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SEASONAL ABUNDANCE OF SHOREBIRDS IN THE JOBOS BAY ESTUARY IN SOUTHERN PUERTO RICO

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Abstract.—From June 1985 to June 1986, 31 censuses were conducted in five estuarine habitats in the Jobos Bay National Estuarine Sanctuary in Puerto Rico to examine the relative seasonal abundance of shorebirds. We observed a total of 22,574 shorebirds of 22 species. The fall migration period (15 Jul.–15 Nov.) had the highest number of shorebirds per census with an average of 1389 birds/census, followed by the winter period (16 Nov.–15 Mar.) with 427 birds/census and spring/summer period (16 Mar.–14 Jul.) with 139 birds/census. Semipalmated and Western Sandpipers together (*Calidris pusilla, C. mauri*), Stilt Sandpipers (*C. himantopus*), and Least Sandpipers (*C. minutilla*) accounted for 84% of the shorebires observed. A distinct fall migration was evident, with a peak on 7 Sep. of 2812 birds of which 65% were Semipalmated and Western Sandpipers, 19% Least Sandpipers, and the remaining percentage from a diversity of species. There was no evidence of a spring migration peak in contrast to shorebird migration in northern South America, suggesting that the Caribbean is bypassed by most north-bound shorebirds.

ABUNDANCIA ESTACIONAL DE PLAYEROS EN EL ESTUARIO DE LA BAHÍA DE JOBOS, PUERTO RICO

Resumen.—Desde junio 1985 a junio 1986, se condujeron 31 censos en cinco áreas del Santuario Estuarino Nacional de Jobos en Puerto Rico, para estudiar la abundancia de playeros durante las estaciones del año. Observamos un total de 22,574 individuos de 22 especies. Durante el período de migración otoñal (15 julio–15 noviembre) se obtuvo el número más alto de playeros migrando con un promedio de 1,389 individuos por censo, seguido por el período invernal (16 noviembre–15 marzo) con 427 individuos y el período de primavera/verano (16 marzo–14 julio) con 139 aves. El 84% de las aves consistieron de las siguientes especies: Playerito Gracioso (*Calidris pusilla*), Playerito Occidental (*C. mauri*), Playero Patilargo (*C. himantopus*), y Playerito Menudo (*C. minutilla*). Fue evidente la migración otoñal, con un incremento el día 7 de septiembre de 2812 aves de las cuales el 65% eran Playeritos Graciosos y Occidentales; el 19% eran Playeritos Menudo y el porciento restante fue constituido por una diversidad de especies. No hubo evidencia de un máximo en la migración de primavera en contraste con la migración de playeros en el norte de Sur América. Esto sugiere que el área del Caribe es sobrevolado por la mayoría de las aves de origen nórdico.

The long-distance migrations of many shorebirds pose challenges for the protection and management of their widely dispersed nonbreeding

and breeding sites. Recent interest in shorebird conservation has emphasized the importance of accurate knowledge of shorebird distribution and abundance along migration routes and on breeding and nonbreeding grounds (Myers 1983, Myers et al. 1987, Senner and Howe 1984). These components of shorebird distribution are relatively well known for North America with less information available for localities south of North America where many shorebird species spend over half their lives (for recent review see Morrison 1984, also Hicklin 1987, Thomas 1987). In the Caribbean, information on the abundance and seasonal distribution of shorebirds is primarily qualitative (e.g., Biaggi 1970, Bond 1979, ffrench 1980, Raffaele 1983, Voous 1983) with few quantitative studies (see West Indian Region in *American Birds*).

Here we describe a one-year quantitative study on Caribbean shorebird seasonal abundance in different estuarine habitats in the Jobos Bay National Estuarine Sanctuary in southern Puerto Rico that complements previous work in northern South America (i.e., McNeil 1970; Morrison 1983; Morrison and Ross 1983a, b; Spaans 1978; Thomas 1987). These observations will be helpful in understanding the pattern of shorebird migration and overwintering in the Caribbean.

