to nest on the ground, while the rest are understory nesters. A higher prevalence of hemoparasite infection was detected in the coastal sampling site at both the species and family levels (37.5% vs 25% and 29% vs 16%, respectively). No infection was observed with the free-range domestic chicken and red jungle fowl from the mountain sampling site, but 8.5% of the bulbuls from the same area and 20% of the domesticated poultry on the coast were found to be infected with *Aegyptianella*. However, statistical analysis found no significant difference in parasitic prevalence between the sites or elevation ($U=10.500$, $p=0.673$).

Keywords: *Aegyptianella*, avian, blood parasites, *Hemoproteus*, Marinduque Wildlife Sanctuary, *Plasmodium*

INTRODUCTION

Avian blood parasites are among the concerns that need to be studied so that management decisions are made to keep the ecosystem healthy and inform humans from possible harm. Wild animals, including domesticated ones, are affected by parasites (Martinez-de la Puente *et al.*, 2010). Birds can fly but are not exempt from being infected with parasites. Although it has been known in many bird species in Europe and North America, studies on the prevalence of blood parasites are still sparse in Asia (Leppert *et al.*, 2004). Despite the extent of knowledge on avian blood parasites, less is

known about the wild and domesticated avian species of the island province of Marinduque, MIMAROPA, Philippines.

Blood parasites or hemoparasites are costly to their host as they negatively affect health and reproduction ability. Species introduced to new areas for captive breeding or in zoological exhibits could be easily infected by blood parasites found in resident birds in the same location (Pierce, 2000).

According to Martinez-Abraín *et al.* (2004), marine, saline, arid, windy, open, alpine, or high-latitude environments or habitats and the high resistance capabilities of the host and the lack of right host-parasite assemblage could be the factors in the absence of blood parasites. Other authors suggested that some blood parasite species are host taxonomic families specific. Consequently, Martinez-Abraín *et al.* (2004) mentioned that birds in smaller communities, such as islands, are less prone to infection by blood parasites because of a lower probability of living with a closely related species that carry parasite than on a larger, more diverse, mainland bird communities. On the other hand, Sebaio *et al.* (2011) found that birds were more infected during the rainy season, while Krams *et al.* (2010) observed that blood parasite prevalence is highest at higher latitudes and more diverse in tropical areas. Parasite prevalence was unrelated to development and lifespan, except that *Plasmodium* was higher in species with longer lifespans and lowered in species with long fledging periods (Scheuerlein & Ricklefs, 2004).

Accordingly, hemoparasitic infection of birds in small islands is less likely because of fewer chance of living with closely related species (Martinez-Abraín *et al.*, 2004). However, avian species confined to small islands may be more vulnerable to hemoparasites because of the limited space and the ever-changing landscape of anthropogenic activities. Clearing large areas for agriculture, settlements, mining, and industrialization decreases biodiversity, exposes other organisms – including humans – to infection, and promotes suitable areas for perpetuating vectors. Also, the introduction of new species may pose problems with the survival of the native ones because novel parasites are more deleterious to the native species other than the food and space competition pressure that the invasive species may provide. The changing climate and global warming are also believed to increase pathogens and their potency.

Birds are important components of the ecosystem (Sanchez, 2021). Extinction of a single bird species confined in an isolated island spells loss of ecosystem services as repopulation of the same island through migration is impossible if the same species cannot sustain long flight (Sanchez *et al.*, 2018). Avian species are also indicators of the ecosystem's health and source of nutrients or pleasure but may also harbor diseases that are of economic or health importance to humans. Thus, avian species monitoring is imperative to detect any zoonotic diseases, assess their present health and those that affect their fitness to reproduce

and maintain the invaluable ecosystem services they provide to humanity, and immediately provide mitigating measures or environmental decisions once needed. Other than this, climate change could promote the extension and distribution of vectors and avian parasites. Thus, baseline studies and understanding the prevalence and diversity of blood parasites are important.

This paper reports the blood parasite prevalence of avian species in the coastal and mountain sites of Marinduque Island, including nest type and location for infected species.

