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SEASONAL AND ANNUAL CHANGES IN THE POPULATION DENSITY OF ZENAIDA DOVES IN THE XEROPHYTIC FOREST OF GUANICA, PUERTO RICO

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Abstract.—The Zenaida Dove (*Zenaida aurita*) is common and widely distributed in the three major life zones (dry, moist, wet) of Puerto Rico. The xerophytic forest of Guánica may be a key habitat for the reproduction of Zenaida Doves in the dry zone. Point-counts (six 3-min stations) were conducted from 1986–1996 and nest-counts (46 0.1-ha strip-transects) from 1987–1992 to study the changes in the density ($\hat{D}$) of Zenaida Doves and their active nests in the xerophytic forest. From 1987–1992, the mean $\hat{D}$ of Zenaida Doves was 4.83/ha and the mean $\hat{D}$ of active nests was 1.66/ha. The mean $\hat{D}$ of active nests was higher in areas dominated by semi-deciduous vegetation than in areas dominated by deciduous and thorn-scrub vegetation. Point-counts and strip-transects suggested a population decline from 1987–1992, with 1989 having the lowest $\hat{D}$ of Zenaida Doves and active nests. The rainfall of the first 6 mo of the year explained 72–80% of the variation in $\hat{D}$ from point-counts and strip-transects from 1987–1992. Point-counts suggested a significant population decline from 1986–1996, with 1989 and 1995 having the lowest counts of Zenaida Doves. The rainfall of the first 6 mo of the year explained a significant proportion (51%) of the variation of point-counts from 1986–1996. To detect 10–25% differences (α = 0.05, power = 0.80) in the annual mean $\hat{D}$ of Zenaida Doves and their active nests, sampling 32 3-min stations and 79 0.1-ha strip-transects monthly from April–June is recommended. These sample sizes are large enough to detect positive or negative trends of 10% through linear regression analysis. The conservation and management of the xerophytic forest may be of critical importance for maintaining current population levels of Zenaida Doves in the dry zone of Puerto Rico.

CAMBIOS ESTACIONALES Y ANUALES EN LA DENSIDAD POBLACIONAL DE LA TÓRTOLA CARDOSANTERA EN EL BOSQUE XEROFÍTICO DE GUÁNICA, PUERTO RICO

Sinopsis.—La tórtola cardosantera (*Zenaida aurita*) es común y se encuentra ampliamente distribuida en las tres zonas de vida de mayor tamaño en Puerto Rico (seca, húmeda, mojada). El bosque xerofítico de Guánica puede ser un hábitat clave para la reproducción de las tórtolas cardosanteras en la zona seca. Se efectuaron conteos de individuos (seis estaciones de 3-min) entre 1986–1996 y conteos de nidos (46 trayectos lineares de 0.1-ha) entre 1987–1992 para estudiar los cambios en la densidad ($\hat{D}$) de las tórtolas cardosanteras y sus nidos activos en el bosque xerofítico. Entre 1987–1992, la $\hat{D}$ promedio de las tórtolas cardosanteras fué 4.83/ha y la $\hat{D}$ promedio de sus nidos activos fué 1.66/ha. La $\hat{D}$ promedio de nidos activos fué mayor en áreas dominadas por vegetación semicaducifolia que en áreas dominadas por vegetación caducifolia y típica del matorral espinoso. Los datos de las estaciones y trayectos lineares sugieren que hubo un decrecimiento poblacional entre 1987–1992, con 1989 teniendo la $\hat{D}$ más baja de tórtolas cardosanteras y nidos activos. La lluvia de los seis primeros meses del año explicó un 72–80% de la variación de $\hat{D}$ en las estaciones y los trayectos lineares entre 1987–1992. La data de las estaciones sugiere que hubo un decrecimiento poblacional significativo entre 1986–1996, con 1989 y 1995 teniendo los conteos más bajos de tórtolas cardosanteras. La lluvia de los seis primeros meses del año explicó una proporción significativa (51%) de la variación de los conteos en puntos fijos entre

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1986–1996. Para detectar diferencias de 10–25% (α = 0.05, poder = 0.80) en los promedios anuales de $\hat{D}$ de las tórtolas cardosanteras y sus nidos activos, se recomienda el muestreo mensual de 32 estaciones de 3-min y 79 trayectos lineares de 0.1-ha entre abril–junio. Estos números de muestra son lo suficientemente grandes para detectar tendencias positivas o negativas de un 10% a través de un análisis de regresión linear. La conservación y manejo del bosque xerofítico puede tener una importancia crítica para el mantenimiento de los niveles poblacionales actuales de las tórtolas cardosanteras en la zona seca de Puerto Rico.