STUDY SITE AND METHODS

The Jobos Bay National Estuarine Sanctuary (henceforth JOBANES) is located along Jobos Bay between the municipalities of Salinas and Guayama on the south coast of Puerto Rico (17°55′ N, 66°15′ W). Jobos Bay and the surrounding area have been described by Seguinot Barbosa (1986). Red mangroves (*Rhizophora mangle*) form a fringe around the bay whereas drier inland sites are dominated by black mangrove (*Avicenia germinaus*) or white mangrove (*Laguncularia racemosa*) with occasional button mangroves (*Conocarpus erectus*). Most (approximately 50%) of the tidelands of the 1140 ha estuary are covered with mangroves. Intertidal exposure of beaches and mud flats appeared to be 1 m or less depending upon the location of the site within the estuary. The few beaches adjoining Jobos Bay and the channels of the estuary are mostly steep (approximately 45°) and thus have limited area of exposure at low tide. We regularly sampled five different habitats with a total surface area of approximately 36.1 ha within the estuary as summarized below:

Salt flat. An area of 8.6 ha bordered on the west and north by houses in the town of Las Mareas and black mangroves on the south and east. The soil consisted primarily of fine sand with some organic matter, which together provided relatively firm support underfoot (a 64 kg person sank only 15 cm or less). The water on the salt flats did not show daily tidal fluctuations but did fluctuate seasonally with rainfall. During all censuses on the salt flat, both exposed sand and standing water were available to the birds. The area sampled was about 30% of the total extent (estimated) of salt flats in and around JOBANES.

Mud flat. Censuses were conducted on two 50 × 100 m grids on a mud flat containing scattered red and black mangroves. The soil was a

black mix of mud and ooze which was very soft underfoot (a 64 kg person sank 50 cm or more). This site was primarily surrounded by mangroves with the exception of a large dike on the south from which our observations were made. Water levels were read from stakes placed at 10 m intervals throughout the grid. These stakes were marked at intervals of 10 cm above the soil, and the average for all stakes on both grids indicated a mean water level range of 0.3–18.0 cm during the year of this study. Most water level fluctuations were associated with seasonal rainfall (maximum in mid-October to early November) rather than daily tidal fluctuations (Waide and Wunderle, unpublished). The grids contained about 1% of the available habitat, although the extent of mud flats varied seasonally with water level.

Mangrove ponds. We sampled a series of small salt water ponds (maximum of 0.2 ha, total 0.6 ha) which were completely surrounded by red and black mangroves. These ponds regularly contained water and had a narrow fringe (0.5 m) of soft ooze-mud along the mangrove-lined edge only during the dry season in February and early March 1986. The area sampled was approximately 20% of the available ponds in JOBANES.

Open water. We conducted censuses in a series of shallow (2 m or less) interconnected bodies of water which always contained water (total surface area 25.9 ha). The open water sites were surrounded with mangroves and usually had a fringe of less than 0.5 m of soft ooze-mud, except during the dry season in February and early March when mud flats accounted for approximately 25% of the surface area. The open water sites sampled represented about 25% of the open water habitat in JOBANES.

Beach. A 190 m stretch of beach along Jobos Bay was sampled regularly. The beach of coarse white sand had the greatest daily tidal fluctuations of any habitat with an estimated maximum intertidal exposure of 1 m. This site represented about 70% of the available beach habitat.

We conducted 31 censuses in each of the five habitats at one- or two-week intervals during a 12-month period from 15 Jun. 1985 to 7 Jun. 1986. We divided the year into three periods, fall (15 Jul.–15 Nov.), winter (16 Nov.–15 Mar.), and spring/summer (16 Mar.–14 Jul.). The fall period covers the interval with the largest numbers of shorebirds and presumably includes most (all?) of the fall migrants. It was not possible to identify exactly when the spring migration began, because there was a general decline in shorebird numbers from the late winter period into the spring/summer period, and thus the selection of the spring/summer interval was based on the desire to have three periods of equal duration.

We sampled weekly during both fall and spring migration periods so as not to miss any major migration waves of short duration. All sampling was done from 0700 to 1400, and we varied the sequence in which habitats were visited on each census day. Censuses were not coordinated with tides since daily tidal fluctuations were either absent in some habitats or of limited magnitude (less than 1 m) in others. During each census, there was always a diversity of water levels and exposed mud and sand flats

available among the five habitats; therefore, we assume that the absence of a species or reduced population density represents migration rather than a local effect produced by daily tidal fluctuations. This assumption is supported by the findings of Collazo and Colon (pers. comm.) which indicate similar seasonal population trends at the Cabo Rojo National Wildlife Refuge located 110 km to the west. Also, we sampled a sixth habitat, an ocean shoreline behind a reef, on an irregular basis and found identical season trends as reported here for five habitats (Waide, Wunderle, and Lodge, manuscript). All birds were observed with a variable power (15–60×) telescope. We sometimes had difficulty distinguishing Semipalmated Sandpipers (*Calidris pusilla*) from Western Sandpipers (*C. mauri*), and thus we pooled these species for some analyses.

