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The Face of Extinction: Are Charismatic Species More Vulnerable To Endangerment?

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THE FACE OF EXTINCTION: ARE CHARISMATIC
SPECIES MORE VULNERABLE TO
ENDANGERMENT?

being

A Thesis Presented to the Graduate Faculty
of the Fort Hays State University in
Partial Fulfillment of the Requirements for
The Degree of Master of Science

by

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The Master of Science Degree

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Preface

This thesis is written in the style appropriate for publication in *Conservation Biology*.

Keywords

charismatic species, exploited species, endangered species, sexual selection traits, extinction traits

Abstract

Conservationists have suggested extinction is non-random; some species are more prone to extinction than others. Multiple traits (e.g., large bodied, long-lived, slow-reproducing, migratory, habitat and/or dietary specialists) have been cited as contributing to the endangerment of species. Due to global anthropogenic demand for wild species (e.g., sport, trade, fashion, medicine, religion, food), I propose charisma as an additional trait of endangerment. This predicts charismatic species are more often targets of direct exploitation than less charismatic species, and that global demand will continue to increase with world population and development. These species represent our most iconic and animated organisms. I quantified charisma through color, ornamentation, and vocalizations in 1609 Old and New World species of passerine and psittaciform birds; this represents approximately 1/6 of all extant avian species worldwide. Color and ornamentation correlate significantly with both exploitation and endangerment, while melodious song, occurring only in passerines, correlates significantly with endangerment only. Mimicry did not appear to have an effect on either exploitation or endangerment. Additionally, an increase in number of variables (e.g., color, ornamentation, mimicry, song), number of colors, and proportion of color increased exploitation and endangerment overall. These charismatic traits, which also represent the exaggerated traits resulting from sexual selection, have been hypothesized as potential contributors to speciation. I propose overexploitation is removing charismatic species from the Earth's biota as well as negatively influencing speciation rates, thereby accelerating homogenization of global biodiversity. This study might be

valuable in identification of species that are potential targets of exploitation, and suggests a need for conservation of charismatic species in the future.

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Contents	Page
Signature Page	i
Preface.....	ii
Abstract.....	iii
Acknowledgments.....	v
Contents	vii
List of Tables	ix
Introduction.....	1
Methods.....	7
Data Collection	7
Endangerment and Exploitation.....	8
Color	9
Ornamentation.....	10
Mimicry.....	10
Song	10
Data Analyses	11
Results.....	13
Color	13
Ornamentation.....	14
Mimicry.....	15
Song	15
Combined Traits.....	15

Discussion.....	16
Exploitation and Endangerment Implications.....	16
Psittaciforms and Passerines.....	17
Charismatic Traits and Sexual Selection.....	19
Charismatic Traits and Taxonomic Levels.....	20
Literature Cited.....	23

List of Tables

Table	Page
1 Avian families and associated Handbook of the Birds of the World authors.....	29
2 Categorization of achromatic and chromatic colors derived from diversity of color found in avian species sampled*	30
3 Categorization of avian song type by description of song per species or family*	31
4 The effect of charismatic traits (color) on exploitation and endangerment (+ indicates increase) for passerines and psittaciforms (combined) and for passerines only (passerine), reporting significant results only	32
5 The effect of charismatic traits on exploitation and endangerment (+ indicates increase) for passerines and psittaciforms (combined), for passerines only (passerine), and psittaciforms only (psittaciform), reporting significant results only	33
6 Scenarios of exploitation and endangerment per avian group and associated implications.....	34
7 Associated charismatic characteristics of endangered avian families, listed in descending order of endangerment	35

Introduction

Humans represent a threat to biodiversity due to overpopulation and unsustainable consumption of resources (Ehrlich 2002). Current extinction rates have been estimated to be approximately 100 to 1000 times the background extinction rate, with an additional 10-fold increase expected to occur in the 21st century (Pimm et al. 1995). Major anthropogenic threats to biodiversity include habitat destruction, introduced species, overexploitation, disease, and pollution (Wilcove et al. 1998). More recently, global climate change has been cited as an additional threat to biodiversity (Thomas et al. 2004). Many species currently face a combination of these threats (Fowler & MacMahon 1982).

Extinction is non-random as some species are more vulnerable to extinction than others (Bennett & Owens 1997; McKinney 1997; Isaac & Cowlshaw 2004). This concept of selective extinction can be traced back to the writings of Alfred Russel Wallace (Fowler & MacMahon 1982), Jean-Baptiste Lamarck, and Charles Lyell (McKinney 1997). Selective extinction is the complement to Darwin's natural selection, as it focuses on differential extinction rather than differential survival. It assumes extinction probability is dependent largely on the interaction of disadvantageous attributes of a species within a given environment. Extinction biases are found at all taxonomic levels (Jablonski 2008) and have been noted in the fossil record where groups with specific attributes are found to be vulnerable or resilient to extinction (McKinney 1997).