Zenaida Doves (*Zenaida aurita*) are common and widely distributed in Puerto Rico (Maldonado-Colón and Pérez-Rivera 1977; Rivera-Milán 1990, 1992; Wiley 1991), where they are hunted from September–November after the peak of the nesting season (Ramos 1994, Rivera-Milán et al. 1990). They are multibrooded habitat generalists capable of rapid population turnover rates (Rivera-Milán 1990, 1995, 1996). Their mean density estimates are higher in the dry zone (0.71 doves/ha, 95% CI = 0.40–1.02 doves/ha) than in the moist (0.22 doves/ha, 95% CI = 0.10–0.33 doves/ha) and wet (0.05 doves/ha, 95% CI = −0.01–0.10 doves/ha) zones of the Puerto Rican mainland (Rivera-Milán 1990, 1995). In the dry zone, their nest density and nesting success are higher in xerophytic than in dry coastal forests (Rivera-Milán 1990, 1996).

The nest density and nesting success of Zenaida Doves are higher and the densities of avian and mammalian predators are lower in the State Forest of Guánica (xerophytic forest hereafter) than in any other forest sampled in the dry zone of the Puerto Rican mainland (Rivera-Milán 1990, 1996). For this reason, the xerophytic forest may be a potential population source for Zenaida Doves in the dry zone, whereas smaller and more fragmented forests in this life zone may be population sinks in which annual reproduction is not enough to offset natural or human-induced mortality (Donovan et al. 1995, Pulliam 1988, Pulliam and Danielson 1991, Robinson et al. 1995). Monitoring changes in the size and success of nesting populations in key habitats should be an integral part of the management of Zenaida Doves and other game and non-game columbids in Puerto Rico (Maldonado-Colón and Pérez-Rivera 1977; Pérez-Rivera and Collazo-Algarín 1976; Rivera-Milán 1990, 1996; Wiley 1979, 1985, 1991). Here I examine (1) the changes in the density and detectability of Zenaida Doves in the three major habitats of the xerophytic forest (deciduous, semi-deciduous, thorn-scrub) during the nesting and non-nesting periods of the year, (2) the relationship of density changes to the rainfall of the first 6 mo of the year, and (3) the descriptive statistics of point- and nest-counts to estimate the sample sizes needed to monitor the annual changes in the density of Zenaida Doves and their active nests in the xerophytic forest during the peak of the nesting season (April–June).

METHODS

Study area.—The xerophytic forest of Guánica (4006 ha; 17°57′N, 66°52′W) lies in the subtropical dry zone (126,000 ha) of Puerto Rico (Ewel and Whitmore 1973) and is dominated by deciduous (2346 ha), semi-deciduous (718 ha) and thorn-scrub (581 ha) habitats (see Lugo et al. 1978, and Silander et al. 1986 for information about the plant species that characterize these habitats). The rainfall pattern is characterized by a relatively small peak from April–June that ends the dry season (December–March), which is followed by a second larger peak from September–November (Faaborg 1982, Faaborg et al. 1984, Lugo et al. 1978, Rivera-Milán 1992, Puerto Rico Department of Natural and Environmental Resources [PRDNER], unpubl. data).

Point and nest counts.—From 1986–1996, unfixed-radius point-counts were conducted at six 3-min stations following the standard methodology established by the PRDNER (Rivera-Milán 1990, 1993). Unfixed- and fixed-radius point-counts (radius = 60 m) were combined with 0.1 ha strip-transects (10 × 100 m) from 1987–1992. Stations were separated by 1.6 km and were along tertiary roads covering deciduous ($n = 2$), semi-deciduous ($n = 2$), and thorn-scrub ($n = 2$) habitats. Nest-counts were conducted at 46 strip-transects in deciduous ($n = 28$), semi-deciduous ($n = 10$), and thorn-scrub ($n = 8$) habitats parallel or perpendicular to the tertiary roads where stations were found. Stations and strip-transects were sampled once per month from February 1987–June 1988. However, from 1989–1992, stations were sampled once in May and strip-transects were sampled twice per month from April–June to cover the nest density peak of Zenaida Doves in the dry zone (i.e., a repeated measures sampling scheme; Winer 1971).

