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Chapter 5

Seasonal variation in riverine diurnal raptors in the Área de Conservación Regional Comunal Tamshiyacu Tahuayo reserve, north-eastern Peru

5.0 Abstract

The tropics are a stronghold for diurnal raptor species, with 28% of these species being found in South America, with Neotropical raptors being a particularly understudied group. In this study we conducted a riverine survey to understand the seasonal distribution patterns of the raptors in the Área de Conservación Regional Comunal Tamshiyacu Tahuayo reserve in north-eastern Peru. In both the dry and rainy seasons, we surveyed five 4 km transects along the Tahuayo river at three different times of day (early/late morning and afternoon), while moving at 4-5 km/hr in a motor boat. A total of 928 individuals were sighted across 26 species of diurnal raptors. Seven of these species showed differences in abundance between the dry and rainy seasons. We compared the results from this study to that of a rapid assessment conducted 13 years prior, the only major bird survey conducted in the reserve, and found 9 new documented raptor species for the reserve. The differences in the findings of this study and the previous one conducted in the reserve display the value of and need for repeated long-term monitoring in areas of high biodiversity to allow a more thorough understanding of the communities found there. The results from this chapter were used to inform which raptor species present in the reserve could be potential predators of the pygmy marmoset and who's vocalisation were used in the playback experiment conducted in Chapter 6.

5.1 Introduction

The tropics are some of the most diverse ecosystems on earth, and 80% of diurnal raptor species either occur partially or wholly in tropical ecosystems (Kennedy, 1986; Bildstein *et al*., 1998). They are one of the most important regions for raptor conservation (Thiollay, 1994), for example the nine countries in the world (Peru, Venezuela, Colombia, Ecuador, Kenya, Tanzania, Sudan, Ethiopia and Uganda) that contain 70 or more diurnal raptor species are located in the tropics (Piana, 2013). It is important to understand raptor community structure and abundance due to their use as biological indicators as well as their role as keystone species in environments

(Gregory *et al*., 2004). For example, the Spotted Owl (*Strix occidentalis*) has been used as a management indicator species to evaluate the effect of old growth logging on small mammals and other organisms on lower trophic levels in the Pacific north west (Dawson *et al*., 1986). South America supports 28% of all known raptor species (Jensen *et al.*, 2005), but Neotropical raptors are a largely understudied raptor group (Piana and Marsden, 2012). Basic data on their habitat preferences and population densities are needed to understand the effects of large-scale habitat degradation and the impacts that raptors have on the rest of the ecosystem (Lloyd, 2003; Saggese, 2021). Raptors are more widely dispersed than most other groups of birds with many of their populations occurring at low densities in the landscape (Andersen, 2007). Rapid assessments and long-term monitoring, however, can be used to evaluate raptor populations.

5.1.1 Quantifying raptor species populations

To quantify the species richness of a bird community in a certain area, a rapid assessment survey can be deployed in lieu of a traditional survey (Herzog *et al*., 2002). They are often used on tropical bird communities to establish where conservation efforts should be focused, and are popular when establishing protected areas (Ruiz-Esparza *et al*., 2016). Rapid assessments are particularly useful when one has limited time, assistance and funds (Poulsen and Krabbe, 1998; Herzog *et al*., 2002). However, they are most often not comparable to other studies as they lack standardization (Herzog *et al*., 2002). Another shortcoming with these studies is the fact that they only present a short snapshot of the study area versus a true look at the species diversity in an area.

Count surveys can estimate the population size of a species in a specific area, and generate other baseline data (like diet and habitat use) for the area or a species that is understudied (Gregory *et al*., 2004). If surveys are repeated over regular intervals, the counts can track changes in bird populations as well as give insight into species seasonal distribution patterns. This is known as monitoring, where trend data can be used to set species conservation priorities (Gregory *et al.*, 2004). However, conducting detailed quantitative studies of bird communities especially in the tropics is labour intensive (Herzog *et al*., 2002), but can provide a more comprehensive look at bird community structure and distribution patterns.

5.1.2 Seasonal Patterns in Neotropical Raptors

Due to a lack of knowledge of migratory patterns in the Neotropics, it was historically assumed that the raptor migrations in this area are complex and confusing (Bildstein and Zalled, 1998). More recent research has shown the Neotropics is host to 4 complete migrants, 36 partial migrants, and 28 local migrant species of Neotropical raptors (Bildstein, 2004). Neotropical raptors, unlike many Neotropical migrants, are known to mostly migrate during the day and over well-established flyways (Bildstein, 2004). The Mesoamerican land corridor connecting North America to South America is estimated to be used by 5 million individual raptors who head south from their northern breeding ground during the boreal autumn (Piana, 2013), and migration has an important role in raptor species richness patterns in the Neotropics (Bildstein, 2004). As research on Neotropical raptor migration mainly focuses on the movement of long-distance North American breeders rather than species who both migrate and overwinter in South America, we know little of the seasonal patterns of these species (Bildstein, 2004). Changes in season also drive the use of varying habitats within the same area, this occurs particularly in the rainy season since heavy rains cause an increase in vegetation cover in different levels of the forest strata (Piana, 2015).