While extinction is non-random due to the interaction of specific traits with the environment, it follows that threats will affect species differentially (Owens & Bennett 2000; Isaac & Cowlshaw 2004). The concept of r and K -selection suggests r -selected species tend to persist in unstable environments, while K -selected species tend to persist in more stable environments (MacArthur & Wilson 1967; Pianka 1970). Long-term survival is based ultimately on population growth rates; r -selected species have rapid rates of reproduction and K -selected species reproduce slowly (MacArthur & Wilson 1967; Pianka 1970). Therefore, r -selected taxa tend to be more resilient and adapted to a human-altered world than their K -selected counterparts (Fowler & MacMahon 1982).

The concept of r and K selection represents a continuum where the life-histories of species fall between two extremes (MacArthur & Wilson 1967; Pianka 1970). K -selected species are large-bodied, long-lived, and slow-reproducing (Pianka 1970), and so require an abundance of resources (Terborgh 1974) and larger home ranges (Gaston & Blackburn 1995). Populations increase slowly, as sexual maturity is late and offspring are few (Pianka 1970). Although K -selected species are efficient competitors once established (MacArthur & Wilson 1967; Pianka 1970), they typically neither disperse nor colonize well (Terborgh 1974). Conversely, r -selected species are small, short-lived, and highly productive (MacArthur & Wilson 1967; Pianka 1970). Their populations increase rapidly, and they disperse easily and persist in variable environments (MacArthur & Wilson 1967; Pianka 1970). Overall, K -selected species have been cited as more extinction-prone than r -selected species.

Additional extinction-promoting traits also have been proposed. Migratory species appear to be at risk as modification of breeding, wintering or migratory habitat would imperil these species (Terborgh 1974). Species that aggregate also have greater vulnerability, perhaps due to more efficient harvest by predators as well as greater resource requirements (Isaac & Cowlshaw 2004). Habitat and dietary specialists also are prone to endangerment due to the specificity of their requirements (McKinney 1997). Species at higher trophic levels require more resources (Terborgh 1974) and have a greater probability of encountering extinction cascades when prey are no longer available (Diamond 1989).

In avian studies, major threats include habitat loss, small range or population size, overexploitation and introduced species (Wilcove et al. 1998). Of approximately 10,000 extant bird species worldwide, a conservative estimate predicts 12% are threatened with extinction (Pimm et al. 2006). The proposed avian extinction rate in the 21st century will be 1000 times greater than the background extinction rate (Pimm et al. 2006). Though conservation efforts appear to have slowed extinction rates, the rate is expected to increase over time, and currently indicates a conservative loss of 10 bird species per year (Pimm et al. 2006).

In this study, I focus on the threat of overexploitation of avian species due to their appearance and behavior. Overexploitation threatens over 1/3 of all endangered bird species worldwide (Rosser & Mainka 2002) as birds are directly removed from the wild by hunting and trade (Broad et al. 2003). Exploitation affects primarily large-bodied and

slow-reproducing species (Owens & Bennett 2000; Purvis et al. 2000; Isaac & Cowlishaw 2004).

I hypothesize charisma as a trait that promotes extinction vulnerability across taxa. This predicts charismatic organisms, either in appearance or behavior, are predisposed to anthropogenic extinction. This trend represents *biophilia* (Wilson 1993), our innate attraction to the natural world, run amok. I base this hypothesis on the assumption that charismatic species are more often targets of the wildlife trade, which includes exploitation for sport, pets, fashion, furnishings, ornamentation, food, and medicinal and religious purposes (Broad et al. 2003). I predict anthropogenic demand for charismatic species will continue to increase with an increasing human population as well as improved global standard of living, exploitation technology, and trade.

This type of selective extinction removes the most charismatic species from the Earth's biota. Economic supply and demand models have been applied to exploitation of rare species; rare species of certain size, bright coloration, taste, or medicinal qualities will become more vulnerable when no alternatives are available to the consumer (Hall et al. 2008). Attributes of rarity, as well as appearance, mimicry, size and personality, can affect price and specifically influence the demand for parrots (Wright et al. 2001). I hypothesize these attributes contribute to the endangerment of all taxa, and predict consumers will pursue alternatives when particular resources (species) are exhausted. Ultimately, this macroevolutionary selection will result in a less diverse biosphere (McKinney 1997) and an accelerated rate of "biotic homogenization" (McKinney &

Lockwood 2001), where nonindigenous and human-adapted species will ultimately dominate.

As aesthetics are often subjective, they can be difficult to quantify. Perceptions of beauty in nature might be universal due to a genetic component (Kellert 1993; Wilson 1993), and that humans demonstrate sensory bias, favoring novelty, pattern, symmetry (Humphrey 1973) and color (Berlyne 1971). Further, aesthetic cross-cultural agreement in animal species has been noted (Maresova et al. 2009), where particular physical traits elicit universal human responses. Preferential traits such as large size, juvenile features, shape, mode of locomotion, posture, texture, similarity to humans, and color (Stokes 2007) have all been reported.