The observations were standardized by sampling all five habitats on every visit and therefore we describe the status of each species in JOBANES by using the convention of Raffaele (1983):

Very Common—20 or more in a single day.
Common—5 to 20 in a single day.
Uncommon—not seen on every census, but more than twice a year.
Rare—two or fewer times a year.

RESULTS AND DISCUSSION

Species accounts.—In the following list we describe the status, seasonal abundance, and habitat preferences of shorebirds in JOBANES and relate them to observations from coastal Surinam (Spaans 1978). Seasonal abundance of individual species, for which there are more than 100 observations are shown in Figure 1.

Black-necked Stilt (*Himantopus mexicanus*). A common summer resident, present from late May until early November, during which time they were observed on the salt and mud flats. A maximum count of 57 was obtained on 15 Jun. when nests were also observed on the mud flats.

Semipalmated Plover (*Charadrius semipalmatus*). A migrant species with occasional sightings throughout the year, but most frequent in fall, winter, and spring; a maximum sighting of 148 individuals in a single flock was made on 25 Jan. Observed most frequently on the salt flats with occasional individuals seen on the mud flats. This species is present in large numbers in Surinam with peaks in October–December.

Wilson's Plover (*Charadrius wilsonia*). A common breeding species most frequently sighted on the mud and salt flats, but absent from all localities from mid-October through mid-January.

Killdeer (*Charadrius vociferus*). An uncommon species with only four sightings scattered throughout the year on the salt and mud flats.

Snowy Plover (*Charadrius alexandrinus*). A rare species at JOBANES, with two sightings in mid-June at the mangrove edge of the open water habitat and along the beach.

Black-bellied Plover (*Pluvialis squatarola*). A common winter resident with individuals sighted throughout the year on mud flats, salt flats, and

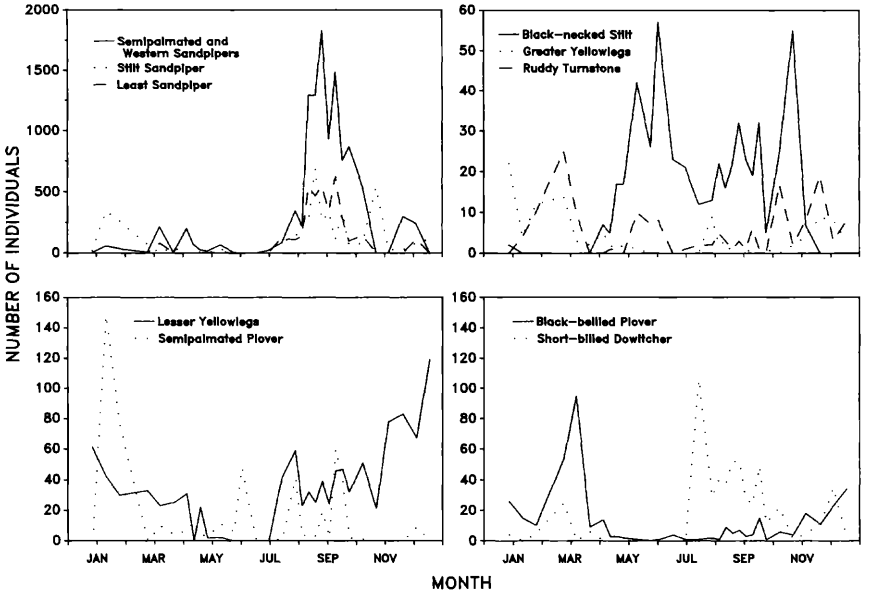

FIGURE 1. Seasonal abundance of individual shorebird species in the Jobos Bay National Estuarine Sanctuary, Puerto Rico (June 1985 to June 1986).

beaches with a maximum of 95 individuals observed on 22 Mar. In Surinam this species is present throughout the year without a distinct seasonal trend.

Marbled Godwit (*Limosa fedoa*). Rare, one individual observed on the mud flat on 28 Jul.

Whimbrel (*Numenius phaeopus*). An uncommon migrant, with a group of five observed on the mud flat on 30 Jun. and a single individual observed on the mud and salt flats on 13 Jul. This species displays an August–October peak in Surinam.

