Research Article

Evaluation of Auditory Counts for Estimating Breeding Populations of White-Winged Doves

MARIO SEPÚLVEDA, *Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA*
FIDEL HERNÁNDEZ,[1] *Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA*
DAVID G. HEWITT, *Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA*
WILLIAM P. KUVLESKY, *Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA*
GARY WAGGERMAN, *Texas Parks and Wildlife Department, San Marcos, TX 78666, USA*
RALPH L. BINGHAM, *Caesar Kleberg Wildlife Research Institute, Texas A&M University-Kingsville, Kingsville, TX 78363, USA*

Abstract

*We evaluated an unverified index (auditory counts) used to estimate breeding populations of white-winged doves (*Zenaida asiatica*) in Texas, USA. Our objectives were to determine optimal survey time of day, year, and count duration, determine if a relationship existed between number of calling doves and population size (nest and dove density), and evaluate an electronic counter to estimate breeding density. We collected data on 15 sites in the Lower Rio Grande Valley of Texas during May–August of 2002–2003. Peak calling occurred between mid-May and late June during 0600–0800 hours. We detected about 60% of calling doves during 2-minute auditory counts. Estimates of breeding doves (pairs ha^{-1}) as determined by auditory counts were positively correlated with both population density ($r > 0.90$, $P < 0.01$) and nest density ($r > 0.94$, $P < 0.01$). The electronic coo-counter tally also exhibited a positive relationship with population density ($r > 0.77$, $P < 0.01$) and nest density ($r > 0.92$, $P < 0.04$). However, the high correlations observed for auditory counts and electronic counter were influenced by 2 high dove-density sites. Our data did not provide convincing support for the premise underlying auditory counts of white-winged doves (i.e., number of doves calling reflects dove abundance). The electronic coo counter was limited in application because it tabulated dove calls based solely on acoustic frequency and therefore could not discriminate against other avian calls with acoustic frequencies similar to those of white-winged doves. Auditory counts may be appropriate as coarse-resolution reconnaissance surveys to locate new white-winged dove areas in need of monitoring but not to obtain reliable abundance estimates. The use of an electronic counter to estimate breeding populations of white-winged doves holds promise, given technical modifications, and warrants further research. Given the current limitations of both auditory counts and electronic counters, alternative survey methods that incorporate detection probabilities (e.g., distance sampling) need to be evaluated for white-winged doves.* (JOURNAL OF WILDLIFE MANAGEMENT 70(5):1393–1402; 2006)

Key words

auditory counts, coo counts, Lower Rio Grande Valley, surveys, Texas, white-winged dove, Zenaida asiatica.

Auditory counts are a common technique used to assess avian populations during the breeding season (McClure 1939, Duke 1966, Scott and Boeker 1972, Dolton 1993). Although auditory techniques vary methodologically, most are based on a common procedure where the number of individuals heard calling along prescribed routes is recorded (Wakeley et al. 1990). An important assumption of indices is that number of birds heard calling provides an accurate index to abundance (Sisson 1968, Keppie et al. 1970). However, because factors such as observer variability and weather can affect detectability of calling birds (LaPerriere and Haugen 1972, Shields 1977, Baskett et al. 1978), this assumption may be violated, thereby invalidating indices (Anderson 2001, Thompson 2002).

An auditory-count index has been used by Texas Parks and Wildlife Department to monitor white-winged dove populations in the Lower Rio Grande Valley of Texas, USA, since 1949 (Uzzell 1949, Cottam and Trefethen 1968). The procedure involves counting the number of calling white-winged doves during 2 minutes at predetermined stops and converting that number to an estimated breeding-pair density using a conversion table (Appendix 1; Uzzell and Kiel 1950). There are 2 primary concerns regarding the validity of this index. First, the methodology is based on the premise that number of calling doves is related to population density, a relationship that has been both questioned (Olson et al. 1983, Armbruster and Basket 1985, Rappole and Waggerman 1986) and supported for doves (Sisson 1968, Keppie et al. 1970). A second and more critical issue is the unknown origin and development of the Uzzell and Kiel (1950) conversion table. An account of the methodology or data used to develop the table does not exist. In fact, according to the only living coauthor, the conversion table was not developed by Uzzell and Kiel (1950) but was already in existence at the time of his hire in 1949 (W. H. Kiel, retired wildlife biologist, personal communication).

Despite the historic and widespread use of an unverified index to monitor white-winged doves in Texas, the validity of the auditory-count index is largely untested (Rappole and Waggerman 1986). In addition, basic survey protocol remains unsubstantiated. For example, timing of surveys is based on subjective estimates of peak diurnal and seasonal calling. The 2-minute duration of auditory counts also represents an arbitrary time period. Our objectives were to

[1] *E-mail: fidel.hernandez@tamuk.edu*

1) quantify peaks in diurnal and seasonal calling, 2) determine percentage of calling doves detected during a 2-minute period, 3) determine if number of calling doves is a correlate of population abundance (nest and dove density), and 4) evaluate the feasibility and practicality of an electronic counter to estimate white-winged dove breeding abundance.

Study Area

We conducted our study in Cameron and Hidalgo counties, Texas, during May–August of 2002 and 2003. These counties lay within a region referred to as the Lower Rio Grande Valley. The Lower Rio Grande Valley was part of the Pleistocene–Recent delta of the Rio Grande and corresponded closely with the Matamoran district of the Tamaulipan Biotic Province (Blair 1950, Jahrsdoerfer and Leslie 1988). The dominant tree species in the Tamaulipan thorn scrub was honey mesquite (*Prosopis glandulosa*; Lonard and Judd 2002). Other common vegetative associations preferred by white-winged doves were dominated by sugar hackberry (*Celtis laevigata*), cedar elm (*Ulmus crassifolia*), anacua (*Ehretia anacua*), Texas ebony (*Pithecellobium ebano*), granjeno (*Celtis pallida*), and brasil (*Condalia hookeri*).

Inland from the Gulf of Mexico, elevation rises about 0.95 m/km and soils gradually changed from silty loams and clays to caliche and gravels (Parvin 1988). The climate in the Lower Rio Grande Valley was semiarid and subtropical with annual rainfall of 38–76 cm. Temperatures averaged about 10°C in January to 36°C in August (Jahrsdoerfer and Leslie 1988).

Methods

Experimental Design

Our sample population included all auditory survey points in Texas Parks and Wildlife Department's 2001 standard operational survey (n = 384 points) in the Lower Rio Grande Valley, which were established systematically along routes to encompass white-winged dove distribution. We used stratified random sampling to select sites for our study. We categorized survey points into 3 strata based on breeding-pair density estimates obtained during 2001 surveys. We defined breeding-pair density strata as low (0–24 breeding pairs ha^{-1}), medium (25–49 breeding pairs ha^{-1}), and high (>50 breeding pairs ha^{-1}). We then randomly selected 5 survey points from each density strata, resulting in 15 total survey points.