Although the *gestalt* of charisma is difficult to quantify, elements of attractiveness, such as color, ornamentation, song, and mimicry, might be quantifiable. I tested these traits, both singly and in combination, to assess their potential effect on exploitation and endangerment. I predict those species with a high intersection of these traits (i.e., most charismatic) will be especially endangered due to direct exploitation. My study examines these characteristics in ~1600 avian species to assess the extinction vulnerability of charismatic species. As most bird species possess some degree of color, ornamentation, and/or vocal ability, they represent an ideal group to test these hypotheses. Although it is difficult to partition and isolate direct exploitation from other threats, I hypothesize a positive correlation exists between charisma and both exploitation and endangerment in wild species due to human preferences.

The potential significance of this study is great, as it might indicate charismatic species are at greater risk of extinction than their less charismatic counterparts. This could serve as an important tool in early identification of species that are potential targets of trade. A positive correlation also might indicate direct anthropogenic selection is more pervasive than realized.

Methods

Data Collection

Data were collected from 1609 extant avian species. I chose the orders Passeriformes and Psittaciformes, as both groups exhibit variation in color, ornamentation, song (oscines) or mimicry, have Old and New World distributions, and are sister taxa (Hackett et al. 2008). This variation in traits allowed for meaningful comparison. By choosing related species, I allowed for comparison among organisms with similar biology and life histories, in order to control for other variables that could affect results.

Representative species are from one family of Psittaciformes or parrots (Psittacidae), and 16 families from the order Passeriformes or passerines (Chloropseidae, Corvidae, Cotingidae, Dicaeidae, Estrildidae, Eurylaimidae, Fringillidae, Irenidae, Nectariniidae, Oriolidae, Paradisaeidae, Parulidae, Philepittidae, Pipridae, Pittidae, and Thraupidae). The BirdLife International (BI) species list was downloaded in July 2009 from www.birdlife.org, and is based on 2008 assessments. I followed the taxonomic assignment provided in the BI 2009 species list, which included both cockatoos and parrots in the Family Psittacidae, and Hawaiian honeycreepers in the Family Fringillidae. Trait data were acquired from Handbook of the Birds of the World (HBW) (Table 1), while exploitation and conservation status data were acquired from BirdLife International (BI).

Endangerment and Exploitation Data

Both BI and International Union for Conservation of Nature (IUCN) rank conservation statuses in increasing order of threat as follows:

LC	least concern
NT	near threatened
VU	vulnerable
EN	endangered
CR	critically endangered

BI and IUCN conservation statuses generally are determined by declines in population size or geographic range size (Rodrigues et al. 2006). Critically endangered (CR) species are estimated to have a $\geq 50\%$ probability of extinction within 10 years or 3 generations (whichever is greater), endangered species (EN), a $\geq 20\%$ probability within 20 years or 5 generations (whichever is greater), and vulnerable species (VU) a $\geq 10\%$ extinction probability within 100 years. Near threatened (NT) species are expected to qualify for a category in the near future (Rodrigues et al. 2006).

The endangerment (NT+VU+EN+CR), or test group in the sample consisted of 366 species (135 parrots + 231 passerines). While all species in the study are exposed to various threats (e.g. exploitation, climate change, habitat loss, introduced species, disease, or pollution) these species are particularly endangered as measured by declines in population or geographic range size. The least concern (LC), or control group consisted of 1243 species, which, although might be exposed to similar threats, are not showing high rates of decline.

The exploitation test group consisted of those species within the endangerment group (NT+VU+EN+CR) that were known to be exploited, or directly removed from the environment. This subset of the endangerment group consisted of 126 exploited and 240 non-exploited species. Exploitation was characterized generally by hunting (e.g., food, persecution) or capture for the cage bird market. Species within the exploitation group (366 spp) were often exposed to other threats as well, most notably, habitat loss. Actual threats were noted in the “Threats” section in each species account (BirdLife International 2011).

Color

Color data were acquired from Handbook of the Birds of the World (Table 1). Color per species was determined by reading “Descriptive notes” and viewing an associated color plate. Color was assigned by main color, therefore, “bluish black” would be categorized as “black”, while a “blackish blue” would classify as “blue.” All 18 colors were noted as either present or absent for each species.

Due to the variation of color in these species (18 total), colors were then grouped into 8 main categories (Table 2) to ensure an appropriate sample size per color. Colors were divided into 4 achromatic divisions (black, white, gray, or brown) and 4 chromatic divisions (red, yellow, green, or blue). The 4 chromatic colors served as test colors.

I estimated the proportion of the species that was chromatic by viewing the color plate. A species with entirely achromatic coloring was assigned 0% chromatic coverage, while a species with complete chromatic coloring was assigned 100%. Colors

were recorded from the male of the species, who was depicted in breeding plumage.

