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RECENT GEOGRAPHIC TRENDS IN NEOTROPICAL AVIAN RESEARCH[1]

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Abstract. Knowledge-based conservation efforts have a greater chance of success than efforts without a sound scientific basis. The geographic distribution of Neotropical ornithological studies published from 1979–1995 is very uneven. Land and human population characteristics, considered an index of threat to a country's avifauna, are not correlated with recent Neotropical avian research efforts. When these statistics are examined in conjunction with publication levels and species richness, three groups of countries are distinguished. The most neglected group of countries (Group 1) have a combination of lower numbers of bird species and publications, yet have high population densities and a high percentage of domesticated lands. A subset of Central American countries is of particular concern for its importance to wintering Nearctic-Neotropic migrants. I suggest that efforts be made to improve research coverage and quality, particularly among Group 1 countries.

Key words: avian research, biodiversity, conservation, Neotropics.

The New World tropics are home to a highly diverse avifauna. It is widely recognized that this diversity is threatened by human population growth and habitat alteration. Indeed, this recognition has been expressed for at least 30 years (Buechner and Buechner 1970, Short 1984, James 1987). The countries where this biological upheaval is occurring are diverse in size, avian diversity, and human population and land characteristics. As such, avian diversity is under more threat in some countries than others.

Our knowledge of Neotropical birds is meager in relation to our knowledge of Nearctic species, a situation of serious concern when we contrast the difference in avian diversity between these geographic zones. The long-term success of Neotropical conservation goals will be hampered by this comparative ignorance. Conservation actions with a strong scientific basis possess a much greater chance of success than those without. Although conservation progress can be made in the face of ignorance, efforts based upon sound research are less risky.

Recognizing this situation, it behooves ornithologists active or becoming active in the Neotropics to focus at least some of their attention on geographic and scientific areas where their results will be of increased value to conservation efforts. Knowledge, regardless of the reasons behind its development (e.g., subspecific systematics), provides operational paradigms and parameters within which successful conservation strategies can be developed.

Where in the Neotropics have recent efforts been conducted, what geographic areas have been neglected, and, importantly, where are human-related pressures most acute?

METHODS

I assembled statistics indicative of geographic patterns of research over the 17-year period from 1979 through 1995. Because political boundaries do not reflect the presence of the tropics Cancer or Capricorn, it is not possible for the assembled data to be restricted to the New World tropics. Therefore, I have included countries through which these tropics pass (Mexico, Chile, Argentina, Paraguay, Brazil), as well as countries in the temperate zones (United States of America, Uruguay), for comparative purposes and completeness. To index geographic research levels, I searched the CD-ROM version of Volumes 115–131 (1979–1995) of the Zoological Record (BIOSIS, Philadelphia, Pennsylvania). Publication records prior to 1979 are not available electronically. Search profiles were "birds and country name," and I used the number of publications matching the search profile for each country as a rough index of the amount of ornithological research conducted on the birds of that country during this period. This index is not a precise assessment of research levels in any country because publications vary in quality and focus. Furthermore, due to the scope of electronic databases, these figures do not reflect the complete published avian-related knowledge base for any country. However, these figures do reflect more than a decade and a half of research reports, and probably provide a reasonably accurate overview of the prevailing trends in the geographic distribution of avian research. From the 41 country-specific searches conducted, 10,251 matches were obtained.

RESULTS

To place geographic "research levels" in perspective, numbers of publications are considered together with statistics for the number of bird species known to occur in each country (species richness), as well as some population and land characteristics for these same countries (Table 1). Human demographic and land-related statistics are used here as an index of human-related pressures on a country's avifauna. Population density, for example, can be viewed as an indicator of the potential demands placed upon a country's natural resources.

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TABLE 1. Number of publications on birds for most New World countries from 1979 to 1995, together with the number of bird species and some population and land characteristics for each country.

