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MIGRATORY BIRD HABITAT USE IN SOUTHERN MEXICO: MIST NETS VERSUS POINT COUNTS

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Abstract.—Most previous studies of habitat use by migratory birds in the tropics have used either mist nets or point counts to assess relative densities of migrants among habitats. We used both methods on the same 30 sites in southern Veracruz: 10 sites in forest (canopy >10 m), 10 sites in second growth (canopy 3–10 m), and 10 sites in the open (canopy <3 m). Results demonstrate that either method used alone is likely to underestimate or miss whole categories of species. Three aerial or canopy-foraging species found on point counts were missed by mist netting, while several others in these categories were under-represented in mist net samples, especially in forest habitats. Nine species represented in mist net samples were not recorded in point counts, probably because of low density and/or secretive habits. The strengths of one method tend to offset the weaknesses of the other, and we propose a methodology that combines both procedures to provide a more accurate assessment of avian habitat use.

HÁBITAT UTILIZADO POR LAS AVES MIGRATORIAS EN MÉXICO: REDES VS. CONTEOS DE PUNTO

Sinopsis.—La gran mayoría de los estudios sobre utilización de hábitat por parte de aves migratorias han utilizado redes o conteos de puntos para determinar densidades relativas de las aves en los hábitats. Utilizamos ambos métodos en las mismas 30 localidades en Veracruz, México. Diez de estas localides fueron en el docel del bosque (>10 m altura), 10 en bosque secundario (docel de 3–10 m), y 10 en áreas abiertas (docel <3 m). Los resultados demuestran que cada método utilizado individualmente subestimará o pasará por alto algunas categorías de especies. Tres especies aéreas, típicas del docel, y que fueron localizadas en conteos de puntos pasaron desapercibidas a las redes. Otras especies fueron subrepresentadas en los muestreos con redes, particularmente en hábitat forestados. Por otra parte, nueve especies que fueron atrapadas en redes pasaron desapercibidas a los conteos de punto, probablemente por su baja densidad o por sus hábitos secretivos. Las fortalezas de un método tiende a emparejar las debilidades del otro. Proponemos una metodología que combina ambos procedimientos y que provee de una evaluación más adecuada sobre la utilización de hábitat por parte de aves.

Determination of avian habitat use is important for understanding both the ecology and conservation needs of a species. Two principal methodologies have been used to obtain this information: mist nets and audiovisual counts. Several authors have noted the inability of mist nets to provide accurate density measures or to sample various parts of habitats, especially those with canopies above net height (MacArthur and MacArthur 1974, Karr 1981, Remsen and Good 1996). Similarly, audio-visual methods are known to have deficiencies in terms of species detection and providing accurate avian densities measures (Conner et al. 1983, Verner 1985, Rappole and Waggerman 1986, Verner and Milne 1990, Rappole et al. 1993, McShea and Rappole 1997). In this paper, mist-netting and audio-visual methods are compared for measuring relative use of three different habitats by migrants: lowland rainforest; second growth; and open (pasture, cropland, and fallow fields).

METHODS

The study sites were located in the Tuxtla Mountain region of southern Veracruz, Mexico (18°30′N, 95°W). All sites were located below 500 m elevation in areas that had once been, or continue to be, covered with lowland rainforest, "*selva alta perennifolia*" of Pennington and Sarukhan (1968). Sites were chosen for sampling by selecting grid squares (1 km on a side) from a 1:50,000 topographic map sheet covering the Santa Martha (southeastern) portion of the Tuxtla range using a random numbers table. Sample sites had to be: (1) accessible (requiring no more than two hours of walking from the nearest road passable by 4-wheel drive vehicle) and (2) have blocks of each of the required habitats at least 10 ha in size within 1 km of each other.

The three habitats we chose to work with were Forest (canopy height >10 m), Second Growth (canopy height 3–10 m), and Open (pasture, cropland, fallow field with canopy height <3 m). These habitats include the majority (>90%) of the non-wetland, lowland habitats of the Tuxtlas (Dirzo and Garcia 1992), and they are classifiable from space using remote-sensing technology (Powell et al. 1992, Rappole et al. 1994). The fact that they can be identified and classified from space means that the amounts of each type can be calculated, as can rates of change over time (Rappole et al. 1994). Ten sites representing each of these three habitats were selected for sampling.

