The black howling monkey *(Alouatta pigra)* is exposed to unregulated mass tourism in many areas of Belize. Is this cause for concern among primate conservationists? (Photo by Adrian Treves.)

TOURIST IMPACTS ON THE BEHAVIOR OF BLACK HOWLING MONKEYS (*ALOUATTA PIGRA*) AT LAMANAI, BELIZE

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INTRODUCTION

Conservationists have identified tourists as potential allies in the protection of wildlife and habitats. From a biodiversity conservation perspective, tourism can do five things: (i) provide funds for protected area management and nature conservation; (ii) provide economic justification for protected areas; (iii) provide local people with economic alternatives to encroachment into conservation areas; (iv) educate and persuade the public and politicians about wildlife and their habitats; and (v) serve as an impetus for private conservation efforts [Brandon, 1996]. However, observed successes in these 5 realms must be balanced against common, negative impacts of tourism. For example, tourism on primates has been shown to alter animals' time budgets; interfere with reproduction; suppress vocalizations, play, and social behavior; disrupt feeding, ranging, and habitat use; and promote disease transmission between humans, wild monkeys, and apes [Lee et al., 1986; Altmann & Muruthi, 1988; Lippold, 1988, 1990; Else, 1991; Zhao, 1991; Stewart, 1992, 1996; O'Leary, 1993; Kinnaird & O'Brien, 1996; de la Torre et al., 2000; Wallis, 2000; Wallis & Lee, 1999]. Thus, the implementation of tourism as a conservation tool for wild primate populations must be undertaken cautiously.

Complicating the picture further, the definition of ecotourism has changed from emphasizing nature-oriented tourism to one that emphasizes cultural aims as well. The Ecotourism Society defines ecotourism as: "purposeful travel to natural areas to understand the culture and natural history of the environment; taking care not to alter the integrity of the ecosystem; producing economic opportunities that make the conservation of natural resources beneficial to local people." It may be impossible to achieve biodiversity conservation and community empowerment objectives simultaneously, although some initial successes appear promising where regulation is enforced [Horwich, 1995; Grieser Johns, 1996; Stewart, 1996; Archabald & Naughton-Treves, 2001].

Scholars from various disciplines have discussed the difficulties of directing tourism revenue accurately to conservation goals and of mitigating negative impacts on habitats and wildlife [Boo, 1990; Jacobson, 1994; Brandon 1996; Brandon & Margoluis, 1996; Higham, 1998; Isaacs, 2000; Archabald & Naughton-Treves, 2001; Liu et al., 2001]. One evident trade-off arises in the scale of tourism and its revenue on the one hand, and the disturbance to wildlife on the other [Isaacs, 2000; Liu et al., 2001]. This trade-off is particularly relevant to primate conservationists because so many primates are threatened or endangered yet subject to mass tourism with little regulation [Teas et al., 1980; Wolfe, 1991; Zhao, 1991; Stewart, 1992; O'Leary, 1993]. For these sites, the window of opportunity for the design of ideal ecotourism has passed. Instead we need basic research on negative impacts of the tourists themselves and suggestions for abating them. To confirm that tourism is a potential tool for primate conservation at such sites, we need information on tourists, primates, tour companies, and local communities. Few projects examine all the stakeholders and subjects simultaneously.

Here we present a study of human impacts on the endangered black howling monkey (*Alouatta pigra*) exposed to three different types of tourist parties at Lamanai Archaeological Reserve in Belize. Ours is the first study to measure tourist behavior, guide behavior, and monkey behavior simultaneously. It allows us to investigate the relationship between scale of tourism and impacts on wildlife. We describe tourist parties most likely to engage in disruptive interactions with primates. This leads to straightforward recommendations that unite the interests of conservationists, tourists, and some tour guides.

Methods

Study Site: Belize is ideal for this study given the exceptional economic importance of tourism for the country and the government's commitment to promoting environmentally sustainable tourism [Norris et al., 1998; Gould, 1999]. Tourism is now the largest sector in the economy, accounting for 25% of the country's gross domestic product. Belize draws tourists because of its Mayan cultural heritage and diverse ecosystems from reefs to rainforest. In 1999, 85,093 out of a total 172,292 tourists (49%) visited Belize's Mayan ruins, while 47,947 (28%) visited the country's six biggest national parks and reserves. Cultural/archaeological tourism is growing, from 48,779 visitors to the Mayan ruins in 1995 to 85,093 visitors in 1999 [Belize Tourism Board, 2001].

Belize's Mayan ruin sites are managed by the Department of Archaeology, under the Ministry of Tourism and Youth. Lamanai Archaeological Reserve (Lamanai or Reserve hereafter) is the third most visited Mayan site in Belize. It is located on the west bank of the New River Lagoon in north central Belize (Figure 1). In 2000, international visitors paid BZ $5.00 (US $2.50) to enter Lamanai, while Belizeans entered for free. From these revenues, two permanent staff members were paid to guard the site, supervise work, and occasionally guide visitors.

