

A Rigorous Assessment of the Avifauna of a Small Caribbean Island: A Case Study in Anegada, British Virgin Islands

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ABSTRACT.—The avifauna of the British Virgin Islands (BVI) has received little attention from researchers. The lack of baseline information is therefore a major hindrance to the construction of management plans. Here we present detailed monitoring data on the species composition and numbers of each species for the island of Anegada, BVI. We surveyed the birds of Anegada between November 2003 and March 2005 utilising a combination of coastal transects, wetland bird counts, point counts, and species-specific survey methods for nocturnal species. A total of 99 different species were recorded, with a large increase in the number of species and number of individuals centred around peak migration in September. Although there is a depauperate terrestrial bird community consisting of predominately generalist species, it holds important populations of regional avifauna. For example, it hosts five regionally important breeding seabird colonies and its wetlands provide an important stop-over and over-wintering site for many species of shorebirds and waterbirds. In addition, the Eastern salt ponds are also the only breeding site for the greater flamingo, *Phoenicopterus ruber*, within the territory. We discuss our findings within the current framework of regional conservation and provide recommendations for the implementation of a territory wide monitoring program as a first step towards meeting the UK's commitments under several multilateral environmental agreements.

KEYWORDS.—birds, breeding status, conservation, salt ponds

INTRODUCTION

The Caribbean is among the most biologically diverse regions on the planet and is considered as one of the most important biodiversity "hotspots" (Myers et al. 2000). The insular Caribbean is comprised of three main island groups: Bahamas, Greater Antilles, and Lesser Antilles. Considering its relatively small land area, it nonetheless supports large numbers of endemic plant and animal species (Conservation International 2005). The birds of the insular Caribbean, represented by over 600 species and 160 of these being recorded as endemic, are a reasonably well-known and visible taxonomic group (Conservation International 2005).

Biogeographically, the British Virgin Islands (BVI) along with Puerto Rico and the US Virgin islands (excluding St Croix) form part of the Puerto Rican bank (Figure 1). This geographic feature is one of six primary Endemic Bird Areas in the insular Caribbean and as such is a priority area for conservation (BirdLife International 2003).

The birds of Puerto Rico and the US Virgin islands have been fairly well studied (Robertson 1962; Kepler 1978; Waide 1991; Latta et al. 1995; Zwartjes 2003; Dugger et al. 2004). By comparison, the bird populations of the BVI have received little attention. The published literature on BVI birds is scant and consists mainly of species sightings recorded during the annual Christmas Bird Count (National Audubon Society 2002), a locally organised activity that contributes to the USA based National Audubon Society scheme. Some early work

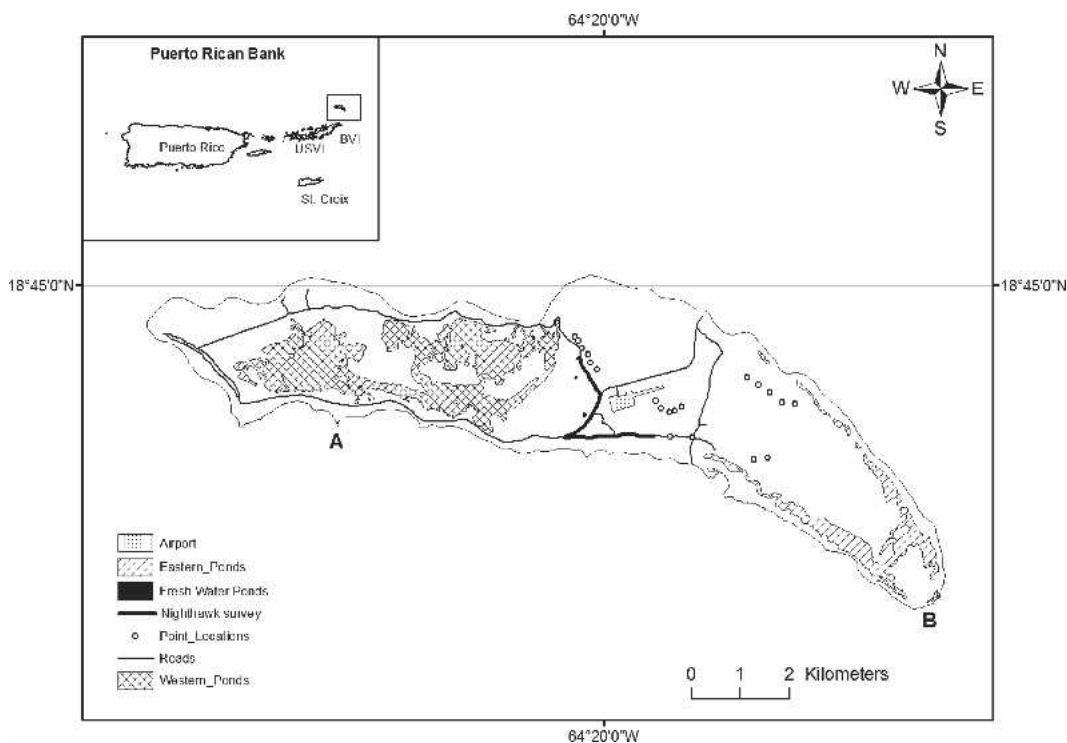


FIG. 1. Map of Anegada, British Virgin Islands highlighting the most salient features of the island and the survey areas.

by LaBastille and Richmond (1973), Norton (1979, 1981, 1989), and Norton et al. (1989) also consists of species sightings but gives no indication of seasonal variation in species composition or population sizes. The only detailed avian research in the BVI has been conducted on the privately owned island of Guana (Mayer and Chipley 1992; O'Connell-Rodwell et al. 2004), and like the majority of BVI avian literature, is not readily accessible.

Through utilization of several different survey techniques to assess both habitat type and the specific bird groups found in these habitats, we present detailed monitoring data on species composition and numbers of each species for the island of Anegada, BVI. The overall aims of this study are as follows; 1. present data that can be used as a reference point for future surveys; 2. allow informed decisions to be made regarding conservation, management and development; and 3. provide a basic blueprint for conducting a complete avifaunal census of a small Caribbean island.