METHODOLOGY

Study area

This study was conducted in the coastal area of Brgy. Ipil, Calancan Bay, Municipality of Sta. Cruz (cited as Ipil, 0–7 m asl) and the mountain of Marinduque Wildlife Sanctuary (MWS 110–770 m asl) along Brgy. Tabionan, Gasan, in the island province of Marinduque–MIMAROPA (Figure 1).

Sample collection

The samples were collected on July 2014 after necessary permits were secured from national and local agencies. Permits for poultry blood sampling were obtained from the chicken's household. Birds were trapped using mist nets, and indigenous traps were visited every 5 to 10 min. Small drops of blood were collected from the wing vein in chicken or bigger birds and by nail clipping in the small ones. Procedures for collecting and preparing samples follow that of Pritchard & Kruse (1985). Three replicates of air-dried blood-smeared slides were prepared and labeled accordingly to ensure enough samples per species. These were soaked in methanol for 3–5 min, air dried, wrapped, and kept secured in a container with silica gel, and Giemsa stained after the fieldwork. Captured birds were released after data collection and ensuring that the bleeding stopped. Identification of the blood parasites through peripheral blood smear microscopy was made by the Veterinary Teaching Hospital, College of Veterinary Medicine (CVM), University of the Philippines Los Baños.

In this study, 192 blood samples were collected from all the avian species captured. The samples were collected from 63 (MWS) and 69 (Ipil) adult resident wild birds and 30 individuals of free-range domestic chicken at each site.

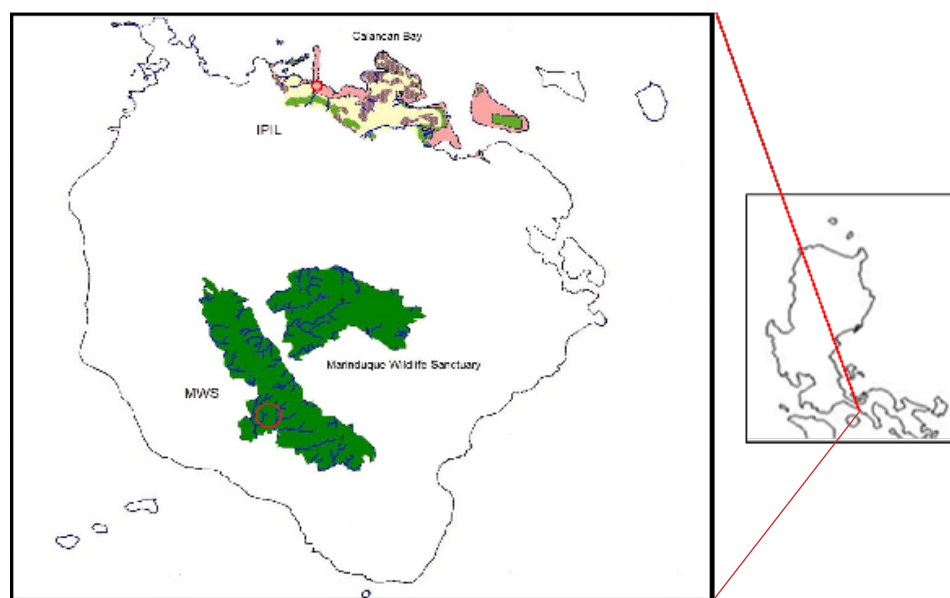


Figure 1. Map of Marinduque and the sampling sites (encircled red). (Source: PENRO Marinduque and <http://geography.about.com>.)

Data analysis

Mann-Whitney U Test was employed to test the difference in the prevalence of infection between sites. The percent prevalence of infected birds was calculated using the following formula:

(Equation 1)

$$\% \text{Prevalence of infected birds} = \frac{\text{total no. of birds infected}}{\text{total no. of birds sampled}} \times 100$$

while the percent prevalence of species infected was determined using the following formula:

(Equation 2)

$$\% \text{Prevalence of species infected} = \frac{\text{total no. of species infected}}{\text{total no. of species sampled}} \times 100$$

On the other hand, the determination of nest type, location, and habitat was based on Guide to Philippine birds authored by Kennedy *et al.* (2000) and personal experience in the field. Nest types were categorized as an open cup, open platform, tree cavity, and burrow on the ground, while the location was identified as on the ground, understory, and mid-story or canopy. Meanwhile, birds' habitat was also classified as forest/forest edge, cultivated areas, human habitation, and disturbed forest. The family classification and scientific names follow that of Jensen *et al.* (2019).

