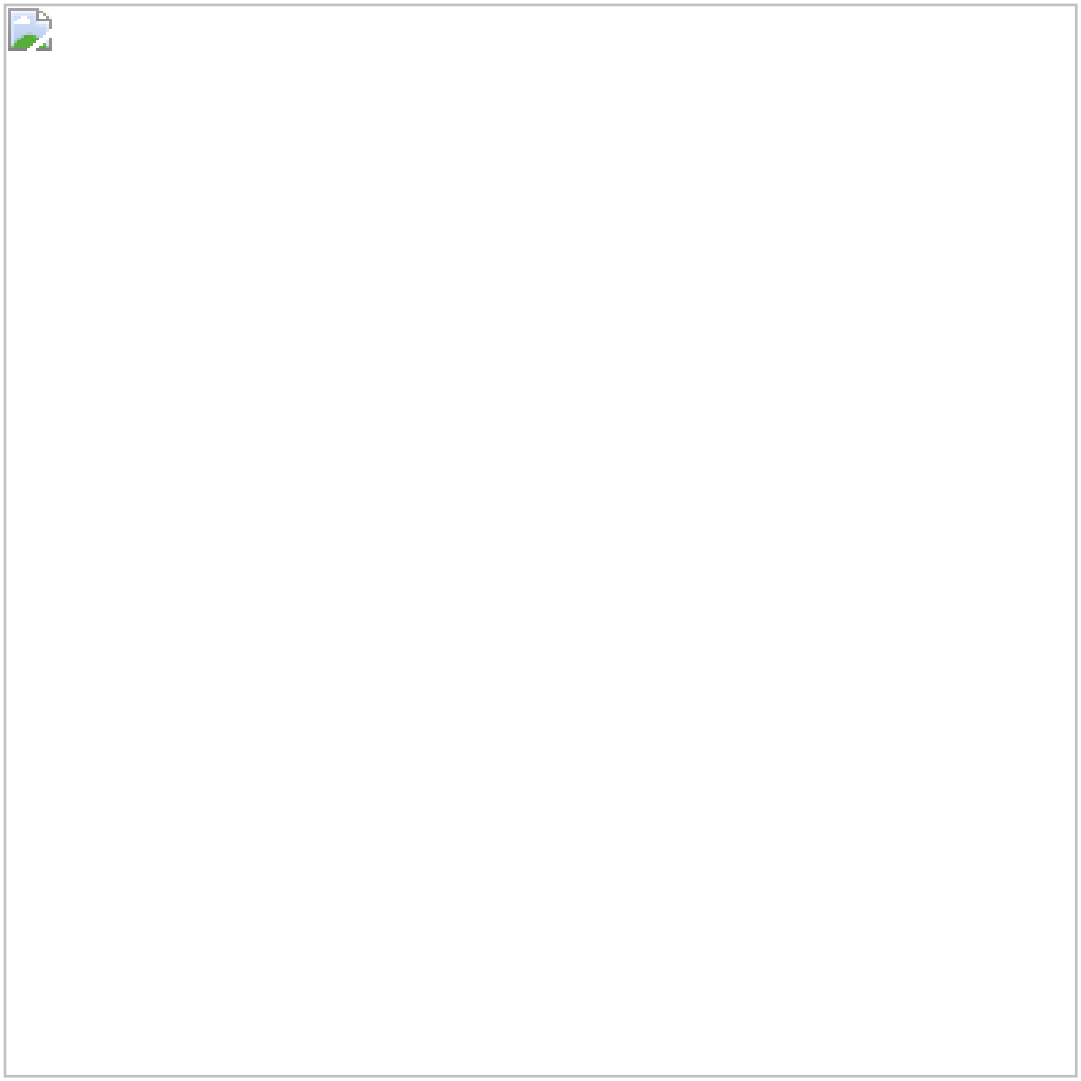

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"Variable Effects of Tourist Presence on the Activity Budget of *Alouatta pigra*"

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Abstract

Background and Research: Wildlife tourism has been considered a useful tool for conservation in some contexts and found to cause diverse effects on biodiversity. We investigated the effect of the number of tourists on wild black howler monkeys' (*Alouatta pigra*) behavior at the Montes Azules Biosphere Reserve (MABR), in the Lacandona forest in Mexico.