MATERIALS AND METHODS

Study site

The island of Anegada ($18^{\circ}30'N$, $64^{\circ}30'W$) is the second largest island in the BVI archipelago and is the northern-most and eastern-most island of the Greater Antilles (Figure 1). It is an emergent coral limestone platform rising to a maximum altitude of 8m and is unique in being the only non-volcanic island in the territory (BVI 1993). Approximately 38 km^2 in area, Anegada is mainly covered in xerophytic scrub-like vegetation (Beard 1949) as well as large areas of salt pond (7.3 km^2). The Western Salt Ponds of Anegada, those salt ponds west of $64^{\circ}20'W$ (Figure 1), were designated a Ramsar site in 1999 (Western Salt Ponds of Anegada; The Ramsar Convention on Wetlands, 2003). Despite its size, there are only ca. 250 people currently inhabiting the island and it has seen very little development to date. The relatively undeveloped nature and large amount of

wetland make it the ideal place to begin detailed surveys within the BVI.

Bird census methods

The avifauna of Anegada was surveyed periodically from November 2003 to May 2005. A variety of survey techniques were used, including coastal line-transects, wetland surveys, and terrestrial point counts (see below for specific details of each). In total, 69 person-days were expended conducting the surveys. Additional bird species that had not previously been recorded during the specific surveying regimes but were encountered opportunistically during the course of other research were noted and included in the species list for the island. Species were confirmed as breeding on Anegada if one of the following was observed: 1. mating behaviour, 2. nest building, 3. active nests, or 4. recently fledged chicks.

Coastal transects and wetland surveys were carried out between 07:45 and 18:30 hours and were used to assess seabirds (Sulidae, Pelecanidae, Fregatidae, Laridae and Sternidae), shorebirds (Haematopodidae, Recurvirostridae, Charadriidae, and Scolopacidae), and waterbirds (Podicipedidae, Ardeidae, Phoenicopteridae, Anatidae, and Rallidae). All surveys took place on clear days with high visibility. Sampling was temporarily suspended during any brief periods of inclement weather.

Coastal transects

During each bout of fieldwork, which took place from May 2004 to March 2005, every effort was made to twice survey the western and northern coastline between points A and B (Figure 1). However logistical constraints sometimes made this impossible. This particular portion of the coastline was chosen for the study because it could be easily surveyed on foot. By contrast, the remaining section of coastline on the southern side of the island would have required the use of a boat. During each survey, the area extending 50 m from either side of the shoreline was examined and a record was made for number of individuals of each species of sea, shore and waterbird.

Surveying continued until transects for that day were complete. The only exceptions to this occurred on days when light/weather conditions deteriorated to the point when visible identification was not possible. In order to minimise any potential bias due to double counting, birds were only recorded when their position relative to the observer (AMcG) was opposite to his direction of travel.

Wetland surveys

As the salt and fresh water wetlands of Anegada differ hugely in their size (surface area of saltwater ponds = 7.3 km²; surface area of freshwater ponds = 0.07 km²), a different approach was used to survey each pond type.

The three freshwater ponds were surveyed by approaching a pond and waiting for 5 minutes to elapse before recording the number of individuals of each wetland bird species present in the following 10 minute period. If numbers were so large that the time spent counting all the individuals present exceeded 10 minutes, counting continued until all birds had been accounted for.

The salt pond surveys consisted of circumnavigating the perimeter of a given salt pond and recording the number of individuals of each wetland bird species encountered on the shoreline and on the water. Surveying continued until an entire pond had been completely circumnavigated. Again, an exception to this occurred in the event that light/weather conditions had deteriorated to the point that visible identification was not possible. As with the coastal transects, birds were only recorded when their position relative to the observer (AMcG) was opposite to his direction of travel.

Point counts

Point counts are widely used as a census technique in ornithological research, particularly for studying passerines (Gibbons et al. 1996; Greenwood 1996). Recently, however, alternative methods have been shown to provide better diversity estimates (Watson 2003, 2004). However, given our

logistical constraints, terrestrial bird populations were assessed via point-counts conducted at 20 sites. Each point was at least 100m from a major edge and the selection of points was based upon a combination of their being within an area that was both representative of the surrounding habitat and relatively easily accessible. All point counts took place within the xerophytic scrub. This was considered to be a single uniform habitat. Each point was visited five times between 20 May 2004 and 3 March 2005. All point counts were initiated between 0545 and 0830 hours. Upon reaching a count station, 5 minutes were allowed to elapse before undertaking a 10-minute count of all individuals of all species heard and/or seen. The radial distance from the point to the location at which each individual was first detected was allocated to one of the following two distance bands radiating out from the point: ≤ 40 m or >40 m. For analytical purposes, the outer limit of the >40 m band was taken as 100 m; it is unlikely that any birds were recorded at greater distances than this. Counts stopped when 10 minutes had elapsed. All records were of individuals rather than clusters. Estimates of density for all the species recorded during point counts were determined by first calculating a mean for each species per point location and then inputting the calculated mean values into Equation 1 to gain density estimates (Henderson 2003).

Equation 1:

$$\text{Density} = \ln(N / N_2) N / (n\pi r^2)$$

where N = the total number of birds recorded, N_2 = the total number of birds recorded in the >40 m band, n = number of point locations, r = radius of the point. Density estimates could not be calculated for species that were only recorded on a single occasion. Those species that were only recorded in the airspace above the point were also excluded (Hutto et al. 1986).

Surveys for nocturnal species

The above sampling regimes were unlikely to record any of the nocturnal species

that could potentially be present on Anegada. Antillean nighthawk, *Chordeiles gundlachii*, were surveyed on a single occasion (i.e., 18 May 2005) by slowly cycling a 3.8km transect (Figure 1) consisting of paved road and dirt track. This was conducted at dusk and the methodology recorded the number of calling individuals. This date coincided with the period when the nighthawks were most vocal and undertaking territorial aerial displays. With the aim of recording number of response calls, we targeted West Indian whistling-duck, *Dendrocygna arborea*, and Puerto Rican screech-owl, *Otus nudipes*, by opportunistic nocturnal playback of calls in areas of suitable habitat. This occurred at various locations throughout the island.

Statistical analysis

In order to predict the total avian diversity on Anegada, we estimated species richness for each habitat type by fitting a hyperbolic equation to the cumulative total number of species recorded (Equation 2). For avian diversity of the island as a whole, we also used the presence or absence of a species during a sampling period. This followed the method developed by Chao (Equation 3). For a full description and relevant discussion of these techniques, we refer the reader to Soberon and Llorente (1993) and Colwell and Coddington (1994) and references therein.

