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OBSERVATIONS ON THE ABUNDANCE, SITE PERSISTENCE, HOME RANGE, FORAGING, AND NESTING OF THE PINE WARBLER ON HISPANIOLA, AND FIRST RECORD OF GROUND NESTING FOR THIS SPECIES

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Abstract. We studied the permanent resident Pine Warbler (*Dendroica pinus*) from October-April 1996–1997 and 1997–1998 in high-elevation Hispaniolan pine (*Pinus occidentalis*) forests of the Sierra de Bahoruco in the Dominican Republic. Using individually color-banded birds, fixed-radius point counts, and extensive behavioral observations, we present some of the first quantified information on abundance, site persistence, home range size, foraging behavior, and nest site characteristics of this species. We recorded a high density of Pine Warblers in the Bahorucos, and site persistence was high both within the same winter (87.5%) and between years (62.5%). Home ranges were large (mean = 3.06 ha) and partially overlapping. Birds typically foraged by gleaning pine needles and branches. Five arboreal nests averaged 8.0 m (SD = 4.3) off the ground and 1.0 m (SD = 1.4) from the trunk of pine trees, but there was considerable variation in nest placement. We also describe the first ground nest reported for this species. Data are compared to the few data available from other island sites, the Bahamas and North America. *Accepted 23 November 1998*.

Resumen. Estudiamos el residente permanente *Dendroica pinus* desde octubre a abril 1996–1997 y 1997–1998 en bosque montañoso de *Pinus occidentalis* en la Sierra de Bahoruco, República Dominicana. Usando aves anilladas para conocer individuos, contéos en puntos, y observaciones de comportamientos, presentamos aquí algunos de los primeros resultados cuantificados de abundancia, persistencia al sitio, área de ámbitos domésticos, comportamiento alimenticio, y caracteristicas donde se encuentran nidos para esta especie. Encontramos una densidad alta de *Dendroica pinus* en la Sierra de Bahoruco, y persistencia al sitio era alta en el invierno (87.5%) y entre años (62.5%). Ambitos domésticos eran grandes (medio = 3.06 ha) y se traslapan parcialmente. Tipicamente, las aves se alimentan por medio de espigando los insectos desde las agujas de pinos y los ramitos. El medio de cinco nidos arbóreos era 8.0 m (SD = 4.3) en altura del suelo y 1.0 m (SD = 1.4) desde el trunco del árbol de pino, pero había mucho variación en posición de los nidos. Comparamos nuestros resultados a los pocos datos que estan disponible desde otros lugares en la isla, las islas Bahamas, y Norteamérica.

Key words: Pine Warbler, Dendroica pinus*, Hispaniola, Dominican Republic, ecology, breeding, foraging.*

INTRODUCTION

The Pine Warbler (*Dendroica pinus*) is a widespread breeding resident of pine forests of eastern North America (American Ornithologists' Union 1998). Northern populations are migratory, but permanent resident Pine Warblers are found in the southern United States,

the northern Bahama Islands, and Hispaniola. On Hispaniola the species is found in the Dominican Republic in high elevation forests of the Cordillera Central, Sierra de Neiba, and Sierra de Bahoruco (Dod 1981, Keith *et al.* in prep.) which are dominated by the native Hispaniolan pine (*Pinus occidentalis*, Richardson 1998). The status of the Pine Warbler is unknown in Haiti, where deforestation is widespread, but populations may persist in suitable habitat in the western extension of the Sierra de Bahoruco, known as the Massif de LaSelle. Whereas the population of resident Hispaniolan Pine Warblers may be augmented by winter resident migratory individuals (Dod 1981), evidence for this influx is lacking (Latta, pers. observ.; Rodewald *et al.* in prep.). Little is known of the breeding biology of the species in the North American portion of its range (Rodewald *et al.* in prep.), and virtually nothing is known of its biology on Hispaniola (Wetmore & Swales 1931, Dod 1981). Here we present our observations from two years of field work in the pine forests of the Sierra de Bahoruco on the abundance, site persistence, home range, foraging behavior, and nesting of the Pine Warbler, and document the first known case of ground nesting by this species.