Males overall tended to be more colorful than females.

Ornamentation

Crests, wattles, or exaggerated tail feathers (i.e., tails that were body length or longer or had a novel shape) were characterized as ornamentation. Tails were measured with a divider from tail base, where proximal tip of undertail coverts ended, to proximal tail end and then compared proportionally to body length. Ornamentation was categorized as absent or present. Bills were not included as ornamentation, although some were highly exaggerated in length, width or shape. This extreme variation made bills challenging to quantify.

Mimicry

Mimicry data were described both at the family and species level under “Voice” in either the family or species section of HBW. Species-level information was used preferentially when available. Mimicry was categorized as absent or present. All psittacidae were described as mimics at the family level, while passerine mimicry data included data at both the species and family level.

Song

Song data were collected from HBW primarily on a per species basis under “Descriptive notes”, followed by “Voice” and then “song” in the species section. I categorized song as

harsh, neutral, or melodious depending upon description provided (Table 3). When song information at the species level was not available, a family assignment was made if family song was described uniformly for that family. Song at this taxonomic level was described in each family section of HBW under “Voice.” If song at the family level was described as “variable,” then an NA would be assigned for those species with no song information provided. Both Psittacidae (parrots) and Corvidae (crows) were described as having no song. Melodious song (i.e., the test group) was compared to harsh song (i.e., the control group). Species with neutral or no song were not used in the analysis, nor were those who had song described as both melodious and harsh.

Data Analyses

Color, ornamentation, song and mimicry were tested both singly and in combination (i.e. increasing number of colors, increasing proportion of color, and increasing number of traits) to observe potential effects on both exploitation and endangerment. Analyses were conducted for 3 avian groups (passerines and psittaciforms combined, passerines only and psittaciforms only) for each trait and trait combination. Mimicry and melodious song, however, were not tested in the psittaciform group, as all parrot species possess the capacity to mimic and do not possess melodious song.

To determine the effect of a trait on endangerment, the frequency of that trait within the endangerment group of species (NT+VU+EN+CR) was compared to the frequency of that trait within the least concern (LC) species. To assess trait effect on exploitation, the frequency of that trait for exploited species within the endangerment

group was compared to the frequency of the trait for non-exploited species within the endangerment group (NT+VU+EN+CR).

I used Chi-square tests of independence to ascertain the effect of independent traits (color, ornamentation, mimicry, or melodious song) on both exploitation and endangerment. T-tests were used to assess the effect of increasing number of colors (R+Y+G+B), proportion of color (0-100%), and increasing number of variables (R or Y or G or B + ornamentation + mimicry + melodious song) on exploitation and endangerment.

To adjust for potential Type I errors due to multiple comparisons, I used a Benjamini and Yekutieli correction for multiple tests (Narum 2006). This correction was chosen over a Bonferroni correction as it better balanced both Type I and II errors. Prior to corrections, a nominal significance level was set at 0.05. For color, there were 24 comparisons that required an adjustment of the significance level to $\alpha = 0.013$. For ornamentation, increasing number of traits, and increasing number of colors, there were 6 comparisons that adjusted the significance level to $\alpha = 0.020$. For both mimicry and song, 2 comparisons adjusted the significance level to $\alpha = 0.033$.

Results

Overall, the combined group (passerines + psittaciforms) exhibited an increase in exploitation and endangerment with increases in color and ornamentation (Table 4 and 5). Further, exploitation and endangerment increased with increasing number of traits (color + ornamentation + mimicry + melodious song), and increasing number and proportion of color. Melodious song was the only variable that had no effect on either exploitation or endangerment in the combined group, but did show an increase in endangerment among passerines. Mimicry did not affect exploitation or endangerment among passerines, and was not tested among psittaciforms nor the combined group.

Color

In general, the presence of chromatic color increased exploitation and endangerment for the combined group (passerine + psittaciform) (Table 4). Red plumage was associated with an increase in exploitation ($X^2 = 23.24$, $df = 1$, $p < 0.001$, $\alpha = 0.013$) but not endangerment ($X^2 = 3.04$, $df = 1$, $p = 0.046$, $\alpha = 0.013$). Blue increased exploitation ($X^2 = 27.26$, $df = 1$, $p < 0.001$, $\alpha = 0.013$) and endangerment ($X^2 = 16.63$, $df = 1$, $p < 0.001$, $\alpha = 0.013$), and green increased exploitation ($X^2 = 6.80$, $df = 1$, $p < 0.006$, $\alpha = 0.013$) and endangerment ($X^2 = 14.85$, $df = 1$, $p < 0.001$, $\alpha = 0.013$). While yellow plumage had no statistically significant effect on exploitation ($X^2 = 0.928$, $df = 1$, $p = 0.197$, $\alpha = 0.013$), it increased endangerment ($X^2 = 5.42$, $df = 1$, $p = 0.012$, $\alpha = 0.013$). Both exploitation ($t = 5.84$, $df = 364$, $p < 0.001$, $\alpha = 0.020$) and endangerment ($t = 5.12$, $df = 1607$, $p < 0.001$, $\alpha = 0.020$) increased with increasing number of colors, while proportion of color increase

both exploitation ($t = 4.52$, $df = 277$, $p < 0.001$, $\alpha = 0.020$) and endangerment for the combined group ($t = 6.66$, $df = 582$, $p < 0.001$, $\alpha = 0.020$).