5.1.3 Diurnal raptors in the Área de Conservación Regional Comunal Tamshiyacu Tahuayo reserve

This study aims to determine which species of diurnal raptors are present in the Área de Conservación Regional Comunal Tamshiyacu Tahuayo reserve (ACRCTT), their relative abundance in riverine habitats and whether any species show seasonal differences in their abundance. The only previous major avian biological survey in the reserve is a rapid biological inventory conducted by the Chicago Field Museum in 2003 (Pitman *et al.*, 2003). This found 110 species of terrestrial mammals, 16 species of primates, 600 species of birds (including 27 diurnal raptor species), 240 species of fish, 77 species of amphibians, and 45 species of reptiles. Since the inventory was completed in the rainy season (March to April), however, there are no survey results documenting how the raptor community changes from the wet to dry season.

5.1.4. Neotropical primate consuming raptors: potential predators of the pygmy marmoset

Raptors are one of the major predators of Platyrrhine primates, with several species of eagle and hawk being able to effectively attack and consume primates (Ferguson-Lees *et al.*, 2001). The most notorious primate predator is the Harpy Eagle (*Harpia harpjya*), which is known to predate upon large-bodied primates from six primate genera (Barnett *et al*., 2011). Other eagles such as the Crested Eagle (*Morphnus guianensis*), Ornate Hawk-Eagle (*Spizaetus ornatus*), the Black-and-White Hawk Eagle (*Spizaetus melanoleucus*) and the Black Hawk-Eagle (*Spizaetus tyrannus*) will also predate upon adult (Adams and Williams, 2017) and juvenile large-bodied primates (Gilbert, 2000) as well as smaller primates (Greco *et al*., 2004; Barnett *et al*., 2015).

The other main aim of this study is to determine which species of diurnal raptors present in the reserve could be potential predators for the eastern pygmy marmoset (*Cebuella niveiventris*). The vocalisations of the primate eating raptors encountered in this study will be used in a subsequent experiment (Chapter 6) to test the differences in anti-predator behaviours in pygmy marmosets found in the reserve.

5.2 Methodology

5.2.1 Study site

The research was conducted in the ACRCTT reserve located in north-eastern Peru, 4°17′37″S 73°14′10″W. The reserve is one of the largest protected areas in the Amazon, covering 420,080 ha (Penn, 2009). Annual precipitation ranges from 2.4 to 3.0 meters with a yearly average temperature of 26°C (Myster, 2015). The area is located on a floodplain which undergoes annual monomodal flooding (Kvist and Nebel, 2001). The reserve encompasses a vast number of different habitats including rivers, canals, oxbow lakes, several types of lowland and upland forests including terra firme, igapo and varzea (Bodmer, 1989). It has high levels of biodiversity, having hundreds of species of mammals, birds, fish and reptiles (Pitman *et al*., 2003). It is known for the high levels of primate species found there as well as being an important flyway for migratory birds (Puertas and Bodmer, 1993), and the reserve officially became a conservation protected area in 1991 (Newing and Bodmer, 2003). Within the reserve, hunting is permitted for subsistence only and is strictly regulated. There is only one man-made structure inside the reserve boundaries; a research centre operated by the tour company, Amazonia Expeditions. Both tourists and scientists visit the research centre and are allowed into the reserve. Amazonia Expeditions has another accommodation site (the main lodge) based outside of the reserve limits, where the majority of tourists stay.

5.2.2 Raptor Survey Methodology

Raptor species were surveyed on 4km riverine transects, three inside of the reserve boundary and two outside (Figure 5.1). These transects were surveyed in both the dry (August-September 2019) and rainy season (May-June 2020). In each season, each transect was surveyed twelve times; four times at three different times of day (early morning from 06:00 in the morning, late morning from 09:00 and in the afternoon from 15:00) to account for differences in activity patterns.