Equation 2:

$$y = S_{\max} x / b + x$$

where $S_{\max}$ and b are fitted positive constants.

Equation 3:

$$S_{\max} = S_{\text{obs}} + (a^*a / 2b)$$

where a = the number of species only found in one sample, b = the number of species only found in two samples, and S_{obs} = the total number of species recorded.

For all results means $\pm$ standard errors

(s.e.) are presented throughout unless otherwise stated.

RESULTS

A total of 99 species were recorded over the seven sampling periods (Table 1). As expected, the number of new species recorded fell over successive sampling periods (Figure 2). Cumulative species data gave an asymptotic estimate of avian species richness of 105 species (Figure 2). Using the presence or absence of a species during a sampling period (Chao estimate, see methods) gave an estimate of species richness of 125 ($S_{obs} = 99$, $a = 25$, and $b = 12$). Of the 99 species recorded on Anegada, 31 species were confirmed as breeding while an additional two species were suspected of breeding (Table 2). Eight of the 31 confirmed breeding species were migratory breeders with Antillean nighthawk, being the only non-seabird species. The remaining 23 confirmed breeding species (Table 2) are all year round residents on Anegada.

Coastal transects

In total, 10 coastal surveys were carried out between May 2004 and March 2005 (Table 3) with a mean number of days to complete a coastal survey = $2.9 (\pm 0.3)$ days. The distance covered during each coastal transect was 24.8 km. An exception was the first survey conducted in May 2004, in which the distance covered was 17.8 km. Overall, 35 bird species totalling 4496 individuals were recorded. The temporal variation in the total number of bird species recorded in each of the coastal transects is shown in Figure 3a. The species composition recorded during transects was highly variable, with some species always being present while others were recorded only once (Table 3). Several shorebird species, such as Bairds sandpiper *Calidris bairdii*, least sandpiper *Calidris minutilla*, piping plover *Charadrius melodus*, and white-rumped sandpiper *Calidris fuscicollis* were only recorded during the September and October surveys. This was also the case for the seabird species black tern *Chlidonias ni-*

ger, brown noddy *Anous stolidus*, and herring gull *Larus argentatus*.

Wetland surveys

Over the course of the study the freshwater ponds were surveyed on 21 occasions and the saltwater ponds on five occasions. In total, 27 species were recorded at the freshwater ponds (Table 4) whereas 44 species were observed on the saltwater ponds (Table 5). Three species were recorded only at the freshwater ponds, 20 species were unique to the saltwater ponds, and 24 species were detected in both habitat types. The temporal variation in the number of species recorded in each of the pond systems is shown in Figure 3b-d. Of the 44 species recorded on the saltwater ponds seven species were found only on the Eastern Ponds and three species only on the Western Ponds. The remaining 34 species were recorded in both salt pond systems.

Across the season, there were large fluctuations in the number of species and in the number of individual birds recorded on the freshwater ponds. A peak occurred in September (Table 4). However, both saltwater pond systems were much more consistent in the number of species recorded during surveys (Table 5), with the mean number of species recorded per survey being 23 ± 1.1 and 23.8 ± 0.9 species for the Eastern and Western Ponds respectively. The total number of birds recorded per survey was also similar between both salt pond systems (Eastern Ponds: mean = 1066 ± 266 birds, range: 280 – 1842; Western Ponds: mean = 1391 ± 140 birds, range: 937 – 1606). A comparison of the asymptotic values of the species accumulation curves indicates that total species richness is greater in the Eastern salt ponds (predicted asymptote = 63 species) than in the Western salt ponds (predicted asymptote = 47 species) (Figures 3c-d).

Point counts

In total, 100 point counts were conducted, with each of the 20 point locations being surveyed 5 times and the mean dis-

TABLE 1. The bird species recorded on Anegada, British Virgin Islands between December 2003 and March 2005. x = presence during a sampling period.

	Sampling period						
Species	Dec 03	Feb 04	May 04	Jul 04	Sep 04	Dec 04	Feb 05
Pied-Billed Grebe							
Podilymbus podiceps	x						
Brown Pelican							
Pelecanus occidentalis	x	x	x	x	x	x	x
Magnificent Frigatebird							
Fregata magnificens	x	x	x	x	x	x	x
Brown Booby							
Sula leucogaster	x	x	x	x	x	x	x
American Bittern							
Botaurus lentiginosus	x						
Great Blue Heron							
Ardea herodias	x	x				x	x
Great Egret							
Ardea Alba	x				x	x	x
Snowy Egret							
Egretta thula	x						
Tricolored Heron							
Egretta tricolor	x						
Little Blue Heron							
Egretta caerulea	x	x			x	x	x
Cattle Egret							
Bubulcus ibis	x	x	x	x	x	x	x
Green Heron							
Butorides virescens		x	x	x	x		x
Yellow-crowned Night Heron							
Nyctanassa violacea				x	x		
Greater Flamingo							
Phoenicopterus ruber	x	x	x	x	x	x	x
Northern Pintail							
Anas acuta	x						
American Wigeon							
Anas americana		x				x	
Blue-winged Teal							
Anas discors	x	x			x	x	x
Green-Winged Teal							
Anas crecca	x	x					x
White-cheeked Pintail							
Anas bahamensis	x	x	x	x	x	x	x
Ring-necked Duck							
Aythya collaris	x	x					
Lesser Scaup							
Aythya affinis	x	x					
Northern Harrier							
Circus Cyaneus						x	x
Osprey							
Pandion haliaetus	x	x	x	x	x	x	x
Merlin							
Falco columbarius	x				x	x	x
American Kestrel							
Falco spavarius	x	x	x	x	x	x	x
Peregrine Falcon							
Falco peregrinus	x		x		x	x	x
American Coot							
Fulica americana	x					x	

TABLE 1. Continued.