STUDY SITE AND METHODS

Study site. We studied Pine Warblers in the Parque Nacional Sierra de Bahoruco of the Dominican Republic as part of a larger study of wintering neotropical migratory birds and avian communities across an elevational gradient. Latta (SCL) was present in the Bahorucos from 1 October 1996 to 1 April 1997, and both SCL and Sondreal (MLS) were present in the same area from 1 October 1997 to 1 April 1998. We selected three study sites in pine forest in the Aceitillar Sector of the park (18°0'N, 71°38'W) in Pedernales Province. These sites were situated at elevations of 1,100 m, 1,375 m, and 1,475 m. Sites were chosen based on accessability, altitudinal range, and general similarity in canopy structure.

The Sierra de Bahoruco is an ancient chain of mountains in the extreme southwest of the Dominican Republic on the Haitian border. The mountains reach their highest elevation at Lomo del Toro at 2275 m which is < 13 km from all study sites. Pine forests predominate at elevations above 750 m, except where scattered pockets and bands of humid broadleaf forest occur. The native pine (*P. occidentalis*) is rarely mixed with introduced *P. caribaea,* which occurs only near abandoned bauxite mining operations. Mature pine forests typically form a pine savanna (Fisher-Meerow & Judd 1989), with a broadleaf shrub understory of variable density present. Typical trees and shrubs found under the pine canopy include *Coccothrinax scoparia*, *Agave antillana*, *Lyonia truncata*, *L. microcarpa*, *Cestrum brevifolium*, *Chamaescrista glandulosa, Coreopsis buchii, Eupatorium illitum, Hypericum hypericoides*, and *Myrica picardae.* A variety of more diminutive shrubs and grasses are present (Fisher-Meerow & Judd 1989). Depending on burn history, regenerating *P. occidentalis* may predominate at some sites.

Vegetation characteristics. Vegetation was characterized using methods based on Schemske & Brokaw (1981). Four 16 m diameter circular plots were randomly placed in representative pine forest at each study site (N = 12 plots). Each plot was at least 200 m from all others. A foliage height profile for pine forest was determined at 20 points located at 1.6 m intervals along the cardinal axes of each circular plot. A 3 m pole marked at 0.5 m intervals was placed vertically at each sample point, and the presence or absence of foliage touching the pole at each height class was recorded. Foliage occurring in height intervals beyond 3 m was measured by sighting along the pole

and recording the presence or absence of foliage at 3–4, 4–6, 6–8, 8–10, 10–12, 12–15, and 15–20 m intervals. Foliage was classified as either pine or broadleaf.

Within each circular plot we also recorded the maximum canopy height of the five tallest trees, and mean canopy cover (average of the canopy cover measured by a spherical densiometer at the midpoint of each cardinal radius).

Point counts. Point count data were used to estimate abundances of Pine Warblers. A total of six fixed-radius point counts (Hutto *et al.* 1986) were conducted by SCL at each site in November, January, and March each year. All birds seen and heard during a 10-minute period at each point were recorded. Each point was at least 150 m from all others. Counts were initiated at sunrise and terminated before 10:00, with most counts completed before 09:30. We estimated the minimum distance to each bird detected during a count within a 25 m radius and calculated the mean number of detections of Pine Warblers at each site during each month sampled.

Mist-netting, site persistence, and home range. Birds were captured in mistnets in three netting sessions each field season: 5–12 November 1996, 11–17 January 1997, and 25 February–3 March 1997; and 29 October–4 November 1997, 8–14 January 1998, and 23 February–1 March 1998. Birds were captured in 12 m mist nets (30 mm mesh) set in three lines of 12–16 nets each, with net lines spaced at 150 m intervals. Each net line was opened from 16:00 of day 1 until dusk, sunrise to sunset of day 2, and sunrise to 10:00 of day 3.

