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WINTER AND SUMMER BIRD COMMUNITIES OF TWIN CAYS, BELIZE

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ABSTRACT

Avian species richness and abundance were studied in order to characterize the bird fauna of Twin Cays, Belize. Auditory and visual surveys were conducted for both migratory and resident species during winter and summer seasons. The Mangrove Yellow Warbler was the most common bird species on the islands in both seasons, with an estimated mean density of 13.4 birds/ha during the winter and 10.9 birds/ha in the summer. The importance of mangrove habitats to a diversity of migratory passerines and resident breeding birds along the Mesoamerican Barrier Reef is supported with 56 species of 20 families recorded from the islands.

INTRODUCTION

Few quantitative surveys of avian species have been conducted in mangrove forests in Central America. This may be due to the tangled maze of prop roots and boles that make moving through the mangrove extremely difficult and inhospitable. Mangroves are also perceived as not having sufficient bird species to warrant such a study. For example, current literature suggests that Central American mangroves are underutilized by migrant birds when compared to similar habitat outside of Central America (Petit et al., 1993). Nevertheless, mangroves have been found to be vital for some species' winter survival. Petit et al. (1995) found that in Panama, Northern Waterthrushes and Prothonotary Warblers were dependent on mangroves for their survival. Arendt (1992) reported that coastal mangroves on Caribbean islands were used by more than 50% of the migratory birds for at least a portion of their winter residence or as stopovers during migration. On some Caribbean islands, mangroves had greater densities of Northern Waterthrushes, Magnolia Warblers, American Redstarts and Yellow-bellied sapsuckers than any other habitat (Wunderle and Waide, 1993). Our primary research objectives were to document avian species structure (diversity, distribution, relative density), and trophic level complexity within the mangrove at Twin Cays during the winter and summer seasons, and to compare the avifauna between these two seasons. In this paper, we describe the avian species richness and relative abundance on Twin Cays, a small archipelago off the coast of Belize, during winter and summer 2004. Attempts to estimate density of all avian populations was not possible due to the small sample size for

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some species and bird movement between Twin Cays and the nearby cays. However, density measurements were estimated for the three most common winter species, Mangrove Yellow Warbler, Northern Waterthrush, and the Clapper Rail; and the two most common summer species, Mangrove Yellow Warbler and Green Heron.

STUDY AREA AND METHODS

We studied species richness, relative abundance, and trophic organization of migrant and resident birds in a mangrove habitat for 2 wk during January 1-14, 2004 and for 1 wk during July 8-15, 2004. The field research was undertaken at Twin Cays located about 20 km SE of Dangriga, Belize. Twin Cays is an archipelago of small peat-based mangrove islands encompassing approximately 72 ha of which 5 to 10 ha are shallow ponds whose sizes vary depending on the seasonal rainfall and inundation of salt water from the surrounding sea (Rodriguez and Feller, 2004). The vegetation characteristics of the study site, while superficially fitting the description of zonation patterns in mangrove forests elsewhere in the Caribbean (Davis, 1940; Thom, 1967; Ball, 1980), were highly mosaic. The vegetation on the two largest islands is dominated by a fringing forest of *Rhizophora mangle* (red mangrove), 4 – 6 m tall, along the water with stands of dwarf *R. mangle* trees, <1.5 m tall, *Avicennia germinans* (black mangrove) and *Laguncularia racemosa* (white mangrove) in mixed stands in the interior of the islands. In some areas, *Batis maritima* (saltwort) occurs in dense patches in the undergrowth. Other habitats include mud flats, moribund or dieback areas, and human-disturbed areas, including several clearcut stands with brush piles and two small garbage dumps. All of these habitats contribute significantly to the perceived avian "diversity" of Twin Cays. For more detailed descriptions of the vegetation of Twin Cays, see Woodroffe (1995) and Rodriguez and Feller (2004).

To inventory the birds in the mangrove on Twin Cays during the winter, we used auditory and visual encounter surveys of point counts, line transects, boat survey techniques, and opportunistic observations (Bibby et al., 2000). The same techniques, with the exception of line transects, were used during the summer session. All counts were conducted by Stephen Mitten who is familiar with the calls, songs, and plumage of the birds of Belize.

To assess numbers and kinds of water birds like Cormorants, Magnificent Frigatebirds and Brown Pelicans along the shoreline and overhead, a boat survey (following Bibby et al., 2000) was employed where a small motorboat 20-30 m out from shore, moved along the shoreline. All birds seen or heard between the boat and as far inland as possible were tallied until the shorelines of East Island and West Island were covered. Double counting of birds was minimized by maintaining a constant boat pace and observing where the birds landed so as not to count them again.

We also conducted 75 6-min, 100-m fixed-radius point counts in the winter and 62 6-min, 100-m fixed radius point counts in the summer to obtain distance sampling data (Buckland et al., 2001). Counts started at 7:00 AM and were completed by 11:30 AM. Points were located within 52 (100 m²) plots that were randomly arrayed over East Island and West Island. During both field seasons, each plot was sampled at least once; some were sampled twice, but not in the same spot within the plot. Due to the

randomness of the point location, the habitat in which the count was taken was recorded. For example, some counts were in mudflats while others were in the fringe forest. Adjacent plots were not counted on the same day. All birds seen or heard within the 100-m² plots were counted. Distances were measured to all visible birds by a Bushnell laser range-finder accurate to ± 1 m beyond 10 m out. All birds closer than 10 m were recorded as 5 m. Most detections were visual. Where detection was aural, we made the laser measurements to the most likely spot. Detections without a reliable distance measurement were discarded. No point counts were conducted during inclement or extremely windy weather. At the four-minute mark, “pishing” was undertaken for 30 s to raise any nearby birds. Species, number, and distance were recorded.