Species	Sampling period						
	Dec 03	Feb 04	May 04	Jul 04	Sep 04	Dec 04	Feb 05
Sora							
<i>Porzana carolina</i>	x	x				x	x
Black-bellied Plover							
<i>Pluvialis squatarola</i>	x	x	x	x	x	x	x
American Golden Plover							
<i>Pluvialis dominica</i>					x		
Piping Plover							
<i>Charadrius melodus</i>					x		
Semipalmated Plover							
<i>Charadrius semipalmatus</i>	x	x	x	x	x	x	x
Snowy Plover							
<i>Charadrius alexandrinus</i>	x	x	x	x	x	x	x
Wilson's Plover							
<i>Charadrius wilsonia</i>	x	x	x	x	x	x	x
Killdeer							
<i>Charadrius vociferus</i>		x	x	x	x	x	x
American Oystercatcher							
<i>Haematopus palliatus</i>	x	x	x	x	x	x	x
Black-necked Stilt							
<i>Himantopus mexicanus</i>	x	x	x	x	x	x	
Greater Yellowlegs							
<i>Tringa melanoleuca</i>	x	x	x	x	x	x	x
Lesser Yellowlegs							
<i>Tringa flavipes</i>	x	x	x	x	x	x	x
Solitary Sandpiper							
<i>Tringa solitaria</i>					x		
Willet							
<i>Catoptrophorus semipalmatus</i>			x	x	x	x	x
Spotted Sandpiper							
<i>Actitis macularia</i>		x		x	x	x	
Whimbrel							
<i>Numenius phaeopus</i>	x	x	x	x	x	x	x
Ruddy Turnstone							
<i>Arenaria interpres</i>	x	x	x	x	x	x	x
Knot							
<i>Calidris canutus</i>		x	x			x	x
Sanderling							
<i>Calidris alba</i>	x	x	x	x	x	x	x
Pectoral Sandpiper							
<i>Calidris melanotos</i>			x		x		
White-rumped Sandpiper							
<i>Calidris fuscicollis</i>					x		
Bairds Sandpiper							
<i>Calidris bairdii</i>					x		
Western Sandpiper							
<i>Calidris mauri</i>	x	x	x	x	x	x	x
Semipalmated Sandpiper							
<i>Calidris pusilla</i>	x	x	x	x	x	x	x
Least Sandpiper							
<i>Calidris minutilla</i>	x	x	x	x	x	x	x
Stilt Sandpiper							
<i>Calidris himantopus</i>	x	x	x	x	x	x	x
Long-Billed Dowitcher							
<i>Limnodromus scolopaceus</i>		x	x	x	x	x	

TABLE 1. Continued.

Species	Sampling period						
	Dec 03	Feb 04	May 04	Jul 04	Sep 04	Dec 04	Feb 05
Short-Billed Dowitcher							
<i>Limnodromus griseus</i>		x	x	x	x	x	
Wilsons Snipe							
<i>Gallinago delicata</i>	x			x		x	x
Laughing Gull							
<i>Larus atricilla</i>			x	x	x		
Ring-billed Gull							
<i>Larus delawarensis</i>	x						
Herring Gull							
<i>Larus argentatus</i>					x		
Royal Tern							
<i>Sterna maxima</i>	x	x	x	x	x	x	x
Sandwich Tern							
<i>Sterna sandwicensis</i>	x	x	x	x	x	x	x
Cayenne Tern							
<i>Sterna eurygnatha</i>				x			
Common Tern							
<i>Sterna hirundo</i>			x	x	x		
Least Tern							
<i>Sterna antillarum</i>			x	x	x		
Gull-billed Tern							
<i>Sterna nilotica</i>			x	x			
Black Tern							
<i>Chlidonias niger</i>					x		
Brown Noddy							
<i>Anous stolidus</i>					x		
White-winged Dove							
<i>Zenaida asiatica</i>	x	x	x	x	x	x	x
Zenaida Dove							
<i>Zenaida aurita</i>	x	x	x	x	x	x	x
Common Ground Dove							
<i>Columbina passerina</i>	x	x	x	x	x	x	x
White-crowned Pigeon							
<i>Columba leucocephala</i>			x				
Mangrove Cuckoo							
<i>Coccyzus minor</i>	x	x	x	x	x	x	x
Yellow-billed Cuckoo							
<i>Coccyzus americanus</i>						x	
Smooth-billed Ani							
<i>Crotophaga ani</i>	x	x	x	x	x	x	x
Antillean Crested Hummingbird							
<i>Orthorhyncus cristatus</i>	x	x	x	x	x	x	x
Green-Throated Carib							
<i>Eulampis holosericeus</i>	x	x	x	x	x	x	x
Belted Kingfisher							
<i>Ceryle alcyon</i>	x	x	x		x	x	
Caribbean Elaenia							
<i>Elaenia martinica</i>	x	x	x	x	x	x	x
Puerto Rican Flycatcher							
<i>Myiarchus antillarum</i>				x			
Gray Kingbird							
<i>Tyrannus dominicensis</i>	x	x	x	x	x	x	x
Black-whiskered Vireo							
<i>Vireo altiloquus</i>							x

TABLE 1. Continued.

	Sampling period						
Species	Dec 03	Feb 04	May 04	Jul 04	Sep 04	Dec 04	Feb 05
White-eyed Vireo							
<i>Vireo griseus</i>							x
Barn Swallow							
<i>Hirundo rustica</i>	x	x	x	x	x	x	x
Northern Mockingbird							
<i>Mimus polyglottos</i>	x	x	x	x	x	x	x
Pearly-eyed Thrasher							
<i>Margarops fuscatus</i>	x					x	
Antillean Nighthawk							
<i>Chordeiles gundlachii</i>			x	x	x		
Yellow Warbler							
<i>Dendroica petechia</i>	x	x	x	x	x	x	x
Magnolia Warbler							
<i>Dendroica magnolia</i>	x						
Cape May Warbler							
<i>Dendroica tigrina</i>						x	
Yellow-Rumped Warbler							
<i>Dendroica coronata</i>		x					
Prairie Warbler							
<i>Dendroica discolor</i>	x						x
Palm Warbler							
<i>Dendroica palmarum</i>	x	x					
Blackpoll Warbler							
<i>Dendroica striata</i>	x						
Northern Waterthrush							
<i>Seiurus novelboracensis</i>	x	x			x	x	x
Common Yellowthroat							
<i>Geothlypis trichas</i>	x					x	
Bananaquit							
<i>Coereba flaveola</i>	x	x	x	x	x	x	x
Indigo Bunting							
<i>Passerina cyanea</i>	x						
Boblink							
<i>Dolichonyx oryzivorus</i>						x	
Black-faced Grassquit							
<i>Tiaris bicolor</i>	x	x	x	x	x	x	x
House Sparrow							
<i>Passer domesticus</i>		x	x	x	x	x	x

