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Source: The Condor, 102(4):887-893. 2000.
Published By: Cooper Ornithological Society
DOI: http://dx.doi.org/10.1650/0010-5422(2000)102[0887:ACOPCA]2.0.CO;2
URL: http://www.bioone.org/doi/full/10.1650/0010-5422%282000%29102%5B0887%3AACOPCA%5D2.0.CO%3B2

*The Condor* 102:887–893


# A COMPARISON OF POINT COUNTS AND SOUND RECORDING AS BIRD SURVEY METHODS IN AMAZONIAN SOUTHEAST PERU[1]

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*Abstract.* We tested the ability of sound recordings relative to that of point counts to estimate species richness in the Tambopata Reserve in southeast Peru. We tested the effect of two environmental factors (estimated richness and presence of noisy species) and two attributes of species (abundance and foraging height) on estimates of species richness made by point counts and sound recordings. Sound recordings are preferred to point counts when richness is high, as during the dawn chorus, because they allow for repeated listenings. Point counts are more effective than sound recordings at detecting rarely heard species. The presence of noisy species at a station had no effect on the relative ability of the two methods to measure species richness. The foraging height of a species had no effect on its relative detectability by either method. Sound recording was found to be a suitable alternative to point counts for estimating species richness and a preferable alternative under some circumstances.

*Key words:* *avifaunal surveys, point counts, sound recording, species richness.*

## INTRODUCTION

Surveying birds in tropical habitats presents researchers with many difficulties not encountered in temperate habitats. High species richness requires that researchers be familiar with a greater number of species and, particularly, a greater number of rare species, than in temperate habitats. Tropical species also display a wide array of spatial distribution patterns as a result of intra- or interspecies flocking, leking behavior, or congregation at a patchily distributed food source such as fruit or a mobile one such as army ant swarms. These can lead to extremely high variance in census results from one survey to another (Karr 1981a). Furthermore, only 32% of tropical-forest bird species defend exclusive territories. The remaining 68% therefore violate a critical assumption of the singing-male census procedure used in temperate habitats (Karr 1981a). To overcome these problems, Karr (1981a) recommends using a wide variety of census procedures ''selected to provide the most comprehensive information for the objectives of the study'' and advocates more extensive use of point counts in tropical habitats.

Sound recording is frequently used in conjunction with playbacks to attract birds to the observer so that they may be identified visually or to attract them to the vicinity of traps. Playbacks also are used occasionally as aural stimuli during point counts to increase the detectability of a given species (Lynch 1995) or to survey otherwise secretive or nocturnal species (Johnson et al. 1981). Parker (1991) advocates the use of sound recordings as an alternative to specimen collection for building an inventory of a diverse avifauna. However, few researchers have used sound recordings as a method of surveying avian communities (Parker and Bailey 1991, Foster et al. 1994).

Here, we test the ability of sound recordings, relative to that of point counts, to estimate species richness in Amazonian forests of southeast Peru. Recordings are well suited to generating species lists but they cannot be used to estimate the abundance of individual species or species diversity. However, species lists for several locations can be used to generate the frequency of occurrence of a given species. Frequency provides a crude index of relative abundance but only for those species that do not occur at all surveyed locations. Thus, a frequency of occurrence index can be useful when the number of sites sampled is high enough that most species occur at less than 100% of stations.

The use of sound recordings has two major advantages over point counts. First, sound re-

[1] Received 24 February 2000. Accepted 25 July 2000.

cordings provide a permanent record of the survey period from which all detections can potentially be identified. This feature of sound recordings has even led to the discovery of taxa new to science (Parker and O'Neill 1985). Second, the use of sound recordings does not require the presence of skilled observers in the field. Thus, an automated sound recording system could save survey time and make much more intensive or extensive surveys possible.