Density and detectability estimation.—The density of Zenaida Doves from fixed-radius point-counts was estimated as $\hat{D} = 3(10^4)N\ \hat{C}^2/\pi$ (Järvinen 1978). Detectability of Zenaida Doves from the center of the stations was estimated as $\hat{C} = (1 - [1 - p]^{0.5})/r$, where p equaled the number of aural and visual detections inside 60 m (N; fixed-count) divided by the number of aural and visual detections made, regardless of radial distance (i.e., inside 60 m/inside + outside 60 m; unfixed-count). The density of active nests of Zenaida Doves from strip-transects was estimated as $\hat{D} = N/2LW$, where L = length, W = width, and N = the number of active nests found per month within the fixed area of the transects (Burnham et al. 1985, Conner and Dickson 1980). Zenaida Doves were easily detected within the 60-m radius (r) of the stations, and their active nests were easily detected by two trained observers walking slowly along the 5-m strips (W) of the transects (Rivera-Milán 1990, unpubl. data).

Stations and strip-transects were always sampled by two trained observers under standard conditions (0600–1030 h, winds < 19 kph, and no rain). The same observers conducted the point- and nest-counts from February 1987–June 1992. Unfixed-radius point-counts were conducted by different observers in 1986 and from 1993–1996. Refer to Rivera-Milán (1993, 1995, 1996) for more information about the counting techniques applied (see Verner 1985 for a review).

Rainfall data.—From 1986–1994, rainfall data were obtained daily from a pluviometer near the office of the resident biologist (between stations 1–3 and 4–6; M. Canals, PRDNER, pers. comm.).

Sample size estimation.—The number of 3-min stations and 0.1-ha strip-transects needed per year to detect 10–50% differences (δ) in the mean $\hat{D}$ of Zenaida Doves and their active nests was computed according to the formula for paired samples (two-tailed alternative; $\alpha = 0.05$, power = 0.80) given by Steel and Torrie (1980:118–119, Equation 5.34). The program TRENDS (Gerrodette 1987, 1993) was used to estimate the number of sampling units (stations and strip-transects) needed to detect increasing or decreasing trends of 10% from point- and nest-counts. Recommendations for the allocation of sampling units are given in proportion to the area covered by deciduous (64%), semi-deciduous (20%), and thorn-scrub (16%) habitats within the xerophytic forest (stratified random sampling design; Scheaffer et al. 1979:59–97).

Statistical analyses.—Analysis of variance (ANOVA) with repeated measures for one factor (time) was used to examine changes in the $\hat{D}$ of Zenaida Doves from point- and nest-counts (Gurevitch and Chester 1986, Winer 1971). Polynomial contrasts (linear, quadratic, cubic) were used to examine the relationship between time (years) and point- and nest-counts (Winer 1971). Greenhouse-Geisser adjustment factor (ϵ) was used to correct the degrees of freedom of the *F*-tests of repeated measures ANOVAs (Winer 1971:523–524). Simple linear regression was used to examine the relationships between changes in $\hat{D}$ and rainfall of the first 6 mo of the year. Multivariate analysis of variance (MANOVA) was used to examine observer and time of day effects on unfixed-radius point-counts from 1986–1996. Point- and nest-counts were log-transformed (ln [x + 1]) before conducting statistical analyses (Sokal and Rohlf 1981). Details of other statistical analyses are given with the corresponding results. All the analyses were performed with the programs SuperANOVA and StatView II (Abacus Concepts 1987, 1989). Significance was accepted at $P \leq 0.05$.

RESULTS

Effects of observer and time of day.—Observer and time of day had no significant effects on the unfixed-radius point-counts from 1986–1996 (observer: $F_{2,61} = 0.497$, $P = 0.61$; starting time: $F_{1,61} = 0.060$, $P = 0.83$; finishing time: $F_{1,61} = 0.045$, $P = 0.88$).

Point- and nest-counts.—Unfixed- and fixed-radius point-counts were significantly correlated on a monthly basis from February 1987–June 1988 ($r = 0.93$, df = 16, $P = 0.0001$). They were also significantly correlated with nest-counts from February 1987–June 1988 (unfixed: $r = 0.49$, df = 16, $P = 0.04$; fixed: $r = 0.48$, df = 16, $P = 0.05$; Fig. 1a,b). The $\hat{D}$ of Zenaida Doves peaked in May 1987 (14.37/ha) and in June 1988 (3.41/ha; Fig. 1a), whereas the $\hat{D}$ of their active nests peaked in April 1987 (1.52/ha) and in June 1988 (1.52/ha; Fig. 1b). Although a peak in nest density occurred from April–June, active nests were observed throughout the year. The abundance of Zenaida Doves reached a minimum level during the dry season (December–March) and a maximum level during the first peak of rain (April–June; Fig. 1a,b).