During the winter, we conducted only eight 150 m-line transects due to time constraints. Transects were kept to preexisting survey lines along ponds and mudflats, and forest edges. The habitats varied among the line transects. All birds seen and heard within 100 m on either side of the transect were counted, and distances were measured to all birds perpendicular to the line with the laser range-finder.

Effort was similar within census techniques, but varied between techniques and between seasons. For example, 9% more point counts were completed in the winter than in the summer, and no transects were carried out during the summer because of time constraint. Point counts received the majority of our field time. Opportunistic observations of birds seen outside of point counts, line transects, and boat surveys were noted, and individuals were counted. The results of these surveys within the mangrove also permitted estimation of species richness and relative abundance indices. Density measurements were obtained for the four most common species observed during point counts. Trophic level was determined from the literature.

Seasonal status of each species was based on Jones and Vallely (2001). In some cases, little information is available for the seasonal status of birds at Twin Cays. Thus, question marks in the appendices indicate a lack of knowledge. The seasonal status includes: (1) P=permanent resident (breeding either documented or assumed); (2) S=seasonal resident only (breeding documented or assumed); (3) V=visitor (nonmigratory that do not breed in area); (4) T=transient (migratory bird that neither breeds nor spends the winter in area); (5) W=winter resident (migratory bird that stays the winter).

We calculated the rarefaction curves for point count and transect census methods for the winter using EcoSim version 7.0, a Monte Carlo simulation technique (Gotelli and Entsminger, 2001). For point-count analyses, the mean number of detections of birds per point at each plot was calculated. The relative abundance (pcRA) value of a given species was expressed as the number of individuals observed per point count. Frequency (pcFR) was equal to the percentage of point counts the birds were observed considering the whole sample. The relative abundance (tRA) of a species encountered by the transect method was expressed as the number of individuals observed per 150 m-line transect, and the frequency (tFR) was determined as the number of transects in which a given species was encountered considering the total number of line transects. We used SPSS 10.0 one-way ANOVA followed by a Tukey *post hoc* tests to examine the relationship between the most numerous species observed by point counts.

Rough density estimates for the three most common winter-bird species and the two most common summer species observed by point counts were obtained using Distance 4.1 Release 2 software (Thomas et al., 2003). Distance 4.1 sampling key

function models (half-normal and hazard-rate with series expansion adjustments) were based on best fit estimators with minimum Akaike Information Criteria (AIC) and/or Delta AIC (AICc). Because of the small sample size, stratification of the data as to the type of habitat where the point count occurred was not implemented. Ideally, this would have been done. For example, Green Herons were more easily detected in the dwarf *R. mangle* stands than in the taller *R. mangle* fringe; thus, the encounter rate would be higher. However, for our purpose, it was presumed to be the same across all habitat strata. This, of course, is not true and causes some bias. Distance data were transformed into 11 intervals of 10 m each. Observational distance measurements were truncated in the field at 110 m and, in the case of the Mangrove Yellow Warbler, further truncated to 10% of the largest observation for analysis to exclude outliers. Nonclustered parameters were chosen with each model although there may have been some possible clustering with the Mangrove Yellow Warbler.

Bird species were identified to 11 feeding guilds based on diet and mode of feeding adapted from classification schemes by Verner (1984) and Thiollay (1994). These guilds are (1) F = species that feed on fish and some invertebrates; (2) P = pirate food from other species or scavenge; (3) F+REP+INV = species that feed on fish, small reptiles and invertebrates; (4) INV+VEG = species that feed primarily on small invertebrates and aquatic vegetative matter; (5) INV = species that feed primarily on small aquatic insects and invertebrates; (6) NEC = nectarivores; (7) R = raptors (carnivores); (8) FRU = frugivores (species that feeds on fruits and buds all year); (9) OMN = omnivores; (10) INS = insectivores; (11) INS+FRU = insectivores-frugivores (species that feed primarily on insects but will take fruit at certain times). Birds were also categorized according to seven habitat categories within Twin Cays. These categories were adapted and modified from schemes of Naka (2004). They are: (1) AIR = overhead; (2) AQU = aquatic; (3) AQUE = aquatic edge; (4) AQUF = aquatic fields (mud flats, wet sandy beaches and marshy fields); (5) C = canopy; (6) U = lower strata (understory and midstory); (7) A = found anywhere within the understory and canopy. Both feeding guilds and habitat categories were based on observations by Mitten during >120 h of behavioral observations in the field, and on the literature (Howell and Webb, 2001).

RESULTS

Species Richness and Composition

We recorded 56 avian species of 20 families on Twin Cays, Belize during the winter and summer of 2004 (Appendices 1 and 2; scientific names provided therein). Of these, 23 species or ~41% of the total, were seen exclusively during the winter while 12 species (21.4%) were found exclusively during the summer. Bird species found during both seasons constituted 38% of the total. A breakdown of the results from the winter and summer seasons follows.