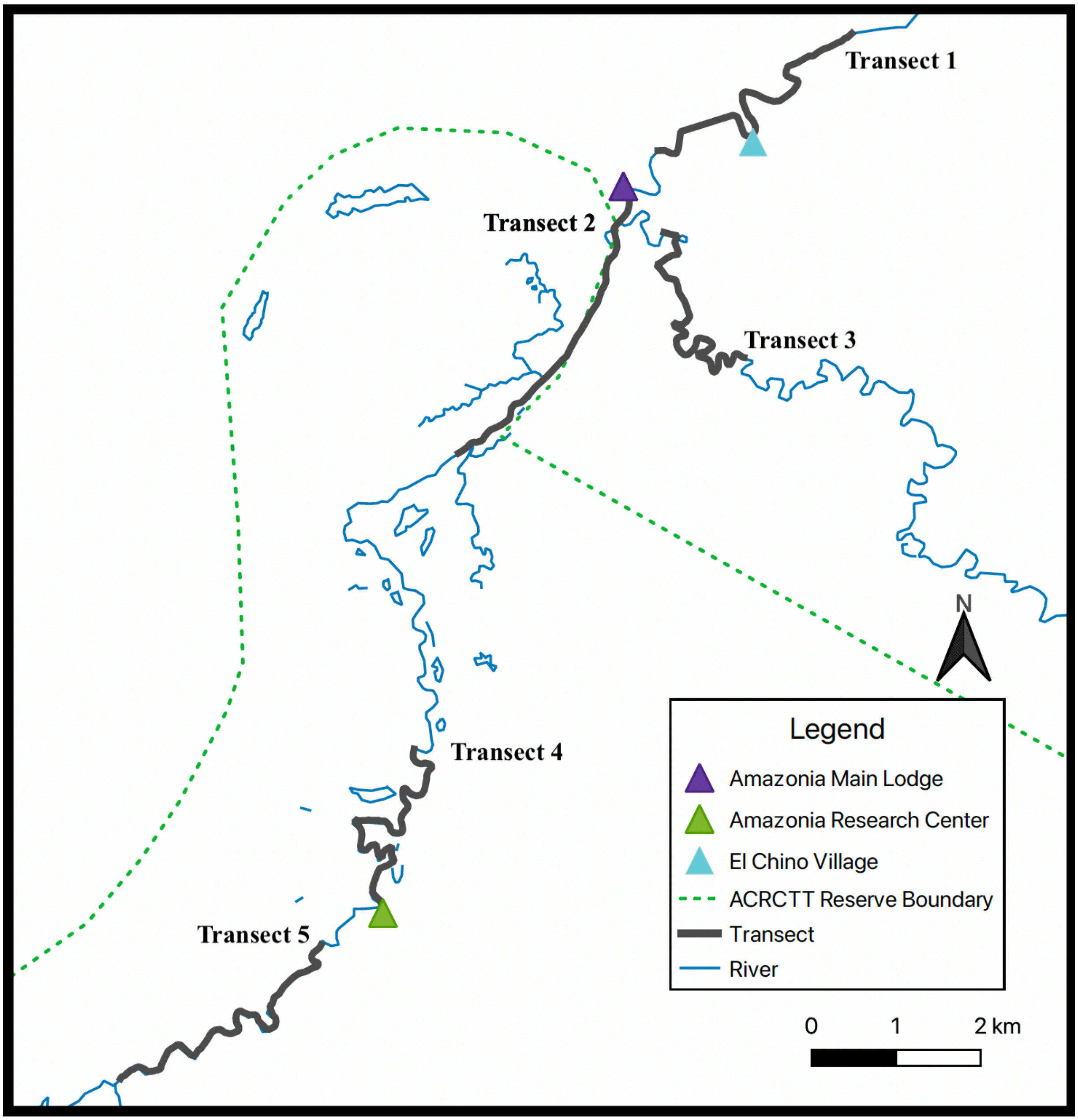

Figure 5.1 A map of the transect locations at the study site including the reserve boundary line.

The surveys were conducted from a small motor boat moving at around 4-5 km/hr. Every time a raptor was seen the following were noted: time, weather, species, and distance from the transect (the middle of the river). The *Field guide to the birds of Peru* (Schulenberg et al., 2007) was used an identification guide. In cases where identification in the field was uncertain (n=7) a photograph was taken (when possible) using a Canon 5D mark ii with a Tamron SP 150-600mm F/5-6.3 Di VC USD G2 lens and later identified through comparison with the field guide. Some vultures were not identified to the species level as they were flying too high or too far away to identify the species.

5.2.3 Statistical Analysis

Only species seen 6 or more times (14 species, Figure 5.2) were included in the analysis so that the assumptions of the chi-squared test were not violated. The statistical program RStudio version 1.1.456 (R Core Team, 2020) was used to run a Pearson's Chi-squared test to see if there were seasonal differences in the number of individuals seen for these 14 species. Another Pearson's Chi-squared test was used to investigate species differences in number of individuals seen at the three times of day. Posthoc tests were conducted with the chisq.posthoc.test package (Ebbert, 2019) with Bonferroni corrections.