We divided the field season into 3 periods based upon historic nesting chronology from Texas Parks and Wildlife Department's nesting transect data: prepeak (1 May–9 Jun), peak (10 Jun–19 Jul), and postpeak (20 Jul–28 Aug). Estimated peak calling of white-winged doves (late May–early Jun) occurred prior to peak nesting. We used the terms prepeak, peak, and postpeak in reference to nesting chronology and not calling chronology.

We conducted 3 types of coo counts using the 15 survey points described above: 2 minutes, 10 minutes, and all morning. We conducted different types of coo counts to address our different objectives.

Assessment of Dove Calling as a Correlate of Population Abundance

We conducted 2-minute auditory counts at each survey point following Texas Parks and Wildlife Department protocol (Waggerman 1999) once per period during 2002. To increase sampling effort within a period, we conducted auditory counts at each survey point 7–10 times per period in 2003. We denoted the number of white-winged doves calling during auditory counts at each survey point and then converted them to breeding-pair density (pairs ha^{-1}) using the conversion table of Uzzell and Kiel (1950; Appendix 1). Because our intent was to relate dove calling to white-winged dove population abundance, it was essential that estimates of both variables were obtained from a common area. Thus, we created a 400-m-radius buffer around each survey point using ArcGIS 8.1 (Environmental Systems Research Institute, Redlands, California) to delineate the area from which dove and nest density estimates were obtained. We chose a distance of 400 m because, on average, an observer is able to hear a white-winged dove calling within this range (G. Waggerman, Texas Parks and Wildlife Department, unpublished data) and this radius had been used in other dove research relating dove calling to nest density (Armbruster et al. 1978, Armbruster and Basket 1985).

To estimate nest density, we delineated brush areas (i.e., potential nesting habitat) and non-brush areas within each buffered survey point and randomly established 3 10 × 100-m transects (0.1 ha) within potential nesting habitat (Rappole and Waggerman 1986). We monitored transects every 4 days throughout each field season (May–Aug, 2002 and 2003). We used a telescopic pole with a 10-cm mirror at the tip to examine each nest found and determine stage of nesting cycle. We numbered each active nest that we found and tagged it for identification with a red tag, which we placed at eye level below each nest.

We also estimated dove density (doves ha^{-1}) within each buffered survey point using fixed-radius point counts (Hutto et al. 1986). These fixed-radius points were located at the beginning and end of each nest transect, resulting in 6 fixed-radius points per survey point (3 transects × 2 fixed-radius points/transect). We conducted point counts instantaneously at a 20-m radius to minimize dove movement into and out of the area of the fixed-radius point. We selected a 20-m radius because this was the approximate distance beyond which vegetation completely obstructed visibility. We surveyed fixed-radius points every 4 days to coincide with nest transect surveys.

Evaluation of Coo-Count Survey

Seasonal peak.—We collected the data from 2-minute auditory counts (see above) throughout the white-winged dove nesting season (May–Aug); thus, we used this data to determine the seasonal peak in calling within a year. We conducted 2 additional types of auditory counts at survey points, all-morning counts and 10-minute counts, to determine peak calling within a day and optimal count duration, respectively.

Diurnal peak.—All-morning counts consisted of 2-minute auditory counts conducted at 20-minute intervals during 0600–1100 hours. We focused counts during the morning period and not throughout the day because previous research had already documented that white-winged doves called more frequently during the morning period (Duvall and Robbins 1952, Peters 1952, Cohen et al. 1960). We conducted all-morning counts once per period at low-density survey points in 2002 and at both low- and medium-density survey points in 2003. We used only low-density survey points initially because we believed that an observer could distinguish individual doves only at low-density survey points. However, during 2002 we discovered that individual doves also could be distinguished at medium-density survey points.

Count duration.—We conducted 10-minute counts 4–8 times per period at low-density survey points in 2002 and at both low- and medium-density survey points in 2003. These counts consisted of 5 consecutive counts of 2 minutes' duration. For each successive time interval (0–2 min, >2–4 min, etc.), we determined only the number of new individuals calling and accumulative total doves calling. We calculated a mean percentage of doves heard for each interval for each site.

Evaluation of Electronic Counter

Personnel in the College of Engineering at Texas A&M University-Kingsville developed an electronic counter to survey calling white-winged dove. The electronic counter was a MATLAB 5.1 (Mathworks, Natick, Massachusetts) computer program that tallied white-winged dove calls based on acoustic frequency corresponding to a white-winged dove call (Irani 2002, Preetham 2002). The electronic counter tallied only total white-winged dove calls and not individual doves.

In 2002 and 2003, we obtained 2-minute recordings during each 2-minute auditory count using a MKH-416 microphone (Sennheiser Electronic Corporation, Old Lyme, Connecticut) and a portable Sony TCD-D100 Portable Digital Audio Tape Walkman Field Recorder (Sony, New York City, New York). Each recording was subsequently processed by the electronic counter to determine total number of calls heard. This procedure involved partitioning each recording into 200 segments and further partitioning each segment into 25-millisecond subsegments (Irani 2002, Preetham 2002). The acoustic frequency of each segment piece was determined, and we then put this information into a matrix to determine if the particular segment occurred within target range for white-winged dove acoustic frequency. Although the mean acoustic frequency of white-winged dove was estimated to be 625 Hz (Waechtler 1977), we set the range from 100 to 1,000 Hz because it was found that white-winged dove acoustic frequencies ranged as low as 100 Hz in high-density situations and as high as 1,000 Hz for individual doves (Irani 2002, Preetham 2002). When a segment met the target acoustic frequency, we tabulated a one in the matrix, and if not, we noted a zero. We totaled the occurrence of ones to estimate the total number of calls detected. We did not attempt to relate range, distribution, and mean calling rate among individuals with different temporal, spatial, and intrinsic characteristics (e.g., age, gender, breeding status, etc.).

Statistical Analyses

Evaluation of coo-count survey.—We estimated peak time of year for dove calling by fitting a linear spline model with unknown knot to weekly averages of 2-minute auditory-count data using PROC NLIN (SAS Institute 2001). The peak time was determined to be the abscissa of the knot. We defined the range of dates for peak calling to be the 95% confidence interval (CI) for the knot. We also used this same approach to determine the diurnal peak in dove calling. To evaluate duration of auditory counts, we calculated the mean percentage of doves heard calling at each interval out of the total number of doves detected during 10-minute counts.

Assessment of dove calling as a correlate of population abundance.—We calculated Pearson's product–moment correlation coefficients between dove calling (i.e., auditory estimate and electronic tally) and population abundance (i.e., dove density and nest density) using 2 different approaches: 1) dove calling to nest-density estimates corresponding to the peak time period as identified by linear spline models, and 2) dove calling to nest-density estimates corresponding to the prepeak and peak period, respectively, following Texas Parks and Wildlife Department protocol. The latter correlation involved a temporal offset because Texas Parks and Wildlife Department protocol associated peak calling, which was believed to occur in May, to peak nesting, which occurred in June.