tance between points = 2.01 ± 0.09 km (range = 0.10 – 4.48 km; $n = 190$ inter-point distances). Overall, 34 species were recorded during point counts (Table 6). Of these, 11 were recorded in $\geq 80\%$ of all point locations. Density estimates were calculated for 18 of the species recorded while 16 species were omitted due to either single observations or to the species having been only recorded in the airspace above the point. The highest density estimates were for bananaquit, *Coereba flaveola*, and black-

faced grassquit, *Tiaris bicolor*. The lowest estimates were for killdeer, *Charadrius vociferus*, and black-whiskered vireo, *Vireo altiloquus* (Table 6).

Nocturnal species

Nine calling Antillean nighthawks were recorded along the road transect. We surveyed for West Indian whistling-duck and Puerto Rican screech-owl in all survey periods across the island with a mean number

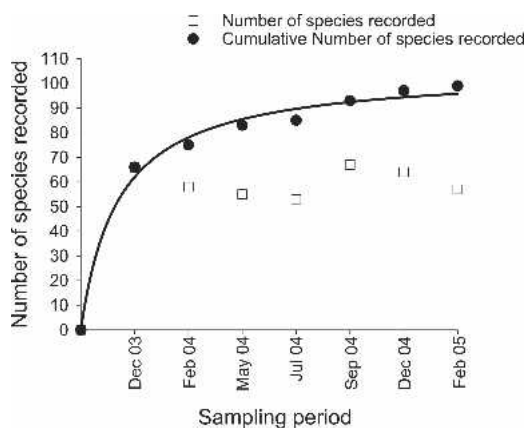


FIG. 2. The number of species recorded per sampling period and the cumulative total number of species recorded from December 2003 to March 2005 on Anegada, BVI.

of nights with playback per survey = 2.6 ± 0.4 . There were no responses to the playback calls of either species.

DISCUSSION

Coastal transects

The coastal bird community on Anegada consisted mainly of year round resident species that breed, such as American oystercatcher *Haematopus palliatus* and snowy plover *Charadrius alexandrinus*, coupled with species that are resident in the British Virgin Islands but do not breed on Anegada, such as brown booby *Sula leucogaster*, brown pelican *Pelecanus occidentalis*, and royal tern *Sterna maxima*. The coastal bird community was supplemented by migrant breeders, such as laughing gull *Larus atricilla* and least tern *Sterna antillarum*, during the spring and summer months and by migratory shorebirds during the autumn and winter months. However, some shorebird species, such as ruddy turnstone *Are-naria interpres*, sanderling *Calidris alba*, and spotted sandpiper *Actitis macularia* were recorded during every survey throughout the calendar year even though their breeding grounds are the high arctic and North America (Hayman *et al.* 1995). In any population there are always a proportion of individuals that do not breed and this is

probably the reason why many of the species that do not breed on Anegada were recorded year round.

Fresh and saltwater ponds

Many of the same species that were recorded on the freshwater ponds were also recorded on the saltwater pond systems. Still, there were three species exceptions, belted kingfisher *Ceryle alcyon*, solitary sandpiper *Tringa solitaria*, and sora *Porzana carolina*, were found only on the freshwater ponds. However, there were large differences in the number of individuals recorded and these probably reflect the amount of available habitat as the saltwater ponds have a surface area 10000 times larger than the freshwater ponds. Nearly twice as many bird species were recorded at the saltwater opposed to freshwater ponds, with over 50% of the additional species being shorebirds. This difference probably reflects both available habitat with a far greater area of shallow edge available and certain shorebird species having a preference for saline environments. It is worth noting that clapper rail, *Rallus longirostris*, was not recorded during any of the wetland surveys even though it has been recorded on Anegada in the past (Norton 1989) and occurs with regularity on other islands in the BVI (AMcG pers obs).

All of the breeding wetland species were confined to the salt ponds. The only breeding wetland species that was not recorded as a year round resident on Anegada was the willet *Catoptrophorus semipalmatus*, whose numbers increased noticeably at the onset of the breeding season in May.

Of the six species of seabird that were recorded breeding on Anegada, five species have not been recorded breeding elsewhere in the BVI archipelago, the laughing gull being the one exception (Schreiber and Lee 2000 and references therein). There are approximately 200-250 pairs of laughing gull, 60-70 pairs of least tern, 20-25 pairs of sandwich tern *Sterna sandvicensis*, 2-4 pairs of gull-billed tern *Sterna nilotica*, common tern *Sterna hirundo*, and cayenne tern *Sterna eu-rygnatha*. Application of the Birdlife Inter-

TABLE 2. The bird species recorded breeding on Anegada, British Virgin Islands between December 2003 and March 2005 with notes on their status.

Species	Resident	Migrant	Notes
Cattle Egret	✓		Suspected but not confirmed
Green Heron	✓		Suspected but not confirmed
Yellow-crowned Night Heron	✓		
Greater Flamingo	✓		18 introduced 1992 ¹
White-cheeked Pintail	✓		
American Kestrel	✓		
Snowy Plover	✓		
Wilson's Plover	✓		
Killdeer	✓		
American Oystercatcher	✓		
Black-necked Stilt	✓		
Willet		✓	
Laughing Gull		✓	Regionally important population ²
Sandwich Tern		✓	Regionally important population ²
Cayenne Tern		✓	
Common Tern		✓	Regionally important population ²
Least Tern		✓	Regionally important population ²
Gull-billed Tern		✓	Regionally important population ²
White-winged Dove	✓		
Zenaida Dove	✓		
Common Ground Dove	✓		
Mangrove Cuckoo	✓		
Smooth-billed Ani	✓		
Antillean Crested Hummingbird	✓		Restricted range species ³
Green-Throated Carib	✓		Restricted range species ³
Caribbean Elaenia	✓		
Gray Kingbird	✓		
Northern Mockingbird	✓		
Antillean Nighthawk		✓	Biome restricted species ³
Yellow Warbler	✓		
Bananaquit	✓		
Black-faced Grassquit	✓		
House Sparrow	✓		

¹Lazell (2002, 2005).²McGowan et al. (2006a).³Birdlife International (2003).

national criteria for assessing a globally significant colony at a regional (Caribbean) level indicates that Anegada has five regionally important seabird colonies with only cayenne tern not exceeding the 1% threshold limit (McGowan et al 2006a). There are also a large number of royal terns, sandwich terns, brown boobies, and brown pelicans that spend the winter months on Anegada. Therefore, Anegada is almost certainly one of the most important islands for breeding seabirds in the BVI and possibly in the Greater Antilles.