RESULTS AND DISCUSSION

The blood parasites

Among the 192 blood samples collected from avian species captured *Plasmodium*, *Hemoproteus*, and *Aegyptianella* were detected in this study.

At the MWS site, three avian species from two of the 12 families were infected with *Plasmodium*. The birds and families infected in this site were mangrove blue flycatcher (*Cyornis rufigastra*) (Muscicapidae) and Philippine bulbul (*Hypsipetes philippinus*) and yellow-vented bulbuls (*Pycnonotus goiavier*) (Pycnonotidae). Ong *et al.* (2015) also observed *Plasmodium*-infected individuals in the flycatcher and fantail families sampled in southern Luzon. Among these infected species, only the Philippine bulbul was observed to harbor *Hemoproteus*, *Plasmodium*, and *Aegyptianella*, wherein eight, ten, and three individuals tested positive. This species also has the highest (60%) hemoparasite infection among the species, with more than three individuals sampled. This species could be more prone to blood parasite infection as this was also the highest among the host species sampled by Ong *et al.* (2015). *Hemoproteus* was the only detected hemoparasites in an individual of this endemic bulbul, while none with the yellow-vented bulbul (Ong *et al.* 2015). On the other hand, five individual species belonging to four of eleven families (Pycnonotidae, Alcedinidae, Columbidae, and Muscicapidae) captured at the Ipil site were found positive for *Plasmodium*, *Hemoproteus*, and *Aegyptianella*. These individuals were Philippine

and yellow-vented bulbuls, white-collared kingfisher (*Todiramphus chloris*), pink-necked green pigeon (*Treron vernans*), and Philippine pied fantail (*Rhipidura nigritorquis*). The pink-necked green pigeon was the only bird species among the group with *Plasmodium*, while both bulbuls had *Hemoproteus* whereas white-collared kingfisher and Philippine pied fantail were observed positive for *Aegyptianella*. Unlike Earle *et al.* (1993), *Hemoproteus* were not recorded with the Columbidae in this study.

Among the families, the descending trend for the prevalence of infection in this study was Muscicapidae (50%) > Pycnonotidae (45.2%) > Phasianidae (9.09%) > Columbidae (4.3%) > Alcedinidae (2.4%). In Ong *et al.* (2015), the family with the highest infection was Pycnonotidae (20%), followed by Columbidae (10%) and Muscicapidae (9.5%). According to Greiner *et al.* (1975), water birds like the Alcedinidae were usually infected by blood parasites (Savage 2003). Composed of two species with 53 individuals captured, the Pycnonotidae had the highest number of individuals sampled. This was also the largest family sampled by Savage (2003) in Madagascar. In comparison, a higher number of individuals and prevalence was observed in this study (24 *vs* 4 individuals, 45.2% *vs* 14%). Eleven individual bulbuls were infected by *Plasmodium*, 10 by *Hemoproteus*, while three by *Aegyptianella*. These bulbuls were uninfected with *Leucocytozoon* or microfilariae like those in Savage (2003). *Hemoproteus* was distributed worldwide in pigeons and Pycnonotidae (Paperna *et al.*, 2008) in temperate and tropical climates (Atkinson, 2008). Ecological behavior was found to intensely affect blood infection by *Hemoproteus* and *Plasmodium* (Laurance *et al.*, 2013). The authors reported that *Hemoproteus*-infected birds are usually insect-eating and locally endemic, while those found in the undergrowth and ground-dwelling were more prone to *Plasmodium* incursion, but both hemoparasites may be observed with rainforest specialists. Zhang *et al.* (2014) also observed a high prevalence of hemoparasites in the Pycnonotidae and Muscicapidae, relating the increased infection to its foraging habit. It must be noted that both species may be observed from the lowland to the upland at the forest edge and cultivated areas. Both also forage and nest understorey. Accordingly, more vectors are lurking from the ground to the understorey.