Evaluation of electronic counter.—We used Pearson's product–moment correlation coefficients to relate electronic-counter tally with population and nest density following the same 2 approaches described above.

Results

Evaluation of Coo-Count Survey

White-winged dove abundance as estimated by auditory counts varied across years. These fluctuations resulted in several sites that did not maintain their original density designation (Table 1). Although our study began with equal allocation of sites by density category in 2001, our study sites consisted of 11 low-, 3 medium-, and 2 high-density categories in 2002 and 10, 2, and 3, respectively, in 2003 (Table 1).

Linear spline models provided a good fit ($R^2 = 0.81$) for calling intensity as estimated by auditory counts (Fig. 1A). We documented that peak calling (knot) occurred during week 5 (95% CI: 1.9–8.1). Thus, the peak calling period approximately occurred between the second week in May and the third week in June. Linear spline models were not good predictors of calling intensity ($R^2 = 0.03$) as estimated by the electronic counter, and a peak (knot) could not be identified (Fig. 1B).

Calling intensity within a diurnal period increased from

Table 1. White-winged dove study sites and corresponding density category (low [0–24 pairs ha^{-1}], mid [25–49 pairs ha^{-1}], and high [50 pairs ha^{-1}]) as determined by 2-min auditory counts, Lower Rio Grande Valley, Texas, USA, May–Jun 2001–2003. Auditory counts were conducted once per site in 2001–2002 and repeated 7–10 times at each site in 2003.

	2001			2002			2003			
Site	***n***	**Estimate[a]**	**Category**	***n***	**Estimate**	**Category**	***n***	**Estimate**	**SD**	**Category**
Anacua	1	157	High	1	198	High	10	148	21.6	High
Banworth	1	60	High	1	7	Low	9	36	25.0	Mid
Bentsen	1	29	Mid	1	12	Low	9	15	5.7	Low
Camp Perry	1	29	Mid	1	22	Low	9	24	13.7	Low
Carricitos	1	12	Low	1	7	Low	10	8	4.7	Low
Gabrielson	1	25	Mid	1	22	Low	9	6	6.2	Low
Goat Island	1	5	Low	1	0	Low	ns[b]	ns	ns	ns
Longoria	1	17	Low	1	5	Low	10	5	4.7	Low
Los Ebanos	1	22	Low	1	7	Low	9	3	4.6	Low
Maria Inez	1	109	High	1	124	High	9	75	12.7	High
Monterrey Banco	1	12	Low	1	5	Low	7	0	0.0	Low
Noriega	1	53	High	1	25	Mid	10	38	10.7	Mid
Pharr Basin	1	12	Low	1	12	Low	9	10	4.3	Low
Rancho Viejo	1	73	High	1	49	Mid	10	50	13.7	High
Santa Ana	1	29	Mid	1	25	Mid	9	20	8.2	Low
Tucker	1	39	Mid	1	0	Low	10	3	3.0	Low

[a] Pairs ha^{-1}.
[b] Not sampled.

0600 hours and peaked at 0740 hours in 2002 (Fig. 2A) and at 0640 hours in 2003 (Fig. 2B). Pooled across years, peak calling (knot) occurred at 0640 hours (95% CI: 0630–0700 hours; Fig. 2C). Regarding the optimal duration for auditory counts, we only heard 69% of the total doves calling during a 10-minute interval at the 0–2-minute interval in 2002 compared with 53% in 2003 (Fig. 3). At the >2–4-minute interval, we heard 88% and 67% of the doves calling in 2002 and 2003, respectively. Pooled across years, we heard 61% and 77% of the doves calling during the 0–2-minute and >2–4-minute interval, respectively (Fig. 3).

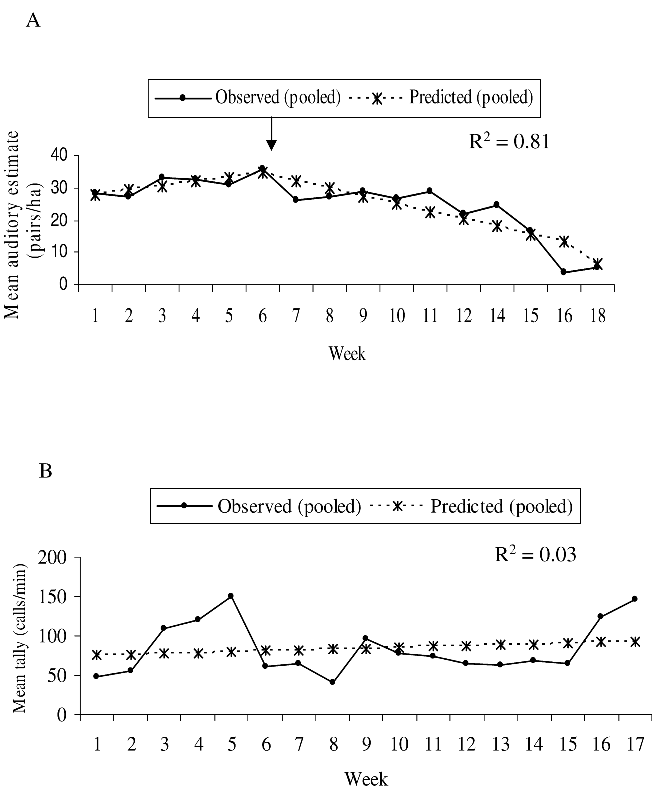

Figure 1. Peak time (week) of white-winged dove calling based on (A) mean auditory estimate (pairs/ha) obtained using 2-min auditory counts and (B) mean tally (calls/min) estimated using an electronic counter pooled over years (2002 [$n = 16$ sites] and 2003 [$n = 15$ sites]), Lower Rio Grande Valley, Texas, USA, May–Aug. Means were calculated per point within a year and then averaged over years. Peaks were estimated by the abscissa of the knot (indicated by arrow) for a linear spline model. Week 1 corresponds to 1 May.

Linear spline models provided a good fit ($R^2 > 0.82$) for nesting activity (Fig. 4). Peak nesting (knot) occurred during week 2 (95% CI: 0.7–3.0) in 2002 and week 3 (95% CI: 2.2–3.2) in 2003 (Fig. 4A,B). Pooled across years, nesting activity peaked during week 3 (95% CI: 2.2–3.4). Thus, the peak nesting period approximately occurred between the second and third week in May. Linear spline models provided a relatively poor fit for dove density (Fig. 5). Dove density slightly increased (slope = 0.4) throughout the study period (Fig. 5).

Assessment of Dove Calling as a Correlate of Population Abundance

Using data obtained during peak calling as estimated by linear spline models (14 May–26 Jun), we detected a positive relationship between auditory counts and both population density and nest density ($r > 0.95$, $P < 0.01$; Table 2, Appendix 2). These high correlations appeared to be influenced by 2 high-density sites (Anacua and Maria Inez; Table 2). Relating calling intensity to population measures using Texas Parks and Wildlife Department protocol (i.e., temporal offset), we also observed a positive relationship between these variables ($r > 0.91$, $P < 0.01$; Table 3, Appendix 3). These correlations also were influenced by the same 2 sites mentioned above (Table 3). When these sites were removed, the relationship between the auditory estimate and dove density ceased to be statistically significant (Table 3).