We used mist netting and point counts to assess bird presence and relative density in the different habitats, and all sampling was performed in January and February of 1993 and 1994. For mist net sampling, we selected a 1-ha portion of each sampling site at random, and set up a grid of 10 nets. The nets were set in four parallel lines in a grid 100 m on a side. Each line of nets was 33 m apart; line 1 had three nets located 50 m apart with one at each end and one in the middle; the second line had two nets with the first net located 25 m from the end of the line and 50 m from the second net in the line; line 3 had three nets set up like line 1; line 4 had two nets set up like line 2. Each net was 12 m × 2.6 m, with 36-mm mesh. All 10 nets on the grid were run simultaneously for 20 h (200 net-hours/site), usually over two successive days of netting, depending on weather conditions. For each bird captured, migrant or resident, we recorded species, site, date, time, net, sex, age, molt, and fat.

Each migrant was banded with a U.S. Fish & Wildlife Service band and released.

Point counts were run on the same habitat blocks on which the mist-netting was performed though not on the same days. We used Variable Circular Plots (Reynolds et al. 1980), modified as follows: 10 counts were performed at each site, with a minimum of 100 m between points. At each point, the observer waited five minutes, recording species and distance from the observer for all individual migrants seen or heard within a 50-m radius. All point counts were performed by JHR.

For the purposes of our statistical analysis of the data, we assumed that one sampling method was superior to the other (the method with the higher number of detections) and examined the efficacy of the method with the lower number of detections by testing the null hypothesis that the two methods were equally effective in detecting the birds at a particular site. We used the *G*-test with Williams' correction to determine probabilities (Sokal and Rohlf 1981), using expected values equal to the maximum number of presence detections found by either method, and only analyzing species where data gave expected values ≥ 5. We reject the null hypothesis for probabilities <0.05 ($G_{adj} > 3.84$).

RESULTS

A total of 401 individuals of 34 migratory species was captured during the 6000 net-hours of sampling (2000 h per habitat type). One hundred and eighty individuals of 25 migratory species were seen or heard during the 300 point counts (100 point counts per habitat type).

Although many of the species detected occurred at frequencies below those needed to make strong statistical inferences, we had sufficient samples to assess the relative efficacy of point counts and mist-netting for 23 within-habitat comparisons and 20 across-habitat comparisons for a given species (Table 1). For example, considering within-habitat comparisons for a given species, netting was superior to point counts in detecting Ovenbirds (see Table 1 for scientific names of species) in Forest and Second Growth and for detecting Indigo Buntings in Second Growth and Open. Point counts were superior to netting in detecting Yellow-bellied Flycatchers and Blue-gray Gnatcatchers in Forest, and Wilson's Warblers in Second Growth. For comparisons across habitats, netting was superior to point counts in detecting Gray Catbirds, Swainson's Thrushes, Worm-eating Warblers, Yellow-breasted Chats, and Indigo Buntings. Point counts were superior to netting for detecting American Kestrels and Wilson's Warblers.

We also compared the relative efficacy of each method in assessing the entire avian community for a given habitat type. For this purpose, we tested the null hypothesis that if a total of X number of species is detected using both methods, each method is capable of detecting all X species. For Forest (X = 20), netting found 15 and point counts found 15. Netting found 5 species not detected by point counts, while point counts detected 5 species not detected by netting. Clearly, there was no significant differ-

TABLE 1. Migrant occurrence rates in Forest, Second Growth, and Open habitat types as detected by mist nets versus point counts, together with results of G-test examining the null hypothesis that the two methods were equally effective. Occurrence at a point is a presence absence datum. The numbers here represent the number of net locations out of 100 at which a species was captured for a given habitat or the number of point counts out of 100 at which a species was seen or heard.