Lamanai is not managed as a wildlife preserve. For example, there are no signs indicating the presence of wildlife or instructing tourists on appropriate behavior on-

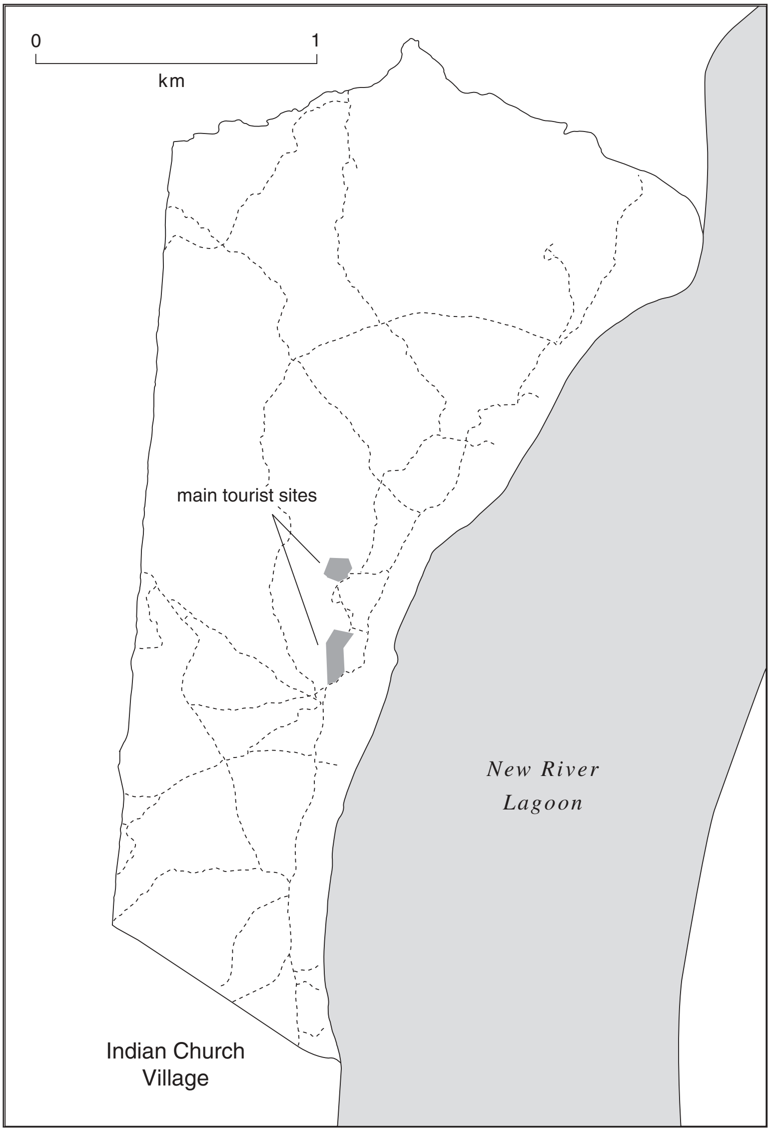

Figure 1. Map of Lamanai Reserve, Orange Walk District, Belize. Dark perimeter line demarcates the boundaries of the Reserve. The main tourist sites (shaded) are connected by broad trails and clearings. Dashed, thin lines are woodland trails or roads. Boats land to the east of the main tourist areas via the New River.

site. However, the site has been maintained for visitors with clearings, trails and a few interpretive signs. The vegetation within Lamanai (~400 ha) is semi-evergreen, seasonally dry forest dominated by broadleaf species (e.g., *Guazuma ulmifolia, Spondias mombin, Stemmadenia donnell-smithii, Enterolobium cyclocarpum*) with pockets of palm (especially *Orbigyna cohune*). The forest provides habitat for diverse wildlife. For example, 370 bird species have been recorded in and near the Reserve [Lamanai Outpost Lodge, 2002]. Also found are the conspicuous black howling monkeys (*Alouatta pigra*, Figure 2), keel-billed toucans (*Ramphastos sulfuratus*) and various parrots, as well as rarer birds and mammals such as tayras (*Eira barbara*), gray foxes (*Urocyon cinereoargenteus*), and agoutis (*Dasyprocta agouti*).