To determine whether sound recordings are an effective alternative to point counts, we asked the following four questions: (1) Do recordings and point counts detect the same number of species? (2) Do recordings and point counts detect the same number of species when species richness varies or noisy species are present? (3) Do recordings and point counts detect the same number of species in different ecological groups? (4) Is the number of species detected by recordings affected by the frequency of changes in microphone direction or re-listening to recordings?

## METHODS

### STUDY SITE

The study was conducted on the trail networks surrounding three tourist lodges (Tambopata Jungle Lodge, Tambopata Research Center, and Cuzco Amozonica Lodge) in the Tambopata-Candamo Reserved Zone of southeast Peru. Tambopata Jungle Lodge is located on the Rio Tambopata, upstream of Puerto Maldonado, Madre de Dios, at the mouth of the Rio La Torre (12°50.3′S, 69°17.7′W). Tambopata Research Center (Ccolpa de Guacamayos) is located farther upstream, halfway between the mouth of the Rio Tavara and Rio Malinowski (13°08.5′S, 69°36.4′W). Cuzco Amazonica Lodge is located on the Rio Madre de Dios, 14 km downstream of Puerto Maldonado (12°33.0′S, 69°03.0′W). Elevation ranges between 200 and 300 m. We conducted our studies during the peak of the dry season, in August and September 1997. Average monthly rainfall at this time of year is 65 mm compared with 300 mm during the peak of the rainy season in December.

This area has one of the highest diversities of avian species in the world. Nearly 600 species have been recorded in the Explorer's Inn Reserve, an area of 5,500 ha in the Tambopata-Candamo Reserved Zone. However, approximately 50% of these are restricted to low floodplain forests that experience regular flooding (Foster et al. 1994). We performed all surveys in upper floodplain and terra firme forests, avoiding areas that showed evidence of seasonal flooding. Canopy height in these forest types is about 35 to 40 m, mostly closed but with some openings and the understory is correspondingly sparse. Dominant tree species include *Ceiba* spp., *Ficus* spp., *Pouteria* spp., and *Pourouma* spp. We avoided distinct microhabitats such as stands of bamboo (*Guadua* spp.)

Survey stations were located ≥200 m apart, which should ensure independence of stations (Reynolds et al. 1980) for most species. Because this study was part of a larger study of the effects of ecotourism on animal communities, half of the stations were located on well-established tourist trails and half were located at least 600 m from any established trail. Each station was sampled twice during the study. No station was sampled twice on the same day, and the order in which stations were sampled for the second sampling was reversed such that each station was sampled at two different times of day. Both samples for all stations were included in the analyses as independent data points because there was no correlation between numbers of species detected on first and second visits.

### POINT COUNTS AND SOUND RECORDINGS

We performed a total of 136 point counts (32 at 16 stations at Tambopata Jungle Lodge, 52 at 26 stations at Cuzco Amazonica, and 52 at 26 stations at Tambopata Research Center) during the first three hours after sunrise (approx. 05:30–08:30) between August 2 and September 11, 1997. Listening time was 10 min at every station. We used a variation of the variable circular-plot method (Reynolds et al. 1980) in which distance from observer was recorded for all birds closer than 100 m (to an accuracy of 5 m), but all birds farther than 100 m were simply recorded as > 100 m. We classified the height of all birds into 5 height categories (1 = on the ground, 2 = understory, 3 = sub-canopy, 4 = canopy, 5 = flying overhead). We also recorded whether the bird was seen, heard, or both seen and heard.

We performed 136 sound recordings simultaneously with the point counts at all stations. We used a Marantz PMD222 portable cassette recorder and a Sennheiser ME-66 microphone capsule with a K-6 power supply covered by a foam windshield. The ME-66 is a strongly directional capsule that discriminates against off-axis sounds to the sides and rear of the microphone. It has very high sensitivity (free-field no-load transmission factor [1 kHz] = 35 $mVPa^{-1} \pm 2.5$ dB) such that even very quiet signals are recorded at a good level. We placed the microphone in a clamp attached to a handle that was hand-held by an assistant at an angle of 20° above the horizontal. Because of the directionality of the microphone, it was necessary to change its orientation at regular intervals during the recording period.