Overall, *Plasmodium* was the most common (6.77%) blood infection in all the wild birds captured from both sites, followed by *Hemoproteus* (5.20%) and *Aegyptianella* (2.60%). These infection rates were higher than those *Hemoproteus* and *Plasmodium* reported by Valkiunas

et al. (2004), Londoño *et al.* (2007), and Gonzalez *et al.* (2014), yet, the respective hemoparasitic prevalence was lower than those observed by Zhang *et al.* (2014) and from separate studies of Wink & Bennett (1976), van Riper III *et al.* (1986), Sehgal *et al.* (2005), and Zhang *et al.* (2014). *Plasmodium*, the most common infection in this study, coincides with the findings of Munro *et al.* (2009) and Sebaio *et al.* (2011). *Plasmodium* infection was reported by Elahi *et al.* (2014) in the greater painted snipes, but none with the same species captured in this study. This hemoparasite was also not detected in the research for birds conducted by Powers *et al.* (1994). The Asian survey of Ishtiaq *et al.* (2007) in Myanmar, India, and South Korea found elevated *Plasmodium* prevalence followed by *Hemoproteus*. It was not noted by Bennett *et al.* (1980), Young *et al.* (1993), Forrester *et al.* (1994), and Merino *et al.* (2000) as *Hemoproteus* was the most common and the sole blood parasite of birds found in the island (Apanius *et al.*, 2000). The prevalence of *Hemoproteus* in this study was lower than those reported in the studies conducted by Bennett & Borrero (1976), Forrester *et al.* (1994), Apanius *et al.* (2000), and Merino *et al.* (2000), but higher than those observed by Bennett *et al.* (1980) and Valkiunas *et al.* (2004). The Philippine bird record for *Hemoproteus* infection was noted in dollarbird, besra, Philippine oriole, Philippine coucal, and spotted wood-kingfisher (Baticados & Baticados, 2012) and in captive Philippine scops owl (Bandoy, 2006). **Table 1** shows the prevalence of hemoparasites and the habitat of birds.

Gonzalez *et al.* (2014) study reported Columbidae and Turdidae among the sampled birds as the families most frequently infected with hemoparasites. Both families were also represented in this study. However, the overall prevalence for Columbidae for this present study was lower (4.3% *vs* 32%), while no birds from the family Turdidae were infected. Wink & Bennett (1976) observed no infection with the family Turdidae and Cuculidae they sampled. The paper of Palinauskas *et al.* (2005) reported a high prevalence of infection in birds under families such as Turdidae and Muscicapidae, much higher than detected in this present study.

In the case of free-range domestic chicken under the family Phasianidae, six individuals from Ipil were infected with *Aegyptianella*, while none were at MWS. The overall result reflects that even though more individual bird species were infected in MWS, *Aegyptianella* infection was only detected in three species belonging to two families. In contrast, Ipil had a few individual birds detected positive for *Aegyptianella* infection, but it had more species or families loaded with blood parasites.

Table 1. Habitat, nest type and location, and prevalence of blood parasites in infected birds from Marinduque Island, MIMAROPA, Philippines.

Species name	Habitat	N	INF	Prevalence (%)		Blood parasites
				Species	Family	
Muscicapidae		4	2		50	
Mangrove blue flycatcher (<i>Cyornis rufigaster</i>)	FE/DF	1	1	100		P
Philippine pied fantail (<i>Rhipidura nigritorquis</i>)	C/FE	3	1	33.3		A
Pycnonotidae		53	24		45.2	
Philippine bulbul (<i>Hypsipetes philippinus</i>)	F/FE	35	21	60		P, H, A
Philippine bulbul* (<i>Hypsipetes philippinus</i>)	F/FE	1	1	100		H
Yellow-vented bulbul (<i>Pycnonotus goiavier</i>)	C/FE	11	1	9		P
Yellow-vented bulbul* (<i>Pycnonotus goiavier</i>)	C/FE	6	1	16.6		H
Alcedinidae		14	1		2.4	
White-collared kingfisher* (<i>Todirhamphus chloris</i>)	C/FE	11	1	9.1		A
Columbidae		23	1		4.3	
Pink-necked green pigeon* (<i>Treron vernans</i>)	C/F	3	1	33.3		P
Phasianidae		61	6		9.8	
Free-range domestic chicken* (<i>Gallus gallus</i>)	C	30	6	20		A