Methods: We used 5-min focal animal sampling, during dry and rainy seasons. We recorded five common behaviors in three wild groups naturally exposed to different degrees of human disturbance (Station, River and Board) without tourists, 5 and 10 tourists.

Results: Five and 10 tourists increased locomoting and reduced socializing, however, differently affected activities' allocation time in the monkeys' groups: in Board, 10 tourists reduced monkeys feeding; ii) in River, 10 tourists reduced socializing; and iii) in Station, 5 tourists increased feeding and reduced socializing, and 10 tourists reduced socializing.

Conclusions: Watching tourism activities affect behavior differently in groups of *Alouatta pigra* in the Montes Azules Biosphere Reserve in in the Mexican state of Chiapas, emphasizing the importance of regulating tourism programs for the conservation of endangered species.

Implications for Conservation: Although longer-term studies controlling for additional variables are needed to provide a more comprehensive understanding of the impact of tourism on wild howler populations, the results from this study remain valuable as a baseline for understanding such effects and for proposing initial strategies to reduce tourism-induced disturbance.

Keywords

Howlers, *Alouatta pigra*, endangered, tourism-induced, wildlife

Introduction

Tourism has been recognized as benefitting biodiversity, providing an important income for local capital maintenance and support the establishment of reserves (Buckley, 2009; Stronza et al., 2019). However, authorities have the challenge to provide incentives for adopting sustainable tourist behavior (Budeanu, 2007).

Primate species have been found to respond to stressful situations, such as tourism, using a range of behavioral and social coping mechanisms (Maréchal et al., 2016). Overall, as the number of people increases, primates tend to reduce their

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time budget in social interactions (Aguilar-Melo et al., 2013) and secrete more cortisol (Vanlangendonck et al., 2015). Howlers (*Alouatta* spp., Atelidae) are negatively affected by high levels of anthropogenic disturbance (Arroyo-Rodríguez & Dias, 2009). *A. palliata* move away from humans (Lippold, 1990). *A. seniculus* increase grunting, howling, fleeing and retreating to better cover (Lynn, 2007). Similarly, *A. pigra*, increase interindividual distances and move away climbing higher into the canopy (Treves & Brandon, 2005), increasing fecal cortisol concentrations (Behie et al., 2010), and increase in levels of botfly parasitism (Treves & Carlson, 2012), vigilance and roaring (Grossberg et al., 2003).

To further investigate the role of tourists on howlers, this study explores the effect of the number of tourists on the behavior of the wild howler (*Alouatta pigra*) in the Montes Azules Biosphere Reserve (MABR) in Mexico.

Methods

Study Area

Fieldwork was conducted in the protected area Montes Azules Biosphere Reserve (MABR; Figure 1a); created in 1978 that spans about 300,000 ha of mature undisturbed forest (Gómez-Pompa & Dirzo, 1995). It is located in southern Chiapas, Mexico, in La Selva Lacandona (16°05'58"N, 90°52'36"W; elevation 10 to 50 m.a.s.l). The original vegetation is lowland tropical rain forest and semi-deciduous rain forest (Holdridge et al., 1971).

Alouatta pigra

The black howler monkey is one of the three native primate species found in Mexico (Figure 1b), considered one of the largest Mesoamerican primates, and has an "endangered" conservation status by the IUCN (Cortes-Ortíz et al., 2020). We studied 15 individuals distributed in three wild groups: Station, River and Board within MABR (Figure 1b). Both the River and Board groups inhabit areas of continuous and secondary forest with a canopy height of 20-30 m and are surrounded by the Lacantún River. As a result, these groups are accustomed to the noise generated by boat engines. The Board group consisted of 2 adult females and 1 adult male. This group is located near trails commonly used by station workers and researchers, and they accustomed to minimizing noise and avoiding disturbance. The river group consisted of 2 adult females, 1 adult male, 1 juvenile female and 1 juvenile male. This group inhabits an area without any trails exist, which minimize human activity and disturbance in their home range. The Station group is located in an area of continuous forest near the biological station, with a canopy height of 20-30 m. This group consisted of 2 adult females, 2 adult males, 2 juvenile females and 1 infant female. They are accustomed to the passage of researchers and reserve workers on the nearby road.