The unfixed-radius point-counts did not differ by habitat type ($F_{2,63} = 1.871$, $P = 0.16$), but they differed by year (Table 1), with 1989 and 1995

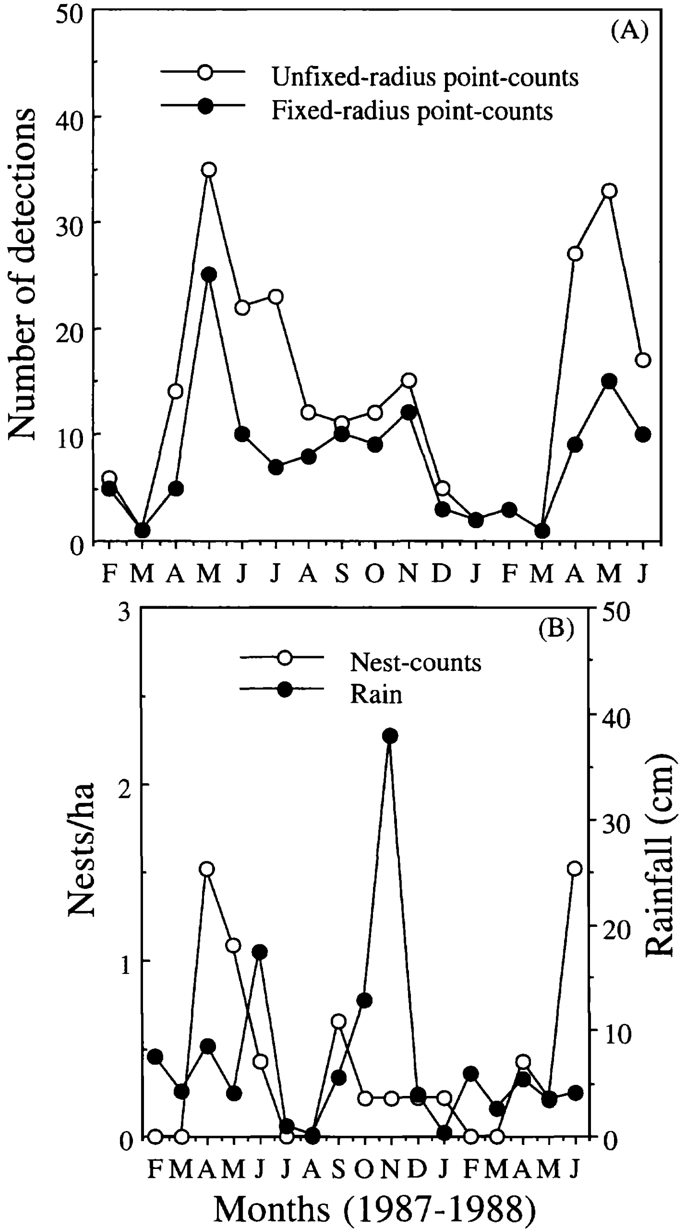

FIGURE 1. (A) Unfixed- and fixed-radius point-counts of Zenaida Doves. (B) Nest density of Zenaida Doves and rainfall pattern in the xerophytic forest of Guánica, Puerto Rico, from February 1987–June 1988.

TABLE 1. Analysis of variance (ANOVA) with repeated measures for one factor (years) for unfixed-radius point-counts of Zenaida Doves in the xerophytic forest of Guánica, Puerto Rico.[a]

Source of variation	df	SS	MS	*F*	*P*
Stations	5	2.915	0.583		
Years	10	14.303	1.430	6.906	0.003
Years (Stations)	50	10.356	0.207		
Linear contrast	1	7.339	7.339	35.432	0.009

[a] Unfixed-radius point-counts (May 1986–1996) were log-transformed (ln + 1) before the analysis.

having the lowest abundance of Zenaida Doves in the xerophytic forest (Fig. 2a). A significant first-degree contrast suggested a linear relationship between time and unfixed-radius point-counts (i.e., a decline in the mean number of Zenaida Doves heard or seen at the six 3-min stations; Table 1). The trend was negative and significant (simple linear regression: $\beta_1 = -0.106$, SE = 0.034, $F_{1,10} = 9.485$, $P = 0.01$). The coefficients of variation (CVs) of unfixed-radius point-counts ranged from 32% in 1994 to 155% in 1995 (within-year non-transformed counts: mean CV = 60%, 95% CI = 34–87%; Table 1 and Fig. 2a).