N- number of individuals; INF-infected; *birds from Ipil; F/FE -forest /forest edge; C-cultivated areas and human habitation; DF-disturbed forest; P- Plasmodium; H- Hemoproteus; A- Aegyptianella

This study observed a single species of wild bird, specifically the Philippine bulbul from the MWS, to have the highest infection among the birds subjected to blood sampling. Seventy-seven percent of this species were infected with three different hemoparasites. However, this site has only three species of wild avifauna infected against the six species from the lowland or two versus five families. According to Zamora-Vilchis (2012), the decreased ambient temperature in the highlands may interfere with hemoparasites in birds and their vectors, leading to low prevalence. The study of Dezfoulia *et al.* (2011) found that rural domestic birds have the highest infection prevalence, probably due to habitat availability for both pathogens and hosts. Unlike Yanga *et al.* (2011), who reported 88% infection in mourning doves, no *Hemoproteus* infection in all wild doves captured in this study was observed. Eighty-five percent of the kestrel, a raptorial bird studied by Dawson & Bortolotti (2000), were found to harbor *Hemoproteus*. Other birds of prey known to harbor the highest prevalence of blood parasites were the owls garnering 53 (Leppert *et al.* 2008) and 63 (Forrester *et al.*, 1994) overall percentage but still, the strigids captured in this study were all hemoparasites free. Hemoparasites in owls were also not observed in all eight tawny-owl (*Strix aluco*) studied by Galeotti & Sacchi (2003). In contrast, the domestic free-range chicken from the MWS was all

free of these infections, unlike those from the Ipil site, wherein 20% tested positive. This site coincides with the findings of Suleiman (2012), wherein 20% were positive for infection but 8% higher than observed by Usman *et al.* (2012) and 10% higher than reported by Farkar *et al.* (2012). Also, Usman *et al.* (2012) only detected *Plasmodium gallinaceum*, although this present study solely observed *Aegyptianella* infection, while Njunga (2003) found both blood parasite species in free-range chicken.

Prevalence of blood parasites

Three genera of blood parasites were identified in all the infected birds from seven avian species belonging to five families (Philippine bulbul and yellow-vented bulbul (Pycnonotidae), Mangrove blue flycatcher and Philippine pied fantail (Muscicapidae), Pink-necked green pigeon (Columbidae), White-collared kingfisher (Alcedinidae), Free-range domestic chicken (Phasianidae). Twenty-three individuals from three of the 12 species belonging to two families captured at the MWS site were infected. On the same note, five species representing four families were infected at the Ipil site. Results showed that the % prevalence of hemoparasites infection was higher at the MWS (36.5%) than at the Ipil site (7.46%). However, 20% of the free-range domestic chicken *Gallus domesticus* from Ipil were infected, while none from MWS.

Based on prevalence, the occurrence of hemoparasites is higher in Ipil (37.5%, 6/16) than in MWS (25%, 3/12). But a higher prevalence of infection was observed when bird families were accounted for (Ipil – 5/11 or 29% vs. MWS – 2/12 or 16%). All host species combined, six species of wild birds (Philippine bulbul, Yellow-vented bulbul, Mangrove blue flycatcher, Philippine pied fantail, Pink-necked green pigeon, and White-collared kingfisher) tested positive for this study. This fraction was lower than those reported by Sousa & Herman (1982), Rodriguez & Matta (2001), Deviche *et al.* (2001), Munro *et al.* (2009), and Dunn *et al.* (2013). Yet concurs with the findings of Savage (2003), Belo *et al.* (2011), and Rodriguez *et al.* (2021), wherein blood parasite infection was high in birds in populated areas or lower elevations than in the forest. It coincides with higher infection in the species and family level at the lowland area, which was more arid than the forested site. This result disagrees with the findings of Tella *et al.* (1999) and Valera *et al.* (2003).