Country	Publications[a]	Bird species[b]	Area (km^2)[c]	Population[c]	Population density[d]	Pop. growth 1980–1995 (%)[e]	Domesticated land (%)[f]	Cropland change 1979–1991 (%)[f]
Anguilla	29	61	91	7,019	771			
Antigua and Barbados	7	140	442	85,000	1,923			
Argentina	810	976	2,777,815	36,610,000	122	1.30	62	0.0
Bahamas	82	222	13,865	254,685	184			
Barbados	8	172	430	257,082	5,979			
Belize	72	533	22,965	188,000	89	2.33	5	9.0
Bolivia	114	1,274	1,098,575	7,400,000	71	2.46	27	12.9
Brazil	840	1,635	8,511,965	153,322,000	185	1.91	29	23.1
Chile	287	448	751,625	13,386,000	184	1.62	24	3.9
Colombia	265	1,695	1,138,915	32,987,000	327	1.89	44	4.1
Costa Rica	340	850	50,900	2,994,000	640	2.66	56	4.5
Cuba	178	342	114,525	10,617,000	993	0.85	57	4.0
Dominica	179	163	751	81,200	1,081			
Dominican Republic	43	254	48,440	7,170,000	1,575	2.18	73	2.4
Ecuador	153	1,559	461,475	10,782,000	409	2.50	28	9.4
El Salvador	18	420	21,395	5,252,000	2,663	1.55	65	1.1
French Guiana	72	707	91,000	93,540	10			
Grenada	20	150	345	110,000	3,188			
Guadeloupe	20	134	1,780	344,000	1,933			
Guatemala	79	669	108,890	9,197,000	925	2.85	30	7.9
Guyana	43	737	214,970	990,000	41	0.87	9	0.1
Haiti	20	220	27,750	6,486,000	2,501	1.93	51	7.9
Honduras	27	684	112,085	5,105,000	503	3.30	39	3.7
Jamaica	83	262	11,425	2,420,000	2,304	1.31	42	1.8
Martinique	11	131	1,079	359,000	3,327			
Mexico	883[g]	1,026	1,972,545	81,140,952	472	2.23	52	0.7
Montserrat	6	111	104	13,000	1,250			
Nicaragua	7	750	148,000	3,871,000	346	3.29	56	2.1
Panama	208	929	78,515	2,466,000	337	2.04	29	16.7
Paraguay	68	600	406,750	4,277,000	117	2.95	59	26.7
Peru	431	1,678	1,285,215	22,332,000	179	2.17	24	6.1
Puerto Rico	173	239	8,960	3,599,000	4,017			
Saint Kitts-Nevis	0	99	261	44,000	1,686			
Saint Vincent	0	129	389	113,950	2,929			
Saint Lucia	2	169	616	146,600	2,380			
Surinam	28	673	163,820	422,000	29	1.76	1	39.7
Trinidad and Tobago	97	433	5,130	1,234,388	2,493	1.24	26	3.4
USA	4,117[h]	768	9,363,130	248,709,873	281	0.98	47	−1.5
Uruguay	58	365	186,925	3,094,000	180	0.61	85	−9.5
Venezuela	315	1,296	912,045	19,735,000	234	2.39	24	4.3
Virgin Islands	58	199	345	117,000	3,391			

[a] Number of publications retrieved from a search profile of "birds and country name" on the CD-ROM version of Vols. 115–131 of Zoological Record.
[b] Total number of species recorded (Groombridge 1994).
[c] Source: Times (1992).
[d] Population density (1993) as persons per 1,000 ha from World Resources Institute (1994: Table 17.1).
[e] Average annual population change (%) from World Resources Institute (1994: Table 16.1).
[f] Percentage of land domesticated and percent change in cropland area (1979–1991) from World Resources Institute (1994: Table 17.1).
[g] Hits due to "Birds and New Mexico" excluded.
[h] This number is an under-representation of publications on the birds of the USA, because similar searches on individual states yielded a higher collective total (although not all 50 states were searched). This situation did not seem to occur in other countries. For example, searching on all states in Mexico yielded a lower collective total than a search on the country alone.

The number of bird-related publications occurring in the Zoological Record database (1979–1995) for each country varied from 0 to 4,117 (Table 1). Calculations of the ratio of bird-related publications to the number of bird species occurring in each country gave values ranging from 0 to 5.36, but 39 of the 41 countries examined had values less than 1.0 (Table 2). Calculations of the ratios of publications to population density estimates (people per 1,000 ha) gave values ranging from 0 to 14.65, with 31 of the 41 countries having values less than 1.0 (Table 2). Ranking each country according to the values of these two ratios (Table 2) showed that research on the birds of the United States of America (USA) far exceeded the research

TABLE 2. Rankings by country from lowest to highest values for two ratios: (1) the number of publications on birds of the specified country over a 17-year period divided by the number of bird species occurring in that country, and (2) the same number of publications divided by the population density of the specified country (data from Table 1).