The other breeding wetland species included american oystercatcher, black-

necked stilt *Himantopus mexicanus*, greater flamingo *Phoenicopterus ruber*, killdeer *Charadrius vociferus*, snowy plover, white-cheeked pintail *Anas bahamensis*, Wilsons plover *Charadrius wilsonia*, and yellow-crowned night heron *Nyctanassa violacea*, which breed on Anegada in various small numbers. Anegada is renowned locally for its breeding population of greater flamingos, 18 birds having been reintroduced in 1992 (Lazell 2002, 2005) following extirpation in the 1950's due to hunting (Colli 1996). Our current estimate of the population was 102 birds, including 24 chicks, that were successfully reared in 2004. Within

TABLE 3. The species and number individuals recorded during coastal transects on Anegada, British Virgin Islands between May 2004 and March 2005.

Species	Survey									
	May 04	May 04	Jul 04	Jul 04	Sep 04	Oct 04	Nov 04	Dec 04	Feb 05	Mar 05
American Oystercatcher	2	2	6	2		4	2	2	2	2
Bairds Sandpiper					1					
Black Tern					1					
Black-bellied Plover	3	8	2	14	8	5	6	79	2	15
Brown Booby	11						6	2	10	2
Brown Noddy					1					
Brown Pelican	25	20	25	10	103	84	43	37	32	43
Cayenne Tern				2						
Common Tern				1	60	40				
Great Blue Heron							1			
Greater Flamingo		13								
Green Heron		1		1						
Gull-billed Tern				1						
Herring Gull					3	1				
Laughing Gull	49	35	46	63	118	60				
Least Sandpiper					6	4				
Least Tern	7	16	30	28	28	1				
Lesser Yellowlegs					2					
Magnificent Frigatebird			1	2	6	2				
Piping Plover					1					
Royal Tern	9	3	3	12	41	37	9	7	12	12
Ruddy Turnstone	11	16	2	12	108	126	48	44	32	52
Sanderling	6	3	12	1	126	89	141	69	75	124
Sandwich Tern	10	41	53	194	418	230				
Semipalmated Plover				1	99	67	30	34		43
Semipalmated Sandpiper			2		19	14		105		76
Snowy Plover	5	9	11	6	82	59	76	34	8	25
Spotted Sandpiper				7	10	6	1		1	
Stilt Sandpiper		1								
Western Sandpiper										5
Whimbrel			3	8						
White-cheeked Pintail			4		2					
White-rumped Sandpiper						1				
Willet	1	2	4	9						
Wilsons Plover	1		2	28	12	6	14	44	47	33
Transect distance (km)	17.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8	24.8
Total number of species	13	14	16	20	23	19	12	11	10	12
Number of species per km	0.7	0.6	0.6	0.8	0.9	0.8	0.5	0.4	0.4	0.5
Total number of birds	140	170	206	402	1255	836	377	457	221	432
Number of birds per km	7.9	6.9	8.3	16.2	50.6	33.7	15.2	18.4	8.9	17.4

the saltwater pond systems, the Eastern and Western salt ponds were fairly equal both in species richness and numbers of birds. However, the Western salt ponds are a Ramsar site and are approximately three times larger (surface area Western salt ponds = 5.6 km², surface area Eastern salt ponds = 1.7 km²). Clearly, the density of birds is substantially higher on the Eastern

ponds. The Eastern salt ponds are also the preferred breeding location of the island's greater flamingo population. Consequently, it would appear that the Eastern salt pond system should be granted a similar level of protection and, in order to provide national designation with supporting legislation to ensure the conservation of these important wetlands, both salt pond

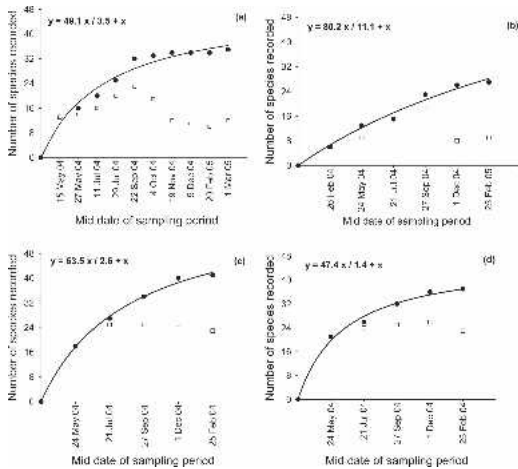


FIG. 3. The number of species and the cumulative total number of species recorded during (a) coastal transects, and surveys of (b) freshwater ponds (c) Eastern saltwater ponds and (d) Western saltwater ponds. ● = cumulative total number of species, □ = number of species recorded per survey

systems have recently been proposed as national parks.

Terrestrial scrub

There is a depauperate terrestrial bird community on Anegada consisting of predominately generalist species such as the northern mockingbird *Mimus polyglottos* (Table 1). This probably reflects a lack of diversity in the terrestrial habitat. Despite this, some terrestrial species appear to be present in relatively high densities (Table 5). However, this may be attributable to some biases in our estimates that result from the inquisitive nature of certain species (e.g. bannaquit). Anegada appears to have a core group of resident passerines (i.e. Gray kingbird *Tyrannus dominicensis*), that are supplemented by migrants during the breeding season (i.e. Antillean Night-hawk), and during the autumn and winter months by North American migrants. Northern waterthrush *Seiurus noveboracensis* appears to be the only migrant that over winters on Anegada in any significant numbers. It can be readily recorded at most areas where mangroves fringe open water. The other North American warbler species detected during our surveys were sightings

of individual birds on just one or two occasions during either the peak migration months of September and October or in the winter. Notably, however, large falls of migrant warblers have been observed in the past (C. Petrovic pers comm). In the case of small passerines, it is extremely difficult to ascertain their actual diversity and numbers passing through Anegada on migration without conducting a constant effort mist-netting study. Anegada may prove to be a regular stopover site for many migrating passerines. As Anegada is very different in topography from the other islands in the BVI, it would be very useful to conduct similar studies elsewhere in the archipelago to compare the diversity and abundance of over-wintering passerines.

