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Sound the stressor: how Hoatzins (*Opisthocomus hoazin*) react to ecotourist conversation

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Abstract Exposure to ecotourists often disrupts animal behavior, which is known to contribute to heightened mortality rates. In the Amazon, the emblematic, communal nesting Hoatzin (*Opisthocomus hoazin*) is frequently pursued by tourists eager for close views. Such encounters may cause heightened stress levels, and egg or nestling predation due to decreased parental attendance to nests and nestlings. The effect of reducing conversational tourist noise near wildlife is poorly understood, but represents one potential mechanism of mitigating the impacts of ecotourists on wildlife. In this study, we approached Hoatzins by canoe, playing recorded tourist conversations at different volumes. Both the distances from which we observed Hoatzins becoming agitated (e.g., clucking, defecation, etc.) and flush (e.g., flight or climbing away) were positively correlated with volume. Within 10 weeks Hoatzins began to habituate to silent approaches. Tourist conversations, however, continued to elicit the same heightened disturbance responses throughout data collection. Therefore, to have the best chance of seeing Hoatzins at a short distance and minimizing potentially negative disturbances, ecotourists should cease all conversation. Although not tested, silence is probably the best strategy when looking for many wildlife species.

Keywords Ecotourism · Noise · Hoatzin · Bird · Conversation · Tropical · Flight initiation distance

Abbreviations

AID Agitation initiation distance
FID Flight initiation distance

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Introduction

Though ecotourism creates economic incentives for conservation, increased visitation to natural environments alters ecological communities. Population sizes and diversity of animal species tend to decrease in areas frequented by humans (Griffiths and Van Schaik 1993), especially near heavily used trails. This is likely due to predation avoidance responses (Hidinger 1996). Ecotourists often desire close encounters with wildlife and are known to relentlessly pursue timid species, which may causing altered hunting patterns and health problems. Fowler (1999) found that penguins' stress hormones elevated with human presence, precipitating such physiological problems as immune system depression, cardiovascular disease, neuron death, and reproductive failure. Even without active pursuit, the mere presence of passing humans can cause species to suspend or reduce foraging efforts (Burger and Gochfeld 1998). Though organisms exposed to human presence may habituate, this process can take days for some species and years for others (Fowler 1999).

Tourism is known to be particularly disruptive to breeding bird colonies (Klein et al. 1995). Flushing parents from nests decrease parental attendance, predicating inadequate heat regulation and increased egg predation (Safina and Burger 1983; Cairns 1980; Ellison and Cleary 1978; Hunt 1972). Gulls, for example, depredated both nests of neighboring waterbird species and conspecifics after temporary parental abandonment (Ellison and Cleary 1978; Gillett et al. 1975; Robert and Ralph 1975), making people directly attributable for decreased reproductive success.

Effects of conversational noise on wildlife have been minimally studied. Eckhardt (2000) found Polar Bears reacted only 6.1% of the time to tourist noise, making such noise an insignificant stressor. Burger and Gochfeld (1998) found negative correlations between foraging activity and noise volume for three species in survey of five bird species in Florida. Klein (1993), using recorded-tourist-noise playback, also found that 11 of the 15 waterbirds examined (Herons, Egrets, Purple Gallinules etc.) altered their behavior in some manner in response to noise (Klein 1993). Of these three studies, none experimentally manipulated noise levels to deduce how differing volumes of tourist conversations affect behavior of species.

The Hoatzin (*Opisthocomus hoazin*) is a flagship species for Amazonian ecotourism, and is sought by many ecotourists. The only completely folivorous bird, Hoatzins are also communal nesters, an unusual behavior among bird species. Because of their behavioral eccentricities and outlandish appearance (e.g., hooks on wings), Hoatzins are often pursued and harassed by tourists, making them ideal organisms for assessing reactions to ecotourism.