The strip-transect nest-counts differed by habitat type and year (Table 2). The $\hat{D}$ of active nests of Zenaida Doves was higher in semi-deciduous than in deciduous and thorn-scrub habitats (Tukey's honestly significant difference method, $P \leq 0.05$). A significant second-degree contrast (quadratic model) suggested a curvilinear relationship between time and nest-counts (i.e., a decrease [1987–1989] followed by an increase [1990–1992] in the mean $\hat{D}$ of active nests of Zenaida Doves in the 46 0.1-ha strip-transects; Table 2). A second-order polynomial regression provided an adequate fit to the nesting trend, with 1989 as its single inflection point or bend ($F_{2,5} = 9.415$, $P = 0.05$; Fig. 2b). The CVs of nest-counts ranged from 178% in 1992 to 501% in 1989 (within-year non-transformed counts: mean CV = 284%, 95% CI = 160–405%; Table 2 and Fig. 2b).

Density and detectability estimates.—Unfixed- and fixed-radius point-counts were significantly correlated on an annual basis from May 1987–

TABLE 2. Analysis of variance (ANOVA) with repeated measures for one factor (years) for strip-transect nest-counts of Zenaida Doves in the xerophytic forest of Guánica, Puerto Rico.[a]

Source of variation	df	SS	MS	*F*	*P*
Habitat type	2	1.506	0.753	7.519	0.002
Strip-transects	43	4.307	0.100		
Years	5	0.841	0.168	2.543	0.047
Years × Habitat type	10	0.275	0.027	0.416	0.898
Years × Strip-transects	215	14.226	0.066		
Quadratic contrast	1	0.673	0.673	10.165	0.004

[a] Strip-transect nest-counts (April–June 1986–1994) were log-transformed (ln + 1) before the analysis.

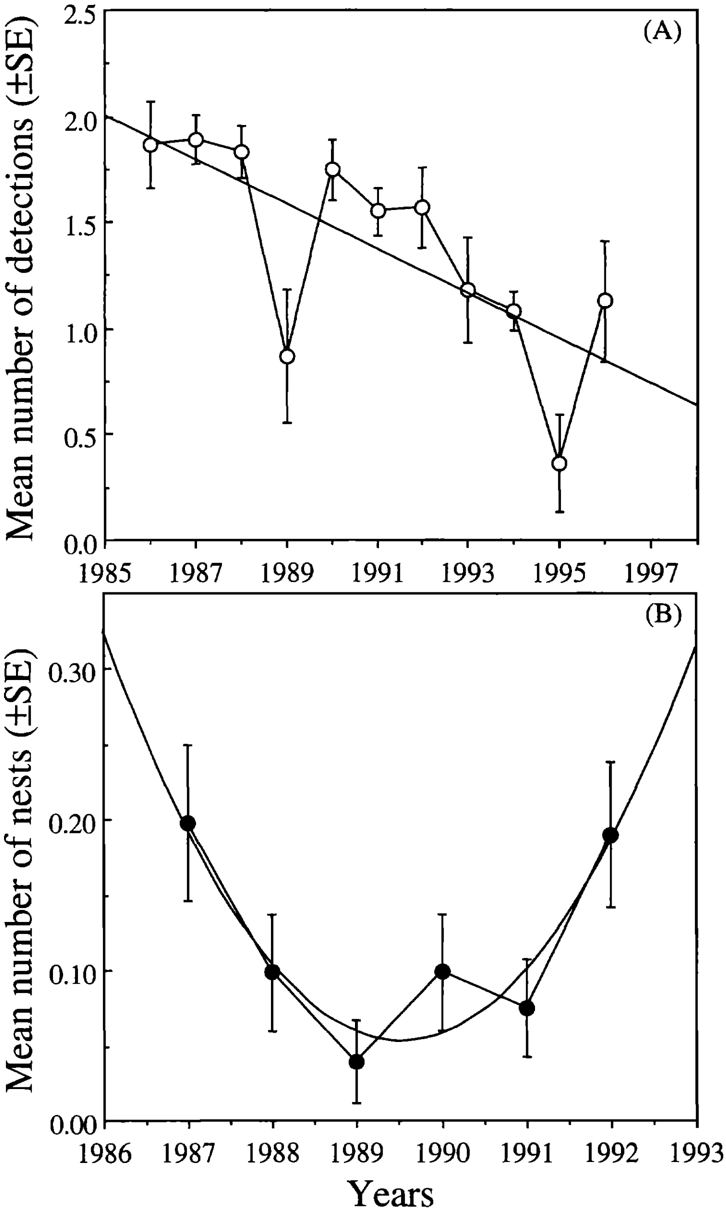

FIGURE 2. (A) Trends from unfixed-radius point-counts (May 1986–1996), and (B) strip-transect nest-counts (April–June 1987–1992) of Zenaida Doves in the xerophytic forest of Guánica, Puerto Rico.