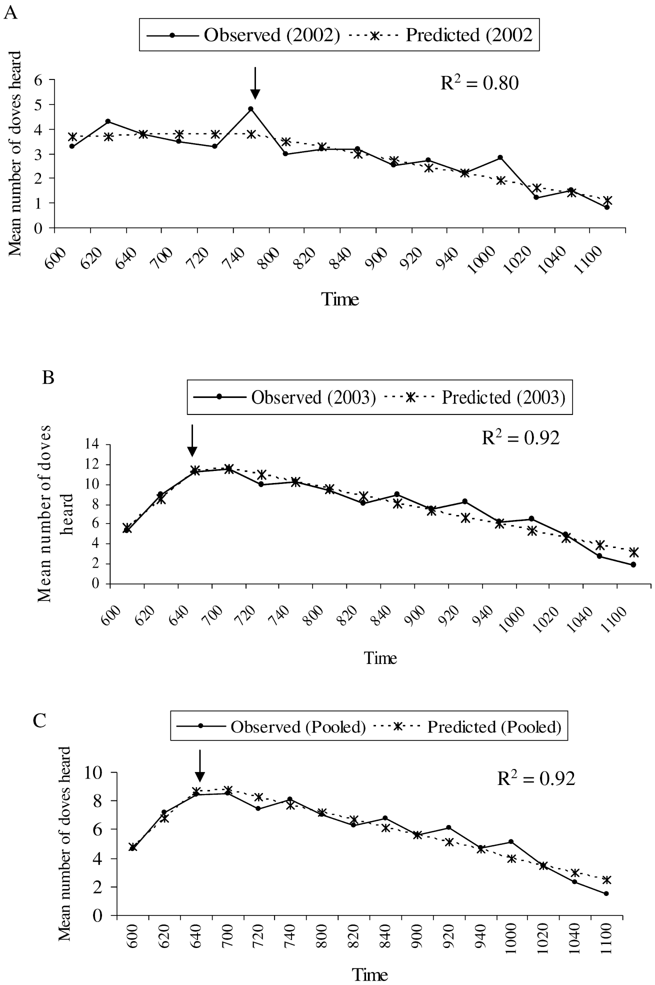

Figure 2. Peak time (hours) of white-winged dove calling based on mean number of doves heard in (A) 2002 ($n = 16$ sites), (B) 2003 ($n = 15$ sites), and (C) pooled data as estimated by the abscissa of the knot for a linear spline model, Lower Rio Grande Valley, Texas, USA, May–Aug 2002–2003. Means were calculated per point within a year and then averaged over years. Arrow denotes knot.

Evaluation of Electronic Coo Counter

Using data obtained during peak calling as predicted by linear spline models, we detected a positive relationship between counter tally and both population density and nest

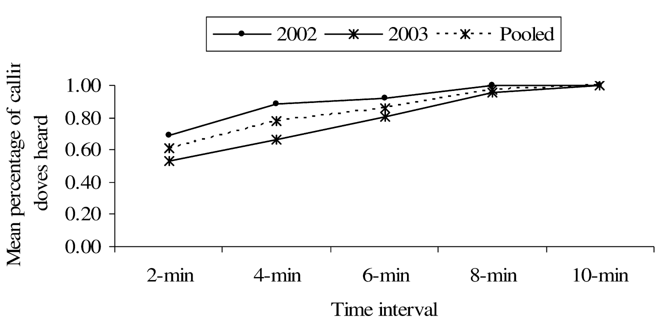

Figure 3. Optimal duration for white-winged dove auditory counts showing the mean percentage of doves heard by an observer from the total number of doves calling during a 10-min coo count in 2002 ($n = 6$ sites) and 2003 ($n = 10$ sites), Lower Rio Grande Valley, Texas, USA, May–Jun 2002–2003. Means were calculated per point within a year and then averaged over years.

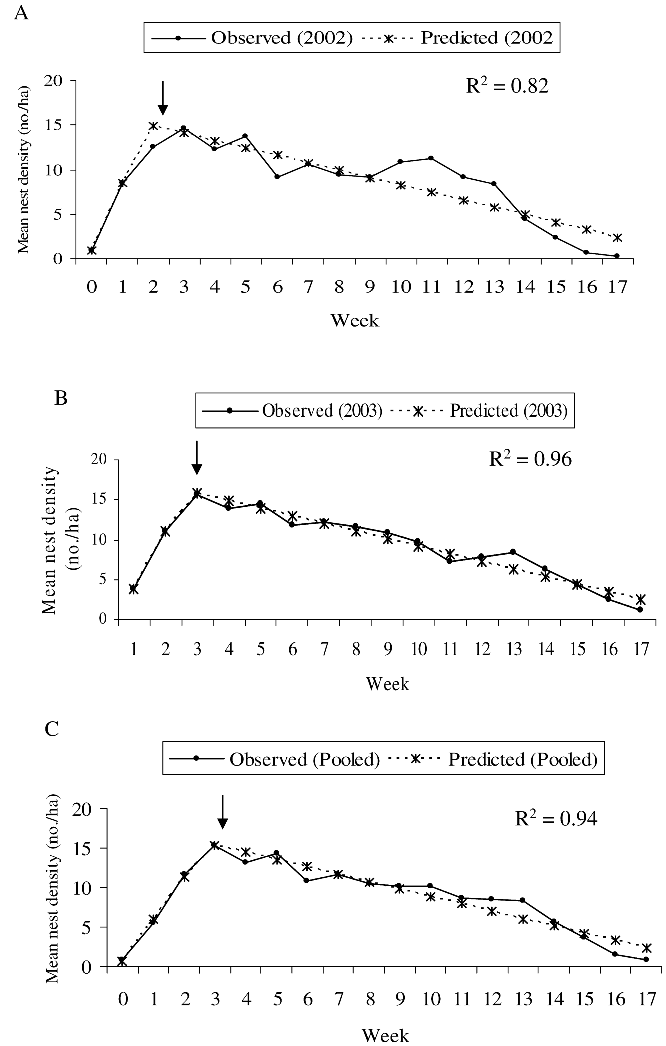

Figure 4. Peak time (week) of white-winged dove nesting based on mean nest density (nests/ha) in (A) 2002 ($n = 16$ sites), (B) 2003 ($n = 15$ sites), and (C) pooled data as estimated by the abscissa of the knot (indicated by arrow) for a linear spline model, Lower Rio Grande Valley, Texas, USA, May–Aug 2002–2003. Means were calculated per point within a year and then averaged over years. Week 1 corresponds to 1 May.

density ($r > 0.92$, $P < 0.01$; Table 2). As was the case with the auditory estimate, these high correlations were influenced by the 2 high-density sites previously mentioned (Table 2). Relating the counter tally to population and nest density using Texas Parks and Wildlife Department protocol (i.e., temporal offset), we also observed a positive relationship between these variables ($r > 0.77$, $P < 0.04$; Table 3). However, the relationship was not statistically significant when we removed the 2 high-density sites (Table 3).

