Bird Conservation International (2012) 22:348–353. © BirdLife International, 2011
doi:10.1017/S0959270911000517

Threatened birds of Guatemala: a random subset of the avifauna?

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Summary

Identifying attributes that affect the vulnerability of a species to extinction is important as it allows conservation efforts to be focused on more susceptible species. We assessed whether threatened birds of Guatemala are a random subset of the avifauna, considering their taxonomic affiliation, body size, diet and geographical distribution. We found that threatened bird species in Guatemala were neither taxonomically nor geographically randomly distributed. Large-bodied species and Psittaciformes, Galliformes, Falconiformes and Ciconiformes were among the most threatened groups, and the Pacific slopes of the country hosted more threatened birds than would be expected. Published scientific information regarding Critically Endangered bird species in Guatemala is scant and biased against nocturnal and aquatic species. Research and conservation efforts ought to be oriented toward these species and regions to safeguard the Guatemalan avifauna. This study allows an overall consideration on whether we are conserving the species and areas that are important for threatened birds.

Resumen

La identificación de los atributos que afectan la vulnerabilidad a la extinción en las especies permite focalizar los esfuerzos de conservación en las especies más susceptibles. Nosotros evaluamos si las aves amenazadas de Guatemala son un subconjunto aleatorio de su avifauna, en relación a su afiliación taxonómica, tamaño corporal, dieta y distribución geográfica. Las especies de aves amenazadas en Guatemala no están ni taxonómica ni geográficamente distribuidas al azar. Las especies con mayor tamaño corporal, y los Psittaciformes, Galliformes, Falconiformes y Ciconiformes son los grupos más amenazados, y las laderas del Pacífico albergan más especies de aves amenazadas de lo que se esperaría por simple azar. La información científica publicada respecto las especies críticamente amenazadas en Guatemala es escasa y sesgada contra especies acuáticas y nocturnas. Los esfuerzos de investigación y conservación deberían ser orientados hacia estas especies y regiones para proteger la avifauna de Guatemala. Este estudio permite una reflexión global sobre si estamos conservando las especies y las áreas que son importantes para las aves amenazadas.

Introduction

Extinction risk does not affect all bird species equally, some groups being more or less susceptible (Russell *et al.* 1998, Owens and Bennett 2000). It is necessary to understand the factors that determine whether a species is threatened in order to properly focus conservation efforts on more susceptible species (e.g. Carter *et al.* 2000). Biological attributes such as body size, diet and habitat use might interact with external factors such as habitat loss or hunting, rendering some species more susceptible to threats than others (Owens and Bennett 2000).

The avifauna of Guatemala is severely threatened. In 30 out of 77 bird families found in Guatemala, 60% or more of the species are threatened. At the species level, 46% (223) out of

484 resident bird species are regarded as threatened (Eisermann and Avendaño 2006a). Habitat loss is considered the main threat to birds (IUCN 2008). To be cost-effective, conservation actions need to prioritise taxa and geographic areas that are particularly vulnerable (e.g. Rodriguez *et al.* 2004, Carwardine *et al.* 2008).

Here, we explore whether the threatened birds of Guatemala are a random subset of the avifauna, considering their taxonomic affiliation, body size, diet and geographic distribution, factors that can impinge upon proneness to extinction (Gaston and Blackburn 1995). If threats are randomly distributed, orders containing more species should hold more threatened species compared with those that are species-poor. Further, threatened species should be randomly distributed across the range of body size and diets, proportional to the species richness for each size and diet class. Similarly, biomes covering larger areas, and thus supporting richer bird assemblages, should hold more threatened species than geographically-restricted biomes that are comparatively poor in species. Departures from randomness will allow taxa, species groups, or biomes that might require special conservation attention to be identified.

Methods

To test departures from randomness, we compared whether the observed frequency of threatened species per order, body size, diet class and geographic area, differed from the expected frequency, assuming that the proportion of threatened species would be evenly distributed across these gradients or classes (Kattan 1994). We classified each of the 484 resident bird species according to their taxonomic affiliation to family and order level (Howell and Webb 1995), average body size, diet and IUCN Red List criteria applied on a national level (Eisermann and Avendaño 2006a), as well as their presence in the seven recognised biomes of Guatemala (Eisermann and Avendaño 2006a, Howell and Webb 1995, Villar 1994).

To analyse whether threats are randomly distributed across taxonomic affiliation, we tested if the number of threatened species per order differs from what would be expected by chance. For the χ^2 test, some orders were pooled to obtain expected values greater than 5. As 46% of this fauna is regarded as threatened, if threats are randomly distributed across taxa, we would expect 46% of the species of each order to be listed as threatened. Similarly, we tested whether the proportion of threatened birds differs among body size and diet categories (carnivores, frugivores, frugivores-insectivores, granivores, granivores-frugivores, insectivores, nectarivores, omnivores). Body size and diets were obtained from Howell and Webb (1995).