All mist-netted Pine Warblers were aged and sexed according to the criteria of Pyle *et al.* (1987), and then banded with a combination of a single numbered metal band and three colored plastic bands such that each bird was uniquely identified. Following each mist-netting session a mean of 59.7 $\pm$ 20.5) person-hours were spent relocating color-banded birds at each site. Once resighted, a bird was followed as long as possible so that multiple resight locations were probable on a given day. Resighting effort varied somewhat between sites, but continued until all previously identified site-faithful birds were relocated, or no more banded birds not already resighted during that banding session (November, January, or March) were identified.

We describe both within-year and between-year site persistence. The former is defined as those birds banded in November or January and subsequently recaptured or resighted in a following banding session (January or March of the same field season), whereas the latter is defined as any of the within-year site persistent birds (from the 1996–1997 field season) which were captured or resighted in the 1997–1998 field season.

Resight locations were also plotted on a gridded map which used natural features and a 50 x 25 m grid system established in each site. Minimal activity ranges were determined in 1997–1998 for relocated birds by enclosing plotted positions of each individual in a minimum convex polygon (Holmes *et al.* 1989) calculated by drawing straight lines between the outermost observation points. Areas of these polygons were then determined by computer from a digitized image using ARC INFO software. Resight data from all months (November, January, March) were pooled to define these home ranges. Only individual birds which were observed on more than 5 days and during two or more field sessions (November, January, March) were used in home range calculations. We believe that the increased number of resight points obtained by pooling across months presents a more accurate description of the home range.

Foraging behavior. Foraging observations were made in both 1996–1997 and 1997–1998 from 07:00–18:00 h by walking slowly through the habitat until a foraging bird was located. The first foraging event 5 s after an individual was initially detected was recorded to avoid a bias toward more conspicuous feeding techniques. Only a single foraging event was recorded per individual per day to reduce the problem of autocorrelation inherent in sequence data (Wagner 1981). Foraging observations from both years were combined for descriptive analyses.

We used the terminology of Remsen & Robinson (1990) for foraging maneuvers and foraging site classifications. Foraging maneuvers included "glean" (designating all near-perch maneuvers in which the forager remains on a perch and picks a food item from the substrate surface), "hang" (bird actually hangs from a perch by its feet), "reach" (bird extends its legs in any direction to obtain food), "jump" (any lunging or jumping from the substrate to obtain a food item), "sally" (aerial foraging and aerial maneuvers to forage on the surface of substrates), and "probe" (any maneuver in which the forager obtains a food item from the subsurface by probing or pecking).

The location of the food item, or the "substrate type" was assigned to one of seven categories: pine needle, pine branch, pine trunk, pine cone, broadleaf leaf, air, and "other." Foraging site was also characterized with respect to (1) whether the substrate was alive or dead, (2) orientation of the foraging surface (upper, side, lower), (3) estimated height of the bird above the ground, (4) horizontal position of the bird (inner 1/3 of tree, middle 1/3 of tree, outer 1/3 of tree), and (5) foliage density, or the amount of light passing through an imaginary 2.0 m diameter sphere surrounding the foraging site (low = 75–100% of light passes through, moderate = 25–74%, high = 0–24%). Height estimates were checked daily with a rangefinder ($\pm$ 0.5 m) to assure accuracy.

In Dominican pine forests most species of birds participate at times in mixed-species foraging flocks (Latta & Wunderle 1996a). Although flocking may alter the foraging behavior of some bird species (Latta & Wunderle 1996a, 1996b), flocking and solitary birds were lumped together for this analysis. This is justified because of the low flocking propensity of Pine Warblers and the relatively few changes in foraging behavior displayed by flocking Pine Warblers and other species (Latta & Wunderle 1996a).