Behavioral Data Collection

Monkeys' behavioral data were collected by a field observer researcher using 5-min focal animal observations following Altmann (1974). Samples were taken in three conditions: without tourists, and in the presence of 5 and 10 tourists. During the study, tourists observed monkeys from the base of the trees where they were located, at distances ranging between 15 to 30 m depending on the height of the tree. Each focal individual was observed for 5 min and five activities were recorded: feeding, resting, locomoting, socializing and vocalizing (Table 1). We conducted focal animal observations for a total of 2 h per session, with the focal animal randomly changed after each 5-min observation period. All groups were observed during five time periods: 7:00 to 9:00, 9:00 to 11:00, 11:00 to 13:00, 13:00 to 15:00 and 15:00 to 17:00, for the same number of days when possible. Observing sessions for all groups took place from February 2017 to March 2018, covering dry (from February to March 2017 and March 2018) and rainy (December 2017) seasons, to align with the periods of high tourist influx at ecotourism centers. A single group of tourists was organized daily to visit one of the monkey groups. Since ecotourism centers in this region do not have an established behavior code for tourists during their visits inside the MABR, we wanted to document the actual impacts of day-to-day tourist disturbance (including laughing, shouting, talking, camera shoots, vine movements) as closely as possible. Behavioral data for tourists were not registered.

Data Analyses

A total of 3895 activity time records (2507, 833, 645; 0, 5 and 10 tourists, respectively; Table 2) were sampled in 254 observation hours (76 for River, 85 for Board, 93 for Station) for 84 days. We performed generalized linear models with mixed effects (GLMM) with a binomial distribution, introducing group identity as the random variable. To perform GLMMs, we clustered activity time records of the 15 individuals at 0, 5 and 10 tourist treatments during four sampling events, in 180 records by activity (15 × 3 × 4) reaching 900 total records (180 × 5). We used the 'cbind' function in R (R Core Team, 2020) to construct a two-column matrix that represented the time spent and not spent on each activity by each individual: "cbind(scans.activity,scans.noactivity)". This matrix was used as the response variable in the GLMMs. We created five separate GLMMs, one for each activity (feeding, locomotion, resting, socializing, and vocalizing). The number of tourists and its interaction with monkey group were entered as the predictor variables in the GLMM. To account for the non-independence of the records, we included the random effects of the number of tourists, monkey group, individual identity, and sampling event. After fitting each of the five models, we examined the residuals plot to evaluate the heteroscedasticity and normality

