Effects of Point Count Duration, Time-of-Day, and Aural Stimuli on Detectability of Migratory and Resident Bird Species in Quintana Roo, Mexico¹

James F. Lynch²

Abstract: Effects of count duration, time-of-day, and aural stimuli were studied in a series of unlimited-radius point counts conducted during winter in Quintana Roo, Mexico. The rate at which new species were detected was approximately three times higher during the first 5 minutes of each 15-minute count than in the final 5 minutes. The number of individuals and species detected in 15-minute counts declined by >60 percent over the first 3 hours after sunrise. Use of aural stimuli (playbacks of prereorded warbler "chip" notes, imitated owl calls, "spishing") offset this temporal reduction in detection rate for Nearctic migrants, but not for most permanent residents. The relative precise if the sample of points is large and especially if the probability of detecting targeted species is high. Different combinations of sample size and count duration can yield equally precise estimates of occurrence rates.

The point count method is commonly used to survey breeding bird communities in temperate North America (Verner 1985), where investigators have studied the effects of count duration, radius of the count area, and time-of-day (Gutzwiller 1991; Robbins 1981; Buskirk and others, Dawson and others, Gates, Petit and others in this volume). However, there have been only two previous quantitative assessments of the point count method in the Neotropics, where a high proportion of the landbird species that breed in temperate North America spend most of the year (Blake 1992, Hutto and others 1986). Given the precarious status of some Nearctic migrants (Askins and others 1990, Hagan and Johnston 1992, Keast and Morton 1980, Rappole and others 1983), additional information on their winter distribution and ecology is urgently needed. If point counts are to be employed in such studies, several questions should be addressed: (1) Are point counts suitable for surveys of nonbreeding birds in the Neotropics? (2) Which extrinsic factors influence the results of winter point counts in the Neotropics? (3) How can survey protocols be modified to increase the efficiency of winter point counts in the Neotropics?

Methods

Between 1984 and 1990, 1 conducted approximately 1200 unlimited-radius point counts of winter bird communities in the Yucatan Peninsula of Mexico, Belize, and Guatemala (Lynch 1989, 1992). Because the primary focus of my research was the distributional ecology of Nearctic migrants, I supplemented my point counts with three types of aural stimuli: (1) playbacks of prerecorded "chip" notes of the Hooded Warbler (*Wilsonia citrina*) and Kentucky Warbler (*Oporomis formosus*), (2) whistled imitation of the

¹ An abbreviated version of this paper was presented at the Workshop on Monitoring Bird Population Trends by Point Counts, November 6-7, 1991, Beltsville, Maryland.

call of the Ferruginous Pygmy-Owl (*Glaucidium brasilianum*), a common diurnal predator of small birds, and (3) "spishing" sounds of the kind ornithologists often use to instigate approach or vocalization by birds. During the winters of 1986-87 and 1987-88, I conducted a series of experimental point counts to quantify the effects of aural stimuli, time of day, and duration of count.

This study was conducted within a 10-km radius of the coastal village of Puerto Morelos, in northeastern Quintana Roo, Mexico (lat. $20^{\circ}51$ 'N., long. $86^{\circ}54$ 'W.). Local annual rainfall is approximately 1200 mm, and a dry season extends from about November to May (Lynch 1989). Counts were restricted to the interior (>100 m from roads or clearings) of extensive tracts of relatively undisturbed medium-stature (canopy height = 12 m to 20 m), semievergreen tropical forest. Elevations of survey sites ranged from 5 m to 25 m above sea level.

I generally began conducting point counts within 15 minutes of local sunrise and continued for approximately 3 hours, by which time bird activity had declined markedly. I alternated 15-minute "unsupplemented" counts (no aural stimuli used) with 15-minute "supplemented" counts, during which I alternated playbacks of Hooded Warbler "chip" notes, imitated owl calls, "spishing" and periods of silence. No attempt was made to distinguish the individual effects of the three stimuli. Count results were tallied by 5-minute intervals, and detections made within 30 m were compiled separately. The distance between survey points was 200-300 m, and the travel time between points was 3-6 minutes (mean = 5 minutes). The term "species occurrence" refers to the detection of one or more individuals of a given species during a single point count.