	Within-habitat comparisons									Among-habitat comparisons
	Forest			Second growth			Open			
Species	Mist net	Point count	G^a	Mist net	Point count	G	Mist net	Point count	G	G
Turkey Vulture (*Cathartes aura*)	0	0	—	0	2	—	0	1	—	—
Sharp-shinned Hawk (*Accipiter striatus*)	1	0	—	2	0	—	0	0	—	—
American Kestrel (*Falco sparverius*)	0	0	—	0	1	—	0	4	—	4.61[b]
Yellow-bellied Flycatcher (*Empidonax flaviventris*)	0	6	5.64[b]	1	0	—	0	0	—	2.40
Least Flycatcher (*Empidonax minimus*)	0	0	—	12	17	0.46	1	4	—	1.04
Northern Rough-winged Swallow (*Stelgidopteryx serripennis*)	0	0	—	0	0	—	0	2	—	—
Blue-gray Gnatcatcher (*Polioptila caerulea*)	0	5	4.61[b]	2	0	—	1	1	—	0.55
Gray Catbird (*Dumetella carolinensis*)	1	0	—	4	0	—	1	0	—	5.64[b]
Swainson's Thrush (*Catharus ustulatus*)	2	0	—	3	0	—	0	0	—	4.61[b]
Wood Thrush (*Hylocichla mustelina*)	8	5	0.37	2	2	—	0	0	—	0.28
Cedar Waxwing (*Bombycilla cedrorum*)	0	0	—	1	0	—	0	0	—	—

TABLE 1. Continued.

Species	Within-habitat comparisons									Among-habitat comparisons
	Forest			Second growth			Open			
	Mist net	Point count	G[a]	Mist net	Point count	G	Mist net	Point count	G	G
White-eyed Vireo (*Vireo griseus*)	3	5	0.26	16	6	2.77	1	2	—	0.81
Blue-headed Vireo (*Vireo solitarius*)	0	1	—	1	1	—	0	0	—	—
Yellow-throated Vireo (*Vireo flavifrons*)	0	0	—	1	0	—	0	0	—	—
Blue-winged Warbler (*Vermivora pinus*)	0	0	—	3	2	—	0	0	—	—
Nashville Warbler (*Vermivora ruficapilla*)	0	0	—	0	0	—	1	0	—	—
Northern Parula (*Parula americana*)	0	0	—	0	2	—	2	0	—	—
Yellow Warbler (*Dendroica petechia*)	0	0	—	1	0	—	0	2	—	—
Magnolia Warbler (*Dendroica magnolia*)	1	7	3.14	11	12	0.02	0	1	—	1.11
Black-throated Green Warbler (*Dendroica virens*)	0	4	—	2	4	—	0	0	—	2.30
Black-and-white Warbler (*Mniotilta varia*)	1	4	—	5	2	0.73	0	1	—	0.04
American Redstart (*Setophaga ruticilla*)	3	6	0.55	6	3	0.55	0	0	—	0.00
Worm-eating Warbler (*Helmitheros vermivorus*)	0	0	—	1	0	—	0	0	—	—
Ovenbird (*Seiurus aurocapillus*)	7	1	3.14	11	1	6.14[b]	2	0	—	11.44[b]

TABLE 1. Continued.

Species	Within-habitat comparisons: Forest — Mist net	Forest — Point count	Forest — G^a	Second growth — Mist net	Second growth — Point count	Second growth — G	Open — Mist net	Open — Point count	Open — G	Among-habitat comparisons — G
Northern Waterthrush (*Seiurus noveboracensis*)	0	0	—	0	0	—	1	0	—	—
Louisiana Waterthrush (*Seiurus motacilla*)	3	3	—	3	0	—	0	0	—	0.55
Kentucky Warbler (*Oporornis formosus*)	17	12	0.46	7	2	1.72	0	0	—	1.47
Common Yellowthroat (*Geothlypis trichas*)	0	0	—	0	2	—	1	3	—	1.71
Hooded Warbler (*Wilsonia citrina*)	10	15	0.54	13	7	1.01	0	1	—	0.00
Wilson's Warbler (*Wilsonia pusilla*)	4	7	0.44	8	26	6.12[b]	3	6	0.55	6.58[b]
Yellow-breasted Chat (*Icteria virens*)	1	0	—	10	2	3.60	3	1	—	4.82[b]
Summer Tanager (*Prianga rubra*)	0	2	—	4	0	—	0	0	—	—
Western Tanager (*Piranga ludoviciana*)	0	0	—	0	0	—	1	0	—	—
Rose-breasted Grosbeak (*Pheucticus ludovicianus*)	0	0	—	0	0	—	1	0	—	—
Indigo Bunting (*Passerina cyanea*)	2	0	—	12	0	11.88[b]	8	0	7.72[b]	22.33[b]
Lincoln's Sparrow (*Melospiza lincolnii*)	0	0	—	0	0	—	3	2	—	—
Baltimore Oriole (*Icterus galbula*)	0	0	—	1	1	—	2	1	—	—

[a] Results of G-test with Williams' correction ($G = G_{adj}$) comparing mist net versus point counts within and among habitat types.
[b] $P < 0.05$.