Greater Yellowlegs (*Tringa melanoleuca*). A common winter resident and uncommon spring and fall migrant found on flats and along the mangrove edges; maximum sighting of 22 on 11 Jan. This pattern of abundance is in contrast to Surinam where distinct migratory peaks in March–April and in October were found.

Lesser Yellowlegs (*Tringa flavipes*). A common to very common migrant and winter resident, frequently encountered from late July until early May on mud and salt flats and along the mangrove edges of the pond and open water habitats. The maximum count of 119 individuals occurred on 28 Dec., which approximately coincides with the maximum count in Surinam.

Willet (*Catoptrophorus semipalmatus*). An uncommon fall migrant; a flock of seven was observed along the mangrove edge of the open water

habitat on 10 Aug. 1985, with additional August sightings on the mud flats. Our observations correspond to the July–August peak in Surinam, where the species is an abundant fall transient.

Spotted Sandpiper (*Actitis macularia*). An uncommom fall migrant, with consistent sightings of individuals from 10 Aug. to 5 Oct. (maximum of six on 28 Sep.). A rare winter resident with sightings of individuals in mid-November and mid-January. The species was sighted occasionally in all habitats, but was most common along the mangrove edges of the isolated ponds. This species appears to mostly bypass our site (and most of the Caribbean?) for it is recorded as a transient and winter visitor in large numbers in Surinam.

Ruddy Turnstone (*Arenaria interpres*). A common winter resident, most abundant from mid-November through March (a maximum of 25 on 9 Mar.), with occasional sightings throughout the remainder of the year on salt and mud flats. The seasonal abundance here appears to coincide with that observed in Surinam.

Wilson's Phalarope (*Phalaropus tricolor*). Uncommon, one individual observed on 14 Sep., and five individuals observed on 28 Sep., all on the salt flat.

Short-billed Dowitcher (*Limnodromus griseus*). A common fall migrant with a maximum of 106 individuals sighted on 27 Jul., an uncommon winter resident, and rare spring transient. This is in contrast to Surinam where it is a "transient in very large numbers" in both spring and fall. In JOBANES it was observed on the mud and salt flats.

Red Knot (*Calidris canutus*). A uncommon migrant, with salt flat sightings of two individuals each on 13 Jul. and 30 Nov., and a flock of 14 found on 25 Jan. 1986 on the mud flats. For Surinam, this species is described as a "transient in small numbers" with peaks from August through October and again in May, suggesting that they mostly bypass the Caribbean during migration.

Sanderling (*Calidris alba*). Rare, with only one individual sighted on 11 Jan., on the mud flat. Thus this species bypasses the site (and the Caribbean in general?) and is found further south as a transient in Surinam in small numbers.

Semipalmated Sandpiper (*Calidris pusilla*). The most abundant fall migrant with small to large numbers present on exposed mud and salt flats from 27 Jul. through 19 Oct. (a maximum of 1819 on 7 Sep.). During the winter months, a moderate sized flock (300+) was encountered on 30 Nov. and again on 14 Dec. 1985 on the salt flats. Smaller flocks (20–215) were encountered through late January until the end of May. The end of the fall migration in late October or early November in JOBANES appears to coincide with the peak of migration on the Surinam coast. However, whereas a spring migration period is evident in Surinam it appears to be absent in JOBANES, suggesting that Semipalmated Sandpipers bypass this part of the Caribbean on their way north. Recaptures of Semipalmated Sandpipers banded in Surinam suggest that

while southbound migration is principally down the eastern coast of North America and across the Atlantic, northbound migration routes are more westerly, bypassing Puerto Rico (Spaans 1984).

Western Sandpiper (*Calidris mauri*). A common fall migrant, with individuals and small flocks present with other peep from 27 Jul. through 19 Oct. on the mud and salt flats. The fall migration peak of Western Sandpiper occurred on 24 Aug. (71 individuals), slightly earlier than the Semipalmated Sandpiper peak on 7 Sep. The species is rare or uncommon in the winter and spring when individuals were occasionally sighted. The abundance of this species appears to coincide with their status in Surinam.

Least Sandpiper (*Calidris minutilla*). A very common fall migrant with large flocks present on the salt flats and smaller flocks on the mud flats from late July through early October (624 maximum on 21 Sep.). An uncommon winter resident and spring migrant at JOBANES. The fall migration at JOBANES coincides with that in Surinam, but in contrast to Surinam, no spring migration was observed at JOBANES.