1) Winter: Forty-four bird species of 20 families were recorded during the winter survey. Of these, three families comprised 45% of all species recorded (Ardeidae, Parulidae and Scolopacidae). The families Parulidae and Scolopacidae had the highest number of species (seven species each). With the exception of the Mangrove Yellow

Warbler, all species within these two families were winter migrants. By a small margin (54.5% to 45.5%, respectively), the number of migratory species (winter and transients) was greater than nonmigratory species, i.e. permanent residents, visitors that do not breed in the area, and seasonal species (breeding only). The family Ardeidae had the greatest number of permanent species represented with six. Most permanent residents were aquatic or semiaquatic species such as Brown Pelicans and members of the Family Ardeidae (see Appendix 2.). Based on male plumage, the Mangrove Yellow Warbler (*Dendroica petechi*) had both northern migrants (*Dendroica petechi petechi*) (~10 %) and resident populations (*Dendroica petechi erithachorides*) (~90%) represented on Twin Cays. More species were counted by point counts (24 species) than by the other methods, 20 by line transect, 14 by boat, and 12 species were incidentally observed outside of sampling protocol (see Appendix 1 and Fig.1).

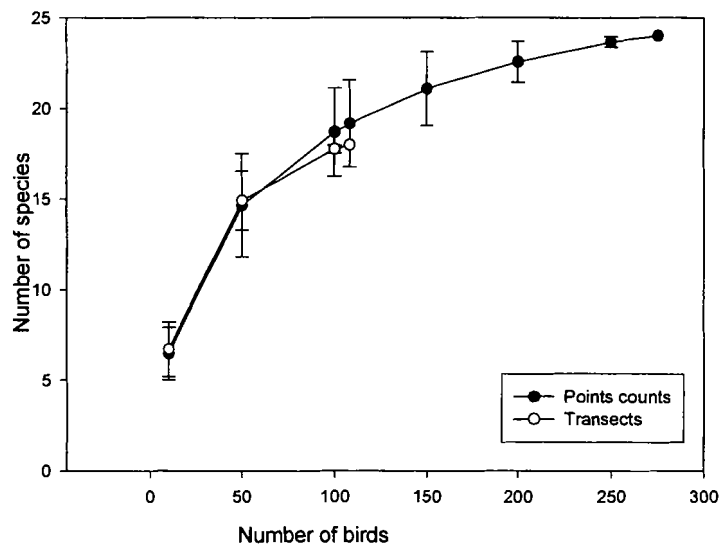


Figure 1. Species rarefaction curves in Twin Cays mangroves based on point counts and transects (Winter 2004).

Brown Pelicans, Magnificent Frigatebirds and Double-Crested Cormorants were excluded from point counts or line transects because they were seen but were either well outside the 100 m range or continually flying back and forth over the mangrove canopy. A nesting pair of ospreys was also excluded from line transect or point count data, so sampling method did not bias the data. Six species were recorded by only point counts, four by only line transects and excluding the four aforementioned species, one species was seen only by boat (Belted Kingfisher). Most species were seen by more than one method and 16 species were recorded by both point-counts and line-transect methods (Appendix 1). Accumulative species curves (i.e., rarefaction curves based on Monte Carlo simulations) revealed that the rate at which new bird species were being added had reached an asymptote with point counts but was still rising with line transects (Fig. 1). This is not surprising given the small number of line-transect samples (eight) and, with more effort, line transects may add number of species.

2) Summer: Thirty-three species of 17 families were recorded during the summer survey of Twin Cays (see Appendix 1). Two families comprised 33% of all species recorded (Ardeidae, and Parulidae; seven species and four species, respectively). All seven species of the family Ardeidae that were seen during the winter were observed during the summer, including the Little Blue Heron, which Valley and Jones (2001) list as a winter resident. Three of the four warblers were winter migrants that presumably never returned north. Permanent residents accounted for nearly 50%, and winter Neotropical migrants that never returned north made up ~18% of species observed. Seasonal residents (three are known for certain; White-Crowned Pigeon, Wilson's Plover and Brown-Crested Flycatcher) made up 9% of the total summer species composition. Hummingbird nests have been found previously on Twin Cays (Feller, personal observation), but it is not known which of the two summer hummingbird species breeds on the cays. They were not observed breeding in this survey, and thus were not included as seasonal breeders in data presented here. Ten species were counted during the boat survey, 19 by point counts, and 10 were incidentally seen outside of sampling protocol. Brown Pelicans, Magnificent Frigatebirds, and Double-Crested Cormorants were again excluded from the analysis but were nevertheless seen during point counts.

Species Abundance

Most species were encountered in low numbers in both seasons (Appendix 1). During the winter, four of the top five species that had high pcRA values were also the top four most frequently (high pcFR value) encountered species (i.e., Mangrove Yellow Warbler, Great-Tailed Grackle, Clapper Rail, and Northern Waterthrush; Plate 1). These same four species were also found in the top five highest tRA (Table 1, Appendix 1).

Table 1. Mean number of individuals per point count of the most common bird species at Twin Cays in winter and summer. Values are means \pm 1 SD (number of birds seen in all point counts).