1992 (r = 0.86, df = 5, P = 0.03; Table 3). The detectability ($\hat{C}$) of Zenaida Doves ranged from 0.002 in May 1989 to 0.008 in May 1987 (Table 3). However, their $\hat{C}$ did not differ significantly among years ($F_{1,16}$ = 1.236, P = 0.28) or habitat types (deciduous mean $\hat{C}$ = 0.004, SE = 0.0009; semi-deciduous mean $\hat{C}$ = 0.001, SE = 0.0008; thorn-scrub mean $\hat{C}$ = 0.003, SE = 0.0010; $F_{2,15}$ = 2.097, P = 0.12).

The density ($\hat{D}$) of Zenaida Doves and their active nests were significantly correlated on an annual basis from 1987–1992 (r = 0.97, df = 5, P = 0.0009; Table 3). The $\hat{D}$ of Zenaida Doves ranged from 0.14/ha in May 1989 to 14.37/ha in May 1987, whereas the $\hat{D}$ of their active nests ranged from 0.65/ha in April–June 1989 to 3.00/ha in April–June 1987 (Table 3). An extrapolation of these density estimates to the 3645-ha covered by deciduous, semi-deciduous, and thorn-scrub habitats within the xerophytic forest resulted in a mean population size of 17,605 Zenaida Doves and 6051 active nests from 1987–1992 (Table 3).

Abundance and rainfall.—The $\hat{D}$ of Zenaida Doves and their active nests were not correlated with rainfall on a year-round basis because the second peak of rain (October–November) did not coincide with a significant increase in nesting activity (doves/ha: r = 0.30, df = 16, P = 0.25; nests/ha: r = 0.05, df = 16, P = 0.85; Fig. 1a,b). However, the rainfall of the first 6 mo of the year explained 72% of the variation of $\hat{D}$ of active nests from April–June 1987–1992 (P = 0.03), and 80% of the variation of $\hat{D}$ of Zenaida Doves from May 1987–1992 (P = 0.02; Table 3). Moreover, the rainfall of the first 6 mo of the year explained 51% of the variation of the unfixed-radius point-counts of Zenaida Doves from May 1986–1996 (P = 0.01; Table 3).

Sample size estimates.—The number of independent sampling units needed per year decreased as a function of the desired level of sensitivity of a test (α and β), the size of the detectable difference (δ) and the precision (S^2) of point- and nest-counts. Sampling 32 3-min stations and 79 0.1-ha strip-transects would be needed to detect 10–25% differences in the annual mean $\hat{D}$ of Zenaida Doves and their active nests (two-tailed paired t-test, α = 0.05, power = 0.80; Fig. 3a). However, sampling 12 3-min stations and 45 0.1-ha strip-transects would suffice to detect positive or negative trends of 10% through linear regression analysis (CVs decreased with abundance, two-tailed paired t-test, α = 0.05, power = 0.80–1.00; Fig. 3b).

DISCUSSION

When conducting unfixed-radius point-counts it was assumed that Zenaida Doves were equally detectable from the center of the 3-min stations at multiple spatio-temporal scales (Verner 1985). The detectability ($\hat{C}$) of Zenaida Doves did not differ significantly among years or habitat types. The data suggest that the assumption was met and that the unfixed-radius point-counts provide an adequate index to the annual changes in the density ($\hat{D}$) of Zenaida Doves and their active nests in the xerophytic forest of Guánica. The size of the nesting population of Zenaida Doves in the

TABLE 3. Annual changes in the detectability and density of Zenaida Doves and rainfall of the first 6 mo of the year in the xerophytic forest of Guánica, Puerto Rico.[a]

Year	Detections unfixed-counts	Detections fixed-counts (60 m)	Detectability	Doves/ha	Nests/ha	Rainfall 6 mo (cm)
1986	37	—	—	—	—	87.35
1987	35	25	0.008	14.37	3.00	48.74
1988	33	15	0.005	2.72	1.52	23.67
1989	12	3	0.002	0.14	0.65	22.40
1990	30	14	0.005	2.70	1.52	38.81
1991	23	7	0.003	0.51	1.09	23.14
1992	25	17	0.007	8.51	2.17	51.79
1993	16	—	—	—	—	17.60
1994	12	—	—	—	—	17.30
1995	4	—	—	—	—	16.81
1996	16	—	—	—	—	32.30
$\bar{x}$	22.09	13.50	0.005	4.83	1.66	34.54
SE	3.282	3.16	0.001	2.267	0.339	6.471
95% CI	14.78–29.40	5.38–21.62	0.003–0.007	−1.00–10.65	0.79–2.53	20.12–48.95
CV (%)	49.27	57.33	46.03	115.09	50.02	62.13
$\bar{x}$ population estimate of doves = 17,605 (95% CI = 0–38,819)[b]						
$\bar{x}$ population estimate of nests = 6051 (95% CI = 2880–9222)						

[a] Unfixed-radius point-counts were conducted at six 3-min stations from May 1986–1996. Fixed-radius point-counts were conducted from May 1987–1992. Nest-counts were conducted at 46 0.1-ha strip-transects in April–June 1987–1992.