At the time of year when this study was conducted (early December to mid-February), local sunrise occurred between about 0608 and 0624 c.s.t. (U.S. Department of Commerce 1990). For analysis, mornings were divided into three 1-hour count periods (0600-0659, 0700-0759, 0800-0859).

Data were subjected to multiple linear regression analysis and ANOVA, using the General Linear Models Procedure of the SAS statistical package (SAS Institute 1985).

Results

I identified 72 species of birds in 71 fifteen - minute unlimited-radius point counts. There were 673 detections of individual birds or conspecific groups, of which 595 or (88 percent) could be identified to species.

Effects of Aural Stimuli

When the data were pooled across the three time periods (0600-0900), counts supplemented by aural stimuli yielded about 11 percent more species occurrences per 15-minute

² Zoologist, Smithsonian Environmental Research Center, P.O. Box 28, Edgewater, Maryland 21037

count than did unsupplemented counts (*table 1*). Most of this difference was attributable to a statistically significant increase of about one species in the mean number of migratory species encountered in supplemented counts from 0800-0859. Aural stimuli had no significant effect on detection rates of migrants early in the morning (0600-0659). As a group, residents showed no consistent response to the experimental aural stimuli at any time from 0600-0900 (*fig. 1; table 2*), although a few resident taxa (e.g., several hummingbird species) reacted aggressively to the Ferruginous Pygmy-Owl call.

The total number of species detected in point counts supplemented by aural stimuli was 19 percent higher than in unsupplemented counts (65 versus 53), but this may, in part, reflect the larger number of supplemented versus unsupplemented counts (39 versus 32).

Effect of Count Duration

On the average, 55 percent (range = 51 percent to 66 percent) and 82 percent (range = 75 percent to 85 percent) of all initial species detections occurred within the first 5 minutes and first 10 minutes, respectively, of 15-minute counts, regardless of the time of morning or the use of aural stimuli (*table 1*). The detection rate of new species in the 0- to 5-minute interval (1.02 species per minute) was three times as high as in the 10- to 15-minute interval (0.34 species per minute).

Effect of Time of Morning

The mean number of species detections per 15-minute count (supplemented and unsupplemented counts pooled) declined significantly (P < 0.001) from 11.5 between 0600 and 0659 to 6.6 between 0800 and 0859. This temporal decline was much steeper for unsupplemented counts (-62 percent) than for supplemented counts (-23 percent). Time of morning had no statistically significant effect on the number of migrant occurrences in counts supplemented by aural stimuli (P < 0.05, *table 2*). However, the number of resident detections per count showed a highly significant (P < 0.0001) temporal decline in both supplemented and unsupplemented counts.

Effect of Limiting the Count Radius

Unlimited-radius counts yielded 81 percent more occurrences than did counts restricted to a 30-m radius (table 3). However, the effect of restricting count radius was not uniform across species. Some large, highly vocal species (e.g., Plain Chachalaca (Ortalis vetula), Collared Forest-Falcon (Micrastur semitorquatus), Yellow-lored Parrot (Amazona Ferruginous Pygmy-Owl, Golden-fronted xantholora), Woodpecker (Centurus aurifrons), Brown Jay (Cyanocorax morio)) were rarely or never detected within 30 m of the observer, but were commonly detected at greater distances. Restricting the count radius to 30 m reduced the number of detections of such species to the point where little useful information on their occurrence was obtained. At the opposite extreme, some smaller and quieter species (e.g., American Redstart (Setophaga ruticilla), Black-and-white Warbler (Mniotilta varia), White-eyed Vireo (Vireo griseus), Blackthroated Green Warbler (Dendroica virens)) were almost always detected within 30 m of the observer. Limiting the count radius had little effect on the detectability of such species.

Discussion

Utility of Winter Point Counts in the Neotropics

Most species detections of birds in forested habitats are based on vocalizations (Hayward and others 1991, Skirvin 1981). Because territorial singing by overwintering migrants is infrequent during the nonbreeding season, one might have predicted that winter point counts of migrants in tropical forest would not be effective. However, extensive survey data from the Yucatan Peninsula indicate that winter point counts in the lowland tropics can, in fact, yield useful quantitative data from both migratory and permanently resident species (Lynch 1989; 1991, 1992). Species-specific "chips" and other nonsong vocalizations are used frequently by both migrants and residents during winter in Quintana Roo, and many local residents also use territorial songs at that season. As a result, an estimated two-thirds to three-quarters of all species identifications in this study were made on the basis of aural cues.