Most research has focused on their unusual attributes; however, several studies have determined tourism to be a considerable threat to Hoatzins. While adults may habituate to human presence, juveniles remain chronically stressed (Müllner et al. 2004; Müllner 2004). To escape threats, juvenile Hoatzins drop from their perches, which usually means they fall into a lake or river. This requires them to swim back to shore, thereby exposing themselves to an array of natural aquatic predators, such as caimans, piranhas, and other predatory fish (Müllner 2004). Chick survival is therefore consistently lower in human-disturbed areas than in more natural habitats (Strahl 1988). Hoatzins have a long incubation period (32 days) and the major cause of nest failure is egg predation, which can be exacerbated by humans flushing an incubating individual (Müllner 2004; Domínguez-Bello et al. 1994). Whether Hoatzins will re-nest after losing a clutch is not yet well understood, but if they do not, disrupting incubating Hoatzins could be highly detrimental to their overall population viability (Domínguez-Bello et al. 1994; Müllner 2004).

Ecotourism in general is detrimental to Hoatzins, as the majority of tourists continue approaching the birds until they flush and as nesting often coincides with the peak of the tourist season (Strahl 1988). The reduction of tourist noise levels represents a potential approach for mitigating many of the negative effects of ecotourism on Hoatzins and probably other targeted wildlife species alike. In this study, we examine how Hoatzins respond to varying conversational noise volumes and thus clarify whether or not noise reduction is a viable method for reducing ecotourism's footprint.

Methods

Study site and research protocol

We chose three oxbow lakes, located in the Madre de Dios region of southeastern Peru, as study sites, each supporting at least one Hoatzin family group (minimum 8 individuals). The lakes, Condenado 1, Condenado 2, and Sachavacayoc, are of varying ages and structures. All lakes have heavy tourist traffic from surrounding ecotourism lodges. Each day, guides fill 8–10 m canoes with up to 10 tourists and paddle around one of the lakes, searching for wildlife. Prior to the initiation of this study, we quantitatively analyzed tourists' conversation volumes with a noise meter to determine a benchmark for average emitted-tourist-noise volume.

We recorded noise levels (in decibels) every 5 min for 40 min periods. Five groups of tourists were examined, with varying group sizes from extremes of one tourist with two guides to eleven tourists with six guides. Because distance from the noise source affects the noise meter's readings, we standardized the position of noise monitoring to 3.5 m from the linear center of the tourist group. We calculated the average noise level from the five groups and noted the loudest recorded volumes. The four volumes used in this study were: an average noise level (50 db), the highest recorded noise level (60 db), a negative control (no noise), and a positive control (70 db). We played a 3-min recording of tourist conversation at each of these noise levels by calibrating speakers to the desired volumes with the noise meter, positioned 3.5 m away from the speakers.

Flight initiation distance (FID) and agitation initiation distance (AID) were used as metrics to quantify Hoatzins' responses to each noise level. FID is defined as the distance from an approaching observer to an organism when the organism responds with movement (Ydenberg and Dill 1986). Similarly, we defined AID as the distance from the observer to the organism when the Hoatzins displayed a characteristic sign of unrest (defecation, clucking, fluffing feathers, or bodily repositioning).

Data collection coincided with the height of the tourist season in the Peruvian Amazon (June 30, 2007 to August 5, 2007). Each day, we chose the sampling location (either both Condenado lakes or Sachavacayoc Lake) at random, and approached Hoatzins by canoe, between 5:40 AM and 11:00 AM, canceling efforts only during rain or extreme cold fronts, locally known as "friajes." A total of 10 days were spent at Sachavacayoc Lake and 15 at the Condenado Lakes. At the start of each sampling day, we recorded a variety of potential confounds including temperature, cloud cover, a qualitative weather assessment (sunny, cloudy, foggy, or completely overcast), number of birds present, and distance of birds to tree cover. Both flock size and distance to refuge have been shown to influence FID in some species (Dill and Houtman 1989, Gutzwiller et al. 1998). No birds were observed nesting throughout the summer; therefore, potential differences between nesting and non-nesting birds did not confound the analysis.

Once a group of Hoatzins was found, we chose a target bird. Only birds perching visibly were chosen so that monitoring of behavior would be possible throughout the effort. As it was impossible to identify Hoatzins individually, we made an effort to vary target subjects by choosing birds in different positions relative to the rest of the group in order to increase the likelihood of using different individuals. Though a total of only 32 individuals were recorded among all the lakes at one time (8 on Condenado 1, 15 on Condenado 2, 9 on Sachavacayoc), the population size sampled was likely higher—many other birds were consistently observed in inaccessible areas surrounding each of the lakes. Although Hoatzin behavior is likely stereotypic, the few number of groups approached limits our ability to generalize our results to all Hoatzin populations.