In passerines, only exploitation ($X^2 = 12.85$, $df = 1$, $p < 0.001$, $\alpha = 0.020$) increased with blue plumage while endangerment did not ($X^2 = 4.52$, $df = 1$, $p = 0.021$, $\alpha = 0.020$). Neither red, yellow, nor green plumage increased either exploitation or endangerment in passerines. Increasing proportion of color, however, increased endangerment in passerines ($t = 2.93$, $df = 322$, $p = 0.004$, $\alpha = 0.020$) but not exploitation ($t = 0.503$, $df = 229$, $p = 0.615$, $\alpha = 0.020$). Increasing number of colors had no effect for both exploitation and endangerment among passerines. Within the psittaciform group, no single color, color combination, nor increasing proportion of color promoted exploitation or endangerment.

Ornamentation

Both exploitation ($X^2 = 13.50$, $df = 1$, $p < 0.001$, $\alpha = 0.020$) and endangerment ($X^2 = 15.01$, $df = 1$, $p < 0.001$, $\alpha = 0.020$) increased with ornamentation for the combined group (passerines + psittaciforms). Only endangerment ($X^2 = 8.09$, $df = 1$, $p = 0.005$, $\alpha = 0.020$), and not exploitation ($X^2 = 4.73$, $df = 1$, $p = 0.034$, $\alpha = 0.020$), increased with ornamentation in passerines. In psittaciforms, while ornamentation showed an increase in exploitation ($X^2 = 6.77$, $df = 1$, $p = 0.009$, $\alpha = 0.020$), no statistically significant effect was detected in endangerment ($X^2 = 2.59$, $df = 1$, $p = 0.074$, $\alpha = 0.020$).

Mimicry

Mimicry had no effect on exploitation or endangerment among passerines (Table 5).

Psittaciforms were not tested in this category as all are mimics; mimicry was not tested within the passerine + psittaciform group as psittaciforms would bias the analyses.

Song

While exploitation ($X^2 = 0.089$, $df = 1$, $p = 0.765$, $\alpha = 0.020$) showed no relationship with melodious song in the passerine group (Table 5), endangerment increased significantly with melodious song ($X^2 = 5.74$, $df = 1$, $p = 0.011$, $\alpha = 0.020$). Neither psittaciforms nor the combined group was tested as the psittaciforms do not have melodious song and would bias the result.

Combined Traits

As the number of traits increased (R, Y, G, or B + ornamentation + mimicry + melodious song), so did exploitation ($t = 2.95$, $df = 130$, $p = 0.004$, $\alpha = 0.020$) and endangerment ($t = 5.53$, $df = 1607$, $p < 0.001$, $\alpha = 0.020$) for the combined passerine + psittaciform group (Table 5). Psittaciforms exhibited an effect within exploitation ($t = 2.95$, $df = 130$, $p = 0.004$) but not endangerment with increasing number of traits. Combined traits had no effect among passerines in either exploitation or endangerment.

Discussion

Charismatic traits such as color, ornamentation, and melodious song appeared to increase exploitation, and consequently, endangerment in birds (Tables 4 and 5). Additionally, both exploitation and endangerment tended to increase with increasing number of traits, increasing number of colors, and greater proportion of color per species. Melodious song was found to increase endangerment in passerines (songbirds), while mimicry had no effect on either exploitation or endangerment in passerines.

Exploitation and Endangerment Implications

In general, a trait that had a higher observed than expected value for any avian group (passerines + psittaciforms, passerines only, psittaciforms only) in either the exploitation or endangerment group, suggested the trait influenced vulnerability overall (Table 6). I propose exploitation of species is the only threat to discriminate between the charismatic and non-charismatic due to human preference. I propose other threats (e.g., habitat loss, climate change, introduced species, disease and/or pollution) are not selecting against charismatic traits such as color, ornamentation, mimicry and melodious song.

Overall, the combined group exhibited a positive relationship between exploitation and endangerment in color and ornamentation. Thus, charismatic traits might not only influence exploitation in this group, but are likely contributing to species endangerment as well. Other threats (e.g., habitat loss, climate change, introduced species, disease, pollution) did not obscure the pattern. Thus, overexploitation appears to be a significant threat for endangered charismatic species.

A trait that increased exploitation with no effect on endangerment for a specific group could indicate that while exploitation occurs because of this trait, the effect on endangerment is obscured by other threats (e.g., habitat loss, climate change, introduced species, disease, pollution). This relationship existed for color red in the combined group, color blue in passerines, and for ornamentation and number of traits in psittaciforms.