Winter point counts in Quintana Roo do present some

			Count interval		
	n	0-5 minutes	5-10 minutes	10-15 minutes	0-15 minutes
Time	S (U)	S (U)	S (U)	S (U)	S (U)
0600-0659	12 (8)	6.1 (7.9)	2.8 (2.2)	2.2 (1.9)	11.1 (12.0)
0700-0759	16 (14)	4.9 (5.2)	3.1 (3.4)	1.7 (1.5)	9.6 (10.1)
0800-0859	11 (10)	4.3 (2.6)	2.1 (0.9)	2.2 (1.0)	8.5 (4.5)
Total (3 hours)	39 (32)	15.3 (15.7)	8(6.5)	6.1 (4.4)	29.2 (26.6)

Table 1—Mean number of new species detections as a function of time of morning and count interval in 71 point counts conducted during winter in Quintana Roo, Mexico. Counts were either supplemented by aural stimuli (S) or were unsupplemented controls (U)



Figure 1--Effects of time of morning and the use of aural stimuli on the number of (A) resident and (B) migrant bird species detected in 15-minute unlimited-radius point counts conducted during winter in Quintana Roo, Mexico.

 Table 2--Summary of results of multiple regression analysis testing the effects of aural stimuli (AS) and time of morning (T) on the number of species detections in 71 winter point counts in Quintana Roo, Mexico

			Coe	Coefficient	
Response variable	Mean	Intercept	AS	Т	R ²
Total species/count Resident species/count Migrant species/count	9.7 7.1 2.6	14.4 10.7 3.7	1.4 * 0.1 ns 1.3 *	-0.06 *** -0.05 *** -0.01 ns	0.50 **** 0.52 **** 0.22 ***

Significance levels: ns = P > 0.05; * = P < 0.05; *** = P < 0.001; **** = P < 0.001.

special problems. A major limitation is the relatively short period each morning during which spontaneous vocalizations are frequent enough to make point counts effective. In "standard" (i.e., unsupplemented) counts, the mean number of species detected in 15-minute counts declined by about 60 percent between 0600 and 0900. Limited data suggest that detection rates continue to decline after 0900, at least during winter. Using point counts, Blake (1992) also documented a marked diurnal decline in bird occurrences during the winter dry season in a Costa Rican lowland tropical forest. Blake suggested that point counts in such habitats should be restricted to the first 3 hours of the morning. Although Hutto and others (1986) found only a slight (and statistically nonsignificant) temporal decline in detection frequencies at a highland and lowland forest site in western Mexico, future investigators in the tropics must consider the possibility of strong diurnal variation in point count results.

Tradeoffs Between Count Duration and Travel Time

In this study, most species detections occurred within the first 5 to 10 minutes of point counts (Hamel 1984, Hutto and others 1986, Scott and Ramsey 1981). This temporal pattern might appear to favor a sampling design consisting of numerous short counts. For example, on the basis of my data from Quintana Roo, six 5-minute counts would be expected to yield about 50 percent more species occurrences than two 15-minute counts. In fact, however, the apparent advantage of short counts tends to be offset by a concomitant increase in total travel time.

Given the 5-minute travel time recorded in the present study, one could actually perform 18 (not 36) 5-minute counts, or 12 (not 18) 10-minute counts, or 9 (not 12) 15minute counts in a 3-hour field session. Without the use of aural stimuli, these three sampling designs would be expected to yield approximately 94, 89, and 80 species occurrences per

Table 3-Most frequently detected species (>10 occurrences) arranged in increasing order of their tendency to be detected >30 m from the observer in 71 winter point counts conducted in Quintana Roo. Common names follow the American Ornithologists' Union (A.O.U.) Check-list (1983).