Starting an approach within a birds' threshold of perception often changes FID (Blumstein 2003). As such, we standardized all approaches to begin a minimum of 75 m from the birds, a distance at which we never observed any acknowledgement of our presence. Though approach angle may also be an important factor (Burger and Gochfeld 1990), the varying width of the lakes and locations of the Hoatzins made adopting one standard angle impossible. At requisite distance, we chose one of four noise levels at random and cued the recording. We used Rangefinder binoculars, calibrated each day with a GPS unit, to measure FID and AID. The binoculars' readings never varied more than 3 m from the GPS unit's approximation of distance.

We recorded AID when Hoatzins displayed one of the aforementioned signs of agitation, and marked FID after either short hops into lakeside vegetation or sustained flight. Both FID and AID were measured from the tip of the boat to the bird's position. We approached each group of birds no more than three times per day and each approach was spaced at minimum 40 min intervals to ensure independence of sampling. Indeed, subsequent analysis showed the number of previous approaches to not influence FID or AID. Hoatzins were approached a total 108 times: 10 approaches at each noise level for each of the Condenado Lakes and 7 at each noise level for Sachavacayoc Lake.

Data analysis

We analyzed AID and FID as a function of noise volume and potentially confounding factors. These factors included the following continuous variables: temperature, Julian date, time, number of conspecifics visible within 50 m, and cloud cover. Each of these was considered individually and in a multiple regression. Likewise, an Analysis of Variance (ANOVA) was used with categorical factors, including noise levels, weather categories, and distance to tree cover, both individually and together. Because the distance to tree cover tended to fall into three discrete bands, these data were grouped and analyzed with the other categorical variables. A non-parametric Kruskal–Wallis Analysis of Variance was necessary to examine the importance of location, as values could not be transformed to generate residuals with a normal distribution.

We used Analysis of Covariance (ANCOVA) to test potential habituation within each noise level. For this design, we grouped FID and AID responses by both noise level and Julian Date. By doing so, we could discern whether or not AID or FID values progressively decreased over the summer within each individual noise treatment, thereby demonstrating a tendency towards habituation. All statistical tests were done using JMP software.

Results

Noise significantly altered Hoatzin behavior, manifested by increasing FID and AID values with elevated volumes (Fig. 1). Both global ANOVA tests for AID and FID that included all categorical variables were significant (AID: $P = 0.01$, FID: $P < 0.01$), with noise contributing the most to explained variance (AID: $P < 0.01$, FID: $P < 0.01$). For AID, a subsequent individual ANOVA analysis with Tukey post-hoc tests ($P < 0.05$ threshold) revealed significant differences in noise levels among the control (0 db), mean (50 db), and positive control (70 db; Fig. 1). The highest observed noise (60 db) was significantly different only from the positive control (70 db). For FID, Tukey post-hoc tests indicated the only significant difference to be between the positive control and no noise (70 db and 0 db). Though FID increased as noise increased, the relative differences between other noise levels were too small to be significant (Fig. 1b). No other categorical variables significantly explained variation in AID or FID, both in the overall test and individual analysis (Table 1).

Multiple regression models that included all continuous variables were not significant for AID or FID (AID: $P = 0.13$, FID: $P = 0.48$); however, temperature was significant in the AID model ($P = 0.05$; Table 2). Individual regressions for each variable again demonstrated temperature to be the only significant factor explaining variation in AID ($P = 0.02$). As temperature measurements were only taken at the beginning of each day, and temperature changes over the course of a morning, we did a second analysis restricting the data set to the first approaches of each day (always done within 10 min of measuring the temperature). When only these approaches were used, temperature was still negatively correlated with AID ($P = 0.01$).