Bird species	Winter	Summer
Mangrove Yellow Warbler	1.7 \pm 1.1 (67)	1.7 \pm 0.9 (79)
Great-Tailed Grackle	1.2 \pm 0.4 (29)	2.0 \pm 2.0 (39)
Clapper Rail	1.3 \pm 0.6 (25)	0
Northern Waterthrush	1.1 \pm 0.3 (20)	0
Green Heron	0	1.6 \pm 0.5 (23)

The only significant difference between these four species in mean number of individuals recorded per point count was between the Mangrove Yellow Warbler and the Northern Waterthrush ($F = 3.820$, $df = 100$, $P = 0.012$; Tukey *post hoc*, $P = 0.034$). The Mangrove Swallow had the second highest pcRA value but had one of the lowest relative frequency values (pcFR). This was due to having one large flock fly over during one point count. It was encountered on only two of the 75 point counts. The most frequently (high pcFR value) encountered species during the summer were the Mangrove Yellow Warbler,

Great-Tailed Grackle, and Green Heron, and they had the highest pcRA values. There was no significant difference among the Great-Tailed Grackle, Mangrove Yellow Warbler and Green Heron in mean number of individuals recorded per point count (ANOVA, $P > 0.05$). There was a notable increase in the pcFR for the Yucatan Vireo from winter to summer. The pcRA and pcFR values of the Green Heron increased between the winter and summer seasons. These values decreased in the Clapper Rail. The Mangrove Yellow Warbler was the single most abundant species within the mangrove and had the highest encounter rate no matter what season or sampling method used (around 25%).

Table 2. Density analyses of common bird species at Twin Cays, Belize: D = estimated density (birds/ha) \pm 1 SE; 95% CI = log-based 95% confidence interval of birds/ha. Calculations of D and 95% CI are based on key function models for best fit using Distance 4.1 Release 2 software.

Species	Season	D	95% CI
Mangrove Yellow Warbler	Winter	13.4 ± 0.4	7.5, 24.1 ^a
Mangrove Yellow Warbler	Summer	10.9 ± 5.6	4.2, 28.7 ^a
Northern Waterthrush	Winter	4.8 ± 1.6	2.5, 9.0 ^b
Clapper Rail	Winter	0.8 ± 0.3	0.4, 1.6 ^a
Clapper Rail	Pooled	0.9 ± 0.2	0.5, 1.4 ^c
Green Heron	Summer	1.1 ± 0.6	0.4, 2.9 ^a

Key function models based on best fit:

^a Hazard/Polynomial

^b Half-normal/Cosine

^c Hazard/Cosine

Density Measurements

Density measurements (number of individual/ha) were problematic given the small sample size. Nevertheless, approximate densities with the log-based 95% confidence intervals (CI) were calculated using the Distance 4.1 software for the three most common winter species (Mangrove Yellow Warbler, Clapper Rail, and Northern Waterthrush) and for the two most common summer species (Mangrove Yellow Warbler and Green Heron, Table 2). In addition, we pooled the data from the winter and summer Clapper Rail surveys to obtain an overall Clapper Rail density estimate. Sufficient data were not available to estimate the summer Clapper Rail population. The Great-Tailed Grackle had high pcRA and pcFR values, but there was considerable movement onto and off the cays from neighboring cays due to two active dump sites, which made a density estimate for this species unfeasible.

During the winter season, the Mangrove Yellow Warbler had the highest estimated “mean” density followed by the Northern Waterthrush and the Clapper Rail,

although low sample size limited the statistical power. The sizes of the bird populations were estimated by multiplying the mean density of birds/m² by total area (Rodriguez and Feller, 2004). If these densities are accurate, the total population of Mangrove Yellow Warblers, Northern Waterthrushes, and Clapper Rails on Twin Cays would be ~965, 343, and 56 individuals, respectively. In the case of the Mangrove Yellow Warbler and the Northern Waterthrush, substantial upward bias in point-count estimates of density may have occurred due to probable movement of birds towards the observer by “pishing”. However, this practice allowed an increase in detectability. As Buckland et al. (2001) point out, bias occurs because probability of detection is a non-increasing function of distance from the point so that objects moving towards the observer are more likely to be detected when closer to the point, leading to overestimation of object density. Likewise, in the case of the Clapper Rail, density measurements were probably underestimated as birds moved away from the observer. The log-based 95% CI for the Mangrove Yellow Warbler, the Northern Waterthrush, and the Clapper Rail are given in Table 2. To compensate for these biases, the lower confidence interval for the Mangrove Yellow Warbler and the Northern Waterthrush and the higher confidence interval for the Clapper Rail were used to calculate more realistic population estimates of ~38, 181, and 113 individuals, respectively.

The summer density measurements for the Mangrove Yellow Warbler were almost 11 birds/ha, with 95% CI levels ranging from approximately 4 to 29 birds/ha (Table 2). Taking the lower confidence level for the same reasons as stated above, the Mangrove Yellow Warbler density estimate for Twin Cays during the summer stands at around 300 individuals. However, there was no significant difference between estimates obtained during the winter from those obtained during the summer. The estimated Green Heron summer density was just over 1 bird/ha, but ranging from near 0 to almost 3 birds/ha (Table 2). A crude estimate would put the number of Green Herons on Twin Cays as between 29 to 216 individuals with the actual number being closer to ~70 birds. Numbers were not sufficient to estimate the summer Clapper Rail population. Thus, we pooled the data from both winter and summer surveys to obtain an estimate of Clapper Rails. The pooled data resulted in a slightly higher estimate for density (i.e., from 0.8 to 0.9 birds/ha) and a tighter range for the 95% CI levels. The lower encounter rate for the Clapper Rail in the summer does not necessarily indicate a drop in the population, but more likely it indicates decrease in the detection function. Not only were summer point counts decreased from the winter season, the rails were much more secretive and less vocal in July than in January, contributing to the difficulty in obtaining sufficient data for analysis.