5.3 Results

A total of 928 individual sightings (392 in the rainy season and 536 in the dry season) across 26 species of diurnal raptors (24 species in the rainy season and 17 in the dry season) were detected on the five transects (Table 5.1). Transect 1 was where the most species (18) and total individuals were seen (287). On transects 2 and 4 we saw the fewest species, encountering only 15 on transect 2 and 14 on transect 4. On transect 4 we encountered the fewest total individuals (140). In the early morning (across all transects and seasons) we saw 295 individuals and 21 species, late morning we encountered 348 individuals and 19 species and, in the afternoon, we encountered 285 individuals and 21 species. The five most abundant species across both seasons were the Black-Collared Hawk, Turkey Vulture, Black Vulture, the Yellow-Headed Caracara and Slate-Coloured Hawk (Table 5.1).

Table 5.1 Inventory of all species of diurnal raptor seen in the survey along with their IUCN listing, breakdown of sightings across seasons (Rainy: May-June 2020 and Dry: August-September 2019) and if they were encountered in the rapid survey conducted by the Chicago Field Museum.

Order	Family	Common Name	Species Name	IUCN Listing	Trend	Rainy	Dry	Total Seen	Seen in Chicago Field Museum rapid survey
Accipitriformes	Accipitridae	Bicoloured Hawk	*Accipiter bicolor*	Least Concern	Decreasing	3	0	3	No
		Black-Collared Hawk	*Busarellus nigricollis*	Least Concern	Decreasing	111	51	162	No
		Broad-winged Hawk	*Buteo platypterus*	Least Concern	Increasing	2	0	2	No
		Crane Hawk	*Geranospiza caerulescens*	Least Concern	Decreasing	1	2	3	Yes
		Gray-Headed Kite	*Leptodon cayanensis*	Least Concern	Decreasing	1	15	16	No
		Great Black Hawk	*Buteogallus urubitinga*	Least Concern	Stable	7	31	38	Yes
		Harpy Eagle	*Harpia harpyja*	Near Threatened	Decreasing	0	1	1	No
		Hooked-Billed Kite	*Chondrohierax uncinatus*	Least Concern	Decreasing	2	0	2	No
		Ornate Hawk Eagle	*Spizaetus ornatus*	Near Threatened	Decreasing	2	0	2	Yes
		Plumbeous Kite	*Ictinia plumbea*	Least Concern	Decreasing	15	19	34	Yes
		Roadside Hawk	*Buteo magnirostris*	Least Concern	Increasing	4	10	14	Yes
		Short-tailed Hawk	*Buteo brachyurus*	Least Concern	Stable	3	0	3	Yes
		Slate-Coloured Hawk	*Leucopternis schistaceus*	Least Concern	Decreasing	65	64	129	Yes
		Snail Kite	*Rostrhamus sociabilis*	Least Concern	Increasing	1	0	1	No
		Swallow-Tailed Kite	*Elanoides forficatus*	Least Concern	Increasing	1	10	11	Yes
		Zone-tailed hawk	*Buteo albonotatus*	Least Concern	Stable	1	0	1	No

	Cathartidae	Black Vulture	*Coragyps atratus*	Least Concern	Increasing	34	99	133	Yes
		Greater Yellow-Headed Vulture	*Cathartes melambrotus*	Least Concern	Decreasing	0	22	22	Yes
		King Vulture	*Sarcoramphus papa*	Least Concern	Decreasing	1	4	5	Yes
		Lesser Yellow-Headed Vulture	*Cathartes burrovianus*	Least Concern	Stable	8	37	45	No
		Turkey Vulture	*Cathartes aura*	Least Concern	Stable	34	119	153	Yes
	Pandionidae	Osprey	*Pandion haliaetus*	Least Concern	Increasing	9	0	9	Yes
Falconiformes	Falconidae	Bat Falcon	*Falco rufigularis*	Least Concern	Decreasing	1	1	2	Yes
		Laughing Falcon	*Herpetotheres cachinnans*	Least Concern	Decreasing	3	0	3	Yes
		Black Caracara	*Daptrius ater*	Least Concern	Stable	6	8	14	Yes
		Yellow-Headed Caracara	*Milvago chimachima*	Least Concern	Increasing	77	43	120	Yes

Seasonal Patterns

The Pearson's Chi-squared test showed that different species showed significantly different distributions between the two seasons ($X^2 = 176.92$, df=13, $p < 0.001$, N= 900 individual sightings; Figure 5.2). The posthoc tests showed that the Black-Collared Hawk ($p < 0.001$), Osprey ($p < 0.01$) and Yellow-Headed Caracara ($p < 0.001$) were seen more often in the wet season, whereas the Greater Yellow-Headed Vulture ($p < 0.01$), Black Vulture ($p < 0.01$), Lesser Yellow-Headed Vulture ($p < 0.05$) and Turkey Vulture ($p < 0.001$) were seen more often in the dry season. All other species showed no significant seasonal differences.