To assess whether threatened species are randomly distributed across Guatemala, we estimated the percentage of the country's area occupied by each biome and quantified the number of threatened species per threat category (Vulnerable, Endangered, Critically Endangered) occurring in each one. The number of threatened species per biome was compared to the expected number of threatened species based on the proportion of the total avifauna supported for each biome.

Results

Species vulnerability is associated with taxonomic affiliation ($\chi^2_{13} = 37.1$; $P < 0.0004$; Table 1). A greater proportion of Psittaciformes, Galliformes, Falconiformes and Ciconiformes were threatened than would be expected by chance, while fewer than expected Passeriformes were threatened (heterogeneity $\chi^2_{10} = 15.40$; $P = 0.118$). All 15 Psittaciformes species are threatened, while 79% of Galliformes, 72% of Ciconiformes and 71% of Falconiformes species are regarded of conservation concern (Table 2). Threatened species were larger than those regarded as of least concern ($F_3 = 13.73$; $P < 0.001$). Average body size (in cm; mean ± SD) of resident threatened Guatemalan birds differs across IUCN categories. 'Least Concern' species averaged 23.8 ± 12.4, 'Vulnerable' species 27.4 ± 19.0, 'Endangered' species 36.7 ± 22.1 and 'Critically Endangered' species 55.9 ± 34.4. On average, 'Critically Endangered' species are 2.4 times larger than species of 'Least Concern', and significantly different from all other categories ($P < 0.02$ in all cases,

https://doi.org/10.1017/S0959270911000517 Published online by Cambridge University Press

Table 1. Number of threatened bird species in Guatemala. Figures are the observed and expected number per taxonomic orders. Some taxa were grouped in order to attain the requirements of the χ^2 proof that does not permit expected numbers smaller than 5.

ORDER	Observed (expected)
Podicipediformes, Pelecaniformes, Anseriformes and Charadriformes	9 (5.5)
Caprimulgiformes and Cuculiformes	6 (7.3)
Tinamiformes and Trogoniformes	7 (5.0)
Strigiformes	10 (7.8)
Piciformes	11 (7.8)
Passeriformes	88 (112.8)
Apodiformes	9 (19.8)
Ciconiformes	13 (8.2)
Coraciformes	5 (5.0)
Falconiformes	24 (15.6)
Galliformes	11 (6.4)
Gruiformes	8 (5.9)
Columbiformes	7 (8.2)
Psittaciformes	15 (6.9)
Total	223

unequal N HSD test). Large-bodied species are persecuted for trade and have low reproductive rates which might account for their higher degree of threat (Owens and Bennett 2000). In fact, large bodies are a common attribute of threatened Neotropical birds (Kattan 1992, 1994), indicating that larger species might need special attention. Further, the proportion of species under threat is also related to food habits ($\chi^2_7 = 15.96$; $P = 0.02$). The proportion of carnivorous species under threat was 1.35 times higher than expected by random. The frequency of other trophic groups did not differ from that expected by a random distribution (heterogeneity $\chi^2_6 = 11.19$; $P = 0.08$).

Threatened species tended to be concentrated in particular areas ($\chi^2_4 = 579.4$; $P < 0.001$). The Subtropical Humid Forest, located on the Pacific slope, contains 7.6 times more threatened species than would be expected according to its area (Table 3). This biome supports 32% of the threatened species in an area equivalent to only 4.2% of Guatemalan territory.

In summary, threatened Guatemalan birds are not a random subset of the country's avifauna, as threatened species are neither taxonomically nor geographically randomly distributed. Large-bodied species and Orders such as Psittaciformes, Galliformes, Falconiformes and Ciconiformes are among the groups with the highest proportion of threatened species, and the Pacific slope is a key area for threatened bird conservation.

Discussion

Effective conservation plans need to be supported by scientific and technical information (Pullin *et al.* 2004). Information regarding threatened Guatemalan birds is scant at best (see Appendix 1 in Eisermann and Avendaño 2006a). The number of published scientific papers per species within families containing 'Critically Endangered' species does not differ from that for less threatened and non-threatened species (1.8 vs 1.7 papers respectively; $z = -0.37$; $P = 0.36$). According to the list by Eisermann and Avendaño (2006b) there are no Guatemalan publications available on the conservation of 'Critically Endangered' Anatidae, Rallidae and Strigidae or Sunbittern *Eurypyga helias*, the single species of the Eurypygidae. An evaluation of waterbird populations in Guatemala (Eisermann and Avendaño 2006b) reveals that data are deficient for understanding population sizes and trends of 'Critically Endangered' waterbirds such as *Pardirallus maculatus*.

https://doi.org/10.1017/S0959270911000517 Published online by Cambridge University Press

Table 2. Number of threatened bird species of Guatemala according to IUCN categories applied to the country. Figures are for the 30 bird families that have 60% or more of their species threatened (after Eisermann and Avendaño 2006a).