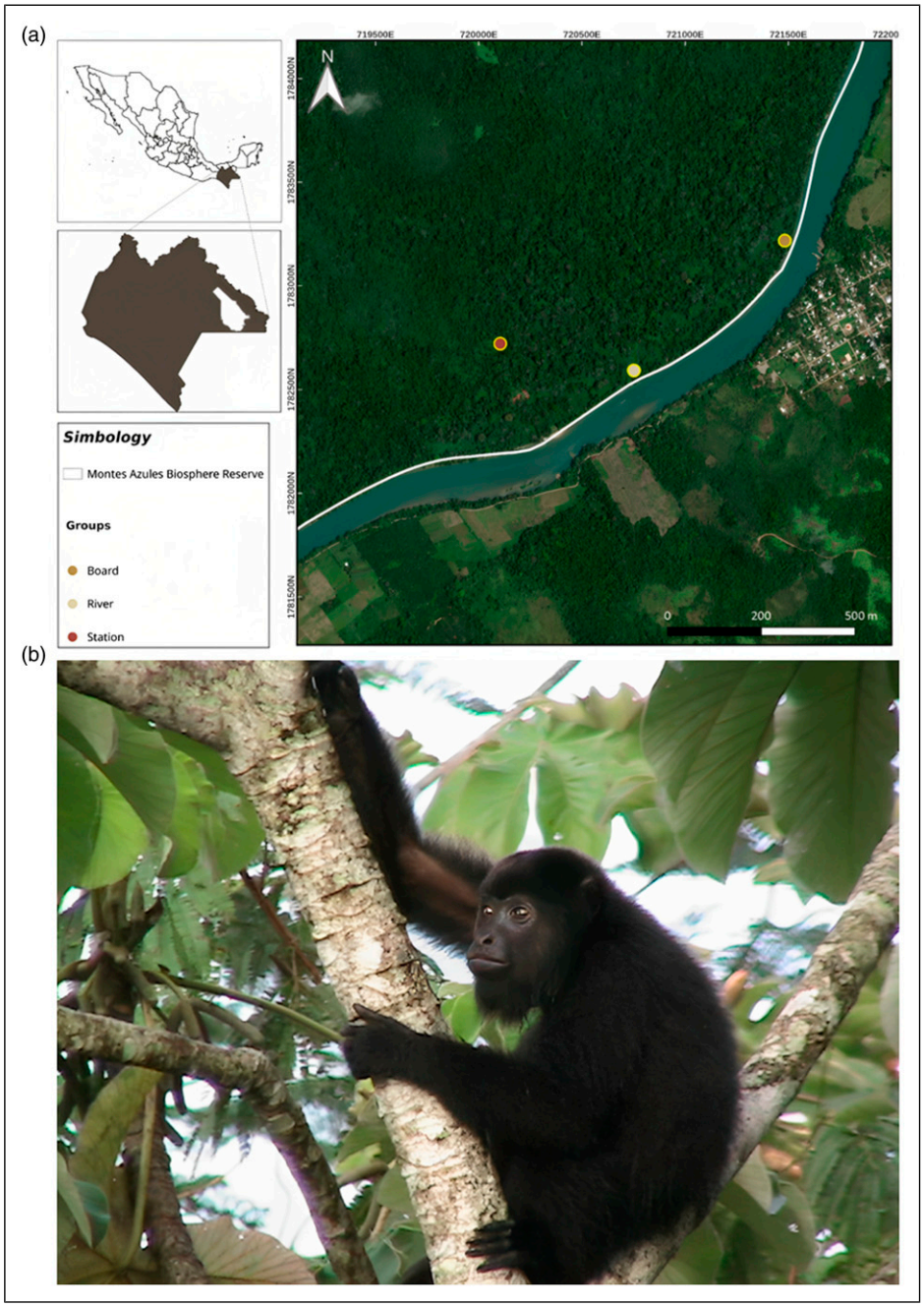

Figure 1. a) *Study Area*. Geographical location of Montes Azules Biosphere Reserve (MABR), Chiapas, Mexico. White boxes show the Mexican territory where the study area is located, and dots shows the studied howlers groups distribution within the study site. Station (S) bordered by continuous forest (red circle); River (R) surrounded by the Lacantún River, secondary and continuous forest (white circle); and Board (B) surrounded by the Lacantún River, secondary and continuous forest (yellow circle). b) *Study Species*. Howler (*Alouatta pigra*) in their natural habitat (MABR), in the Lacandona forest in Mexico.

assumptions of the GLMMs (Crawley 2007). The models were fitted using the 'glmer' function in the lme4 package in R (Bates et al., 2015). To evaluate models overdispersion, the variance inflation factor was included ($\hat{c}$ = residual deviance/residual df) with the 'c_hat' function in the AICcmodavg package (i.e., the observed variance is higher than the variance of a model; Mazerolle, 2020). For models with $\hat{c} > 1.1$ we included a random effect of each record (Harrison, 2014). To evaluate differences across the number of tourists within groups, Bonferroni *post hoc* tests were performed with the 'pair' function in the emmeans package (Lenth 2020; Zar 1996).