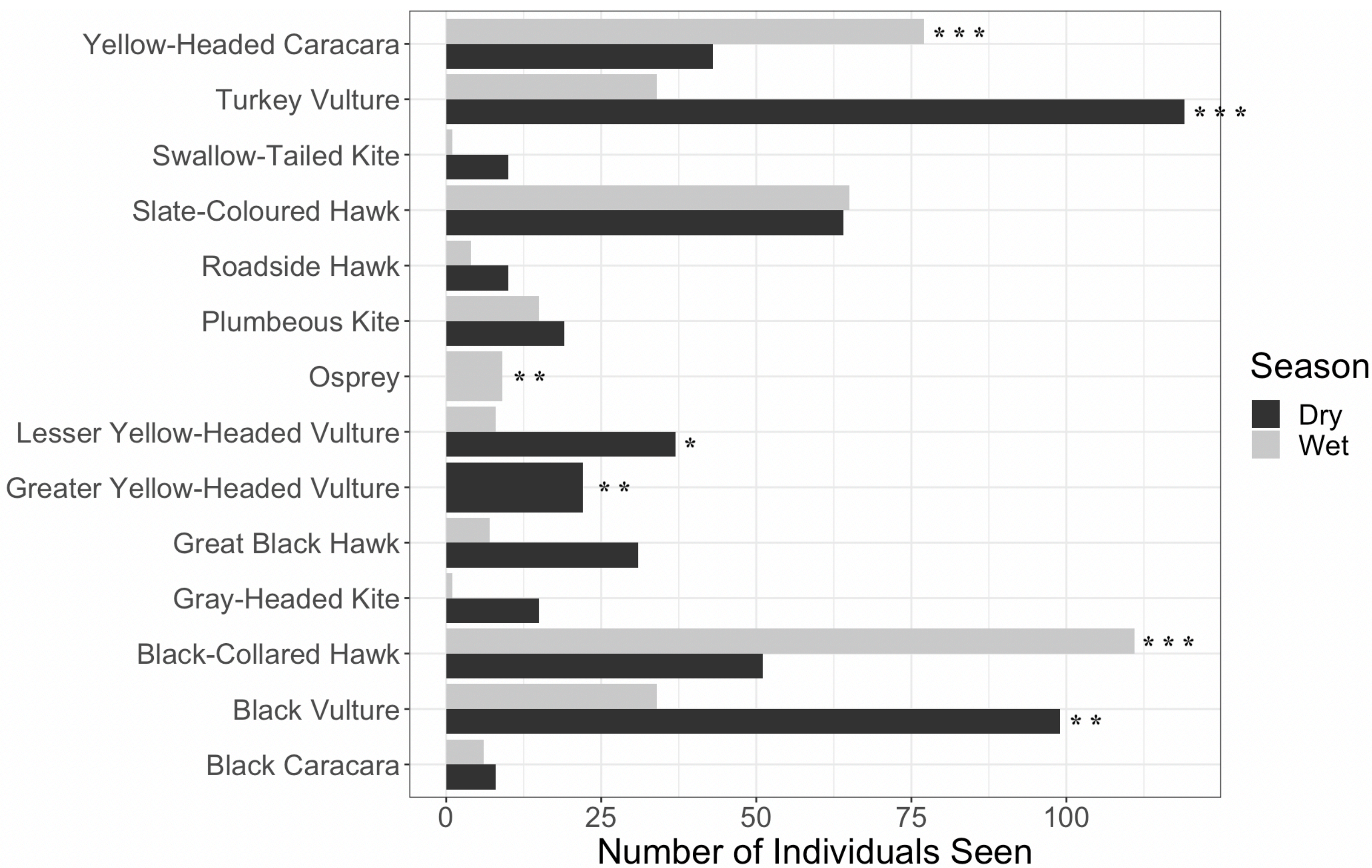

Figure 5.2 The fourteen-bird species seen at least 6 times during the survey, with the number of individuals seen in both seasons. Species where post-hoc tests indicate seasonal differences in sightings are marked with *** for a significant difference at the $p < 0.001$ level, ** for a significant difference at the $p < 0.01$ level and * for a significant difference at the $p < 0.05$ level.

Time of Day

The results from the Pearson's Chi-squared test found that different species showed significantly different distributions between the time of day they were encountered (X^2= 92.625, df=26, $p < 0.001$, N=900 individual sightings; Figure 5.3). Specifically, posthoc tests showed Black Vultures were encountered significantly more in the late morning ($p < 0.001$) as were the Greater Yellow-Headed Vulture ($p< 0.05$). The Slate-Coloured Hawk was encountered significantly more in the early morning ($p < 0.001$). All other species showed no significant differences based on the time of day.