For analysis of the recordings, each was listened to once and some portions were listened to twice. The only data generated by the analysis of the recordings were full species lists for each time interval of each recording period; that is, species were not recorded cumulatively, a completely new list was started for each new time interval. Ken Rosenberg, of the Cornell Laboratory of Ornithology (Ithaca, New York), listened to six of our 10-min recordings to double check the accuracy and completeness of our identifications. He agreed with 96% of our identifications, failed to detect the remaining 4%, and detected an additional 9% of species. However, his assessment was not independent as he referred to our data sheets while listening to the recordings.

### STATISTICAL ANALYSES

We tested the relative effectiveness of point counts and sound recordings for detecting species richness across all census periods. We used the Wilcoxon signed-rank test for paired data because the distribution of the differences was non-normal (Kolmogorov–Smirnov test; $d = 0.13$, $P < 0.05$).

We also tested the effect of two environmental factors (1—richness and 2—the presence of noisy species such as Mealy Parrots *Amazona farinosa* and Screaming Pihas *Lipaugus vociferans*) on the relative effectiveness of the two methods. To test the effect of species richness, we calculated the Kendall Tau coefficient between species richness and the difference in the number of species detected by recordings and point counts for each survey period. To determine the effect of noisy species, we compared the differences in number of species detected by each method at stations with noisy species versus stations without noisy species. We also compared overall richness, as estimated by both methods combined, at stations with versus stations without noisy species. We used Student's *t*-tests for testing differences between means when the assumption of normality was met. When this assumption was violated, we used the Kruskal–Wallis analysis of variance.

We tested the effect of two attributes of species (1—abundance and 2—foraging height) on the relative effectiveness of the two methods. To test for the effect of abundance, we grouped species into four classes according to the proportion of stations at which they were recorded (<2%, 2–9%, 10–25%, >25%). We then used the chi-square test to compare the number of species in each class detected by point counts versus sound recordings. Because species abundance patterns were different at different lodges, we analyzed each lodge separately in order not to dilute any possible effect of species abundance.

To test the effect of foraging height, we assigned each species a foraging height class of 1 (ground), 2 (understory), 3 (sub-canopy), or 4 (canopy), according to which category it was found in most frequently by point counts. We then used the chi-square test to compare the number of species in each class detected by point counts versus sound recordings. The fifth category, ''flying over,'' is not included here because most species detected at this height were detected more frequently at height 4. The only two species recorded exclusively in height category 5 were White-collared Swift (*Streptoprocne zonaris*) and Greater Yellow-headed Vulture (*Cathartes melambrotus*). These two were recorded only visually, by point counts.

Finally, we investigated the effect of recording time, frequency of changes in microphone direction, and second listenings to recordings on species richness as detected by sound recordings. To test the effect of the frequency of changes in microphone direction, we compared the number of species recorded in the first 5 min (eight 90° changes in direction) with the number recorded in the last 5 min (four 90° changes in direction) of every recording period. Differences between the paired listenings were not normally distributed (Kolmogorov–Smirnov test; $d = 0.13$, $P < 0.05$), so we used the Wilcoxon signed-rank test. To test the effect of second listenings, we took a random sample of 20 of our recording periods and listened to them a second time to determine whether a significant number

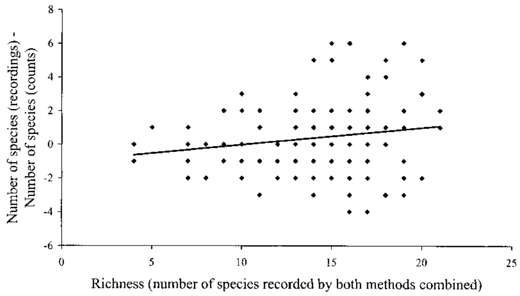


FIGURE 1. Relative effectiveness of point counts versus sound recordings with respect to station richness. Points greater than zero indicate stations at which more species were recorded by recordings. Points less than zero indicate stations at which more species were recorded by point counts.