[b] Lower 95% CI assumed to be 0 because value was negative. Mean number of doves and nests per ha multiplied by 3645 ha covered by deciduous (2346 ha), semi-deciduous (718 ha), and thorn-scrub (581 ha) habitats.

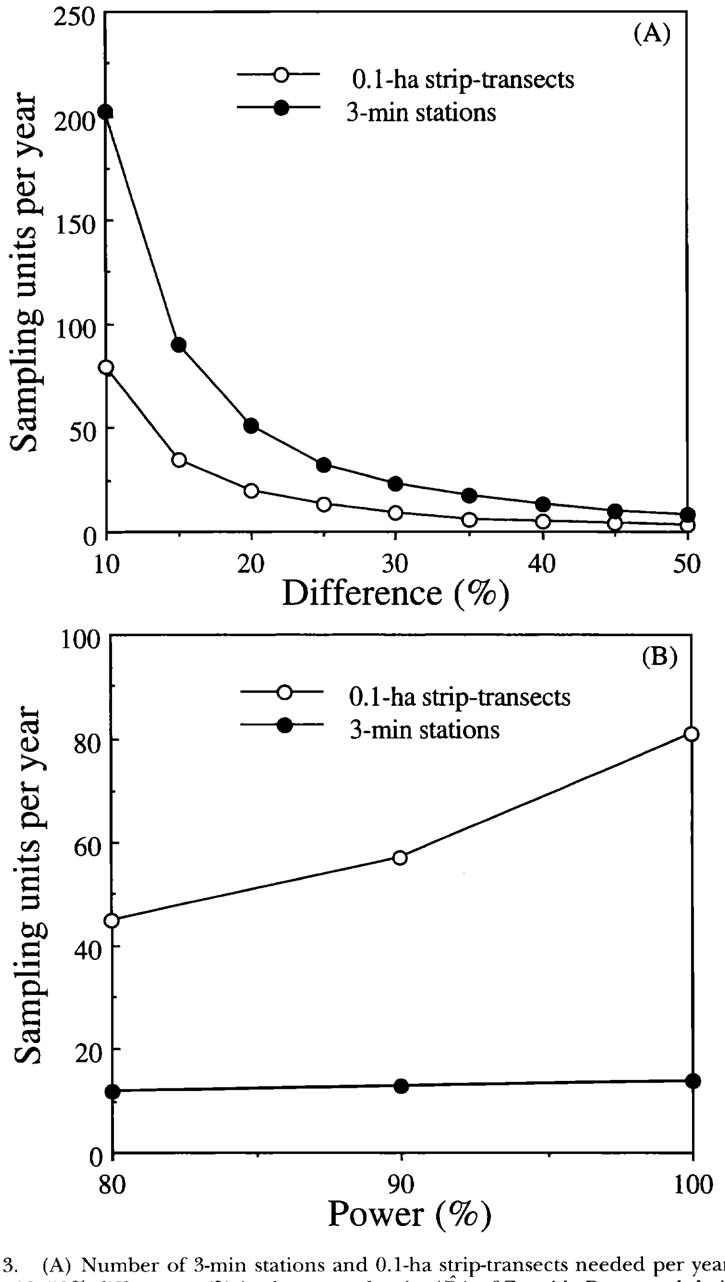

FIGURE 3. (A) Number of 3-min stations and 0.1-ha strip-transects needed per year to detect 10–50% differences (δ) in the mean density ($\hat{D}$) of Zenaida Doves and their active nests (α = 0.05, power [1 − β] = 0.80; Steel and Torrie 1980). (B) Number of 3-min stations and 0.1-ha strip-transects needed per year to detect increasing or decreasing trends of 10% from point- and nest-counts of Zenaida Doves in the xerophytic forest of Guánica, Puerto Rico (mean CV of point-counts = 60%, mean CV of nest-counts = 284%, CVs decreased with abundance, two-tailed paired *t*-test, α = 0.05, power = 0.80–1.00; Gerrodette 1987, 1993).

xerophytic forest probably was at its lowest in 1995, when only 16.81-cm of rainfall were recorded during the first 6 mo of the year.