Nesting behavior. Pine Warbler nests were located by observing adult behavior and during intensive searches for nests of the White-winged Crossbill (*Loxia leucoptera*). No systematic attempt was made to locate all Pine Warbler nests at any site. At three nests, we were able to sample vegetation in a 16 m diameter circular plot surrounding the nest. At each plot we measured (1) mean canopy height of the 10 tallest trees, (2) mean canopy cover (average of the canopy cover measured by a spherical densiometer at the midpoint of each cardinal radius), (3) the number of woody shrub stems (< 3 cm diameter-at-breast-height [DBH]) counted in 2 m wide transects along each cardinal radius, and (4) the number of live pines in each of five DBH classes (3–8 cm, 9–15 cm, 16–23 cm, 24–38 cm, > 38 cm).

Statistical analyses. The software package SYSTAT 5.2 (Wilkinson 1992) was used to perform various statistical tests described in Sokal & Rohlf (1981). A probability of Type I error of 0.05 or less was accepted as significant, but greater values are shown for descriptive purposes. Data presented are means $\pm$ 1 SD. We used an independent samples t-test to test for differences in point count abundances between years. We used an analysis of variance to test for effects of month or site on

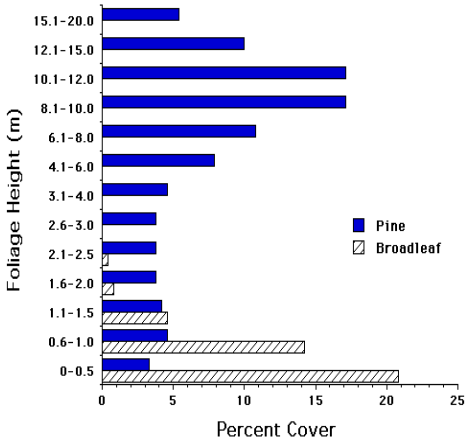

FIG. 1. Representative foliage height profile for pine forest in the Sierra de Bahoruco, Dominican Republic in December 1996. Twenty vertical transects were run in each of N = 12 plots. Percent cover represents the percentage of vegetation touches in a given height interval. Height intervals increase with height.

point count abundances of Pine Warblers.

RESULTS

Vegetation characteristics. A foliage height profile (Fig. 1) shows a fairly open canopy, a sparse intermediate layer, and a denser mixed-broadleaf understory. Canopy cover averaged 51.1 ± 26.4%. The canopy consisted only of pine, with greatest cover in the 6–15 m height categories, and a maximum pine height of 23 m. Mean and median pine heights were 17.7 ± 4.9 m and 19.0 m respectively. The intermediate layer also consisted solely of pine. Broadleaf trees and shrubs formed a dense ground cover and understory, with broadleaf trees extending to 2.5 m in height. Young pine were also present in the understory.

Point counts and mist-netting. The mean number of Pine Warblers per point count ranged from 0.33–1.00. We found no difference in abundance between years ($t = -0.49$, $df = 15.7$, $P = 0.631$), and no effect of month ($F = 0.025$, $df = 2$, $P = 0.975$) or site ($F = 1.956$, $df = 2$, $P = 0.197$) on number of birds detected. We then calculated a mean of 0.62 ± 0.23 Pine Warblers per point count across all years, sites, and months.

Site persistence. Pine Warblers showed high site persistence both within and between years. Of 24 birds banded, 21 (87.5%) were resighted within the same winter and in the

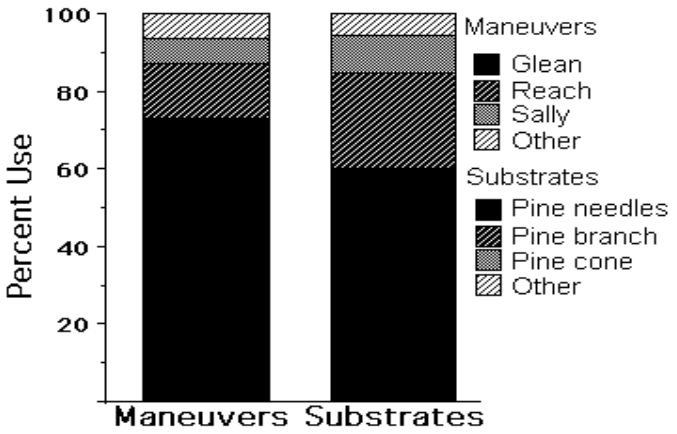

FIG. 2. Percent use of N = 249 foraging maneuvers and foraging substrates by Pine Warblers (*Dendroica pinus*) in the Sierra de Bahoruco, Dominican Republic from October-April 1996–1997 and 1997–1998.