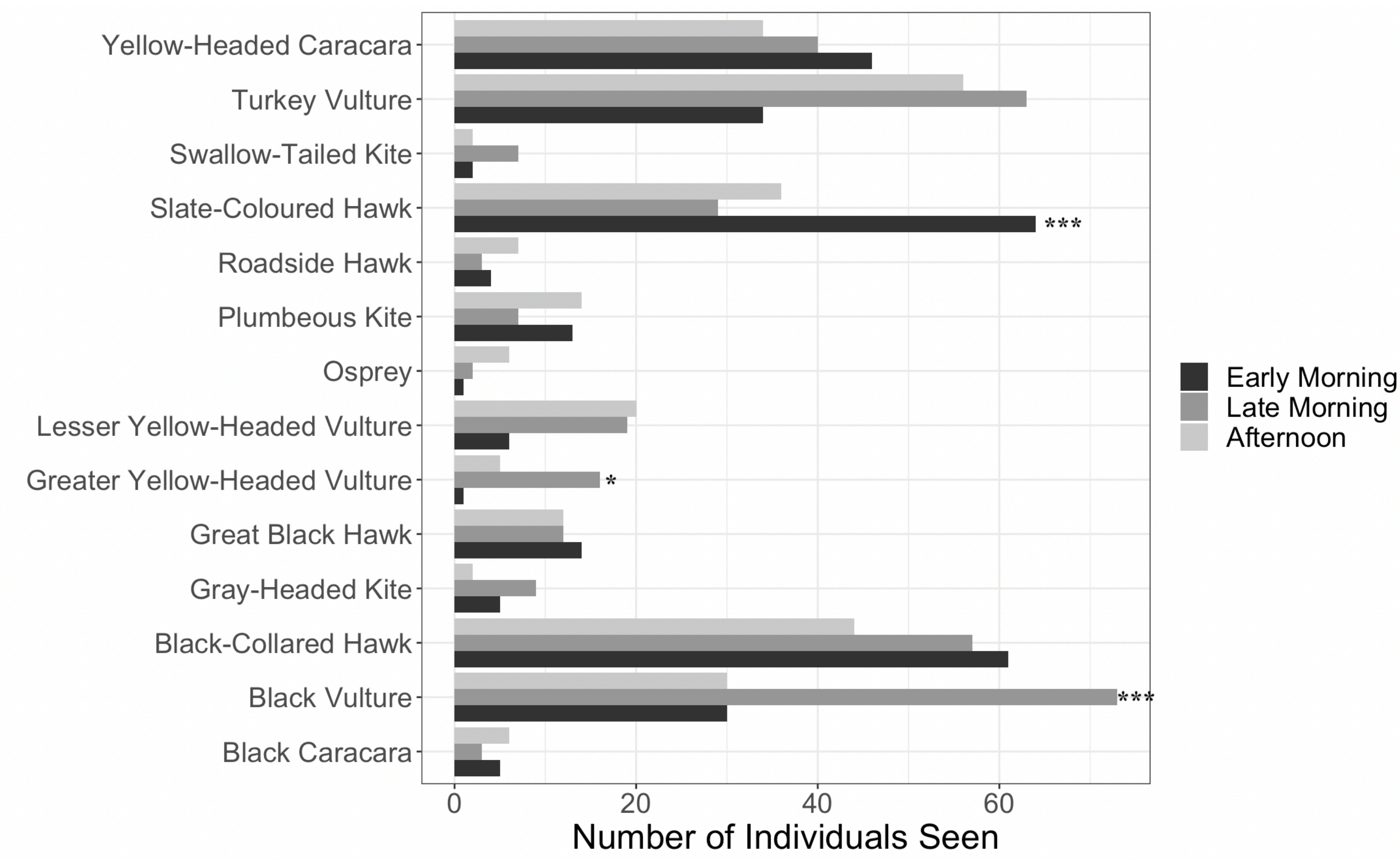

Figure 5.3 The fourteen-bird species seen at least 6 times during the survey, with the number of individuals seen across the three times of day. Species where post-hoc tests indicate differences in sightings across time are marked with *** for a significant difference at the $p < 0.001$ level, and * for a significant difference at the $p < 0.05$ level.

5.4 Discussion

5.4.1 General Findings

This survey found nine new documented raptor species for this area. All ten of these species (Table 5.1) were expected as the ACRCTT reserve lies in their expected ranges according to Schulenberg *et al*. (2007). Some of these species were encountered only a handful of times, suggesting they may be harder to encounter than other species and so it is not surprising they were not counted in previous surveys. The differences in individuals of the different species encountered during the different times of day was not surprising as different species of bird are more active during different times of day.