Overall, the prevalence of blood parasite infection for wild birds was 21%, while 17.7% for all, including free-range domestic chicken. This finding was lower than what was observed and cited by Zhang *et al.* (2014) from studies conducted in tropical regions except for Costa Rica and higher than reported by Gonzalez *et al.* (2014) and Gutiérrez-Lopez *et al.* (2015). *Plasmodium* was the most common having a prevalence of 6.77%, followed by *Aegyptianella* (5.72%) and *Hemoproteus* (5.20%). In contrast, Murata (2002), Savage (2003), Gonzalez *et al.* (2014), and Zhang *et al.* (2014) observed a higher prevalence of *Hemoproteus* than *Plasmodium*. *Hemoproteus*, according to Paperna *et al.* (2008) and other studies cited, were the most dominant bird hemoparasites in Southeast Asia and elsewhere, followed by *Plasmodium*. Studies on hemoparasites where *Plasmodium* was the most common were observed by Akinpelu (2008), Davis *et al.* (2013), and Gumba *et al.* (2014), but in contrast with Barnard & Bair (1986), Zamora-Vilchis *et al.* (2012), and Zhang *et al.* (2014). However, these authors did not observe *Aegyptianella* in their studies except Tarello (2006), who first reported its prevalence on falcons in the Middle East. Only 2% prevalence of infection was observed by Tarello (2006) in 1,706 individuals of falcons, still lower than perceived in this study. According to LaPointe *et al.* (2012), *Plasmodium* was highly diversified in songbirds, pheasants, and doves.

Nest type and location

Based on nest type, all the birds captured in this study used an open cup, open platform, tree cavity, and burrow on the ground. Most infected birds

were found to be using an open cup, open platform, and burrow nest located in the understory or on the ground. Rodriguez *et al.* (2021) found that open-cup nesters were more infected than cavity nesters. Unlike cavity nesters, birds tending eggs or young in the open cup nest were more exposed to vectors from all directions. Potential vectors favor the understory-canopy (Gonzalez *et al.*, 2014). However, studies like Pulgarín *et al.* (2018) found no connection between the prevalence of infection with the environment, nest type, and height but by phylogenetic background. Ecological specialization may also play a role in the blood parasite infection of birds (García-Longoria *et al.*, 2014). Birds may belong to specialists utilizing a single resource and thrive in a special environment or be generalists with a wide range of habitats and food sources. According to García-Longoria *et al.* (2014), habitat generalists are more exposed to and infected by hemoparasites *vis-a-vis* the specialist. Meanwhile, more species of parasites were expected in birds with bigger colonies (Lopez *et al.*, 2013). It was observed in this study that more birds were captured in the family Pycnonotidae, although it was composed of only two species. The yellow-vented bulbul has a wide range of habitats, while the Philippine bulbul may also be encountered in lowland areas, and both are quite common. These species being a generalist or having a broader range of habitats, including its habit, may provide clues on the vulnerability to hemoparasites infection. Diverse habitat has sundry vectors, while a large population can sustain more infections. The meta-analysis of Rifkin *et al.* (2012) and the observations of Lopez *et al.* (2013) coincide with this study. **Table 2** shows the infected species and their nest type and location preferences.

Difference in the prevalence of hemoparasites between sites

This study found a higher prevalence (20% vs. 0%) of hemoparasites in free-range domestic chicken on the site along the coast than in the mountain. More species (3 vs 6) and families (2 vs 5) of avian species from Ipil than the MWS were infected in this study. This finding agrees with the study by Loiseau *et al.* (2011). In contrast, Dowling *et al.* (2001) and Gutiérrez-Lopez *et al.* (2015) found lower prevalence in coastal areas or within marine environments. Salt spray and the absence of apposite vectors were said to be the limiting factor for the infection of birds in this area. The increased prevalence of infection in the lower elevation noted in Pierce (1980) was also observed in this study. This may be due to temperature differences affecting the development and abundance of parasites. As proof, a low prevalence of avian hematozoa was expected in

Table 2. Prevalence of blood parasites, nest type, and location among infected avian species from the coastal (Ipil) and upland (MWS) areas of the Marinduque Island, MIMAROPA, Philippines.