Discussion

Our findings support general survey protocol of Texas Parks and Wildlife Department relative to timing of survey but not use of the current survey to estimate dove abundance. The consensus of white-winged dove biologists has been that peak calling is approximately 3 weeks long and lasts

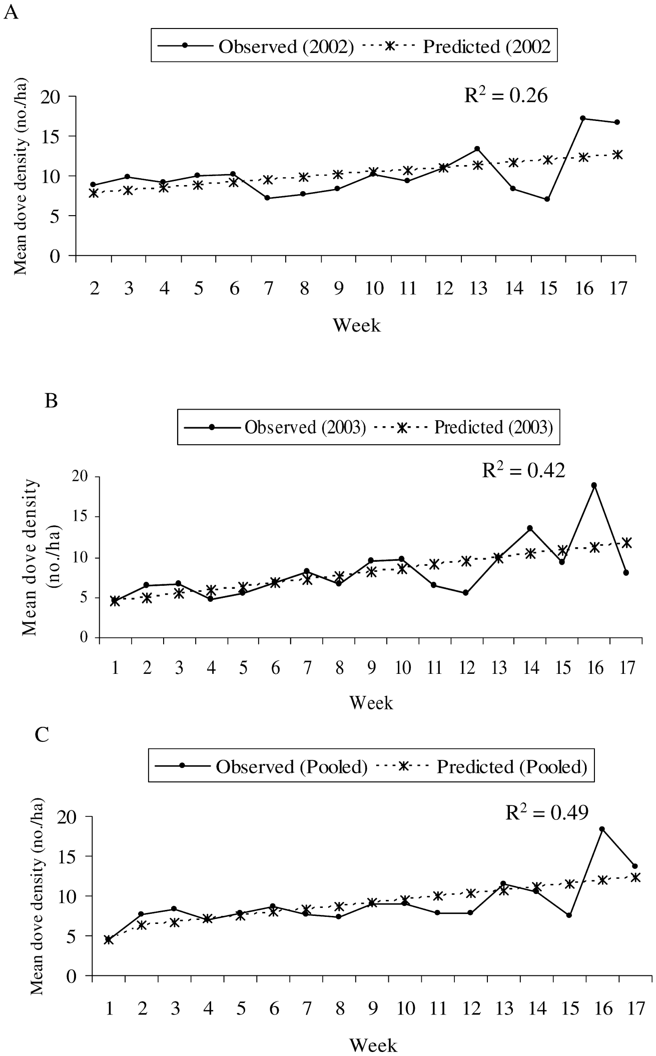

Figure 5. Peak time (week) of white-winged dove density (doves/ha) based on fixed-radius point counts in (A) 2002 ($n = 16$ sites), (B) 2003 ($n = 15$ sites), and (C) pooled data as estimated by the abscissa of the knot for a linear spline model, Lower Rio Grande Valley, Texas, USA, May–Aug 2002–2003. Means were calculated per point within a year and then averaged over years.

from 20 May through 10 June (Waechtler 1977). We documented that peak calling occurred between the second week in May and the third week in June, which coincides with the approximate time period during which Texas Parks and Wildlife Department conducts its surveys (21 May–7 Jun). We also documented that diurnal peak calling occurred during 0600–0800 hours. This finding supports previous research (Waechtler and DeYoung 1990) that indicated that peak calling occurred within the first 2 hours of daylight (0600–0800 hours). Our and previous data for diurnal peak calling coincide with the general time period during which Texas Parks and Wildlife Department conducts surveys (0630–0930 hours).

Our data imply that current duration (2 min) of auditory counts is not sufficiently long to capture a large percentage of cooing doves in an area. Only about 60% of the total doves calling were detected during a 2-minute period. We acknowledge that length of time for which a count is conducted is critical, with longer counts resulting in possible bias because of dove movement into and out of the area. Overestimate of dove density could result from auditory counts of longer duration (e.g., 4 min or longer; Irby 1964, Rappole and Waggerman 1986). However, discussion of the appropriate duration of auditory counts is somewhat moot because the premise underlying the index appears unsubstantiated based on our and prior research.

Auditory counts for white-winged doves are based on the premise that number of calling doves is an accurate index of dove abundance. Our analyses documented a positive relationship between auditory counts and both population density and nest density. However, the strength of these correlations decreased when the high-density sites were removed. Two sites (Anacua and Maria Inez) had relatively high densities of white-winged doves. These sites were >3 standard deviations from mean dove density (calculated without these 2 sites) and skewed the data to appear very highly correlated. We note these sites were not true outliers because high densities such as these do occur in colonial nesting settings. Rather, our study did not contain sufficient study sites for medium- and high-density strata, thereby resulting in the appearance of skewness. Medium-density sites were incorporated into the study design; however, these sites became low density during 2002 and 2003. Hence, our data contained primarily low-density sites and a few high-density sites, a problem also encountered by prior research attempting to relate number of calling doves with white-winged dove nest density (Waechtler and DeYoung 1990). Naturally, the ideal data set would contain sites that spanned the entire range of nest densities.

Table 2. Pearson's product–moment correlation coefficients between dove calling (2-min auditory counts and electronic-counter tally) and population measures (nest density [nests ha^{-1}] and white-winged dove density [doves ha^{-1}]) during peak calling (14 May–26 Jun) as determined by fitting a linear spline model to auditory coo-count data, Lower Rio Grande Valley, Texas, USA, 2002 and 2003.

		Nest density						Dove density					
		All sites			No outliers[a]			All sites			No outliers		
Year	**Survey method**	***n***	***r***	***P***	***n***	***r***	***P***	***n***	***r***	***P***	***n***	***r***	***P***
2002	Auditory	16	0.95	<0.01	14	0.64	0.01	16	0.96	<0.01	14	0.60	0.02
	Tally	12	0.92	<0.01	10	0.59	0.07	12	0.94	<0.01	10	0.38	0.27
2003	Auditory	15	0.95	<0.01	13	0.66	0.02	15	0.96	<0.01	13	0.75	<0.01
	Tally	15	0.97	<0.01	13	–0.14	0.63	15	0.94	<0.01	13	–0.13	0.68

[a] We removed 2 relatively high-density sites that were skewing data to determine those sites' effect on correlation coefficients.

Table 3. Pearson's product–moment correlation coefficients between dove calling (2-min auditory counts and electronic-counter tally) during peak calling (1 May–9 Jun) and population measures (nest density [nests ha^{-1}] and white-winged dove density [doves ha^{-1}]) during peak nesting (10 Jun–19 Jul) as defined by Texas Parks and Wildlife Department, Lower Rio Grande Valley, Texas, USA, 2002 and 2003.