5.4.2 Seasonal Patterns

5.4.2.1 Species with expected seasonal patterns

Of the 14 species included in the analysis, six (Swallow-Tailed Kite, Slate-Coloured Hawk, Roadside Hawk, Great Black Hawk, Gray-Headed Kite and the Black Caracara) showed no significant seasonal variation, 3 of which were expected as they are year-round residents (Slate-Coloured Hawk, Gray-Headed Kite, Black Caracara; Bildstein, 2004). With the Great Black Hawk and the Roadside Hawk being classified as irregular migrants but both are listed as mostly permanent residence in Loreto, Peru (Bildstein, 2004; Schulenberg *et* al., 2007). Another expected result was the seasonal differences for the two complete migrant species; the Osprey and the Broad-Winged Hawk (which were not included in the analysis). Both are known to overwinter in the region (June-August) and travel within and out of the Neotropics during the austral summer (October- May) (Zalles and Bildstein, 2000). Even though both the Swallow-tailed Kite and Black Vultures are both partial migrants (Bildstein, 2004) in this area of Peru they are permanent residences (Schulenberg *et al*., 2007).

The Greater Yellow-Headed Vulture and the Lesser Yellow-Headed Vulture are irregular/local migrants and the Turkey Vulture is a partial migrant (Bildstein, 2004) so this could account for them having higher encounter rates in the dry season. However, according to Schulenberg *et al.* (2007) all these species are permanent residents in the Loreto region of Peru. The North American breeding populations of the Turkey vulture (*Cathartes aura meridionalis*) is the most numerous partial migrants found in the Neotropics (Bildstein, 2004). The Black Vulture and the

Greater and Lesser Yellow-Headed Vultures may have been seen more often in the dry season as the water level drops so there is more land on the river banks to perch and they have more opportunity find carrion (Robinson, 1994). This difference is more likely due to changes in habitat use across seasons as these vultures use open areas by forest clearings which becomes more prevalent as the water level drops in the dry season (Schulenberg et al., 2007).

5.4.2.2 Species with unexpected seasonal patterns

The Black-Collared Hawk was seen more than twice as often during the rainy season, which was unexpected since they are classified as irregular migrants (Bildstein, 2004). They are considered permanent residents in this area of Peru (Schulenberg et al., 2007) in their range. This result could indicate seasonal differences in habitat use in their residential area. A shift in their foraging behaviour could be the reason for this, since during the rainy season, land is flooded and could restrict their diet to focus more on fish and less on reptiles and amphibians (Robinson, 1994). It could also be that during the dry season (overlapping with austral winter) they are in a migrant-resident competition for resources with the migratory Osprey, causing them to shift foraging habits and therefore are found less often on the river (Bildstein, 2004).

We had expected to see a significant difference in the number of Plumbeous Kites (*Ictinia plumbea*) since they are austral migrants who breed in the southern cone area of South America and migrate north towards the equator in austral winter (June-August) (Bildstein, 2004). They do occur in Peru year-round even though they are partially migratory so boreal, astral and both types of migrants are also arriving in Peru along with the year-round residents (Schulenberg et al., 2007). Although there were fewer Plumbeous Kites seen in the wet season, this was not a significant difference so it could be that this area is mostly comprised of year-round residents rather than migrants.

Although we observed a seasonal pattern for the Yellow-headed Caracara, this was in the opposite direction compared to what was expected; they are partial migrants who travel to the area during the dry season (Jensen, 2003) but we observed significantly more in the rainy season. However, the numbers seen suggest they may be permanent residents in the area (Schulenberg et al., 2007). One explanation for this significant seasonal difference could be that, in the rainy season the reptiles, amphibians and insects, which make up a bulk of their diet (Mora and González, 2019), are driven higher up in the canopy and therefore are made easier prey during this time of year. This would mean the raptors are more visible from the river during the surveys as they hunt in the visible tree line.

5.4.3 Comparisons with to the Chicago Field Museum rapid survey

The Chicago Field Museum rapid survey was completed in the rainy season (March to April) and focused on all bird species present across the reserve (Pitman *et al*., 2003). Their surveys were conducted along temporary trail systems and their transects focused on a wide variety of habitat types from terra firme forests to oxbow lakes. The basic experimental differences (sites surveyed, time span, season sampled, and purpose) between the survey they completed and the one reported on in this study will account for the vast majority of the differences in species of raptor encountered in both.