TABLE 1. Vegetation structure at three Pine Warbler (*Dendroica pinus*) nests in the Sierra de Bahoruco, Dominican Republic. Vegetation measures were collected in 16 m diameter circular, nest-centered plots in March 1998.

Vegetation measure	Nest 1	Nest 2	Nest 3
Mean canopy height	19.0	22.1	19.4
Mean canopy cover (%)	34.9	63.5	60.1
Number of stems < 3cm			
Pine	8	3	40
Broadleaf	85	0	68
Number of trees in DBH classes			
3–8 cm	1	0	52
9–15 cm	3	23	12
16–23 cm	3	13	2
24–38 cm	6	7	6
> 38 cm	0	2	2

same study area 45 days or more after banding. Within-winter site persistence was slightly higher for males (92.9%, N = 14) than females (80%, N = 10). Site persistence was also high between years with 62.5% of N = 8 birds banded in 1996–1997 being resighted in 1997–1998.

Home range. We collected location data on 16 banded Pine Warblers. Of these 16 birds, we had locations of nine of these birds on more than five days through the winter, with at least three days of observations in each of two months (November, January, or March). We calculated mean home range for these Pine Warblers in the November-March period as 3.06 ha $\pm$ 1.61 (range = 0.51–5.99).

Foraging behavior. We recorded 249 foraging observations. Typical foraging involved the gleaning of small insects from pine needles in the outer portions of the high pine canopy. Gleaning was the most common recorded foraging maneuver (Fig. 2), observed in 72.9% of feeding attempts, whereas reaching was used in 14.2% of observations. Pine needles and pine branches or twigs dominated as foraging substrates (Fig. 2) and were used in 60.0% and 24.8% of feeding attempts, respectively. Pine needles were always green and considered alive; pine branches or twigs were needleless and presumed dead in 18.2% (8 of 44) of observations. Foraging on these pine branches was almost always (95.4%) on the upper (as opposed to side or lower) surface. Mean bird height when foraging was 9.75 m $\pm$ 4.61 and the mean relative bird height was 0.64 $\pm$ 0.23. Fifty-eight percent of foraging observations were recorded in the outer third of the pine canopy, with less than 15% of observations taken from the inner one-third of the tree. Foliage density surrounding foraging birds reflected this preference for the outer canopy with 70.4% of observations in areas of moderate foliage density (27.6% in low and 2.0% in high foliage density). We were rarely able to see prey items, but these were assumed to be small insects. On two occasions small leptidopteran larvae were taken, and in one case the bird was observed to remove a pine seed from an open cone.

Nesting. We located six Pine Warbler nests in two study sites in 1998. Nest-building commenced in February with our first observations of nest-building on 17 February 1998. Six nests were located before 1 April. Excluding the unique ground nest (see below), all nests were placed in the fork of a horizontal branch of a *P. occidentalis* tree (N = 2) or on the branch where it joined the trunk (N = 3). Mean nest height was 8.0 m $\pm$ 4.3 (range = 2.0–12.0 m), and the mean distance of the nest from the trunk was 1.0 m $\pm$ 1.4 (range = 0–3 m). Although nest heights varied considerably, nests were generally placed in the upper canopy of the nest tree, as mean nest

FIG. 3. Photograph of first-reported ground nest built by Pine Warblers in *Pinus occidentalis* forest in the Sierra de Bahoruco, Dominican Republic, March 1998.

height relative to tree height was 0.82 ± 0.09.

Three nests located in the same study site were mapped and vegetation structure surrounding each nest was characterized. Nests were on average 144.7 ± 26.4 m from each other. Vegetation surrounding these nests differed from a nest with a fairly open pine canopy and a moderately dense broadleaf understory (Table 1, Nest 1), to sites with a denser pine canopy (Table 1, Nests 2 and 3) with either a mixed, dense pine and broadleaf understory (Nest 3) or an open understory (Nest 2). However, the number of large DBH pine trees was relatively constant among the sites.