Trophic Organization

Survey data indicated that the aquatic field category was the predominant habitat for bird species on Twin Cays (see Appendix 2). It constituted 33% (summer) to 41% (winter) of the total bird species. Equal numbers of species were represented in most of the other habitats with five to nine species in each or 11 to 20% of the total. We found a small decline during the summer survey in the number of species using each habitat, but the relative percentage stayed roughly the same. The two exceptions were the canopy category, which increased from 15% to 27% of the total, and the understory, which

decreased by ~50% in number of species. This decrease was due to the significant reduction in understory Neotropical warbler species during the summer.

During the winter, the main avifauna guilds were groups that fed primarily on fish and small animals (12 species) and insectivores (11 species). These were followed by species that fed primarily on aquatic invertebrates (eight species), species that fed on aquatic vegetation and small invertebrates (four species), insectivore-frugivores (three species), omnivores (two species), and nectarivores, frugivores, raptors, and pirates having one species each. Clearly, primarily insectivorous species (combining insectivores including the vireos with species that fed on aquatic invertebrates) accounted for the vast number of species (47%) and fish eaters, including pirates and the laughing gull accounted for 32%. Frugivores and nectarivores accounted for <5%. These numbers stayed about the same during the summer with the exception of species feeding on insects and aquatic invertebrates, which decreased from 47% to ~39 % of the total. Again, this was due to the drop in Neotropical migrant shorebirds and warblers in the summer.

DISCUSSION

There are no previously published descriptions of avian species richness on Twin Cays. In this study, we found that the number of forest-restricted birds on the Cays was small. The majority of birds could be classified as either "wetland" birds or secondary growth species. The bird list therefore includes a number of species that are not restricted to mangrove forests but rather are either wetland species (e.g., Black-Bellied Whistling Duck, Lesser Scaup and Blue-Winged Teal), or inhabit the aquatic edge (Laughing Gull and Caspian Tern). In addition, distinctive vegetation types such as dwarf, scrub, and mixed woodland stands were also found within the islands (Rodriguez and Feller, 2004), and these habitats contributed significantly to the avian diversity of Twin Cays. The Twin Cays "bird list" at present constitutes 56 species: 44 species recorded during the winter and 33 species during the summer. Almost 38% of the bird species were recorded during both the winter and summer seasons.

The species accumulation curves from the point counts leveled off, which suggested that our sampling intensity was adequate for the seasons sampled. Spring and fall seasons are known to have greater numbers of migratory species as documented on neighboring Carrie Bow Cay (Ed Hunt, Carrie Bow Naturalist Log, Sept. – Oct. 1999; April – May 2001). Line transects with more effort may have produced a higher number of species. Blake and Loiselle (2001) documented that, at least within tropical forests, few species are obtained by both mist-netting and point counts. Some migrants are less territorial and less vocal and therefore harder to capture by point counts (Wang and Finch, 2002). However, this may not necessarily hold true for mangroves. While mist netting of birds for sampling may complement the visual and auditory searches by capturing more elusive birds, time constraints dictated that point counts and line transect were the best use of the time available.

Mangroves are a favorite habitat for a number of migrant species. (Arendt, 1992) Migrants and transients were 54% of the winter species detected. This is slightly higher than the 30% to 47% encountered in previous surveys of the West Indies (Wunderle and

Waide, 1993; Latta et. al., 2003). However, those studies did not concentrate on mangroves exclusively.

This study indicates that insectivores predominate during the winter, which is consistent with studies done elsewhere (Faaborg and Terborgh, 1980). Latta et al. (2003) predicted a shift to frugivores during the summer, but this does not hold true for mangroves. The small number of frugivores and nectarivores may be a function of lower food availability. During the summer, Green-Breasted Mangos and Rufous-Railed Hummingbirds were observed visiting the flowers of *A. germinans* and feeding on associated insects. The Cinnamon Hummingbird may be a seasonal bird here as well. The White-Crowned Pigeon, a frugivorous species, was recorded both in June and in January in very low numbers. According to Jones and Valleley (2001), this species resides primarily on the mainland during the winter.

The exact number of permanent residents on Twin Cays is not known. Possibly 25% of the recorded species could be permanent residents that live out their lives on the cays. Ardeids, in particular, appear to use the island for breeding. Two pairs of Great Egrets and a pair of Tricolored Herons were observed either preparing or sitting on nests. Green Herons and Yellow-Crowned Night Herons were the most frequently encountered, which suggested they were the most abundant herons. There was an increase in the Green Heron point-count relative abundance (pcRA) value and relative frequency value (pcFR) from the winter to the summer season. We think this represents a true increase in the Green Heron population because many of the birds encountered were juveniles. Jones and Valleley (2001) lists the little Blue Heron as a winter resident on the cays, but Little Blue Herons in juvenile plumage were seen during the summer on Twin Cays, which suggested year-round residency.

Pelicaniform birds, including Brown Pelicans, Double-Crested Cormorants, and Magnificent Frigatebirds, were very common around the fringe. Sixty-six Double-Crested Cormorants were counted one morning around Twin Cays. Flocks of Brown Pelican varied from day to day with up to 70 individuals on some days; on other days, only a few individuals were noted. Magnificent Frigatebirds nested on nearby cays, and their numbers fluctuated from day to day, as well.