Seasonality

Anegada functions as both a breeding and over-wintering location for a wide variety of bird species. However, as a result of its location at the outer edge of the archipelago and its large permanent wetlands, Anegada is most important as a passage/over-wintering site for a wide variety of shorebirds and waterbirds that breed in North America. Peaks in the number of wetland species and individuals of each species were observed during September (Tables 4, 5, Figures 3a-d), which coincided with the onset of the wet season and autumn migration. It is exceptionally difficult to try to gain an estimate of the total numbers of migrant shorebirds utilising Anegada without mark-recapture studies to calculate turnover rates. However, we suspect that Anegada could be very important for migratory shorebirds. It is interesting to note that the large increase in numbers and species is not reflected in the spring migration. This could be due to our sampling regime and we may have missed the main spring migration if it occurred between mid March and late April. Alternatively, many bird species may not stop-off as often during spring migration because birds that arrive earlier on the breeding grounds tend to have higher breeding success (Drent et al. 2003). Anegada clearly functions as a wintering site as well as a stop-over site for

TABLE 4. The seasonal change in the mean number of each bird species $\pm$ s.e. recorded during a 10 minute observation period of the freshwater ponds on Anegada, BVI between February 2004 and March 2005.

Species	Mid date of sampling period					
	26 Feb 04	24 May 04	21 Jul 04	27 Sep 04	01 Dec 04	25 Feb 05
American Coot					0.5 $\pm$ 0.5	
Belted Kingfisher				0.2 $\pm$ 0.2		
Black-necked Stilt		1.2 $\pm$ 0.5	1.0 $\pm$ 0.4	6.4 $\pm$ 3.5	10.0 $\pm$ 7.1	
Blue-winged Teal	16			5.6 $\pm$ 2.7	4.2 $\pm$ 3.6	9.0 $\pm$ 8.0
Cattle Egret		0.5 $\pm$ 0.5	2.0 $\pm$ 1.8	0.6 $\pm$ 0.4		1.5 $\pm$ 1.5
Great Blue Heron	1					1.0 $\pm$ 1.0
Greater Yellowlegs		0.2 $\pm$ 0.2	0.2 $\pm$ 0.2	4.0 $\pm$ 1.4	0.2 $\pm$ 0.2	1.0 $\pm$ 1.0
Green Heron						0.5 $\pm$ 0.5
Gull-billed Tern		0.5 $\pm$ 0.5	0.8 $\pm$ 0.8			
Killdeer			0.6 $\pm$ 0.2	0.6 $\pm$ 0.4		
Laughing Gull		5.2 $\pm$ 2.2	4.8 $\pm$ 1.9	2.2 $\pm$ 1.1		
Least Sandpiper				9.6 $\pm$ 6.2		
Lesser Yellowlegs	5	0.5 $\pm$ 0.5	0.6 $\pm$ 0.4	6.6 $\pm$ 3.9	2.0 $\pm$ 0.9	3.0 $\pm$ 1.0
Little Blue Heron				0.2 $\pm$ 0.2		
Long-billed Dowitcher	1					
Magnificent Frigatebird		0.2 $\pm$ 0.2		0.2 $\pm$ 0.2		
Pectoral Sandpiper				0.2 $\pm$ 0.2		
Semipalmated Plover				0.6 $\pm$ 0.4		
Semipalmated Sandpiper				28.2 $\pm$ 16.9		
Solitary Sandpiper				1.6 $\pm$ 1.0		
Sora					0.2 $\pm$ 0.2	1.5 $\pm$ 0.5
Spotted Sandpiper			1.0 $\pm$ 0.8	1.4 $\pm$ 0.7		
Stilt Sandpiper	1			4.4 $\pm$ 3.7		
White-cheeked Pintail	18	0.7 $\pm$ 0.2	17.4 $\pm$ 3.9	14.0 $\pm$ 5.6	4.2 $\pm$ 3.1	3.0 $\pm$ 3.0
White-rumped Sandpiper				0.2 $\pm$ 0.2		
Willet		0.5 $\pm$ 0.3				
Wilsons Snipe					1.0 $\pm$ 1.0	0.5 $\pm$ 0.5
Total number of surveys	1	4	5	5	4	2
Total number of species	6	9	9	19	8	9
Total number of birds	42	39	142	434	90	42

some North American shorebirds. As evidence of this, individually colour banded ruddy turnstones and sanderlings from Delaware Bay were re-sighted continually throughout the winter months in 2003/04 and 2004/05.

Threatened species

We had expected to encounter the globally threatened West Indian whistling-duck due to Anegada's extensive and remote saltwater pond systems with large tracts of mangroves. However, similar studies in the Turks and Caicos Islands also

found that West Indian whistling-duck was absent on some large, uninhabited islands that have vast wetlands on them (Hilton et al. 2000ab). This may be due to the presence of mammalian predators or the lack of suitable crop fields for foraging (L. Sorenson pers. comm.). On this point there has been an astonishing improvement in the fortunes of West Indian whistling-duck after rat eradication on some islets off the coast of Antigua (Daltry et al. 2001). Any plans for the re-introduction of the West Indian whistling duck would need to conduct a series of evaluations to try and discern why this species is currently absent and whether it actually ever occurred on Anegada in the past.

TABLE 5. The total number of each bird species recorded during the wetland surveys carried out on Anegada, BVI between May 2004 and March 2005.