Regressing Julian date against FID yielded a significant negative relationship ($P = 0.05$), indicating that Hoatzins may have begun to habituate to the approaches over time. Subsequent ANCOVA combining date and noise to explain the decreases in AID and FID were significant (AID: $P < 0.01$, FID: $P = <0.01$; Fig. 2). However, the significant

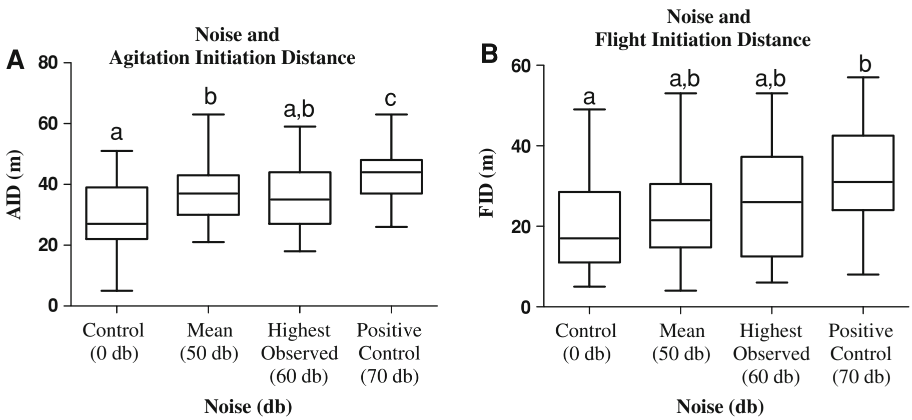

Fig. 1 Effects of noise level treatments on **a** agitation initiation distance (AID) and **b** flight initiation distance (FID) values at each noise level. Whiskers represent high and low values, the bounds of *boxes* are the upper and lower quartiles, and the *center line* is the median. *Differing letters* demonstrate statistical significance by ANOVA test ($F = 7.91$, $P < 0.01$ and $F = 4.83$, $P < 0.01$) with Tukey post-hoc analysis at a 5% threshold for agitation initiation distance and flight initiation distance, respectively. In both cases, higher noise levels cause a heightened response from the Hoatzins

Table 1 Effects of categorical variables on agitation initiation distance and flight initiation distance with individual ANOVA analysis

		Noise	Approach number	Distance to refuge	Weather	Location
AID	*F*-value	7.91	1.46	0.71	0.05	0.34
	P-value	<0.01	0.24	0.50	0.99	0.71
FID	*F*-value	4.83	0.88	0.08	1.38	0.38[a]
	P-value	<0.01	0.42	0.92	0.25	0.68[a]

Models that provided residuals not normally distributed were transformed. Noise was significant for both AID and FID- as noise increased, AID and FID values decreased

[a] Unable to be transformed, Kruskal–Wallis test used

Table 2 Effects of continuous variables on agitation initiation distance and flight initiation distance with individual regression analysis

		Time	Julian date	Start temperature	Cloud cover
AID	*R*-squared	0.01	0.02	0.05	0.01
	P-value	0.46	0.16	0.02	0.29
FID	*R*-squared	<0.01	0.04	0.01	<0.01
	P-value	0.60	0.05	0.41	0.82

Temperature is negatively correlated with AID. When analysis of temperature is restricted to the first approach of each day (10 min within temperature measurement), the result is still significant ($P < 0.01$). Likewise, Julian Date is negatively correlated with FID, indicating habituation may have occurred