Table 1. Monkeys' Descriptions by Behavior Category.

Behavior category	Description
Feeding	Puts food in mouth, including foraging (feeding behavior, which includes searching for/manipulating items)
Resting	Motionless, passive with eyes open or closed
Locomoting	Walking and moving between branches
Socializing	Grooming, playing, nursing, or interacting with another individuals
Vocalizing	Any solo or group calling that the target individual participates in

Table 2. Total Behavior Records and Sample Observation Hours of Three wild Howler Monkey (*Alouatta pigra*) Groups with Different Numbers of Tourists in the Montes Azules Biosphere Reserve (MABR), in the Lacandona forest, Mexico.

Behavior Records

	Number of tourists			
Monkey group	0	5	10	Total
Board	817	270	179	
River	799	231	253	
Station	891	332	213	
Total	2507	833	645	3985

Sample Observation Hours

Monkey Group	Number of tourists			
	0	5	10	
Board	54	14	16	
River	51	15	10	
Station	58	21	14	
Total	163	50	40	253

Table 3. Variance Inflation Factor ($\hat{c}$) of Models Used to Evaluate Overdispersion, in the Montes Azules Biosphere Reserve (MABR), in the Lacandona Forest, Mexico.

Models	Random effects	$\hat{c}$
Feeding	tourists × group × individual × month	0.72
Locomotion	tourists × group × individual	0.98
Resting	tourists × group × individual × month	0.50
Socializing	group × individual × month	1.04
Vocalizing	tourists × group × individual	0.99

Results

No overdispersion ($\hat{c}$) was detected either of the models (Table 3). Tourist number did not affect the time employed in feeding ($X^2 = 0.94$, $df = 2$, $p = 0.62$; Figure 2a), resting ($X^2 = 2.45$, $df = 2$, $p = 0.29$; Figure 2b) and vocalizing ($X^2 = 1.79$, $df = 2$, $p = 0.40$; Figure 2c). Differences in locomoting ($X^2 = 7.48$, $df = 2$, $p = 0.023$) were found, Bonferroni tests show that monkeys spent more time in this activity with five (Z = 2.52, $p = 0.030$) and ten (Z = 2.39, $p = 0.044$; Figure 2d) tourists, compared to no tourists present (0). Socializing was also found affected by number of tourists ($X^2 = 27.83$, $df = 2$, $p < 0.001$), and Bonferroni tests showed monkeys spent less time when five (Z = 3.35, $p = 0.002$) and ten (Z = 4.48, $p < 0.001$; Figure 2e) tourists where present, compared to no tourists present.

When analyzing the interaction between the number of tourists and the monkey group, it was found that there were not significant changes in locomoting ($X^2 = 2.40$, $df = 4$, $p = 0.66$; Figure 3a), resting ($X^2 = 6.44$, $df = 4$, $p = 0.16$; Figure 3b), and vocalizing ($X^2 = 2.26$, $df = 4$, $p = 0.68$; Figure 3c). However, the interaction between variables significantly changed in feeding ($X^2 = 21.12$, $df = 4$, $p < 0.001$). Bonferroni tests showed that Board monkeys reduced feeding with 10 tourists, compared to 5 and no tourists (Z = 2.49, $p = 0.034$; Figure 3d). While in Station, monkeys increased feeding with 5 tourists, compared to no tourists (Z = 3.46, $p = 0.001$) and 10 (Z = 2.90, $p = 0.010$). Finally, socializing significantly changed based on the interaction between variables ($X^2 = 58.21$, $df = 4$, $p < 0.001$). Bonferroni tests revealed that River monkeys socialized less with 10 tourists compared to none (Z = 2.66, $p = 0.021$) and 5 (Z = 2.50, $p = 0.032$), and Station monkeys socialized less with 5 (Z = 6.74, $p < 0.001$) and 10 (Z = 5.98, $p < 0.001$; Figure 3e) tourists compared to no tourists.