Location	Common name	Scientific name	N	Infected	Nest type/ Location	Prevalence (%)	Blood parasites
MWS	Mangrove blue flycatcher	<i>Cyornis rufigastra</i>	1	1	Open cup/ understory	100.0	<i>Plasmodium</i> sp.
	Philippine bulbul	<i>Hypsipetes philippinus</i>	27	21	Open cup/ understory	77.7	Overall
	Yellow-vented bulbul	<i>Pycnonotus goiavier</i>		1		8.3	
Ipil	Philippine bulbul	<i>Hypsipetes philippinus</i>	1	1	Open cup/ understory	100.0	<i>Hemoproteus</i> sp.
	White-collared kingfisher	<i>Todirhamphus chloris</i>	11	1	Burrow/ ground	9.0	<i>Aegyptianella</i> sp.
	Pink-necked green pigeon	<i>Treron vernans</i>	3	1	Open platform/ understory	33.3	<i>Plasmodium</i> sp.
	Yellow-vented bulbul	<i>Pycnonotus goiavier</i>	6	1	Open cup/ understory	16.6	<i>Hemoproteus</i> sp.
	Philippine pied fantail	<i>Rhipidura nigritorquis</i>	3	1	Open cup/ understory	33.3	<i>Aegyptianella</i> sp.
	Domestic chicken	<i>Gallus gallus</i>	30	6	Open cup/ ground	20.0	<i>Aegyptianella</i> sp.

higher altitudes due to cold ambient weather (Zamora-Vilchis *et al.*, 2012), as these habitats harbor scarcer vectors (Loiseau *et al.*, 2011). High temperatures may elevate the occurrence of hematozoa in the lowland as its fuels increase in population and diffusion (Zamora-Vilchis *et al.*, 2012). Low-lying (Loiseau *et al.*, 2011) and exposed habitats (Galeotti & Sacchi, 2003) also have a high prevalence of blood parasites due to greater parasite diversity. *Plasmodium* infection was related to elevation, season, and kind of forest (van Riper III *et al.*, 1986), while *Leukocytozoon* was more prevalent with highland birds except for *Hemoproteus* (Ashford *et al.*, 1976). Accordingly, there was an increased prevalence of infection in forested habitats due to the high availability of vectors (Tella *et al.*, 1999). Meanwhile, the season was known to affect the prevalence of parasites in birds. Bennett *et al.* (1980), Young *et al.* (1993), and Sebaio *et al.* (2011) noted that birds sampled during the wet season have greater parasite prevalence than dry spells. The % prevalence of blood parasites of birds and species for MWS (23 individuals infected /63 heads captured = 36.5%, 3 species infected/12 species = 25%) and Ipil (14 individuals infected/69 overall captured = 20.28%, 5 species infected/16 species = 31.25%) revealed that there are differences between sites. More individuals were infected in MWS, but this was only confined to three species in contrast with Ipil, where lesser individuals were affected, but the blood infections were scattered across several species. However, the results of the Mann-Whitney U-test did not show any significant difference between the sites

($U=10.500$, $p=0.673$). A study showing no significant difference in hemoparasites prevalence between sites, years, and seasons from the coastal to mountain areas of Costa Rica may be found in Valkiunas *et al.* (2004). Costa Rica findings disagreed with the Hawaiian site, wherein decreased parasitemia level was observed at an altitude of 1,500 m and above while a high infection rate from the mentioned height down to 900 m (van Riper III *et al.*, 1986). Meanwhile, Deviche *et al.* (2001) noted that prevalence was host specific and not connected with foraging habits, while Menzies *et al.* (2021) support that hemoparasite infections are associated with feeding stratum and social behavior. Studies conducted by González-Olvera *et al.* (2022) found no differences in infection between the wet and dry seasons and habitat conditions.

CONCLUSIONS AND RECOMMENDATION

The results of this study suggest that habitat, nest type, and location may influence the prevalence of blood parasite infection in avian species. Birds using open-type nests close to the ground or understory were infected. Of all the species sampled in this study, the Philippine bulbul has the highest number of blood parasites infected individuals. This study also presented baseline data on the presence of blood parasites and their prevalence in the island province of Marinduque and could provide helpful information for future studies. It is recommended that additional studies and

sampling of all known bird populations, different nest types and locations, and habits on this island be made to monitor trends, diversity, and prevalence, examine host-parasite relationships and determine any threat that the island resident avian species may face other than climate change and anthropogenic pressure.

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