		Nest density						Dove density					
		All sites			No outliers[a]			All sites			No outliers		
Year	Calling	*n*	*r*	*P*	*n*	*r*	*P*	*n*	*r*	*P*	*n*	*r*	*P*
2002	Auditory	16	0.95	<0.01	14	0.61	0.02	16	0.97	<0.01	14	0.63	0.02
	Tally	12	0.92	<0.04	10	0.56	0.09	12	0.94	<0.01	10	0.34	0.34
2003	Auditory	15	0.94	<0.01	13	0.65	0.02	15	0.91	<0.01	13	0.54	0.06
	Tally	15	0.92	<0.01	13	−0.44	0.14	15	0.77	<0.01	13	−0.13	0.68

[a] We removed 2 relatively high-density sites that were skewing data to determine those sites' effect on correlation coefficients.

Our dataset did not allow for a complete evaluation of the hypothesized relationship; however, we contend auditory counts are not a valid index of white-winged dove abundance. Rappole and Waggerman (1986) reported that auditory estimates of white-winged doves were poorly correlated nest-count estimates. Previous research on mourning dove (*Zenaida macroura*) also reported no consistent relationship between numbers of cooing doves and numbers of nests (Armbruster et al. 1978, Armbruster and Baskett 1985). Further, our estimates of white-winged dove density obtained using auditory counts grossly exceeded estimates of dove and nest density obtained using transects—up to 33 times higher. Rappole and Waggerman (1986) observed similar gross overestimation, with auditory-count estimates exceeding nest-count estimates up to 15 times higher.

Evaluation of Electronic Coo Counter

Waechtler and DeYoung (1990) reported a positive relationship between dove calling as measured by an electronic counter and nest density. We also documented a positive relationship between our electronic-counter tally and both population and nest density. However, as was the case with auditory counts, high-density sites influenced the relationship. Despite this outcome, there could be other reasons why we did not document a consistent, significant correlation between electronic counter tally and measures of population density beyond the statistical and biological ones mentioned above. For example, number of doves calling can vary dramatically at a site even within a single morning (Waechtler and DeYoung 1990). This minute-by-minute variation in number of doves calling can affect the consistency of electronic counters and therefore the hypothesized dove calling–population size relationship. Furthermore, the electronic counters used by Waechtler and DeYoung (1990) and our study were based solely on acoustic frequency of white-winged doves. Because of the relatively wide acoustic frequency range of white-winged doves (100–1,000 Hz; Irani 2002, Preetham 2002), it is likely for other bird calls to lie within the target acoustic range, thereby biasing tabulations of white-winged dove calls. Mourning dove and white-tipped dove (*Leptotila verreauxi*) calls are known to fall within the acoustic frequency range of white-winged doves (Irani 2002, Preetham 2002). One possible solution is to modify the electronic counter to evaluate incoming calls based not only on acoustic frequency but also spectrogram. Dahlquist et al. (1990) used spectrograms to distinguish vocalizations of male Gould's wild turkeys (*Meleagris gallopavo mexicana*) by comparing points of different spectrograms and determining their correlation. They determined that correlation coefficients >0.41 generally indicated the same individual. However, there still remained subjectivity in individual identification especially for analyses that produced correlation coefficients near the landmark value (e.g., 0.40).

Management Implications

Although our data support the general survey protocol of Texas Parks and Wildlife Department (e.g., timing of survey), we discourage continued use of auditory counts to estimate white-winged dove abundance. Convincing data are lacking to support the underlying assumption of auditory counts (i.e., dove calling is an accurate index of abundance). The distribution of white-winged doves has been expanding northward to urban areas outside of its historic Lower Rio Grande Valley range (George et al. 1994). In this context, auditory counts may be appropriate as coarse-resolution reconnaissance surveys to locate new white-winged dove areas in need of monitoring but not to obtain reliable abundance estimates. The use of an electronic counter to estimate breeding populations of white-winged doves holds promise given technical modifications and warrants further research. In light of auditory-count limitations and current challenges facing electronic counters, other methods that incorporate detection probabilities (e.g., distance sampling [Buckland et al. 2001]) need to be evaluated as a potential survey method for white-winged doves (Breeden et al. 2004).

Acknowledgments

We thank K. Bautch, J. B. Breeden, A. Felton, K. Pruit, and the numerous research technicians who assisted with data collection. We also thank Texas Parks and Wildlife Department, United States Fish and Wildlife Service, and private landowners for providing access to their lands and cooperation with our project. Texas Parks and Wildlife Department (White-Winged Dove Stamp Fund) provided financial support for our research. We thank B. M. Ballard, L. A. Brennan, Associate Editor Carroll, and 3 anonymous reviewers for providing helpful comments on an earlier version of this manuscript. This manuscript is Caesar Kleberg Wildlife Research Institute Publication Number 05-110.

Literature Cited

Anderson, D. R. 2001. The need to get the basics right in wildlife field studies. Wildlife Society Bulletin 29:1294–1297.

Armbruster, M. J., and T. S. Baskett. 1985. A seven-year study of mourning dove call-counts and nesting activity in central Missouri. Transactions of the Missouri Academy of Science 19:23–30.

Armbruster, M. J., T. S. Baskett, and K. C. Sadler. 1978. Evaluating call-count procedures for measuring local mourning dove populations. Transactions of the Missouri Academy of Science 12:75–90.

Baskett, T. S., M. J. Armbruster, and M. W. Sayre. 1978. Biological perspectives for the mourning dove call-count survey. Transactions of the North American Wildlife and Natural Resources Conference 43: 163–180.

Blair, W. F. 1950. The biotic provinces of Texas. Texas Journal of Science 2:93–117.

Breeden, J. B., F. Hernández, N. J. Silvy, R. L. Bingham, and G. L. Waggerman. 2004. An evaluation of sampling methods for white-winged dove surveys in urban areas. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 58:in press.

Buckland, S. T., D. R. Anderson, K. P. Burnham, J. L. Laake, D. L. Borchers, and L. Thomas. 2001. Introduction to distance sampling: estimating abundance of biological populations. Oxford University, New York, New York, USA.

Cohen, A., H. S. Peters, and L. E. Foote. 1960. Calling behavior of mourning doves in two Midwest life zones. Journal of Wildlife Management 24:203–212.

Cottam, C., and J. B. Trefethen. 1968. Whitewings: the life history, status, and management of the white-winged dove. Van Nostrand Reinhold, Princeton, New Jersey, USA.

Dahlquist, F. C., S. D. Schemnitz, and B. K. Flachs. 1990. Distinguishing individual male wild turkeys by discrimination of vocalizations. National Wild Turkey Symposium 6:149–156.

Dolton, D. D. 1993. The call-count survey. Pages 233–252 *in* T. S. Baskett, M. W. Sayre, R. E. Tomlinson, and R. E. Mirarchi, editors. Ecology and management of the mourning dove. Stackpole, Harrisburg, Pennsylvania, USA.