When a trait had no effect on exploitation but increased endangerment, this might indicate species are exploited without our knowledge, or, it might be these species are exploited and the pattern is not apparent with the current sample size. Again, as exploitation is probably the only charisma-biased threat, the increases in endangerment without increases in exploitation might indicate exploitation is occurring. This relationship applied to yellow plumage in the combined group, as well as to passerines with ornamentation, melodious song and increasing proportion of color.

If no effect was observed in exploitation or endangerment, either the trait does not have an effect on extinction risk, or the sample size might be too small to detect the pattern. No pattern occurred in passerines with colors red, green and yellow, number of colors, mimicry, and increasing number of traits. In parrots, this was observed for red, blue, green, yellow, increasing number of colors, and increasing proportion of color.

Psittaciforms and Passerines

Psittaciforms are probably influencing some statistical patterns detected in the combined group results. Parrots represent a highly exploited group, possibly due to an overlap of

charismatic traits such as color, ornamentation, and perhaps, mimicry. Combined passerine + psittaciform analyses demonstrated increases in exploitation and endangerment for the majority of color and ornamentation tests. Although some results are probably due to the influence of parrots in the sample, passerines exhibited endangerment with ornamentation as well. These results might be attributed to comparison of a consistently multi-colored and highly endangered group (parrots) with an often less colorful and less endangered group (passerines).

Color demonstrated no effect on either exploitation or endangerment within the psittaciforms. This could be due to the trait having no effect, a small sample size within the exploitation and endangerment groups, or the multi-colored nature of many parrot species. This multi-colored quality did not allow for a sufficient control group to make meaningful comparisons. Ornamentation, however, did increase exploitation risk in parrots. Cross-cultural studies have reported preferred parrot species tend to be large, colorful, and long-tailed (Frynta et al. 2010).

Exploitation and endangerment patterns emerged within the passerines, however, indicating combined results are not entirely due to the influence of the psittaciforms (Tables 4 and 5). Passerines exhibited some vulnerability to extinction through color, ornamentation, and song, but not mimicry. Blue plumage increased exploitation, while greater proportion of color increased endangerment, indicating that charismatic features could be affecting vulnerability to extinction in this group. Passerines, unlike psittaciforms, tended to exhibit greater variation in traits among species (especially color) which allowed for better comparison of the test variable (i.e., distinct test and control

groups where species do not uniformly possess the trait). Both ornamentation and melodious song increased endangerment in passerines as well.

I suggest a gradient exists where species with multiple charismatic traits might be exploited first. This additive effect was evident in these analyses, where increased number of traits, number of colors, and proportion of color further contributed to extinction vulnerability. Without the presence of parrots, perhaps other species would be more heavily exploited. This might explain why I observed only some exploitation and endangerment patterns due to charismatic traits among the passerines, especially in color. As some traits appeared to influence vulnerability to extinction, however, the data suggested species are being selectively removed from the wild due to their charismatic traits.

Charismatic Traits and Sexual Selection

The charismatic traits of color, song, mimicry and ornamentation that appeal to humans are also the elaborate secondary sexual characteristics of Darwin's "sexual selection" (*sensu* Zahavi & Zahavi 1997). In this reproductive fitness model, both mate choice and male competition can select for extravagant traits. Darwin associated the occurrence of sexual traits with high species richness, indicating these traits promoted cladogenesis and diversification (Panhuis et al. 2001). Studies have since reported more speciose groups tend to contain more ornamented species (Møller & Cuervo 1998), suggesting sexual selection might contribute to the high species richness observed in the passerines. These "sexy" traits appear to promote radiation through sexual selection, and result in increased

rates of speciation. These traits, then, might be described as the “key characters” (Marzluff & Dial 1991) of speciation.

Sexually selected species (Morrow & Pitcher 2003), as well as species rich families (Bennett & Owens 1997; Bennett et al. 2001) tend towards endangerment. Elaborate secondary sexual traits have been correlated with extinction risk (McLain et al. 1995; Sorci et al. 1998; Bennett et al. 2001). Extinction-prone families include Psittacidae (parrots), Columbidae (pigeons) and Phasianidae (pheasants) (Bennett et al. 2001), all of which tend to be colorful or highly ornamented. Studies reviewing the effects of sexual selection (Morrow & Pitcher 2003) and species richness (Bennett et al. 2001) on extinction, however, are unclear as to the underlying cause that promotes both speciation and extinction. I propose, aside from the natural selection cost (i.e. where exaggerated traits become disadvantageous), this observed extinction risk in highly charismatic families might be the result of anthropogenic overexploitation. Paradoxically, the sexually selected traits that promote speciation have become the charismatic traits that now also promote extinction.