A single Peregrine was observed during the winter presumably hunting the flocks of shorebirds that frequented the ponds within the interior of Twin Cays. A nesting pair of Osprey represented the only other raptors present, though Common Black Hawks were numerous in adjacent mainland mangrove forests.

Two rail species were documented. The Clapper Rail was common along the fringe, small creek waterways, and in the dense ponded dwarf stands. The Rufous-Necked Woodrail apparently resides on Twin Cays but in very low numbers. None, however, were found during the summer.

All together, 10 species of shorebirds were recorded on Twin Cays with eight species during the winter. Of these eight winter species, we observed two flocks of Least Sandpipers, consisting of more than 15 individuals, as well as solitary birds. In addition, there were at least three Black-Bellied Plovers and at least two pairs of Greater Yellowlegs. Ruddy Turnstones and Spotted Sandpipers were seen feeding around the dump. A Spotted Sandpiper was observed feeding on small *Uca* spp. Several flocks of Short-Billed Dowitchers, each with more than nine individuals, were also observed. A flock of five Short-Billed Dowitchers was observed during the summer along with two

Greater Yellowlegs. While absent or overlooked during the winter, two Semipalmated Plovers and 11 Wilson Plovers were observed in the summer. Of the 11 Wilson Plovers, at least three pairs were nesting, although only one nest with four eggs was discovered. It is of note that the breeding habitat of these birds is limited to the cleared, burned, and filled areas of the Cays.

Undoubtedly, the presence of tidal channels affects the distribution and habitat use by shorebirds at Twin Cays. Kelsey and Hassall (1989) have documented that wet moist soil harbors more invertebrates and therefore more food for water birds. Water depth plays a significant impact on the species use of habitats. Too much water or not enough water decreases available foraging habitat (Isola et al., 2000). Danufsky and Colwell's (2003) work suggested that habitat characteristics had a significant impact on species richness and densities for the winter shorebird community in California. They found that the amount of standing water correlated positively with the Wimbrel and negatively for the Dowitcher. As the hydrology of Twin Cays is altered with the cutting of survey lines and other anthropogenic development, it would be interesting to note changes in habitat use among migratory shorebirds; however, the low numbers of birds would require much time and effort to get substantial data.

A small number of Belted Kingfishers inhabit Twin Cays during the winter. The American Pygmy Kingfisher was not encountered, but has been noted from Twin Cays previously (Anne Chamberlain, Carrie Bow Naturalist Log, April, 2001), and has been recorded on other offshore islands (Jones and Vallely, 2001).

Insectivorous passerines composed a large percentage of the species recorded. Of the two vireo species, the Yucatan Vireo was encountered significantly more often than the Mangrove Vireo. There was a notable increase in the relative point count frequency value for the Yucatan Vireo from winter to summer. The Yucatan Vireo was observed behaving much like a sapsucker woodpecker, digging deep into tree branches and boles presumably to extract wood-boring insect larvae or other arthropods.

Only two species of flycatchers were recorded, which was surprising given the number of moths and other flying insects observed. The Great-Crested Flycatcher was observed during the winter and the Brown-Crested Flycatcher in the summer. There were at least three breeding pairs of the Brown-Crested Flycatchers, which was consistent with Jones and Vallely (2001) who reported that the Brown-Crested Flycatcher is migratory in Belize.

Three swallow species (Tree Swallow, Mangrove Swallow, and Barn Swallow) observed in the winter were not seen in the summer. However, we did record two martin species (Purple Martin and Gray-Breasted Martin) during the summer.

Nine species of warblers were documented in our surveys: seven during the winter and four during the summer. The Mangrove Yellow Warbler was by far the most numerous in both seasons. Three of the four summer warbler species were Neotropical migrants, two of which were not seen during the winter (the Yellow-Throated Warbler and the Palm Warbler). The Palm Warbler was found feeding in the dense understory of *B. maritima*. During the winter, the Mangrove Yellow Warbler and Northern Waterthrush were the most numerous, followed by the American Redstart. The other warbler species appeared in low numbers. The high density of Mangrove Yellow Warblers (~7 - 24 birds/ha) and Northern Waterthrushes (~2 - 9 birds/ha) suggest that the mangrove is a rich habitat for insectivorous species. The Mangrove Yellow Warbler feeds primarily in

the mid to upper canopy while the Northern Waterthrush feeds on insects in the understory. One Mangrove Yellow Warbler was observed feeding on a small Mangrove Tree Crab, *Aratus pisonii*.

In conclusion, the mangrove forests of Twin Cays are vital to many bird species, particularly migratory passerines and wetland birds. High numbers of resident Clapper Rails, Green Herons, migrant Northern Waterthrushes, and both resident and migrant populations of Yellow Warblers use the islands during the winter and summer seasons. In all appearances, mangroves seem essential for some species' survival. The abundance of ground or understory bird species is primarily a function of habitat availability, food resource availability, and low predation pressure. Anthropogenic alteration of hydrology and forest structure, and the introduction of feral dogs assuredly will take their toll on birdlife. Changes are already visible on the Cays in the breeding presence of Wilson Plovers in clearcut and filled areas. As further changes are implemented, the suitability of the islands as habitat for the current assemblage of migratory and resident birds is likely to be reduced.