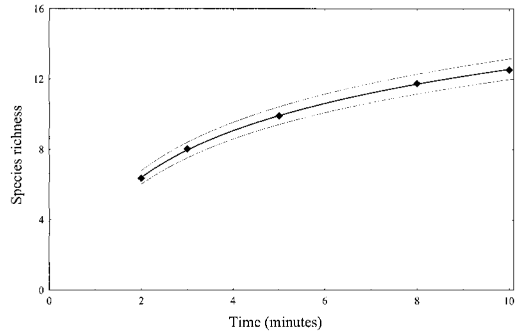


FIGURE 2. The relationship between cumulative species richness and recording time. Outer curves delineate the 95% confidence interval.

of new species would be detected. During the second listening, we used the species list from the first listening as a guide in order to focus more intently on listening for species that had not been detected the first time. The sample size of 20 was chosen based on the sample size necessary to detect a 10% difference in means with a significance level of 0.05 and a power of 95% (Sokal and Rohlf 1981). Values reported below are means ± SE.

## RESULTS

There was no significant correlation between the number of species recorded on first and second visits to a station by either point counts ($r = -0.06$, $P = 0.64$), recordings ($r = -0.1$, $P = 0.48$), or both methods combined ($r = -0.2$, $P = 0.17$). Thus, we include both visits to a single station as independent samples in the analyses that follow.

On average, sound recordings detected more species per station than point counts. The average numbers of species per count period as detected by point counts and recordings, respectively, were 12.03 ± 0.28 and 12.40 ± 0.30. However, the difference between the two methods was not significant (Wilcoxon signed-rank test; $Z = 1.67$, $n = 136$, $P = 0.09$). Recordings detected more species than point counts at stations with high species richness (Fig. 1). There was a significant correlation between station richness and the difference in number of species detected by the two methods ($n = 136$; Kendall Tau = 0.12, $P < 0.05$). The presence of noisy species at stations did not affect the relative effectiveness of the two methods or overall species richness at that station ($P > 0.07$ for all tests).

Although recordings detected more species per station than point counts, point counts detected more species overall. The total number of species detected by point counts was 172, compared with only 150 detected by recordings. There were no species detected by recordings but not by point counts. Of the 22 species detected by point counts but not by recordings, 15 were from visual records only. These include largely nonvocal species such as hummingbirds and raptors. Three others were species with inconspicuous vocalizations such as *Tangara* tanagers. The remaining four were rare species that were heard at a great distance and were likely not picked up by the microphone.

At all three lodges, rare species were more likely to be detected by point counts than by recordings. However, the differences were all statistically nonsignificant. Both methods detected the same number of species in all of the other three abundance classes. Foraging height had no significant effect on the frequency with which species were detected by point counts versus recordings.

The relationship between recording time and species richness shows the expected logarithmic pattern of diminishing returns (Fig. 2). The best-fit curve follows the function: richness = 3.75 + 8.82 log(time). Given the width of the 95% confidence interval, we can be quite confident in the shape of the curve. In the 8–10-min interval, 0.39 new species were added per minute of recording compared with 3.17 species per minute during the first 2 min.

Significantly more species were detected during the first 5 min (change in microphone direction every 30 sec then every 45 sec) of a recording period than during the last 5 min (change in microphone direction every 75 sec) (Wilcoxon signed rank test: $Z = 2.71$, $P < 0.01$).

Out of 20 recording periods that we listened to a second time, only 2 yielded any new species. These two yielded only one new species each, for a mean of $0.1 \pm 0.1$ new species per second listening.

## DISCUSSION

Bystrak (1981) suggests that breeding bird survey data are least reliable during the flurry of activity associated with the dawn chorus. Observer confusion should result in more birds being overlooked at stations with high species richness. However, this effect should be less pronounced in sound recordings where the observer can compensate for the number of individuals present by listening repeatedly to short segments of the recording. We would therefore predict that sound recordings would more effectively sample stations with high species richness. Our data support this prediction.