Species	Eastern Salt Ponds Survey					Western Salt Ponds Survey				
	May 04	Jul 04	Sep 04	Dec 04	Feb 05	May 04	Jul 04	Sep 04	Dec 04	Feb 05
American Coot				2						
American Golden Plover								15		
American Wigeon				2						
Black-bellied Plover	10	8	25	61	94	9	9	36	73	107
Black-necked Stilt	22	50	46	1		45	87	37	15	2
Blue-winged Teal			124	219	96			6		13
Brown Pelican	1	2	1	15	30					5
Cattle Egret	2	14	12				3			
Common Tern	2									
Great Blue Heron				9	9				20	20
Great Egret			3	7				1	1	
Greater Flamingo	60	20				16	58	122	98	91
Greater Yellowlegs	2	45	77	44	24	13	2	101	76	14
Green Heron			1							
Green-winged Teal					5					
Gull-billed Tern		1					1			
Killdeer				1	11					
Knot				15	50				2	
Laughing Gull	39	22	5			206	534	1		
Least Sandpiper	0	1	84	31	32	3	69	115	99	194
Least Tern	28	161				176	165			
Lesser Yellowlegs		154	152	72	89	15	9	113	64	63
Little Blue Heron								1	2	
Long-billed Dowitcher		4				12	3		2	
Magnificent Frigatebird		1			31				3	24
Pectoral Sandpiper		1				1		5		
Royal Tern	6	7	7		5				14	
Ruddy Turnstone	7		12	18	127	13	5	15	49	36
Sanderling			4	7	99	5	16	3	41	91
Sandwich Tern	12	90	58		29	25	1		1	
Semipalmated Plover			99	28	26	37	51	82	85	105
Semipalmated Sandpiper	15	35	621	57	200	209	126	709	887	364
Short-billed Dowitcher								39		
Snowy Plover	4	7	3	2		19	43	21	20	6
Spotted Sandpiper		5	13	2	1		2	33	2	5
Stilt Sandpiper		4	339	419	282		13	35	147	113
Western Sandpiper		9				9	1			39
Whimbrel	7	6	15	12	11		1	23	28	9
White-cheeked Pintail	6	16	80	52	36	50	41	22	11	14
White-rumped Sandpiper			12					2		
Willet	6	10				11	9	4	1	3
Wilsons Plover	51	61	46	51	57	56	78	65	13	42
Wilsons Snipe				1	1				1	1
Yellow-crowned Night Heron			3							
Total number of species	19	25	25	24	23	21	24	25	26	23
Total number of birds	280	734	1842	1128	1345	937	1327	1606	1755	1361

There are 2 restricted range species that inhabit Anegada. These include the green-throated carib *Eulampis holosericeus* and Antillean-crested hummingbird *Orthorhynchus*

cristatus, both of which seem to be present in healthy numbers and are easily observed all over the island. The near-threatened piping plover was recorded during the Sep-

TABLE 6. The density estimates for each of the species recorded during point counts carried out on Anegada, BVI between May 2004 and February 2005.

Species	Percentage of point locations species recorded	Density estimate per km ²
Bananaquit	100	2045.9
Black-faced Grassquit	100	743.0
Caribbean Elaenia	95	359.8
Yellow Warbler	95	232.7
Antillean Crested Hummingbird	75	199.4
Green-throated Carib	65	164.3
Common Ground Dove	90	155.4
Northern Mockingbird	100	144.3
Gray Kingbird	95	103.8
House Sparrow	10	72.5
Smooth-billed Ani	90	54.0
Zenaida Dove	80	41.6
Mangrove Cuckoo	80	29.4
White-winged Dove	95	23.4
Black-necked Stilt	10	9.1
American Kestrel	55	6.6
Black-whiskered Vireo	10	2.8
Killdeer	15	2.1

Birds only recorded in the airspace overhead and single observations during all point counts are not included.

tember 2004 surveys and is thought to regularly use Anegada as a stop-over location (C. Petrovic pers comm).

Threats

There are several threats that currently face the avifauna of Anegada. Ground nesters such as the small shorebirds, small seabirds, and the Antillean nighthawk are at risk from introduced predators such as feral cats and rats (*Rattus* sp), both found in Anegada. The fact that these birds are still breeding suggests that Anegada may be functioning as a sink (or ecological trap) for some bird species. However, in the absence of breeding success data this is unconfirmed. There has been a proposal for the implementation of a cat and rat eradication programme with regards to the conservation of the critically endangered Anegada Rock Iguana, *Cyclura pinguis*. This could only prove beneficial to Anegada's bird populations. Irrespective of whether the eradication program goes ahead or not, future monitoring founded on our baselines will be informative as to the ongoing status of this animal group.

Development and tourism have risen in

the BVI in recent times. Between 1999 and 2003 the number of people visiting the BVI increased by an average of 43,362 visitors per year and from 484,156 to 657,505 visitors in total for these years. In addition, approximately 33% of all visitors utilise the charter boat industry (BVI Government 2005). The increased number of tourists visiting Anegada most likely reflects the trends seen over the BVI as a whole. Although development in Anegada has been very limited to date there will undoubtedly be more development pressure in the near future. A moderate level of development would not detrimentally affect all the birds of Anegada as it is not anticipated that the two restricted-range hummingbird species would suffer any decreases in population size. Indeed, they seem to thrive on the flowers that hotels and other residences plant in the surrounding gardens. Ultimately, any future development will occur on the coast and should, in terms of maintaining bird diversity, be directed away from the salt ponds, especially the Eastern examples (McGowan et al. 2006b). It would be advisable to restrict access to the salt ponds during the main breeding season (May-Aug) and hence reduce the distur-

bance to the breeding seabird colonies and wader populations because disturbance can cause desertion of adults, which translates into chick mortality (Del Viego et al. 2004). We refer the reader to McGowan et al. 2006b for a full list of recommendations for all major taxonomic groups on Anegada.

There are still large tracts of relatively high-quality bird habitat left in Anegada. The wetlands are very important for breeding seabirds and host regionally significant breeding populations of laughing gull, sandwich tern, gull-billed tern, common tern, and least tern. It is the only location in the BVI where four of these regionally important seabird species breed (McGowan et al. 2006a). Anegada's wetlands are also the only breeding location of greater flamingo within the territory. In addition, the island provides a staging area for many passerine, shorebird, and waterbird species during migration, with many individuals also over-wintering. At present, bird populations are not subject to any concerted monitoring or management in the BVI and current protective legislation is outdated and insufficient. We fully recommend that the BVI seek funding in order to implement the UK governments Multilateral Environmental Agreements (MEA's) with systematic monitoring established as soon as possible. We further suggest that government agencies begin with the most important seabird colonies highlighted here and in McGowan et al. (2006a).

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