5.4.3.1 Accipitridae and Pandionidae

This study found 16 species of Accipitridae and 1 species of Pandionidae, 8 of which were also encountered in the Chicago Field Museum rapid survey which found 13 species of Accipitridae and 1 species of Pandionidae (Table 5.1). This survey found 8 new documented species of Accipitridae for the reserve including; the Black-Collared Hawk, the Gray-Headed Kite, the Bicoloured Hawk, the Broad-winged Hawk, the Harpy Eagle, the Zone-tailed Hawk, the Hook-billed Kite and the Snail kite. It is not strange that the rapid survey did not encounter the Harpy Eagle as they are rare same with the Snail Kite, the Bicoloured Hawk and the Zone-tailed Hawk. The Broad-Winged Hawk is a boreal migrant and encountered most frequently from October to March so it is interesting they did not encounter it as they surveyed in March, however, it is still listed as uncommon to encounter (Schulenberg et al., 2007). The Hook-billed Kite was only spotted twice in the rainy season survey (May-June 2020) so it is not surprising that they did not find this species in their rapid survey methodology. It is surprising they did not encounter the Black-Collared Hawk and the Gray-Headed Kite as they were frequently spotted in this survey. An explanation for why they did not encounter the Gray-Headed Kite is that it might change its foraging behaviour in the two seasons as we only spotted it once during the wet season (when the rapid survey was conducted) and 15 times in the dry season. It is however very strange they did not encounter any Black-Collared Hawks as we found 111 in the rainy season. The rapid survey had 5 species which were not encountered during this survey; Double-Toothed Kite (*Harpagus bidentatus*), Tiny Hawk (*Accipiter superciliosus*), White-Browed Hawk (*Leucopternis kuhli*), Black Hawk Eagle (*Spizaetus tyrannus*) and the Crested Eagle (*Morphnus guianensis*). Not seeing the two species of eagle is not surprising as both are notoriously rare in the area (Pitman *et al*., 2003), much like the Harpy Eagle (Schulenberg et al., 2007). Likewise, the Double-Toothed Kite and the Tiny Hawk are forest dwelling raptors so it is not surprising these were not encountered during our riverine transects (Schulenberg et al., 2007). The Chicago Field Museum had transects across all habitat types and the above species were noted to be either rare when encountered or as simply present (abundance status unclear) (Pitman *et al*., 2003).

5.4.3.2 Cathartidae

For the Cathartidae family this survey found 5 species, 4 of which were encountered in the Chicago field museum inventory, with Lesser Yellow-Headed Vulture not being found in their survey. It is strange that they did not encounter this species, since it was seen in both the wet and dry seasons in our survey. However, it was observed more often in the dry season and their survey was completed in the wet season.

5.4.3.3 Falconidae

This survey encountered 4 species of Falconidae where the Chicago field museum inventory for saw 9 species. They noted that they saw the Red-Throated Caracara (*Ibycter americanus*), Peregrine Falcon (*Falco peregrinus*), Barred Forest Falcon (*Micrastur ruficollis*), Lined Forest Falcon (*Micrastur gilvicollis*), and the Slaty-Backed Forest Falcon (*Micrastur mirandollei*). It is not surprising that we did not see these five falconidae as they are all forest dwelling species (Schulenberg et al., 2007).

<u>5.4.4 Potential predators of the pygmy marmoset in the survey</u>

Quite a few of the species encountered in this survey are known to eat primates as a part of their diet. This includes the Ornate Hawk Eagle, the Harpy Eagle, the Great Black Hawk, the Roadside Hawk, the Slate-Coloured Hawk, the Bicoloured Hawk, and the Grey-Headed Kite (Mcgraw and Berger, 2013).

Using this knowledge, the vocalisations of four of the above species (who consume primates) will be used in a preliminary study conducted with one group of marmosets to discern which two species will be used as the predation stimuli in the final experiment in Chapter 6. They will be chosen by which calls garner the most drastic reaction from the marmosets.

5.4.5 Final Thoughts

This first comprehensive seasonal survey in the ACRCTT reserve has added to our knowledge of the riverine diurnal raptor species in the area. This survey generated some unexpected results, which further highlights the lack of knowledge on these species and generates multiple further questions which could be addressed in a more extensive study. As there is only one prior study on diurnal raptors in the reserve, there is little published knowledge of the area from which to eliminate or support some of the hypothesised reasons for these unexpected results. There were unexpected seasonal differences for a few abundant species like the Black-Collared Hawk which, with further research, could lead to interesting insights in seasonal behavioural shifts in habitat use of Amazonian raptors. A more thorough investigation into the reserve would be crucial in understanding the raptor community in the area, especially expanding the surveys into other habitat types away from rivers. Another major gap is our understanding of nocturnal raptor species in the region, which have never been the focus of an avian survey in this area. The differences in the findings of this study, and the only other prior study on diurnal raptors in the reserve demonstrate the value of repeated monitoring in highly biodiverse areas such as ACRCTT reserve, to better understand avian communities and other species groups to better conserve these biodiversity hotspots.

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