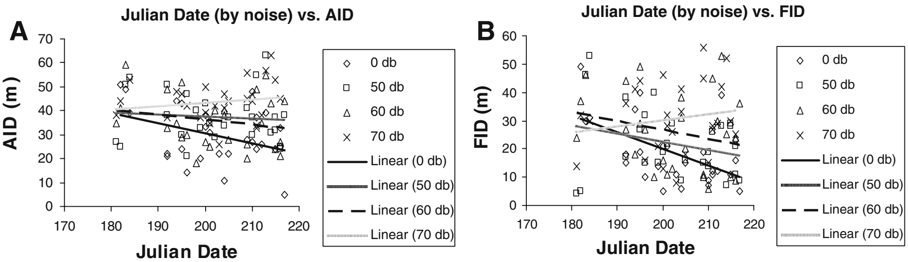

Fig. 2 Analysis of Covariance (ANCOVA) for Julian Date and noise level against **a** AID and **b** FID. Analyses were significant, indicating that habituation rates differ among noise treatments (AID: $P < 0.01$, R-squared = 0.24; FID: $P < 0.01$, R-squared = 0.20). As Julian Date increases (summer progresses), AID and FID values lower significantly for approaches without noise (*solid black lines*; AID: $P = 0.05$, R-squared = 0.14; FID: $P < 0.01$, R-squared = 0.27). Habituation is not observed (regression is not significant) for all approaches with noise, indicating the gravity of noise as a negative stimulus

decrease in FID values as the summer progressed was restricted to the no-noise (control) treatment ($P < 0.01$), indicating that Hoatzins may only habituate in the absence of noise. With respect to AID, a decline was also observed for the control treatment but no others ($P = 0.05$).

Discussion

Reaction to noise volumes

Louder conversations resulted in increased Hoatzin agitation and susceptibility for flushing, as evidenced by the positive associations found between FID and AID and increasing noise levels. Conversation, therefore, seems to be a negative stimulus. Most likely, Hoatzins interpret tourist noise as an indication of possible incipient danger, causing them to react early in an approach with agitation and flight. Due to their unpleasant odor, humans do not generally hunt Hoatzins. Presumably for the same reason, adult birds seem to lack substantial predation pressure. Müllner and Linsenmair (2007), however, found egg and hatchling predation risk to be a leading cause of nest failure. In fact, a diversity of snakes, raptors, and monkeys opportunistically prey on Hoatzin young and eggs (Strahl 1988; Domínguez-Bello et al. 1994). The strong response to tourist conversation may therefore be more of a product of nest predation pressure than direct predation of adults.

The correlation of noise volume with AID was unexpectedly different from that with FID. FID values increased incrementally with noise volume, though only the positive and negative controls were statistically distinct (Fig. 1b). AID increased from the control (0 db) to the mean tourist noise (50 db) to the positive control (70 db), and each was statistically distinct. Where the highest observed noise (60 db) fits is not as obvious: it is significantly different from only the positive control. However, values are markedly closer to the mean noise treatment than to the negative control, indicating that an increase in sample size could reveal a significant difference between the control and high noise treatments (Fig. 1a).

The non-linear increase of AID with increasing noise volume may be a product of the agitation measure. As previously mentioned, agitation was recorded in any instance where Hoatzins altered their behaviors in response to the approach. Fernández-Juricic et al. (2001) notes that alert distances are different from flight distances in that birds may change their flight distances by adapting to a stimulus, but do not similarly change their alert distances. Reaction responses, including flight, defecation, or clucking, occur after detection of a stimulus, and could therefore potentially represent “decisions”. Perception responses, such as raising the head to look at the canoe, occur instinctively and upon immediate detection of a stimulus (Fernández-Juricic et al. 2001). Therefore, perception responses are subject to physiological constraints. The apparent similarity in responses for the mean and high noise volumes could be explained if detection thresholds exist below the mean volume and above the high volume so that the two are indistinguishable. AID includes perception reactions while FID does not, potentially explaining the differing distribution of data. Further investigation into Hoatzins’ physiological hearing constraints is needed before any conclusions can be made.

Habituation to noise and human presence

Noise may in fact be such a strong negative stimulus that it impedes habituation to human presence. Overall, FID significantly decreased throughout the summer, presumably due to recognition that prior approaches of canoes caused no harm. Müllner et al. (2004) similarly found Hoatzins’ flushing inclination to be significantly higher in relatively pristine sites compared to those receiving traffic from ecotourism. Though he attributes this phenomenon either to habituation or to sensitive birds moving out of tourist areas, our results lend credence to the importance of habituation. Likewise, Martínez-Abraín et al. (2008) found increasing human presence to mitigate FID responsiveness in Yellow-footed Gulls, another indication of bird habituation. Within all our noise treatments, however, the only significant decrease in FID occurred during control approaches, indicating that Hoatzins habituated to the approach of the boat, but only when no noise was emitted. This strongly suggests that noise was sufficiently threatening to elicit the same evasive reaction even after multiple exposures.