Charismatic Traits and Taxonomic Levels

In this study, highly endangered families such as the Psittacidae (parrots), Paradisaeidae (birds-of-paradise), Cotingidae (cotingas), Eurylaimidae (broadbills), Pittidae (pittas), Philepittidae (asities), and Chloropseidae (leafbirds) tended to possess an especially high degree of color or ornamentation (Table 7). The Psittacidae possessed color, ornamentation, and mimicry, while the Chloropseidae possessed color but no

ornamentation, and the unique combination of both mimicry and melodious song. In most cases, the most endangered families tended to possess 2-3 charismatic traits, except for the Pittidae, which were colorful only. This supported my results, indicating that ornamentation and color (e.g., appearance) are strong correlates of endangerment.

I suggest this pattern occurs across taxa, and at many taxonomic levels.

Exploitation in both ornamented (e.g., elephants, rhinos, orchids) and colorful species (e.g., tropical fish, parrots, orchids) appears to be prevalent worldwide. Thus, future studies might include other potential charismatic traits (e.g., fragrance, pattern, symmetry, contrast), a more refined study of mimicry or song, or cross-taxa analyses of charismatic traits. Despite reports of taxonomic bias favoring the charismatic (Bonnett et al. 2002; Gunnthorsdottir 2001), this favoritism of charismatic species might be justified. Additionally, conservation groups might consider charismatic features of organisms when evaluating endangerment of species and allocating resources.

Overexploitation might be a greater threat than previously realized, as we continue to selectively remove our most charismatic species from the Earth's biota. Eventually, with the disappearance of charismatic species, more subtle forms of beauty might be exploited. Additionally, we appear to be interfering with speciation, and thereby moving inexorably towards a more homogenous and less biodiverse world. To counteract this *biophilia* (Wilson 1993) run amok, I argue a charismatic bias is necessary for the continued survival of charismatic species. Although some have feared a selective extinction of the less attractive due to taxonomic bias (Maresova & Frynta 2007),

ironically it may be this chauvinism that conserves global beauty and species diversity in the future.

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Table 1. Avian families and associated Handbook of the Birds of the World authors.

<i>Family</i>	<i>Author(s)</i>
Psittacidae (parrots)	Collar 1997
Cacatuidae (cockatoos)	Rowley 1997
Chloropseidae (leafbirds)	Wells 2005b.
Corvidae (crows)	dos Anjos et. al. 2009
Cotingidae (cotingas)	Snow et. al. 2004
Dicaeidae (flowerpeckers)	Cheke & Mann 2008a.
Drepanididae	Pratt 2010
Estrildidae (waxbills)	Payne 2010
Eurylaimidae (broadbills)	Bruce 2003
Fringillidae (finches)	Collar et al. 2010
Irenidae (fairy bluebirds)	Wells 2005a.
Nectariniidae (sunbirds)	Cheke & Mann 2008b.
Oriolidae (orioles)	Walther & Jones 2008
Paradisaeidae (birds-of-paradise)	Frith & Frith 2009
Parulidae (new world warblers)	Curson 2010
Philepittidae (asities)	Hawkins 2003
Pipridae (manakins)	Snow 2004
Pittidae (pittas)	Erritzoe 2003
Thraupidae (tanagers)	Hilty 2011

Table 2. Categorization of achromatic and chromatic colors derived from diversity of color found in avian species sampled.*

<i>Achromatic</i>	<i>Chromatic</i>			
	<i>Red</i>	<i>Yellow</i>	<i>Green</i>	<i>Blue</i>
black	reds	yellows	greens	blues
white	rusts	golds	dark greens	dark blues
gray	pinks		yellow greens	turquoises
brown	oranges		olive greens	violets

**Data obtained from Handbook of the Birds of the World*

Table 3. Categorization of avian song type by description of song per species or family.*

<i>Song</i>		
<i>Harsh (control)</i>	<i>Neutral</i>	<i>Melodious (test)</i>
harsh, shrill, strident, screechy, noisy, grating, hoarse, monotonous, shriek, grating, abrupt, raspy, piercing, unmusical, squeaky, sharp, plaintive, thick, heavy, throaty, dry, uninspired, melancholy, strained, sibilant, hissing, nasal, lisping, wheezy, mechanical, metallic	high, thin, fast, buzzy, weak, quiet, rattle, high pitch, rhythmic, simple, indistinctive, sputter, chitter, whistle, whisper, soft, ringing, chips, twitters, no song, insect-like	rich, complex, energetic, spirited, liquid, bubbly, breezy, fluid, lively, bright, tinkling, rollicking, trills, warbling, leisurely, musical, sweet, melodious, mellow, pleasant, full, deep, fluty, harmonics

**Data obtained from Handbook of the Birds of the World*

Table 4. The effect of charismatic traits (color) on exploitation and endangerment (+ indicates increase) for passerines and psittaciforms (combined) and for passerines only (passerine), reporting significant results only.