A single nest was found constructed on the ground in a pine forest at approximately 1,100 m elevation (Fig. 3). On 27 February 1998, MLS observed a Pine Warbler collecting spider web from the end of a broken pine branch. The bird flew to the ground, then reappeared without the material to collect more spider web from the same location. Again the bird flew to the ground. Upon investigation, the nest under construction was found on the ground, sheltered by dead fern fronds, grasses, and diminutive (<1 m tall) woody shrubs. On 27 February the nest consisted of a well-formed cup, but the cup was nestled in the ground litter and the rim did not rise above ground-level. Construction continued with both male and female participating. By 10 March the nest appeared complete, including its sparse feather lining, but eggs did not appear until approximately 18 March. Two eggs were present on 20 March and were white with sparse brown markings on the larger end. The birds incubated successfully through 30 March, after which we were unable to check the nest again until 28

April. By late April the nest was empty and the adults were not present. The nest did not appear to have been disturbed and there were no signs of eggshell fragments or anything else to indicate the failure (or success) of the nest.

While we did not systematically observe other nest construction efforts, it is worth noting that we observed another pair of Pine Warblers collecting what appeared to be spider webs and placing them in a nest under construction. We also saw a female Pine Warbler removing material from an old nest and using it in the construction of a new nest. The old nest appeared to have been a Pine Warbler nest from the previous year, and was approximately 70 m from the new nest.

We examined closely the structure of the single accessible nest (the ground nest). It was a tightly woven cup of grasses, pine needles, and ferns which measured 59 mm deep and 46 mm in diameter (inside cup measurements). The nest was lined with 6–8 small (probably breast) feathers of the Plain Pigeon (*Columba inornata*), identified by their size, color, and flattened shafts. Plain Pigeons are locally common at this site and are occasionally hunted at a nearby artificial reservoir (Klein *et al.* 1998), where similar feathers have been observed (SCL, pers. observ.).

DISCUSSION

Abundance. Pine Warbler densities in the Sierra de Bahoruco, as measured by point counts, are higher than previous reports from the West Indies (Rodewald *et al.* in prep.). If point count results (0.62 birds per point) are extrapolated across the landscape, Pine Warbler densities from the Sierra de Bahoruco are 315.7 birds/km^2 – far higher than those recorded elsewhere. For example, in similar habitat in the Cordillera Central of the Dominican Republic mean point count abundance of Pine Warblers in winter was 0.44 birds per point count circle using the same methods as described here (Wunderle & Latta 1996). On Abaco Island, Lee (1996) calculated 104.0 Pine Warblers/km^2, and on Grand Bahama Island, Emlen (1977) calculated a mean density of only 27.9 birds/km^2 across 25 study sites. Although Emlen had considerable variation in bird densities (4.3–81 birds/km^2) across the island, variation was not found between "submature" and "young" pines which had nearly identical densities of Pine Warblers.

Differences in Pine Warbler abundance, particularly within Hispaniola, may be related to area effects, altitude, or habitat variation, all of which can affect avian distribution. For instance, habitat area can influence the number of individuals present in an isolated habitat, with bird numbers generally increasing with area (MacArthur & Wilson 1967). Pine forests sampled in the Cordillera Central were remnant patches that were not measured in area but were all estimated to be >100 ha, whereas point counts in the Bahorucos were made in virtually continuous pine forest that covers much of the 800 km^2 park. Altitude can also affect numbers of individuals present (Noon 1981). Study sites in the Sierra de Bahoruco were higher in elevation (1,100–1,475 m) than in the Cordillera Central (643–1,050 m) or Grand Bahama Island (10 m), and altitude alone may contribute to some of the difference in point count estimates between sites. However, birds may be responding to habitat differences that may reflect, in part, altitudinal changes. For example, the Bahamas are forested with *P. caribaea* whereas the native pine on Hispaniola is *P. occidentalis*. Forest structure, though grossly similar between the two Hispaniolan sites, likely varied in the amounts of introduced *P. caribaea*, in the amount and make-up of their broadleaf components, and in the age of pine trees. Age of pine forests is also a possible explanation for low densities in the Bahamas,

as Emlen (1977) did not sample mature pine stands because these had been cut over in recent years. Hispaniolan sites included mature pine trees.