Discussion

The managers of protected natural areas are often unaware of the impact that tourists may have on wildlife (Farrell & Marion, 2001). Our results show that groups of both five and ten tourists had significant effects on the behaviour of the monkeys. Specifically, study groups increased locomoting and reduced socializing, which suggests that tourism can have negative impacts on the primates. Increased locomotion could be a strategy to avoid human presence. However, this is also likely to increase energy expenditure, which can be particularly taxing for howlers who must balance their limited energy budget. Indeed, howlers primarily obtain their energy from a leaf-rich diet, for which they do not have a specialized stomach to extract nutrients efficiently (Milton, 1980). Treves and Brandon (2005) observed that *A. pigra* scattered with tourist parties, and moved higher in the trees, as humans increased. Additionally, Aguilar-Melo et al., (2013) found

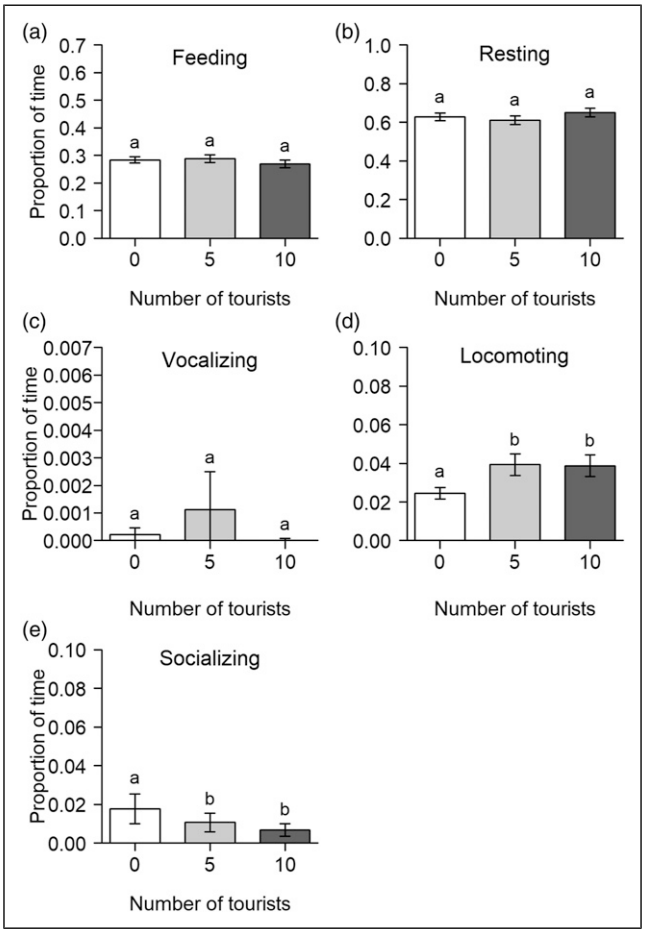

Figure 2. Wild howlers (*Alouatta pigra*) proportion of spent time on a) feeding; b) resting; c) vocalizing; d) locomoting; and e) socializing, when observed in the presence of 0, 5 and 10 tourists at the Montes Azules Biosphere Reserve, in the Lacandona forest, Mexico. Data are presented as mean with their respective SD. Different letters show significant differences between bars ($p < 0.05$).