				Percent
	Occur	rences (maxin	num =71)	occurrences
Species	<30 m	>30 m	Total	>30 m
White-eyed Vireo*	11	0	11	0
Black-throated Green Warbler*	10	0	10	0
Black-and-white Warbler*	12	0	10	0
American Redstart*	24	1	25	4
Red-throated Ant-Tanager	21	1	22	5
White-throated Spadebill	20	2	22	9
Magnolia Warbler*	29	5	34	15
Northern Bentbill	14	3	17	18
Lesser Greenlet	12	4	16	25
Hooded Warbler*	33	13	46	28
Dusky-capped Flycatcher	8	5	13	38
Wood Thrush*	10	10	20	50
Carolina Wren	5	5	10	50
Keel-billed Toucan	7	15	22	68
Bright-rumped Attila	4	12	16	75
Pale-billed Woodpecker	3	10	13	77
Brown Jay	11	41	52	79
Golden-fronted Woodpecker	2	11	13	85
Yellow-lored Parrot	2	12	14	86
Collared Forest-Falcon	0	10	10	100
Plain Chachalaca	0	14	14	100
Ferruginous Pygmy-Owl	0	19	19	100

* Species marked with an asterisk (*) are Nearctic migrants.

morning, respectively, per 3-hour session (*table 4*). However, if aural stimuli are used, all three sampling designs would yield similar results (92 versus 93 versus 88 occurrences, respectively). For unsupplemented counts, doubling travel time to 10 minutes results in essentially identical expected numbers of detections for either 12 10-minute counts (68) or 9 15-minute counts (67), but fewer detections (62) for a sampling strategy consisting of 9 5-minute counts. If travel time is 15 minutes, then 15-minute unsupplemented counts yield more occurrences per morning than either 5-minute or 10-minute counts. These particular numerical values may reflect conditions that prevail during winter in Quintana Roo but, as a rule, longer travel time favors longer count durations.

Tradeoffs Between Statistical Precision, Count Duration, and the Magnitude of Occurrence Rates

The presence or absence data of point counts conform to a binomial distribution and are conveniently expressed as percent occurrences. For sample sizes up to several hundred counts, the confidence limits around observed percentages are so broad that only gross differences can be confirmed statistically (Rohlf and Sokal 1969). The *relative* (but not absolute) confidence limits around an observed occurrence rate shrink as either the sample size of points or the magnitude of the occurrence rate increases (Petit and others 1990), but the latter effect is proportionately much greater. For a sample of 100 counts, the 95 percent confidence limits around a 4 percent observed occurrence rate overlap with those around a nearly four-fold higher occurrence rate of 15 percent (Rohlf and Sokal 1969). Even if the sampling intensity is doubled (n = 200 points), one still cannot statistically differentiate a 4 percent observed occurrence rate from a nearly three-fold higher rate of 11 percent. In contrast, if the observed occurrence rate is 50 percent, a relative change of as little as 30 percent (i.e., an occurrence rate of 65 percent) can be statistically verified in two samples of 200 points. Thompson and Schwalbach (this volume) estimated that as many as 30,000 point counts might be required to detect a 20 percent relative change in the occurrence rates of the rarer bird species in their Indiana study area.

Table 5 provides concrete examples of sample size and point count duration on the reliability of observed occurrence rates observed in Quintana Roo, assuming that (1) diel changes in the detection rates for individual species mirror community trends, (2) counts are conducted between 0600 and 0900, (3) total field time is held constant, and (4) travel time is 5 minutes. These computations indicate that uncommon species occurring in less than 10 percent of 15-minute point counts (e.g., Yellow-throated Vireo (*Vireo flavifrons*) would be more precisely sampled by employing large numbers of short (i.e., 5-minute) counts. For species that occur in 10 percent to 20 percent of 15-minute counts (e.g., Black-throated Green Warbler), 5-minute counts and 15-minute counts

Table 4--The total number of species detections expected per hour of field time in supplemented (S) and unsupplemented (U) point counts as a function of count duration and time of morning. Travel time between points is assumed to remain constant at 5 minutes.

	Du	ration (and number/hour) of co	unts
	5 minutes (n = 6)	10 minutes $(n = 4)$	15 minutes $(n = 3)$
Time	S (U)	S (U)	S (U)
0600-0659	36.6 (47.4)	35.6 (40.4)	33.3 (36.0)
0700-0759	29.4 (31.4)	32.0 (34.4)	28.8 (30.3)
0800-0859	25.8 (15.6)	25.6 (14.0)	25.5 (13.5)
Total (3 hours)	91.8 (94.2)	93.2 (88.8)	87.6 (79.8)

would yield about the same relative error for a given total amount of field time. For species occurring in >20 percent of 15-minute counts (e.g., Wood Thrush (*Hylocichla mustelina*), Magnolia Warbler (*Dendroica magnolia*), and Hooded Warbler), occurrence rates will be more efficiently estimated if 15-minute counts are employed.