Site persistence. Site persistence has not been previously determined for permanent resident or migratory Pine Warblers in any portion of their range (Rodewald *et al.* in prep.), nor for any other resident passerines in the Dominican Republic. Site persistence of permanent resident Pine Warblers determined in this study appears high in comparison to winter resident (migratory) Parulid warblers. For example, overwinter site persistence for a variety of wintering migrants varied from 62–79% in shade coffee plantations in the Cordillera Central of the Dominican Republic (Wunderle & Latta 1994), and these results are comparable to site persistence data for Black-throated Blue Warblers (*D. caerulescens*) and American Redstarts (*Setophaga ruticilla*) from native forest in Jamaica (66–80%; Holmes *et al.* 1989) and *D. caerulescens* in Puerto Rico (42–68%; Wunderle 1995).

Data on annual survival of passerines on Hispaniola are also lacking, although Faaborg and Arendt (1995) calculated an annual survival rate of 55% for the permanent resident Adelaide's Warbler (*D. adelaidae*) in Puerto Rican dry forest. Additional data, both to enlarge sample sizes in these data sets, and to compare results from Pine Warbler to other island birds would be informative.

Home range. Our results, indicating a mean home range of 3.06 ha, suggest a large home range for Pine Warblers in this winter season. There are no comparative data on home ranges of other permanent resident Hispaniolan passerines, but Pine Warbler home ranges are considerably larger than those reported for winter resident warblers. For example, *D. caerulescens* had a mean home range of 0.15–0.31 ha in three Puerto Rican habitats (Wunderle 1995), and American Redstart and Black-and-white Warbler (*Mniotilta varia*) had mean home ranges of 0.44 ha and 1.0 ha, respectively, in Dominican shade coffee plantations (Wunderle & Latta, in prep.). Smaller home ranges may be expected for species such as these, however, because individuals often aggressively defend defined territories throughout the winter, in contrast to the Pine Warbler which appears to wander over larger areas with home ranges of different individuals frequently overlapping one another.

Home range size reported here also appears to be larger than those recorded from North American breeding populations of Pine Warblers (Rodewald *et al.* in prep.), although scant data are available. Breeding territories in Arkansas were estimated to be 0.9 ha in size, and 1.0 ha islands were reportedly used by breeding birds in Minnesota (Howe 1979). However, home ranges of these breeding individuals may be considerably larger than these territory sizes, especially in mixed pine-hardwood habitats (Rodewald *et al.* in prep.).

The lack of small, defended territories in this study is supported by our observation that Pine Warblers are only infrequently involved in intraspecific aggression. Intraspecific aggression between Pine Warblers was recorded only twice in 104 aggressive actions between birds in the Sierra de Bahoruco (Latta, unpubl. data), and only three times out of 64 agressive activities recorded in the Cordillera Central (Latta & Wunderle 1996a).

Foraging behavior. Data from the Sierra de Bahoruco support the now well-established stereotype of Pine Warblers foraging by typically creeping over limbs to glean pine needles in the canopy (Harrison 1984). These results fit closely those obtained by Latta & Wunderle (1998) in the Cordillera Central, and by Emlen (1977) on Grand Bahama

Island. In a study of the assemblage of birds foraging in the pine forests of the Cordillera Central, Latta & Wunderle (1998) found the Pine Warbler to be one of the species with the most restricted foraging substrates, with 93% of observations on pine, and 75% of observations on pine needles. Mean foraging height was an identical 9.7 m $\pm$ 3.5, but foraging tended to be in the outer reaches of the pine branches where foliage density was lower. In the Cordillera Central, 74% of foraging was in the outer 2/3 of the tree (58% this study) and 86% of foraging attempts were in the most open foliage density class (28% this study). This may reflect differences in vegetation structure, or Pine Warblers in the Cordillera Central may use more exposed positions when foraging in mixed-species flocks. Mixed-species flocks tend to be larger and more prevalent in the Cordillera Central than in the Sierra de Bahoruco (SCL, pers. observ.).