ence in the effectiveness of each method for this habitat type. For Second Growth (X = 31), netting found 27 species and point counts 19. Netting found 12 species not detected by point counts while point counts detected four species not detected by netting. There was a tendency for netting to be superior to point counts in this habitat, but the trend in this sample was not significant. For Open (X = 23), netting found 16 species and point counts 15. Netting found eight species not detected by point counts while point counts detected seven species not detected by netting. There was no significant difference. For all habitats combined (X = 37 species), netting found 34 and point counts 25. Netting found nine species not detected by point counts while point counts detected three species not found by netting (G_{adj} = 1.52). Again, while there was a trend indicating superiority of netting over point counts in overall species detection, this trend was not statistically significant.

For the 17 least common species in the sample (species with fewer than five detections across all habitats using either method), netting detected eight species not detected by point counts while point counts detected only two species not detected by netting (G_{adj} = 2.36). This trend was suggestive, but not significant.

DISCUSSION

Both mist-net and point-count sampling have strengths that make them suited to detect some species better than others. The results of our study demonstrate that, to a certain extent, the strengths of one method offset the weaknesses of the other, while either method used alone is likely to misrepresent the composition of the avian community. For instance, mist nets set at ground level (0–2.6 m) can miss or under-represent species that forage above net height (e.g., Yellow-bellied Flycatcher, Blue-gray Gnatcatcher, or Magnolia Warbler in Forest habitat; see also Blake and Loiselle 1992:267, Remsen and Good 1996) as well as species that have small home ranges and/or do not fly more than a meter or so at a time (e.g., Common Yellowthroat). Point counts have a higher probability than mist nets of providing a representative index under these circumstances. However, point counts tend to overlook furtive species that don't vocalize often (e.g., Yellow-breasted Chat and Ovenbird). They also often miss uncommon or rare species (e.g., Western Tanager and Rose-breasted Grosbeak in this sample). Missing such scarce birds may be due not only to sampling error (i.e., insufficient sampling effort), but because low density has a negative effect on vocalization frequency for many species (Rappole and Waggerman 1986). Mist nets appear more effective in documenting the presence of these species. An additional problem with point counts is their dependence on observer experience, a factor that is difficult to measure objectively.

Neither mist nets nor point counts alone provided an accurate assessment of migrant habitat use in the tropical habitats surveyed in our study because of inherent biases in each technique. Therefore, we propose a methodology that combines the two methods. This methodology will, we believe, provide an accurate index of relative density for the avian community across the array of distinct habitats found in a region.

A new method that combines use of point counts and mist nets.—(1) Select habitat types for sampling. (2) Select a random sample of blocks, including a minimum of 10 blocks at least 10 ha in size representing each habitat type. (3) Place 10 mist nets in a 1 ha grid as described above, and run each net a minimum of 20 hours (two days +/−). (4) Record presence/absence only for each species captured by each net (not total captures). Recaptures are ignored. The total sample will be 10 net locations per block, 100 per habitat type. (5) Perform point counts using procedures described above on the same 10, randomly selected blocks of habitat used for the mist net sampling (but not at the same time—netting can disrupt point counts). The total will be 10 point counts per block, 100 per habitat. (6) Choose the higher of the two values (total net locations/100 or total point count locations/100) at which a species was found in each habitat as the relative abundance index number for that species. The highest possible score for any species in a given habitat, whether mist net or point count value is chosen, would be 1.00 (at least one individual of a species captured at every net location or observed at every point count location).

J. G. Blake (pers. comm.) notes that this method provides a more restricted sampling area for mist nets than point counts. A possible modification that might alleviate this problem to a degree would be to place nets at the same 100 m intervals as the point count locations, rather than in a grid. F. G. Stiles (pers. comm.) comments that some experience and knowledge of habitat structure and bird community composition may be required to design the best sampling configuration for a particular region.

An additional consideration in selection of a sampling methodology is its cost relative to other methodologies. Clearly, most audio-visual methods are far cheaper in time and effort per unit of area sampled than any method involving mist netting. However, if accuracy is a consideration, our study indicates that some form of mist-netting likely should be used to supplement audio-visual sampling, and vice versa. Further testing and comparisons of hybird audio-visual/mist netting census techniques likely will be required to optimize time, effort, and accuracy in assessment of avian community composition for different habitats.

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