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APPENDIX 1

Common Name	Scientific Name	wpcFR	wpcRA	spcFR	spcRA	tFR	tRA	WB (N)	SB (N)	WI (N)	SI (N)
Brown Pelican*	<i>Pelecanus occidentalis</i>	*	*	*	*	*	*	11	12		
Double-Crested Cormorant*	<i>Phalacrocorax auritus</i>	*	*	*	*	*	*	66	36		
Magnificent Frigate*	<i>Fregata magnificens</i>	*	*	*	*	*	*	6	4		
Great Blue Heron	<i>Ardea herodias</i>	0.09	0.11	0.03	0.03	0.25	0.25	2	0		
Great Egret	<i>Ardea alba</i>	0.03	0.04	0	0	0.13	0.25	0	1		
Little Blue Heron	<i>Egretta caerulea</i>	0.03	0.03	0.05	0.05	0.38	0.5	1	1		
Tricolored Heron	<i>Egretta tricolor</i>	0.05	0.06	0.02	0.02	0.25	0.38	0	0		
Reddish Egret	<i>Egretta rufescens</i>			0.02	0.02			0	0		
Green Heron	<i>Butorides virescens</i>	0.12	0.12	0.27	0.37	0.38	0.5	0	6		
Yellow-Crowned Night Heron	<i>Nyctanassa violacea</i>	0.07	0.09	0.02	0.02	0.5	0.63	0	0		
Black-Bellied Whistling Duck	<i>Dendrocyna autumnalis</i>			0	0			0	0		1
Blue-Winged Teal	<i>Anas discors</i>	0	0			0.13	0.25	0	0		
Lesser Scaup	<i>Aythya affinis</i>	0	0			0	0	0	0	2	
Osprey*	<i>Pandion haliaetus</i>	*	*	0.02	0.02	*	*	2	0	3	
Peregrine	<i>Falco peregrinus</i>	0.01	0.01			0	0	0	0		
Rufous-Necked Woodrail	<i>Aramides axillaris</i>	0	0			0	0	0	0	1	
Clapper Rail	<i>Rallus longirostris</i>	0.27	0.33	0.13	0.16	0.75	1.88	6	2		
Black-Bellied Plover	<i>Pluvialis squatarola</i>	0.03	0.03			0.38	0.38	1	0		
Wilson's Plover	<i>Charadrius wilsonia</i>			0.03	0.08			0	0		
Semipalmated Plover	<i>Charadrius semipalmatus</i>			0	0			0	0		2
Greater Yellowlegs	<i>Tringa melanoleuca</i>	0.03	0.05	0	0	0.38	0.63	1	0		2
Wimbrel	<i>Numenius phaeopus</i>	0	0			0	0	0	0	1	
Marbled Godwit	<i>Limosa fedoa</i>	0	0			0	0	0	0	1	
Spotted Sandpiper	<i>Actitis macularia</i>	0	0			0	0	0	0	1	
Least Sandpiper	<i>Calidris minutilla</i>	0.01	0.2			0	0	0	0		
Ruddy Turnstone	<i>Arenaria interpres</i>	0	0			0	0	0	0	1	
Short-Billed Dowitcher	<i>Limnodromus griseus</i>	0.01	0.12	0.02	0.08	0.13	1.25	0	0		
Laughing Gull	<i>Larus atricilla</i>	0	0	0	0	0	0	0	0	1	1
Caspian Tern	<i>Sterna caspia</i>	0	0			0	0	0	0	1	
Royal Tern	<i>Sterna maxima</i>	0.01	0.03	0	0	0	0	5	0		2
Sandwich Tern	<i>Sterna sandvicensis</i>			0	0			0	0		1
White-Crowned Pigeon	<i>Columba leucocephala</i>	0	0	0.02	0.02	0	0	0	0	2	

Cinnamon Hummingbird	<i>Amazilla rutila</i>	0	0			0	0	0	0	1	
Green-Breasted Mango	<i>Anthracothorax prevostii</i>			0	0			0	0		2
Rufous-Tailed Hummingbird	<i>Amazilla tzacatl</i>			0.02	0.02			0	0		
Belted Kingfisher	<i>Ceryle alcyon</i>	0	0			0	0	4	0		
Great-Crested Flycatcher	<i>Myiarchus crinitus</i>	0.01	0.01			0	0	0	0		
Brown-Crested Flycatcher	<i>Myiarchus tyrannulus</i>			0.10	0.01			0	0		
Purple Martin	<i>Progne subis</i>			0.02	0.02			0	0		
Gray-Breasted Martin	<i>Progne chalybea</i>			0.03	0.13			0	0		
Tree Swallow	<i>Tachycineta bicolor</i>	0.01	0.11			0	0	0	0		
Mangrove Swallow	<i>Tachycineta albilinea</i>	0.03	0.63			0.13	0.63	0	0		
Barn Swallow	<i>Hirundo rustica</i>	0.01	0.01			0	0	0	0		
Grey Catbird	<i>Dumetella carolinensis</i>	0.03	0.03			0	0	0	0		
Mangrove Vireo	<i>Vireo pallens</i>	0.01	0.01	0	0	0	0	0	0		2
Yucatan Vireo	<i>Vireo magister</i>	0.04	0.05	0.18	0.08	0	0	1	10		
Mangrove Yellow Warbler	<i>Dendroica petechia</i>	0.52	0.9	0.74	1.26	0.88	3.13	9	21		
Magnolia Warbler	<i>Dendroica magnolia</i>	0	0			0.13	0.13	0	0		
Yellow-Throated Warbler	<i>Dendroica dominica</i>			0.02	0.02			0	0		
Palm Warbler	<i>Dendroica palmarum</i>			0	0			0	0		1
American Redstart	<i>Setophaga ruticillia</i>	0.04	0.04	0	0	0	0	0	0		1
Ovenbird	<i>Seiurus aurocapillus</i>	0	0			0.13	0.13	0	0		
Northern Waterthrush	<i>Seiurus noveboracensis</i>	0.21	0.27			0.63	0.75	0	0		
Louisiana Waterthrush	<i>Seiurus motacilla</i>	0	0			0	0	0	0	1	
Common Yellowthroat	<i>Geothlypis trichas</i>	0	0			0.13	0.13	0	0		
Great-Tailed Grackle	<i>Quiscalus mexicanus</i>	0.32	0.39	0.32	0.63	0.63	1.75	4	32		
		1.99	3.66	2.03	3.01			123	125		
TOTAL: 56 species								13 sp.	10 sp.	12 sp.	10 sp.