Emlen (1977) quantified foraging behavior of Pine Warblers on Grand Bahama Island where the birds also typically used the upper and outer portions of the crowns. He analyzed the height above ground at the moment of detection by dividing vegetation structure into five levels or layers of equal depth. Seventy-nine percent of his observations were in the third through fifth layers, and birds used these upper layers in approximately equal proportions. Unlike this study, Emlen (1977) reported that Pine Warblers rarely gleaned twigs, but he did show that insect populations reach higher densities in pine crown tops than in upper and lower portions of trunks.

Pine Warblers in this study did not use pine bark as Emlen (1981) found in one-half of the feeding observations from Andros Island. But the Andros Island population of Pine Warblers is apparently unique in that the lack of avian bark-gleaning specialists has resulted in the absence of selective pressure on Pine Warblers to specialize in the gleaning of foliage (pine needles) in the upper canopy as Pine Warblers do on Grand Bahama Island (Emlen 1981, Emlen & DeJong 1981) and Hispaniola (this study) where bark gleaners are present.

Although we did not record the sex of Pine Warblers during foraging observations, we did not notice any sexual differences in foraging behavior, heights, or locations, as are seen for example in *D. caerulescens* (Latta & Wunderle 1996a). In fact we often noticed male-female pairs, some of which were color-banded, foraging and moving together through the site, suggesting that this species maintains pair bonds throughout the winter. This is supported by observations of Pine Warblers participating in mixed-species foraging flocks in the Cordillera Central (Latta & Wunderle 1996a), which were often found to occur in pairs. A mean of 1.5 individuals was recorded per flock, given that at least one was detected, and despite a high level of species participation, few intraspecific acts of aggression were recorded (see above). However, Pine Warblers did not associate together in species-pairs more often than expected on the basis of census data.

Nesting. Nests described here, with the exception of the unique ground nest, are generally similar to the few nest and egg descriptions available (Bent 1953; Harrison 1984; Rodewald *et al.* in prep.), but nests in this study tended to be lower and closer to the trunk than reported elsewhere. Rodewald *et al.*, (in prep.) report most nest heights are 10–15 m, and Harrison (1984) reports nests as typically 7.6–12.3 m above ground (with one record of 41.0 m) and often far out on limbs. However, because we did not systematically search for Pine Warbler nests, our few data may not be general and may represent only the most easily located nests.

Ground nesting has not been previously recorded for this species so we can not know

the prevalence of this behavior. We do not think the pair was forced into a presumably suboptimal breeding site by habitat considerations, as an abundance of other more typical nest sites occur in pine trees in the immediate area and beyond.

Our observations of Pine Warblers appropriating previously-used nest material appear to be more typical behavior. Burleigh (1958), Harrison (1984), and Rodewald *et al.*, (in prep.) also report Pine Warblers collecting previously-used nest material, including a female taking material from an occupied crow nest, and another individual using material from her own failed nest.

Finally, our data on nesting habitat, nest placement, and nest density (i.e., distance to nearest neighbor) represent some of the first such data for this species, from Hispaniola or elsewhere, other than general characterizations of breeding habitat and nest heights (Rodewald *et al.* in prep.). However, these data should be interpreted with caution due to the small sample size and the possibility of additional, overlooked nests in the area which would affect density estimates. More detailed descriptive studies are justified, as well as a comparative study to see how Pine Warbler nesting sites may differ from surrounding potential habitat. However, it may be that beyond the presence of mature pines, other measurable features of the habitat are of less importance in habitat selection by nesting Pine Warblers.

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