Duke, G. E. 1966. Reliability of censuses of singing male woodcocks. Journal of Wildlife Management 30:697–707.

Duvall, A. J., and C. S. Robbins. 1952. Investigations of methods of determining abundance of breeding mourning doves in certain eastern states. Special Scientific Report, Wildlife 17:15–34. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C., USA.

George, R. R., R. E. Tomlinson, R. W. Engel-Wilson, G. L. Waggerman, and A. G. Spratt. 1994. White-winged dove. Pages 29–52 *in* C. E. Braun, and T. C. Tacha, editors. Migratory shore and upland game bird management in North America. International Association of Fish and Wildlife Agencies, Washington, D.C., USA.

Hutto, R. L., S. M. Pletschet, and P. Hendricks. 1986. A fixed-radius point count method for non-breeding and breeding season use. Auk 103:593–602.

Irani, V. J. 2002. Design of digital call-counter for white-winged doves. Thesis, Texas A&M University-Kingsville, Kingsville, USA.

Irby, H. D. 1964. The relationship of calling behavior to mourning dove populations and production in southern Arizona. Dissertation, University of Arizona, Tucson, USA.

Jahrsdoerfer, S. E., and D. M. Leslie Jr. 1988. Tamaulipan brush land of the Lower Rio Grande Valley of South Texas: description, human impacts, and management options. U.S. Fish and Wildlife Service Biological Report 88(36), Fort Collins, Colorado, USA.

Keppie, D. M., H. M. Wight, and W. S. Overton. 1970. A proposed band-tailed pigeon census a management need. Transactions of the North American Wildlife and Natural Resources Conference 35:157–171.

LaPerriere, A. J., and A. O. Haugen. 1972. Some factors influencing calling activity of wild mourning doves. Journal of Wildlife Management 36:1193–1199.

Lonard, R. I., and F. W. Judd. 2002. Riparian vegetation of the Lower Rio Grande. Southwestern Naturalist 47:420–432.

McClure, H. E. 1939. Cooing activity and censusing of the mourning dove. Journal of Wildlife Management 3:323–328.

Olson, T. E., C. E. Braun, and R. A. Ryder. 1983. Cooing activity and nesting of mourning doves in northeastern Colorado. Southwestern Naturalist 28:335–340.

Parvin, B. 1988. The disappearing wild land of the Rio Grande Valley. Texas Parks and Wildlife 46:2–15.

Peters, H. S. 1952. A summary of mourning dove call count investigations in Ohio. Special Scientific Report, Wildlife 17:35–46. U.S. Department of Interior, Fish and Wildlife Service, Washington, D.C., USA.

Preetham, S. 2002. Design of a digital call counter for white-winged doves using frequency estimation in a noisy environment. Thesis, Texas A&M University-Kingsville, Kingsville, USA.

Rappole, J. H., and G. Waggerman. 1986. Calling males as an index of density for breeding white-winged doves. Wildlife Society Bulletin 14: 151–155.

SAS Institute. 2001. SAS software release 8.2. SAS Institute, Cary, North Carolina, USA.

Scott, V. E., and E. L. Boeker. 1972. An evaluation of wild turkey call counts in Arizona. Journal of Wildlife Management 36:628–630.

Shields, W. H. 1977. The effect of time of day on avian census results. Auk 94:380–383.

Sisson, L. H. 1968. Calling behavior of band-tailed pigeons in reference to a census technique. Thesis, Oregon State University, Corvallis, USA.

Thompson, W. L. 2002. Towards reliable bird surveys: accounting for individuals present but not detected. Auk 119:18–25.

Uzzell, P. B. 1949. Status of the white-winged dove in Texas. Performance report. Texas Parks and Wildlife Department Federal Aid Project W-30-R, Austin, USA.

Uzzell, P. B., and W. H. Kiel Jr. 1950. Unpublished progress report. Texas Parks and Wildlife Department, Austin, USA.

Waechtler, D. G. 1977. Electronic call-counts as an estimator of nesting white-winged dove populations. Thesis, Texas A&M University-Kingsville, Kingsville, USA.

Waechtler, D. G., and C. A. DeYoung. 1990. Evaluation of an electronic device for counting the calls of white-winged doves. Texas Journal of Agriculture and Natural Resources 4:57–59.

Waggerman, G. 1999. White-winged and white-tipped dove density, distribution, and harvest. Texas Parks and Wildlife Department Federal Aid Project W-128-R-7, Austin, USA.

Wakeley, J. S., T. H. Roberts, and C. O. Martin. 1990. Auditory survey techniques. U.S. Army Corps of Engineers Wildlife Resources Management Manual. Technical Report EL-9007, U.S. Army Corps of Engineer Waterways Experiment Station, Vicksburg, Mississippi, USA.

Associate Editor: Carroll.

Appendix 1. Conversion table relating calling intensity of white-winged doves to breeding-pair density (pairs ha^{-1}), based on unpublished work by Uzzell and Kiel (1950).

Birds calling	Pairs ha^{-1}
1	5.0
2	7.5
3	12.5
4	17.5
5	22.5
6	25.0
A[a]	27.5–42.5
B[b]	45.0–47.5
C[c]	50.0–75.0
D[d]	>75.0

[a] Individual birds difficult to distinguish.
[b] Cooing almost continuous (infrequent 2- to 3-sec breaks).
[c] Constant cooing (no breaks).
[d] Audible roar.

Appendix 2. Data used to calculate Pearson's product–moment correlation coefficients between dove calling (2-min auditory counts and electronic-counter tally) and population measures (nest density [nests ha^{-1}] and white-winged dove density [doves ha^{-1}]) during peak calling (14 May–26 Jun) as determined by fitting a linear spline model to auditory coo-count data, Lower Rio Grande Valley, Texas, USA, 2002 and 2003.