During point counts, noisy species such as Mealy Parrots and Screaming Pihas often drowned out the calls of other birds. We hypothesized that this phenomenon might be less pronounced using sound recordings because the observer can adjust the output volume in order to amplify background sounds, allowing him/her to ''hear through'' the noisy species. However, the corresponding prediction, that sound recordings would detect higher species richness than point counts for stations at which noisy species were present, was not supported by our data. Indeed, there was not even a discernable effect of noisy species on richness as detected by the two methods combined.

Bart and Schoultz (1984) showed experimentally that as the number of individuals of a given species present at a station increased from one to four, the percentage of these individuals detected by observers performing point counts decreased from 72% to 49%. Therefore, abundant species tended to be underrepresented by point counts. Although this is not a problem for measuring species richness, where each species is simply recorded as present or absent, abundant species might still be under-recorded by point counts when observers become acclimatized to hearing the songs of very abundant species as a constant background sound. This effect might be less pronounced in sound recordings where the observer is removed from the context of the surrounding habitat of the point count and is only listening to sounds on a tape. Our results, however, do not show any noticeable trend toward higher detectability of abundant species by sound recordings.

Although due in part to visual records, the higher detection rate of rare species by point counts also can be explained by the fact that point counts detect species from 360° around the observer for the entire 10 min, whereas our recordings only detect species from a sector approximately 140° wide at any one time. All else being equal, this means that a bird that vocalizes only once during the count period is approximately 2.6 (360/140) times more likely to be detected by point count than by sound recording. However, a bird that vocalizes 5 times is only 1.09 [P (at least one detection) $= 1 - $P (no detections) $= 1 - (220/360)^5 = 0.915$; $1/0.915 = 1.09$] times as likely to be detected by point count than by sound recording. By our definition of rare (recorded at less than 2% of stations), species may be rare either because their numbers are low or because they vocalize infrequently. The hypothetical bird that called only once is much more likely to belong to the ''rare'' class than the hypothetical bird that called 5 times. Thus, we would intuitively expect the greater degrees of coverage provided by point counts to result in higher detection rates of rare species.

Foraging height is an important source of bias when surveying birds by mist nets in sub-tropical forests (Karr 1981b); this bias also exists when using point counts (Waide and Narins 1988). In the latter experiment, observers located on the ground detected fewer canopy species than observers located at the top of a 22-m tower. We would expect this to be the case based solely on the fact that birds in the canopy must be farther away from a ground observer than from an observer located in a tower. In the types of habitat in which our study was located, canopy height averaged 30 m with occasional emergent trees up to 50 m. Thus, a bird located at a ''ground distance'' of 0 may actually be 50 m distant.

However, we have no reason to expect that this bias would affect point counts and sound recordings differentially. With the microphone held at an angle of 20° above the horizontal, a sound emanating from directly above the microphone is coming in at an angle of 70° from the main axis. The polar pattern of the ME-66 is such that, at 70° from the main axis, the detection threshold for a 4 kHz sound is between 10 and 15 dB, compared to less than 5 dB for a 4 kHz sound emanating from an angle of less than 60°. For an 8 kHz sound, the effect is even more pronounced. At an angle of 70° from the main axis, the detection threshold is between 20 and 25 dB. Thus, the microphone may fail to pick up very high frequency sounds located directly above it. However, it should be noted that this change in detection threshold with frequency is very similar to that of a human with good hearing. At 4 kHz, the human detection threshold is near 10 dB but at 8 kHz, it is near 20 dB (Dooling 1982).

One of the most important attributes of a species affecting its detectability by point counts or sound recordings is song frequency. It is well known that high-frequency songs attenuate faster than low frequency songs (Richards 1981). Faanes and Bystrak (1981) showed experimentally that birds with high-frequency songs tend to be missed by point counts more frequently than birds with low-frequency songs. However, we can think of no reason why the effect of song frequency should be any more pronounced in either point counts or sound recordings.