White-rumped Sandpiper (*Calidris fuscicollis*). An uncommon fall migrant with small numbers (1–6) observed with other peep on salt and mud flats from mid-August through mid-October (ten maximum on 31 Aug.), but absent for the remainder of the year. The August–September peak in migration on the Surinam coast suggests that this species mostly bypasses Puerto Rico on its southward migration.

Pectoral Sandpiper(*Calidris melanotos*). An uncommon spring and fall migrant observed only on the salt flats. In Surinam, this species is scarce along the coast, although it is more abundant in inland localities.

Stilt Sandpiper (*Calidris himantopus*). An abundant fall migrant and winter resident regularly sighted through early March (690 maximum on 31 Aug.). Uncommon in the spring, when a flock of eight and another of 34 were sighted on different dates in May. This species was most abundant on the salt flats, but small flocks were encountered on the mud flats and along the mangrove edges of the ponds and open water habitats. The large fall migration peak in late August to early September, low numbers in winter, and absence of a spring migration are characteristic of Stilt Sandpiper populations in both JOBANES and in Surinam.

Ruff (*Philomachus pugnax*). One individual was observed on 21 Sep. on the salt flat.

Distribution and abundance.—During the one-year census period we observed 22 species of shorebirds in five habitats in JOBANES, which represent 61% of the shorebird species known from Puerto Rico (Raffaele 1983). Also during this period, we recorded a total of 22,574 shorebirds in the five habitats during 31 censuses (Table 1). Since the birds were not individually marked it was not possible to determine the actual number of individuals.

The number of shorebirds observed per census (Fig. 2) reached a peak on 7 Sep. 1985, when 2812 shorebirds were recorded, most of which were "peep" sandpipers (1830 Semipalmated/Western Sandpipers, 546 Least Sandpipers). The lowest counts occurred in June when counts of 42 and

TABLE 1. Abundances of all species of shorebirds observed at JOBANES during 13 censuses in the fall (15 Jul.–15 Nov.), seven censuses in the winter (16 Nov.–15 Mar.), and 11 censuses in the spring/summer (16 Mar.–14 Jul.). Numbers in parentheses represent the percent relative abundance during each season and are calculated only for species with sample sizes >300.

Species	Fall	Winter	Spring/ summer	Total
Semi./West. Sandpiper	9731 (53.9)	648 (21.7)	634 (41.5)	11,013
Stilt Sandpiper	3169 (17.5)	1122 (37.6)	94 (6.2)	4385
Least Sandpiper	3437 (19.0)	118 (3.9)	110 (7.2)	3666
Lesser Yellowlegs	519 (2.9)	435 (14.6)	105 (6.9)	1059
Short-billed Dowitcher	459 (2.5)	82 (2.7)	6 (0.4)	547
Semipalmated Plover	176 (0.9)	234 (7.8)	106 (6.9)	516
Black-necked Stilt	283 (1.5)	2 (0.01)	215 (14.1)	500
Black-bellied Plover	76 (0.4)	173 (5.8)	133 (8.7)	382
Ruddy Turnstone	51	78	45	173
Greater Yellowlegs	22	72	16	110
Wilson's Plover	47	4	42	93
White-rumped Sandpiper	33	0	0	33
Spotted Sandpiper	29	2	0	31
Red Knot	0	16	2	18
Pectoral Sandpiper	8	0	9	17
Willet	11	1	0	12
Whimbrel	0	0	7	7
Killdeer	3	0	1	4
Wilson's Phalarope	5	0	0	5
Snowy Plover	0	0	2	2
Sanderling	1	0	0	1
Ruff	1	0	0	1
Total	18,060	2987	1527	22,575

49 shorebirds were obtained on 30 Jun. and 7 Jun., respectively. The fall migration period (15 Jul.–15 Nov.) had the highest number of shorebirds per census with an average of 1389 shorebirds/census, followed by the winter period (16 Nov.–15 Mar.) with 427 shorebirds/census and spring/summer period (16 Mar.–14 Jul.) with 139 shorebirds/census. Semipalmated/Western Sandpipers, Stilt Sandpipers, and Least Sandpipers accounted for 84% of the shorebirds observed in JOBANES during the study. However, their relative abundance changed seasonally as illustrated by the rankings of the common species in the three sampling seasons (Table 1). Some of the shorebird species showed different preferences for the five habitats (Waide, Wunderle, and Lodge, manuscript).