		Counter			Auditory			Dove estimate				Nest estimate			
Year	Site	*N*	Tally	SD	*N*	Estimate[a]	SD	*N*	Dates[b]	Density	SD	*N*	Dates	Density	SD
2002	Anacua	1	400		1	198.0		6	11	57.3	11.8	3	6	123.3	34.1
	Banworth	0			1	7.0		6	10	1.2	1.7	3	6	0.0	0.0
	Bentsen	1	27		1	12.0		6	11	2.1	1.4	3	6	0.0	0.0
	Camp Perry	0			1	22.0		6	8	0.2	0.5	3	6	0.6	1.4
	Carricitos	1	19		1	7.0		6	10	2.4	2.3	3	6	1.1	1.7
	Gabrielson	1	109		1	22.0		6	10	0.4	0.9	3	6	0.0	0.0
	Goat Island	0			1	0.0		6	9	1.0	1.5	3	6	0.0	0.0
	Longoria	1	39		1	5.0		6	10	0.8	1.3	3	6	5.6	1.8
	Los Ebanos	1	12		1	7.0		6	11	2.3	2.2	3	6	1.7	2.8
	Maria Inez	1	266		1	124.0		6	11	51.0	12.8	3	6	37.8	9.6
	Monterrey Banco	0			1	5.0		6	5	0.8	1.2	3	6	0.0	0.0
	Noriega	1	74		1	25.0		6	11	2.0	1.4	3	6	1.1	1.7
	Pharr Basin	1	28		1	12.0		6	10	2.4	2.2	3	6	1.1	2.7
	Rancho Viejo	1	126		1	49.0		6	11	6.4	3.8	3	6	13.4	4.2
	Santa Ana	1	11		1	25.0		6	10	1.7	1.7	3	6	0.0	0.0
	Tucker	1	7		1	0.0		6	11	2.1	1.8	3	6	0.6	1.4
2003	Anacua	11	880.4	251.2	11	162.9	14.4	6	11	48.5	14.8	3	11	134.9	26.4
	Banworth	6	66.3	97.6	10	38.6	23.2	6	11	0.7	1.4	3	11	0.0	0.0
	Bentsen	6	2.7	2.5	10	17.1	5.3	6	10	2.1	2.3	3	11	2.7	2.5
	Camp Perry	11	3.1	3.0	11	18.4	13.9	6	10	0.4	1.3	3	11	0.0	0.0
	Carricitos	11	12.6	13.4	11	8.1	4.7	6	10	0.9	1.8	3	11	1.2	1.7
	Gabrielson	5	101.0	124.9	10	6.5	5.8	6	9	0.4	0.7	3	11	0.0	0.0
	Longoria	11	10.0	13.9	11	6.4	5.1	6	8	0.0	0.0	3	11	1.2	1.7
	Los Ebanos	8	26.1	65.1	10	4.1	4.1	6	5	0.5	0.7	3	11	0.0	0.0
	Maria Inez	6	158.2	139.2	10	78.8	11.6	6	11	23.3	11.8	3	11	47.3	12.7
	Monterrey Banco	5	23.0	45.9	8	0.0	0.0	6	6	0.0	0.0	3	11	0.0	0.0
	Noriega	11	7.6	7.0	11	33.3	13.3	6	11	1.2	1.5	3	11	1.8	1.7
	Pharr Basin	4	11.0	13.0	10	11.3	4.6	6	9	0.7	1.2	3	11	0.3	1.0
	Rancho Viejo	11	36.2	62.7	11	48.6	12.2	6	10	4.1	3.2	3	11	7.0	2.3
	Santa Ana	5	15.4	27.8	10	18.0	9.0	6	10	1.2	1.7	3	11	0.0	0.0
	Tucker	11	60.4	90.8	11	2.9	2.8	6	10	0.0	0.0	3	11	0.0	0.0

[a] Pairs ha^{-1}.
[b] Number of survey dates.

Appendix 3. Data used to calculate Pearson's product–moment correlation coefficients between dove calling (2-min auditory counts and electronic-counter tally) during peak calling (1 May–9 Jun) and population measures (nest density [nests ha^{-1}] and white-winged dove density [doves ha^{-1}]) during peak nesting (10 Jun–19 Jul) as defined by Texas Parks and Wildlife Department, Lower Rio Grande Valley, Texas, USA, 2002 and 2003.

		Peak calling						Peak nesting							
		Counter			Auditory			Dove estimate				Nest estimate			
Year	Site	*N*	Tally	SD	*N*	Estimate[a]	SD	*N*	Dates[b]	Density	SD	*N*	Dates	Density	SD
2002	Anacua	1	400		1	198.0		6	9	47.3	12.4	3	5	107.3	17.1
	Banworth	0			1	7.0		6	6	0.7	1.1	3	5	0.0	0.0
	Bentsen	1	27		1	12.0		6	7	3.2	3.5	3	5	0.0	0.0
	Camp Perry	0			1	22.0		6	6	1.1	1.8	3	5	0.7	1.5
	Carricitos	1	19		1	7.0		6	8	1.3	1.4	3	5	0.0	0.0
	Gabrielson	1	109		1	22.0		6	7	0.0	0.0	3	5	0.0	0.0
	Goat Island	0			1	0.0		6	4	1.3	1.1	3	5	0.0	0.0
	Longoria	1	39		1	5.0		6	9	1.2	1.4	3	5	5.3	1.9
	Los Ebanos	1	12		1	7.0		6	7	2.1	2.2	3	5	4.0	1.5
	Maria Inez	1	266		1	124.0		6	10	37.4	10.8	3	5	33.3	6.7
	Monterrey Banco	0			1	5.0		6	5	0.8	1.2	3	5	0.0	0.0
	Noriega	1	74		1	25.0		6	8	2.5	1.5	3	5	2.6	1.5
	Pharr Basin	1	28		1	12.0		6	7	1.5	2.0	3	5	0.0	0.0
	Rancho Viejo	1	126		1	49.0		6	9	6.2	3.2	3	5	10.7	2.8
	Santa Ana	1	11		1	25.0		6	6	2.0	1.4	3	5	0.0	0.0
	Tucker	1	7		1	0.0		6	9	2.5	2.1	3	5	0.0	0.0
2003	Anacua	9	776.1	379.3	10	148.4	21.6	6	10	46.3	12.3	3	10	98.7	27.4
	Banworth	8	62.4	85.6	9	35.6	25.0	6	10	0.0	0.0	3	10	0.0	0.0
	Bentsen	8	3.5	3.1	9	14.6	5.7	6	10	2.8	2.5	3	10	2.0	1.7
	Camp Perry	8	6.4	12.3	9	23.6	13.7	6	8	0.0	0.0	3	10	0.0	0.0
	Carricitos	9	13.6	14.6	10	8.2	4.7	6	8	0.2	0.5	3	10	2.3	1.6
	Gabrielson	6	44.0	50.5	9	6.4	6.2	6	10	0.7	0.9	3	10	0.0	0.0
	Longoria	10	27.4	53.4	10	4.6	4.7	6	7	0.0	0.0	3	10	1.3	1.7
	Los Ebanos	9	25.2	61.2	9	2.9	4.6	6	5	0.0	0.0	3	10	0.0	0.0
	Maria Inez	8	134.5	130.1	9	75.3	12.7	6	10	36.8	19.3	3	10	39.7	12.5
	Monterrey Banco	5	23.0	45.9	7	0.0	0.0	6	4	0.0	0.0	3	10	0.0	0.0
	Noriega	9	33.2	51.2	10	38.1	10.7	6	9	0.0	0.0	3	10	2.3	1.6
	Pharr Basin	5	8.4	12.2	9	10.3	4.3	6	9	1.5	1.7	3	10	0.0	0.0
	Rancho Viejo	9	26.9	30.7	10	50.0	13.7	6	9	5.9	3.2	3	10	8.7	3.2
	Santa Ana	6	15.5	24.6	9	20.0	8.2	6	10	1.2	1.5	3	10	0.0	0.0
	Tucker	9	57.3	53.4	10	3.4	3.0	6	7	0.0	0.0	3	10	0.0	0.0

[a] Pairs ha^{-1}.
[b] Number of survey dates.