Rank	Ratio for number of bird species	Country	Ratio for population density	Country
1	0.000	Saint Kitts-Nevis	0.000	Saint Kitts-Nevis
2	0.000	Saint Vincent	0.000	Saint Vincent
3	0.009	Nicaragua	0.001	Saint Lucia
4	0.012	Saint Lucia	0.001	Barbados
5	0.039	Honduras	0.003	Martinique
6	0.042	Surinam	0.004	Antigua and Barbados
7	0.043	El Salvador	0.005	Montserrat
8	0.047	Barbados	0.006	Grenada
9	0.050	Antigua and Barbados	0.007	El Salvador
10	0.054	Montserrat	0.008	Haiti
11	0.058	Guyana	0.010	Guadeloupe
12	0.084	Martinique	0.017	Virgin Islands
13	0.089	Bolivia	0.020	Nicaragua
14	0.091	Haiti	0.027	Dominican Republic
15	0.098	Ecuador	0.036	Jamaica
16	0.102	French Guiana	0.038	Anguilla
17	0.113	Paraguay	0.039	Trinidad and Tobago
18	0.118	Guatemala	0.043	Puerto Rico
19	0.133	Grenada	0.054	Honduras
20	0.135	Belize	0.085	Guatemala
21	0.149	Guadeloupe	0.166	Dominica
22	0.156	Colombia	0.179	Cuba
23	0.159	Uruguay	0.322	Uruguay
24	0.169	Dominican Republic	0.374	Ecuador
25	0.224	Panama	0.446	Bahamas
26	0.224	Trinidad and Tobago	0.531	Costa Rica
27	0.243	Venezuela	0.581	Paraguay
28	0.257	Peru	0.617	Panama
29	0.291	Virgin Islands	0.809	Belize
30	0.317	Jamaica	0.810	Colombia
31	0.369	Bahamas	0.966	Surinam
32	0.400	Costa Rica	1.049	Guyana
33	0.475	Anguilla	1.346	Venezuela
34	0.514	Brazil	1.560	Chile
35	0.520	Cuba	1.606	Bolivia
36	0.641	Chile	1.871	Mexico
37	0.724	Puerto Rico	2.408	Peru
38	0.830	Argentina	4.541	Brazil
39	0.861	Mexico	6.639	Argentina
40	1.098	Dominica	7.200	French Guiana
41	5.361	USA	14.651	USA

levels exhibited by the other New World countries examined.

Examination of the number of publications in relation to the number of bird species occurring in each country indicates that 87.5% of the 40 non-USA countries showed research levels that were less than 10% of the level occurring in the USA (Table 2); 22.5% of these countries exhibited levels of research that were less than 1% of the value for the USA (Table 2). The picture is similarly stark when considering the ratio of publications to population density (Table 2): 82.5% of the countries examined showed less than 10% of the USA research level, and 50% showed levels of less than 1%. For the sake of avian conservation efforts alone, some change in the geographic distribution of research effort seems warranted.

A low level of research product by itself does not indicate a level of neglect that should raise concern, however. The level of neglect must be viewed in the context of other factors. The two simple ratios in Table 2 begin to incorporate these factors, but research and conservation needs can be more comprehensively assessed with the addition of more factors, especially indicators of environmental health, such as the percentage of land area under the hand of humans and human population growth.

Multiple regression of the variables bird species, area, population, and population density on publica-

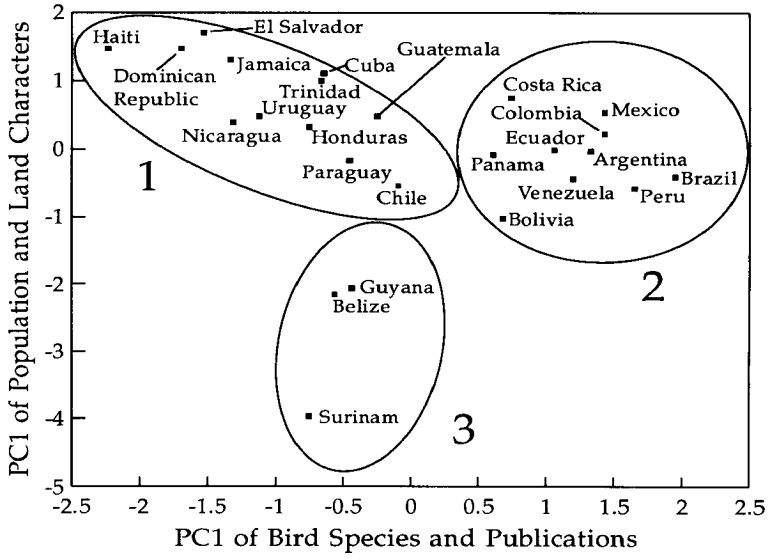

FIGURE 1. Bivariate plot of individual country scores on the first principal components of two analyses based upon log-transformed data from Table 1. Three groups are envisioned and are discussed in the text as numbered here.

tions (Table 1) showed a highly significant relationship with the inclusion of just two variables: population and area ($r^2 = 0.90$, $P < 0.001$). An analysis with the subset of countries for which additional variables were available (population growth, domesticated lands, and cropland change; Table 1) gave similar results; population and area again showed a significant relationship with publications ($r^2 = 0.90$, $P < 0.001$). In these analyses, population was positively correlated with publications, and area was negatively correlated. Thus, variables used as an index of human-related pressures on a country's avifauna were not correlated with the index of avian research (number of publications), nor with species richness.