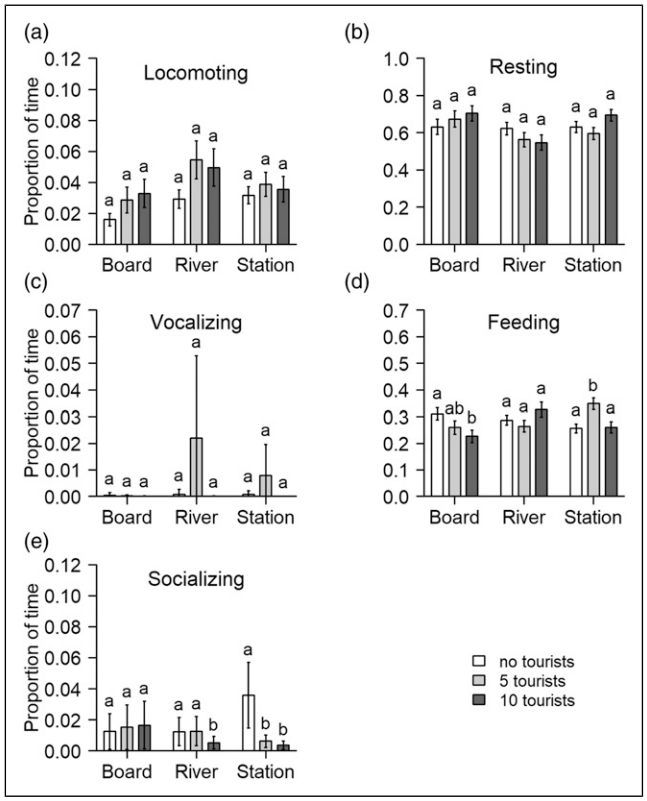

Figure 3. Effect of tourist number (0, 5 and 10) in three wild howlers (*Alouatta pigra*) groups (Board, River and Station) on a) locomoting; b) resting; c) vocalizing; d) feeding; and e) socializing, at the Montes Azules Biosphere Reserve (MABR), in the Lacandona forest, Mexico. Data are presented as mean with their respective SD. Different letters indicate significant differences between tourist number treatments within the same monkey group ($p < 0.05$).

that *A. palliata* spent less time engaged in social interactions as the number of tourists increased. Similar trends were found for *Alouatta pigra* (Grossberg et al., 2003; Treves & Brandon 2005), *Cebuella pygmaea* (De La Torre et al., 2000) and *Gorilla gorilla* (Klailova et al., 2010). A reduction in social interactions could cause disruptions in the affiliative and agonistic dynamics and, thus, compromise the stability of the social organization of monkey group (Aguilar-Melo et al., 2013).

Results show that River monkeys reduced socializing with 10 tourists and Station monkeys reduced socializing with 5 and 10 tourists. We expected that these groups, which has several juveniles therein, would socialize more, since juvenile monkeys overall are more active in social interactions compared to adults (Fagen, 1992) including *A. palliata* (Asensio et al., 2022). Engaging in play is widely believed to be a key trait that may provide benefits for achieving greater social competence and potentially lead to greater reproductive success (Bekoff & Byers, 1998).

The most common responses of monkeys to human disturbances mostly included moving the branches in an attempt to scare away the humans, climbing to the highest part of the canopy, and placing the males lower on the branches than the rest of the group, suggesting an alertness to protect the group (Pers. Obs.). The limitations in this study were the low number of monkey's studied groups, the limited sampling days due to the low tourists flow in the area, and the failure to record tourists behaviour. Future studies should include the observation of alarm/distress/stress behaviors in more monkey's groups, as well as their real time responses to particular human disturbances by recording tourists behaviour, in a greater number of observation sampling days, both in rainy, and dry seasons.

Implications for Conservation

The variability of our results indicates the importance of longer-term studies controlling for additional variables that can provide a more comprehensive understanding of the

impact of tourism on wild howler populations. Nevertheless, the current study can be used as a baseline to understand the effect of tourism on howler monkey behavior. Although our observations were recorded with only 5 to 10 tourists, the boats used for tourist activities in the MABR have a capacity of up to 20 observers and are often filled to maximize income. Therefore, it is crucial to propose strategies to reduce tourism-induced disturbance in monkeys inhabiting the MABR while still allowing for a profitable tourism industry. One potential approach is to establish basic rules for tourists' behavior that promote responsible tourism practices and reduce the negative impact of human activities, especially in situations where large groups are involved.

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Declaration of Conflicting Interests

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