Semipalmated Sandpipers are one of the most abundant small shorebirds in eastern North America (Harrington and Morrison, 1979) and certainly the most abundant species on our Caribbean site. Banding studies summarized by Morrison (1984) indicated that a higher proportion of juvenile Semipalmated Sandpipers are recovered than adults on Caribbean islands. Morrison (Op. cit.) attributes this to several possible factors: differential navigational abilities, with more juveniles being deflected

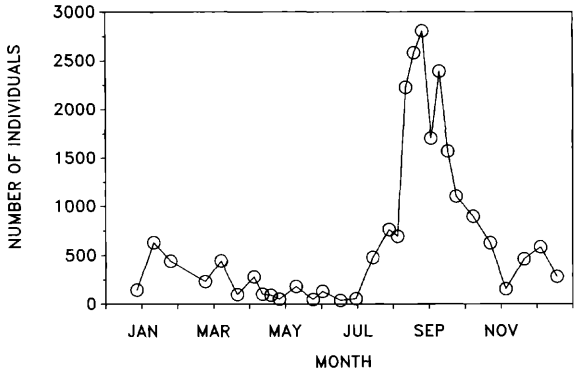

FIGURE 2. Seasonal abundance of all shorebirds in the Jobos Bay National Estuarine Sanctuary, Puerto Rico (June 1985 to June 1986).

westward by the tradewinds; differential flight range abilities, producing a "shortfall" of juveniles on the islands whereas adults bypass the Caribbean islands on a direct flight to northern South America; and differential points of departure from the U.S. coast, producing different arrival locations. Whether these factors also produce a preponderance of juveniles of other shorebird species within the Caribbean when en route to South America is presently unknown.

Our observations are consistent with the radar observations of Richardson (1974, 1976), which demonstrate that spring and autumn migration routes differ for many birds, with a heavier volume of offshore, trans-Atlantic migration between eastern North America and northern South America in the fall than in the spring. With the possible exceptions of Black-bellied Plovers and Ruddy Turnstones (both showed minor March peaks) or Semipalmated Sandpipers (a small March–April peak), we found no evidence for a spring migration through JOBANES. In addition, a spring migration appears to be absent at Cabo Rojo, Puerto Rico, another Caribbean site where systematic shorebird sampling has been made (Collazo and Colon, pers. comm.). Yet, in northeastern Venezuela, Guyana, and Surinam, distinct spring migration peaks are observed for the Least Sandpiper, Red Knot, Willet, Short-billed Dowitcher, Spotted Sandpiper, Greater Yellowlegs, and Lesser Yellowlegs (McNeil 1970, Spaans 1978). Thus most north-bound shorebirds from South America must be bypassing the Caribbean in the spring by flying non-stop over the Caribbean and Atlantic to eastern North America (e.g., Short-billed Dowitcher, Red Knot, and possibly Greater Yellowlegs and Willet) or by flying along Central America and the western Caribbean en route to the Mississippi Valley (Spaans 1978, 1984). Furthermore, McNeil (1970) has shown that most North American shorebird species departing from northeastern Venezuela in northward spring migration have sufficient

energy reserves to reach the southern United States by a non-stop flight over the Caribbean.

One possible explanation for why most north-bound shorebirds bypass the Caribbean islands may be limited food supplies on Caribbean mud flats in the spring. If many Caribbean mud flats are influenced primarily by rainfall runoff, then the January–May dry season (Faaborgh et al. 1984, Wunderle 1982), when hot, dry, and extremely saline conditions prevail, may limit invertebrate populations for the spring migrants. This food limitation may be especially severe if the fall migrants seriously deplete invertebrate populations as observed in North America (Boates and Smith 1979, Lank 1983, Schneider and Harrington 1981). Once the invertebrate prey populations are depleted in the fall they may not be able to recover during the dry season, and hence remain at low levels throughout the winter and spring. Invertebrate populations may finally recover during the wet season, just as the south-bound migrants return. Consistent with this food depletion hypothesis is our observation that the two species which breed at JOBANES, Black-necked Stilt, and Wilson's Plover, disappeared during the dry season. Furthermore, rainfall influenced mud flats may be especially important to shorebirds in the Caribbean where daily vertical tidal change is usually less than 1 m (Gross 1972) and thus the area of tidal mud flat exposure is relatively small. This explanation may also account for the absence of large shorebird flocks overwintering in the Caribbean.

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