To explore relationships among countries for which full data were available (Table 1), principal component analyses were performed on correlation matrices of log-transformed data. One analysis included human population density, population growth, and domesticated land figures, whereas the other included number of publications on birds and number of bird species. The first principal components (PC1) for these two analyses explained 52.9% and 74.7%, respectively, of the variance associated with the data. For the first analysis, human population density was the factor with the highest eigenvector on PC1; for the second, number of publications and bird species had equal eigenvector values. The second principal components (PC2) explained 33.4% and 25.3% of the variance, respectively. Principal component scores were generated for each country in both analyses. A bivariate plot of the first principal components (PC1 scores) was used to visualize relationships among countries when all of these variables were considered (Fig. 1).

Three groups of countries may be distinguished in this graphic summary of multivariate relationships (Fig. 1): Group 1 (Haiti, Dominican Republic, El Salvador, Jamaica, Nicaragua, Uruguay, Honduras, Cuba, Trinidad and Tobago, Paraguay, Guatemala, and Chile); Group 2 (Panama, Bolivia, Costa Rica, Ecuador, Venezuela, Argentina, Colombia, Mexico, Peru, Brazil); and Group 3 (Surinam, Belize, and Guyana). The division between Group 1 and Group 2 is subjective, and is based upon a combination of numbers of bird species and bird-related publications. Group 3 is composed of three countries that are distinct based upon their population and land characteristics; in publications and bird species these countries match Group 1 countries. Qualitatively, these groups may be characterized as follows: Group 1: countries having a combination of comparatively lower numbers of bird species and publications on birds, yet having high population densities and a high percentage of domesticated lands; Group 2: countries having a combination of relatively high numbers of bird species and publications on birds, yet having, on average, lower population densities and percentages of developed lands than Group 1 countries; and Group 3: countries that are similar in species richness and publications (combined) to Group 1 countries, but which have much lower population densities and percentages of developed lands.

DISCUSSION

These analyses provide a general overview of relative research coverage and make a step toward understanding research needs in the face of threats to avian preservation posed by land and human population characteristics. By country, research publication levels show a positive correlation with human population and a negative correlation with land area. Importantly, however, research levels do not show a correlation with species richness, nor with human population and

land characteristics reflecting human pressures on associated avifaunas and ecosystems. Thus, recent New World avian research efforts at a gross level are not correlated with factors often driving conservation needs (i.e., population density, percentage of domesticated lands, species richness, etc.). This is very disturbing.

Compared with avian research levels on birds in the USA, the great majority of Neotropical countries are dramatically understudied. However, there are differences among these many countries that cause some to be more "conservation critical." Part of my intent here is to draw attention to these areas. Future research efforts can be directed to areas where conservation concerns are (or should be) highest. I suggest that Group 1 countries are those most neglected and most in need of avian research. With more data, other countries in Table 1 might be added to Group 1. One region of obvious neglect occurs in Central America in Guatemala, Honduras, El Salvador, and Nicaragua. This region should be of particular concern to societies in the USA and Canada, for the size and geographic position of this Neotropical region make it very important for nonbreeding Nearctic-Neotropic migrants.

All ornithologists (and, indeed, societies) have a stake in Neotropical avian diversity and the ecosystems upon which this diversity relies. Because local capabilities are often low in relation to the magnitude of the research needed, collaborations and cooperation facilitating foreign research are imperative. Collectively, we should seek to increase overall Neotropical research support and production, especially in Group 1 countries. *Product* is a crucial concept here: the publication of past, present, and future *results, data sets, and analyses* are all equally important. Too often research is undertaken and the field aspect completed with little or no externally visible product. Given low levels of research support and the great need for Neotropical research results, full publication should be viewed as an obligation. To some this obligation is already familiar, but this is not the case in all of the countries examined, nor among all organizations conducting Neotropical avian research.

In addition, I would stress the long-term importance, usefulness, and necessity for research specimens of birds. A tremendous amount of our understanding of Neotropical ornithology is based upon specimens, and this resource is not growing in accord with our interest in this region, as it should be (Winker 1996). The need for actively collecting birds is addressed at greater length by Remsen (1995) and Winker (1996). Here, let it suffice to emphasize that most avian populations can easily withstand limited scientific collecting, and that properly vouchered specimens may be one of the most important contributions researchers can make, because these specimens serve critical roles in such things as the development of basic life history research (Winker et al. 1996), and in systematics and taxonomy through the delineation of evolutionarily important lineages.

Our research can give form and direction to successful conservation efforts, but the two may be only loosely connected. A great deal of successful conservation could be accomplished based upon knowledge already possessed. The research community should actively promote and support scientifically sound conservation efforts. At the same time, conservationists and natural resource managers should strive to base their efforts on quality information.

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