Zenaida Doves had a high reproductive potential in the xerophytic forest, especially when there was enough rainfall during the first 6 mo of the year (e.g., 48.74 cm in 1987 and 51.79 cm in 1992 [high density of active nests] vs 22.40 cm in 1989 and 23.14 cm in 1991 [low density of active nests]). The rainfall of the first 6 mo of the year explained 72–80% of the annual changes in $\hat{D}$ of Zenaida Doves and their active nests from 1987–1992; and, from 1986–1996, it explained 51% of the annual changes in their abundance from unfixed-radius point-counts. Thus, rainfall can be used to predict years of low and high reproduction of Zenaida Doves and other columbids showing parallel responses to similar or covarying resources in the xerophytic forest and in other forests of the dry zone (Rivera-Milán 1990, 1992, 1995, 1996). Moreover, these data can be used for the management of harvest rates of Zenaida Doves and other columbids in the dry zone by implementing more effective hunting regulations such as shorter open seasons and reduced bag limits during years with low rainfall and nest density (Ramos 1994, Rivera-Milán et al. 1990).

The rainfall of the first part of the year influences the population dynamics of Zenaida Doves and other bird species in the xerophytic forest by increasing soil moisture, primary productivity, and vegetation cover in deciduous and semi-deciduous habitats (Faaborg 1982, Faaborg et al. 1984, Lugo et al. 1978). The second and greater peak of rain (October–November) is followed by a period of increasing dryness (December–March) and decreasing soil moisture and vegetation cover. Vegetation cover at the nest is the most important microhabitat variable affecting the reproductive success of Zenaida Doves (Rivera-Milán 1996). Therefore, the dry season constrains the foraging (availability of fruits and grass seeds) and nesting (vegetation cover and predation rates by birds and mammals) ecology of Zenaida Doves in the xerophytic forest.

A significant relationship has also been found between the rainfall of the first 6 mo of the year and the calling and nesting activity of columbids in other forests of the dry zone (Rivera-Milán 1990, 1992, 1996). Rainfall, however, seems less important than the availability of fruits of key tree species (e.g., *Syzygium jambos, Solanum torvum,* and *Cecropia shreberiana*) as a predictor of the calling and nesting activity of columbids in the moist and wet zones. Quantitative studies about the fruiting phenology of key tree species are needed to understand better the dynamics of columbid nesting populations in mesic environments (Bancroft et al. 1990, Cardona et al. 1986).

Population monitoring and habitat management.—An effective sampling scheme is needed to monitor the annual changes in the abundance and reproduction of Zenaida Doves in the xerophytic forest. I recommend sampling 32 3-min stations (21 in deciduous, 6 in semi-deciduous, and 5 in thorn-scrub habitats) and 79 0.1-ha strip-transects (38 in deciduous, 12 in semi-deciduous, and 10 in thorn-scrub habitats) monthly from April–

June. Because of the short duration of point-counts, stations can be established at intervals of 800-m along tertiary roads (Rivera-Milán 1993).

This sampling scheme can be implemented by two trained observers from the PRDNER as part of the monitoring project for columbid game species (*Columba squamosa, Z. aurita, Z. asiatica,* and *Z. macroura*) in Puerto Rico (Rivera-Milán 1993). With this sampling intensity, point- and nest-counts should have the precision needed for year-to-year comparisons of mean $\hat{D}$ estimates of Zenaida Doves and their active nests (e.g., paired-comparisons of mean counts in years of low vs high rainfall) and for population trend monitoring (e.g., standard error of the slope of a linear regression; Geissler 1984, Gerrodette 1987, Harris 1986). Moreover, this sampling scheme can be used to evaluate management efforts aiming to improve the quality (productivity) of nesting and foraging habitats of Zenaida Doves and other columbids in the xerophytic forest.

Density can be a misleading indicator of habitat quality (Van Horne 1983). For this reason, long-term reproductive success data are also needed to evaluate the potential value of the xerophytic forest as a population source in the dry zone (Donovan et al. 1995). An average of 10,723 (95% CI = 6329–15,117) Zenaida Doves are killed annually during the September–November hunting season, and most of the approximately 4200 hunters concentrate their hunting efforts in the dry zone (Ramos 1994, Rivera-Milán et al. 1990). The xerophytic forest may be a key habitat for the reproduction of Zenaida Doves in the dry zone of the Puerto Rican mainland. Therefore, its conservation and management may be of critical importance for maintaining current population levels.

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