*Excluded from point counts and line transects. WB (N) = winter boat count of individuals. SB (N) = summer boat count. wpcFr = winter point count frequency value for all birds observed, spcFr = summer point count frequency value for all birds observed. Point count frequency (pcFR) values are equal to the percentage of point counts the species was observed considering the total number of point counts. wpcRA = winter point count relative abundance. spcRA = summer point count relative abundance. Point count relative abundance (pcRA) values of a given species are expressed as the number of individuals observed per point count. Line transect relative abundance (tRA) value of a species encountered was expressed as the number of individuals observed per 150 m line transect. Line transect frequency (tFR) value was determined as the number of transects in which a given species was encountered considering the total number of 150 m line transects. WI (N) = Winter Incidentals (N), SI (N) = Summer incidentals (N).

APPENDIX 2

Species #	Common Name	Seasonality	Habitat	Feeding guild
1	Brown Pelican	P	AQU	F
2	Double-Crested Cormorant	P or V?	AQU	F
3	Magnificent Frigatebird	P	AIR	P
4	Great Blue Heron	P or V?	AQUE	F+REP+INV
5	Great Egret	P or V?	AQUE	F+REP+INV
6	Little Blue Heron	W	AQUE	F+REP+INV
7	Tricolored Heron	P or V?	AQUE	F+REP+INV
8	Green Heron	P	AQUE	F+REP+INV
9	Yellow-Crowned Night Heron	P	AQUE	F+REP+INV
10	Blue-Winged Teal	T	AQU	INV+VEG
11	Lesser Scaup	T	AQU	INV+VEG
12	Osprey	P	AQUE	F
13	Peregrine	W or T?	AIR	R
14	Rufous-Necked Woodrail	P?	U	INV+VEG
15	Clapper Rail	P	U	INV+VEG
16	Black-Bellied Plover	W	AQUF	INV
17	Greater Yellowlegs	W or T?	AQUF	INV
18	Wimbrel	T	AQUF	INV
19	Marbled Godwit	W or T?	AQUF	INV
20	Spotted Sandpiper	W	AQUF	INV
21	Least Sandpiper	W or T?	AQUF	INV
22	Ruddy Turnstone	W	AQUF	INV
23	Short-Billed Dowitcher	W or T?	AQUF	INV
24	Laughing Gull	P or V?	AQU	OMN
25	Caspian Tern	W or T?	AQU	F
26	Royal Tern	V	AQU	F
27	White-Crowned Pigeon	S	C	FRU
28	Cinnamon Hummingbird	P?	C	NEC
29	Belted Kingfisher	W	AQUE	F
30	Great-Crested Flycatcher	T	C	INS
31	Tree Swallow	W	AIR	INS
32	Mangrove Swallow	P	AIR	INS
33	Barn Swallow	T	AIR	INS
34	Grey Catbird	W or T?	U	INS+FRU
35	Mangrove Vireo	P	C	INS+FRU
36	Yucatan Vireo	P	C	INS+FRU
37	Yellow Warbler	P and W	C	INS
38	Magnolia Warbler	W or T?	C	INS
39	American Redstart	W	U	INS
40	Ovenbird	W	U	INS
41	Northern Waterthrush	W	U	INS
42	Louisiana Waterthrush	W	U	INS
43	Common Yellowthroat	W	U	INS
44	Great-Tailed Grackle	P	A	OMN

Seasonality: P=permanent resident; B=seasonal resident; V=visitor (non-migratory; do not breed in area); T= transient (migratory; neither breeds nor spends the winter); W=winter resident (migratory; stays winter).
Habitat: AIR=overhead; AQU=aquatic; AQUE=aquatic edge; AQUF=mudflats, wet sandy beaches, marshy fields; C= midstory, canopy; U=lower strata (understory to midstory); A=anywhere within mangrove.
Feeding guild: F=fish, some invertebrates; P=pirate food or scavenge; F+REP+INV=fish, reptiles, invertebrates; INV+VEG=aquatic vegetation, invertebrates; INV=aquatic insects, invertebrates; NEC=nectarivores; R=raptors (carnivores); FRU=frugivores (fruits, buds); OMN=omnivores; INS=insectivores; INS+FRU=insectivores-frugivores (insects, fruit).



Plate 1

Plate 1. A. Mangrove Yellow Warbler; B. Northern Waterthrush; C. Yucatan Vireo; D. Green Heron (Juvenile); E. Clapper Rail; F. Osprey