The quantitative advantage of any particular combination of count duration and sample size appears to be modest, at least under the conditions that prevail during winter in Quintana Roo (table 5). This finding is consistent with the results of Gutzwiller (1991), who obtained similar estimates of bird community richness whether he used many short point counts or fewer long counts. A more important determinant of the precision of point counts is the absolute magnitude of occurrence rates. The relative error of the occurrence rate of an abundant species that is recorded in 65 percent of all 15minute point counts (e.g., Hooded Warbler) is 15 percent for 100 15-minute counts, and 20 percent for 200 5-minute counts. However, for a rare species such as Yellow-throated Vireo, whose occurrence rate in 15-minute counts is only 6 percent, the corresponding relative errors exceed 80 percent (table 5). Consequently, if one wishes to improve the precision of point count surveys of rare species, often it will be far more cost-effective to increase the occurrence rate per sample point (e.g., by employing aural stimuli) than to extend the count duration or increase the number of points sampled.

Pros and Cons of Using Aural Stimuli to Supplement Point Counts

Aural stimuli can substantially increase the delectability of many species, especially where spontaneous vocalizations are infrequent. In addition, birds responding to playbacks frequently approach the observer more closely and persistently than they would otherwise, thereby facilitating determination of sex, age, and color band combinations. Single-species playbacks have generally been used, but songs and calls of several target species can easily be combined on a single playback tape (Johnson and others 1981). Appropriate predator calls and generalized alarm calls also elicit responses from a range of species.

The use of aural stimuli in point count surveys does, however, have potential disadvantages. R. Hutto has suggested (personal communication) that the responses of some species to playbacks might not be constant across habitats; i.e., that detectabilities may vary spatially. This concern also applies to most other survey methods, including "standard" point counts. Indeed, one can argue that a higher proportion of the birds actually present in an area will be detected, regardless of habitat, if appropriate aural stimuli are employed. For example, use of aural stimuli in Quintana Roo virtually elim-

Table 5--Relative error (RE) of observed occurrence rates as a function of their magnitude, given two hypothetical sampling strategies. Data are extrapolated from observed frequencies in 71 winter point counts conducted in Quintana Roo. Given a constant travel time of 5 minute between sample points, both sampling strategies would require the same total field time. For each species the smaller relative error is underlined. See text for further explanation.

		Hypothetical sampling strategy						
			15-minute counts (n = 100 points)			5-minute counts ($n = 200$ points)		
		Percent	95 percent		Percent	95 percent		
Species	F(obs)	Occurrence	Confidence Limit	RE	Occurrence	Confidence Limit	RE	
				pct			pct	
Yellow-throated Vireo	4/71	6	(2-13)	103	3	(1-6)	<u>84</u>	
Black-throated Green Warbler	10/71	14	(8-22)	50	8	(5-13)	50	
Wood Thrush	20/71	28	(20-38)	32	16	(11-22)	36	
Magnolia Warbler	34/71	48	(38-58)	21	26	(20-33)	24	
Hooded Warbler	46/71	65	(55-74)	15	35	(28-42)	20	
Hypothetical species	65/71	92	(87-95)	9	50	(43-57)	14	

inated the apparent diel decline in migrant detections that was indicated by unsupplemented point counts, a result that is hardly attributable to bias on the part of supplemented point counts. On the contrary, the unsupplemented "standard" point counts introduced artifactual variation by failing to detect quiescent birds that were, in fact, present throughout the morning sampling period. Whether supplemented point counts are more effective than standard counts in reducing spatial (as opposed to temporal) artifacts in detection rates remains to be demonstrated, but I predict that habitat-reduced variation in detectability also will be reduced, not increased, by the use of aural stimuli.