Various authors have commented on the effect of count duration on the precision of point counts (Dawson et al. 1995, Lynch 1995). We limited our analysis to the effect of recording time on estimates of species richness. Obviously, the recording time chosen for any study will depend on the goals of that study and, particularly, the habitat in which that study takes place. If birds move quickly in a given habitat, then recordings will continue to detect new species for longer than if birds move slowly. In this study, 8 min of recording yielded a similar measure of species richness as 10 min of point counting. Furthermore, the number of new species added per minute dropped below 0.5 after 8 min of recording. We suggest that the researcher could use his/her time more effectively by performing a greater number of recordings than by extending recording time much beyond 8 min. However, a longer recording time may be necessary for rare species when using a directional microphone to compensate for the fact that only 39% of the circular plot is recorded at any one time. Further studies are needed to measure the rate of new species detection beyond 10 min.

Due to the movements of birds, a count lasting x min should yield a lower estimate of species richness than two, non-continuous counts lasting x/2 min each. In the first 5 min of every recording bout, we made eight changes in microphone direction, whereas in the last 5 min, we made only four. Thus, we effectively made two non-continuous counts in each of the four directions in the first 5 min but only one continuous count in each direction in the last 5 min. We would therefore predict that more species would be recorded during the first 5-min interval of each recording period than during the last 5-min interval. This prediction was supported by our data.

However, these results should be interpreted cautiously. It is possible that this effect may result from birds moving away from the station in response to the presence of the observer over the duration of the recording. Alternatively, birds may become more agitated upon the arrival of the observer and make themselves more conspicuous by calling more frequently. Either of these responses could lead to more birds being detected during the first 5 min of the recording period. Unfortunately, in this study, the more frequent changes in microphone direction were always made during the first 5 min, so our data cannot be used to separate the effect of frequency of change in microphone direction from the effect of bird response to observer presence.

Perhaps the most effective technique for using sound recordings to survey bird populations is to use an omni-directional microphone capsule, thus eliminating the need for changes in microphone direction. Because of their ability to ‘‘pull in’’ distant sounds, directional capsules have been favored by researchers recording bird vocalizations. Many omni-directional capsules, however, have adequate sensitivity for 360° around the microphone. For example, the Sennheiser ME-62 capsule has a detection threshold of less than 10 dB at 360° around the microphone for all sounds with frequencies between 0.125 and 8 kHz. This is the detection threshold in the 1–8 kHz frequency range that is recommended by Ramsey and Scott (1981) for observers performing point counts. Although the omni-directional ME-62 is about 40% less sensitive than the ME-66, this lack of sensitivity is compensated for by the fact that it records in all directions at once. In effect, the omni-directional capsule should provide a more accurate estimate of species richness over a circle of smaller radius. Future studies should investigate the utility of using omni-directional capsules for avifaunal surveys.

Sound recordings perform at least as well as, if not better than, point counts for assessing bird species richness. However, recordings cannot be as effective as point counts for compiling site lists. Without visual detection, recordings will not detect silent species, and a thorough avifaunal inventory of a given area is impossible without skilled observers in the field. Also, rarely-calling species may sometimes be overlooked when using a directional microphone capsule. Sound recording is particularly well-suited to studies focusing on forest passerines in which data are to be collected from many different sites. With some refinement and standardization of the methodology, sound recording has the potential to provide an effective, time efficient tool for avifaunal surveys.

## ACKNOWLEDGMENTS

Many thanks to the organizers of Project Tambopata for providing logistical support during the study. The expertise of Huw Lloyd was invaluable for song identification. Naomi Watts and Matt Schaeffer were brilliant field assistants. We gratefully acknowledge the assistance of Ken Rosenberg in double-checking our song identification. Carole Yauk, Dan Mennill, and two anonymous reviewers provided helpful comments on the manuscript. This research was partially supported by funding from the Natural Sciences and Engineering Research Council of Canada.

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