Habituation in the absence of noise was also observed for AID, though the trend was not as pronounced as that observed for FID ($P = 0.05$). As previously mentioned, AID includes both reaction and perception responses. Birds may habituate to approaches in their response reactions (defecation, clucking, etc.) if the gravity of the threat is quickly dismissed, but do not change their inherent physiological detection ability (Fernández-Juricic et al. 2001). Therefore, if agitation is thought of as a blend of both initial perception and calculated response, it is expected that habituation to AID would be less striking than habituation to FID. Future studies should divide AID into its components to examine potential differences in habituation inclination between perception and reaction responses.

In both cases, habitation was not observed in the presence of noise. This result indicates that keeping tourist noise levels low on lakes may be strategically beneficial for obtaining closer views while minimizing disturbance, even for groups of birds that have had prior exposure to ecotourists. This study, however, only examines habituation over the course of several months. Hoatzins could possibly habituate to noise over longer time periods. Regardless, noise certainly seems to elicit heightened responsiveness and is sufficiently disruptive to at least impede the habituation process.

Confounding variables

Temperature was significantly negatively correlated with AID, indicating that Hoatzins' thresholds for agitation lower with depressed temperatures. The role of temperature in structuring animals' predator avoidance responses is poorly known, but did not significantly explain variation in responses of lizards (Stankowich and Blumstein 2005). In this study, Hoatzins were observed to be less active, huddling together in lakeside vegetation in cold conditions. As the mornings warmed, the Hoatzins became more active. Perhaps because they were more sedentary and thus vulnerable, the Hoatzins stayed on high alert reacting a little earlier to perceived threats.

No other weather conditions or potential confound measured was shown to be significant. In a comprehensive meta-analysis of animal responses to human approaches, Stankowich and Blumstein (2005) similarly found group size to be irrelevant, but did validate the importance of distance to refuge in structuring bird reactions. In this study, Hoatzins did not flush or become agitated earlier when they were farther from tree cover. This is somewhat unexpected given Hoatzins' exceedingly poor flying ability—if refuge is far, they would be expected to flee sooner.

Future research

The results of this study are directly relevant only to Hoatzins on Oxbow Lakes, and thus may not be generalizeable to other populations. Further investigation is needed, both to extend the analysis of noise to other organisms and investigate the potential of habituation over longer time periods. In this study, several potential confounds were not measured and should be examined if this is to be repeated. The number of people participating in each effort varied slightly (from one to three). It has been shown that the number of approaching people affects FID (Geist et al. 2005). This was never a large concern, as the size of the canoe remained constant and group size was minimally variable. However, the fact that rowers changed may be a concern. Though an effort was made to standardize approach speed, people rowed differently. As the speed of an approach often influences an animal's decision to flush (Stankowich and Blumstein 2005), variable speed may have contributed more potential variance to the data. Since noise levels were distributed randomly throughout each effort, any rower-related effects should be distributed similarly across all noise levels. In future studies, agitation initiation distance should be divided and individual components should be examined so as to clarify differences between perception and reaction responses.

Conclusion

Every group of tourists observed on any of the three oxbow lakes throughout the data collection period flushed at least one Hoatzin group. Though Hoatzins are common throughout the region and currently of no conservation concern, the booming ecotourism industry may have negative effects on both Hoatzin populations and individual health. Elevated stress levels may precipitate physiological problems (Fowler 1999), eggs or hatchlings may be depredated when neglected by fleeing parents (Ellison and Cleary 1978), and juveniles may flee into the jaws of natural predators (Müllner 2004). Contrasting rare and endangered species, Hoatzins' apparency makes them great model organisms. Endangered species, however, may similarly respond to conservation. For all its benefits, ecotourism is sometimes destructive. Because fundamentally the interests of ecotourists and wildlife are at odds, alternatives to promote a mutually beneficial association should be sought. Reduction of noise represents one such possible solution. Because high noise volumes were shown to agitate Hoatzins, causing them to flee human presence, silence could potentially yield closer views of less agitated birds. Moreover, it appears that Hoatzins do not habituate to noise, making silence relevant for even well established lodges.

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