FAMILY	CR	EN	VU	NT	LC	% of the family threatened
Accipitridae	3	3	14	4	3	74.1
Anatidae	2		2			100
Psittacidae	2		13			100
Momotidae	2		3		2	71.4
Odontophoridae	1	1	4	1		85.7
Strigidae	1	1	8	4	2	62.5
Ciconidae	1		1			100
Euripigidae	1					100
Nyctibidae		1	1			100
Ardeidae		1	10		1	91.7
Parulidae		1	9	3	2	66.7
Cracidae		1	3	2		66.7
Dendrocolaptidae			12			100
Ramphastidae			3			100
Buconidae			2			100
Formicaridae			2			100
Phasianidae			1			100
Galbulidae			1			100
Pelecanidae			1			100
Burhinidae			1			100
Recurvirostridae			1			100
Charadriidae			1			100
Heliornitidae			1			100
Certhidae			1			100
Peucedramidae			1			100
Cotingidae			1			100
Regulidae			1			100
Aramidae			1			100
Trogonidae			5	2		71.4
Furnaridae			5	1	1	71.4

Publications on Black-throated Bobwhite *Colinus nigrogularis*, a 'Critically Endangered' quail, are limited to the description of a new subspecies in 1932, and two reports in 1935 and 1955; since then, no other information has been gathered (Eisermann and Avendaño 2009). Even within taxa, information is skewed. For instance, for the two 'Critically Endangered' Psittacidae species, 13 out of 18 published papers are available for Scarlet Macaw *Ara macao* contrasting with just five devoted to Yellow-headed Amazon *Amazona oratrix* (see Appendix 1 in Eisermann and Avendaño 2006a, for the full bibliography on Guatemalan birds from 1577 to 2004). The paucity of information highlights a clear need for research focused on the most susceptible and threatened taxa.

Geographically, the Pacific slopes region (Subtropical Humid Forest) should be a prime target for conservation efforts. Although all species found there can be also found in other biomes, mainly in the Atlantic region and Guatemala's highlands, conservation efforts ought to be increased in the Pacific slopes as protected areas cover just 227 ha of this biome, compared to 325,000 ha formally protected in the Atlantic region (Tropical humid and rainforest biomes; CONAP 2006). Guatemala has 297 official protected areas, and new areas are being established, including a growing number of private reserves (CONAP 2010b). Based on a gap analysis, the Guatemalan western volcanic chain, which includes the Pacific slopes, has been recently identified

Table 3. Threatened bird species by biogeographic regions of Guatemala. Figures are the observed and the expected number of species (Observed number of species according to Eisermann and Avendaño 2006a)

Region	Biome in the region (approx)	% of the country that it occupies	Observed threatened species (% of the total threatened)	Expected threatened species for such an area
Atlantic lowlands and Atlantic slopes	Tropical humid forest, tropical rainforest and pine savanna	52.4	161 (72.2)	116.7
Highlands	Mountain broadleaf forest and mountain conifer forest	26.4	102 (45.7)	58.8
Pacific slopes	Subtropical humid forest	4.2	73 (32.7)	9.3
Pacific lowlands	Tropical humid savanna	10.9	71 (31.83)	24.4
Interior valleys	Thorn scrub	6.1	22 (9.86)	13.4

as a priority area for conservation (CONAP 2010a). Our results offer support for this decision. Further, some private protected areas are being established in the Pacific slopes region, offering specialised bird-watching tours, contributing to protection of the threatened avifauna. Besides the native forest contained mainly in these protected areas, the Pacific slopes are also largely covered with coffee and coffee-cardamom plantations (MAGA 2006). These agroforestry systems, together with the public and private protected areas, can contribute to the conservation of local biodiversity, since shade-coffee plantations are capable of holding an important fraction of the original species from native forests, due to the structural and floristic diversity given by the canopy of shade trees (Perfecto *et al.* 2005; see also Nájera and Simonetti 2010). Given that the additional area added to the Guatemalan protected areas system is getting progressively smaller, and the likelihood of protecting larger areas - in Guatemala, and worldwide - seems low (IARNA 2006), biodiversity conservation ought to be attempted in productive landscapes outside protected areas (e.g. Perfecto and Vandermeer 2008), particularly in biomes where agricultural activities are high or increasing, such as the Pacific slopes in Guatemala. In order to protect its avifauna, Guatemala ought to focus on threatened taxa and biomes that currently do not receive the attention required.

Acknowledgements

Andrea Nájera was an AGCI fellowship holder (Agencia de Cooperacion Internacional de Chile).

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Received 29 December 2010; revision accepted 23 August 2011;
Published online 16 December 2011