As is also true of "standard" point counts, counts supplemented by aural stimuli are not immune to temporal artifacts. Resident tropical species, most of which are not responsive to the particular aural stimuli I used in Quintana Roo, showed a diel decrease in detectability even when aural stimuli were employed. Presumably, more appropriate stimuli (e.g., conspecific territorial songs) would have reduced this decline in resident detectability. temporal Seasonal differences in responsiveness to aural stimuli may complicate comparisons of results between breeding and wintering surveys. Although the responses of Hooded Warblers and Kentucky Warblers (Oporomis formosus) to conspecific "chip" notes appear to be similar in the breeding and nonbreeding seasons, the responses of these two species to Ferruginous Pygmy-Owl calls are much weaker during the breeding season in Maryland. Conversely, the response of these two species to conspecific territorial song is strong during the breeding season, but weak during winter (J. Lynch, personal observation).

Perhaps the most cogent objection to the use of aural stimuli is that comparisons with the results of "standard" point counts will be clouded, especially for normally inconspicuous species that respond strongly to playbacks. In this context, it is irrelevant that the higher detection rates produced by aural stimuli may reflect true densities.

Finally, an observer's preoccupation with playbacks, owl calls, and "spishing" undoubtedly reduces his or her ability to distinguish all calling species, especially early in the morning when many species may be vocalizing simultaneously. In addition, shy species may actually retreat or become silent in response to inappropriate aural stimuli, thereby reducing their detectability: The fact that slightly more species were detected early in the morning (0600-0659) in unsupplemented counts in Quintana Roo (*table 1*) suggests that one or both inhibitory effects of playbacks may have applied.

Components of an Effective Point Count Study

Given realistic limitations on sampling effort, standard point counts are clearly unsuitable for confirming even quite large relative differences in the occurrence rates of rare or cryptic species. To increase the ability of point counts to detect biologically significant variation in occurrence rates, investigators should strive to maximize both the probability of detection at each point and the number of points sampled. Detection rates will be higher and less variable if counts are restricted to the most productive portions of the day (Blake 1992, Gutzwiller 1991).

To further increase detectability, observers should consider using unlimited-radius counts, especially for species that are rare or not easily detected at close range (Gates, in this volume). Admittedly, data from unlimited-radius counts cannot be used to calculate absolute densities, but documentation of relative differences may suffice to answer many research questions (Verner 1985). For those wishing to calculate absolute densities from point count data, occurrences within a desired fixed radius can be tabulated separately from more distant detections, as in the present study.

Especially in situations where the daily period of high bird activity is shortened, observers should minimize travel time by moving rapidly between survey locations and by adopting the minimum between-point distance that prevents double counting. Gutzwiller (1991) found that a betweenpoint distance of 200 m was sufficient to assure statistical independence in unlimited-radius point counts of overwintering passerines in Texas, but greater distances are required for taxa (e.g., parrots, corvids, cracids) that are routinely detected at distances of several hundred meters.

Standardization of Point Count Techniques

The desirability of standardizing point count methodology across very different geographic regions, habitats, seasons, taxonomic and behavioral groups, and levels of abundance is problematic. Rare and cryptic marsh birds clearly require a different sampling protocol than do common and conspicuous forest passerines. On the other hand, it is both feasible and desirable to standardize studies of ecologically and behaviorally similar species associated with one general habitat type (e.g., forest), at a particular time of year (e.g., the breeding season).

The point count technique appears to be suitable for documenting patterns in the distribution and relative abundance of birds in the northern Neotropics during winter, based on studies in the Yucatan region, western Mexico, and Costa Rica. The results of similar studies of North Temperate breeding bird communities may not be directly comparable to the cited tropical studies because of seasonal differences in detectability (Lynch and Whigham 1984).

The occurrence rates of certain species are increased if standard point counts are supplemented by aural stimuli. Observers might consider conducting the first 5-10 minutes of each point count without using such stimuli, then employing playbacks as desired for an additional set period. As long as the supplemented and unsupplemented data are tabulated separately, the twin goals of higher efficiency and increased standardization can both be served.

Acknowledgments

E. Balinsky and W. Mayher assisted with the point counts. The manuscript benefitted from careful criticism by Richard L. Hutto, C. John Ralph, and Chandler S. Robbins. This research was supported by the World Wildlife Fund and the Smithsonian Institution. M. McWethy prepared the figure.