<i>Charismatic Trait</i>	<i>Exploitation</i>	<i>Statistic</i>	<i>df</i>	<i>p</i>	<i>Endangerment</i>	<i>Statistic</i>	<i>df</i>	<i>p</i>	<i>α</i>
Red	COMBINED +	$\chi^2= 23.24$	1	<0.001	NO EFFECT				0.013
Yellow	NO EFFECT				COMBINED +	$\chi^2= 5.42$	1	0.012	0.013
Green	COMBINED +	$\chi^2=6.80$	1	<0.006	COMBINED+	$\chi^2=14.85$	1	<0.001	0.013
Blue	COMBINED + PASSERINE +	$\chi^2= 27.26$ $\chi^2= 12.85$	1 1	<0.001 <0.001	COMBINED +	$\chi^2=16.63$	1	<0.001	0.013
Increasing number of colors (R+Y+G+B)	COMBINED +	t= 5.84	364	<0.001	COMBINED +	t= 5.12	1607	<0.001	0.020
Increasing proportion of color	COMBINED +	t= 4.52	277	<0.001	COMBINED + PASSERINE +	t= 6.66 t= 2.93	582 322	<0.001 0.004	0.020 0.020

Table 5. The effect of charismatic traits on exploitation and endangerment (+ indicates increase) for passerines and psittaciforms (combined), for passerines only (passerine), and psittaciforms only (psittaciform), reporting significant results only.

<i>Charismatic Trait</i>	<i>Exploitation</i>	<i>Statistic</i>	<i>df</i>	<i>p</i>	<i>Endangerment</i>	<i>Statistic</i>	<i>df</i>	<i>p</i>	<i>α</i>
Ornamentation	COMBINED +	$X^2=13.50$	1	<0.001	COMBINED +	$X^2=15.01$	1	<0.001	0.020
	PSITTACIFORM +	$X^2=6.77$	1	0.009	PASSERINE +	$X^2=8.09$	1	0.005	0.020
Mimicry	NO EFFECT				NO EFFECT				0.033
Melodious song	NO EFFECT				PASSERINE +	$X^2=5.74$	1	0.011	0.033
Combined traits (R,Y,G or B + traits)	COMBINED +	t=7.05	257	<0.001	COMBINED +	t=5.53	1607	<0.001	0.020
	PSITTACIFORM +	t=2.95	130	0.004					0.020

Table 6. Scenarios of exploitation and endangerment per avian group and associated implications.

<i>Exploitation per Avian Group</i>	<i>Endangerment per Avian Group</i>	<i>Implications</i>
No Effect	No Effect	Suggests traits are not affecting exploitation or endangerment, or low sample size where pattern is not emergent. *Suggests traits do not affect extinction risk overall.
No Effect	Increase	Suggests that while traits are not affecting exploitation, they are emergent in the endangerment group with increased sample size, or some species are not known to be exploited. *Suggests traits do affect extinction risk overall.
Increase	No Effect	Suggests traits increase exploitation, but exploitation is mitigated by other threats as pattern is not emergent in endangerment group. *Suggests traits do affect extinction risk overall.
Increase	Increase	Suggests traits increase exploitation, and exploitation is high, as pattern emerges in endangerment group despite other threats. *Suggests traits do affect extinction risk overall.

Table 7. Associated charismatic characteristics of endangered avian families, listed in descending order of endangerment.

<i>Family</i>	<i>Number of Species</i>	<i>Percent Endangered</i>	<i>Melodious Song</i>	<i>Mimicry</i>	<i>Ornamentation (% species)</i>	<i>Average Number of Colors</i>	<i>Average Percent of Color</i>
Philepittidae (asities)	4	50%	-	-	100%	3	62%
Pittidae (pittas)	31	42%	-	-	0	3.5	76%
Eurylaimidae (broadbills)	15	40%	-	-	33%	1.9	42%
Psittacidae (parrots)	355	39%	-	+	15%	3.8	85%
Chloropseidae (leafbirds)	11	27%	+	+	0	4	98%
Cotingidae (cotingas)	96	25%	-	-	14%	1	40%
Paradisaeidae (birds-of-paradise)	40	25%	-	-	73%	2.7	37%

Fringillidae (finches)	163	21%	+ / -	-	0.6%	1.2	40%
Parulidae (NW warblers)	117	21%	+ / -	-	0	1.6	48%
Corvidae (crows)	117	20%	-	+	23%	0.6	26%
Oriolidae (orioles)	30	20%	+	-	0	1.2	48%
Dicaeidae (flowerpeckers)	45	18%	-	-	0	1.5	33%
Thraupidae (tanagers)	271	14%	+ / -	-	0.02%	1.8	55%
Estrildidae (waxbills)	136	13%	+ / -	-	0	1.5	32%
Nectariniidae (sunbirds)	123	12%	+ / -	-	7%	3.2	54%
Pipridae (manakins)	54	9%	-	-	13%	1.9	48%
Irenidae (fairy bluebird)	2	0%	-	-	0	1.5	60%