Visitors to Lamanai came year-round with the majority from December to March [Grossberg et al., 2003]. Visitors have increased from 10,336 in 1995 to 19,805 in 2000, most of whom are North Americans [Belize Tourism Board, 2001; Grossberg et al., 2003]. The increasing number of cruise ship passengers visiting Belize (7,953 in 1995 to 34,130 in 1999) sometimes resulted in more than 200 visitors per day at Lamanai in the 2000 season (compared with 50-100 per day previously). While the Mayan ruins are the primary attraction of Lamanai, most guiding companies incorporated wildlife viewing into the tour [Grossberg et al., 2003]. This was particularly true for the Lamanai Outpost Lodge (Lodge hereafter) which billed itself as an ecotourist operation [Lamanai Outpost Lodge, 2002]. The Lodge is located in neighboring Indian Church village (Figure 1). Tourists from the Lodge and the village approach the ruins via woodland trails, small motorboat, or by road.

Indian Church village contained 430 residents in 2001. These were Guatemalan immigrants who had resided in the region for up to 25 years. The people respected a taboo against hunting black howling monkeys, which dated back two decades or more [B. Esquivel, personal. communication]. Hunting of other animals and other forms of encroachment on the Reserve did occur on occasion but our team of researchers rarely saw residents within the monkey ranges. Dogs from both the Lodge and the village entered the Reserve and sometimes harassed wildlife.

We identified three types of tours at Lamanai. The first type (mass) was usually composed of international visitors, who arrived by large boat to the main ruins and rarely stayed at Lamanai longer than 2 hours. Mass tours had up to 3 non-local guides and did not stray from the main tourist sites. We identified 22 guides of mass tours during our study. The second type (lodge) originated from the Lodge plus one guide employed by the Ministry of Tourism and Youth who lived in the village and worked on site. These parties were smaller and were guided by foreign or local naturalists, biologists, or archaeologists. These tours tended to be longer in duration, and ranged further afield, although virtually always on trails. The third type of tour (unguided) was often composed of Belizean nationals. Unguided parties were more variable in party size and range use (e.g., picnickers and school groups). If guides were present, they did not make themselves apparent by leading, narrating or answering questions. Often large parties broke into smaller fractions that traveled independently within the site. Unguided tourists often arrived by road, and did at times range far into the Reserve on trails.

Figure 2. Typical howling display posture of *Alouatta pigra* adult male. (Photo by Adrian Treves.)

Black Howling Monkeys at Lamanai

The genus *Alouatta* is widespread in the Neotropics but black howling monkeys (*Alouatta pigra*) are restricted to Belize, the Peten region of Guatemala and the Yucatan peninsula. They are locally abundant but considered threatened because of their narrow geographic range (*per* Cites Appendix II). The genus gets its name from its loud call or roar, emitted in its most elaborate and loudest form by the adult males. Roars are produced under a variety of circumstances and seem to serve various socioecological functions including territorial advertisement, mate attraction, and intimidation of rivals or enemies [Horwich & Gebhard, 1983]. The roar can be heard over several kms and is repeated in series (bouts) of up to several hundred individual roars [Whitehead, 1995]. Black howlers eat mainly fruits and leaves. Groups are stable and composed of 1-4 breeding females, 1-4 adult males, plus infants (0-12 months), and juveniles (1-5 years) [Horwich, 1983a,b; Horwich & Johnson, 1986]. Groups at Lamanai contained 2-10 individuals (average 5-6 [Treves, 2001]). Both sexes disperse although individuals of either sex may occasionally remain in their natal groups. Dispersal has occurred as early as 25-30 months and as late as adulthood at Lamanai [Treves et al., unpublished data].

Lamanai Reserve was home to approximately 17 groups of black howling monkeys [Treves, 2001]. Five howling monkey groups encountered most tourist parties because their ranges overlap the maintained trail system. Exposure to tourists varied markedly among these groups (Table I).

Data Collection

Data were collected in three field seasons: March-December 1999, January-August 2000, and January-May 2001. We collected >3,845 hours of behavioral and ecological baseline data on the monkeys and their ranges [Arrowood et al., 2003; Treves et al., 2001, 2003], conducted monthly census of monkey groups [Treves, 2001; Treves et al., unpublished data], and sampled tourist parties systematically (Table I; [Grossberg et al., 2003]).

Because we were prohibited from marking animals, we relied on range location and group composition to identify groups. We relied on sex, size, coloration, and permanent features to identify individuals within groups. With these techniques, we established secure identification for 10 groups in the Reserve. These 10 groups ranged in the southern and central portions of the Reserve, where we focused our activities. Behavioral data were collected dawn to dusk by 1-5 researchers (with a mode of 2) working simultaneously. The researchers took turns either remaining with the monkeys continuously and dividing the observational effort between monkeys and tourists, or following tourist parties around the ruins to study their attributes and behavior [Grossberg et al., 2003]. On the few occasions when >2 researchers were present for >1 hour, the surplus researchers were in training. Researchers attempted to minimize noise and movement while following monkeys on and off trail. There were no guidelines on proximity except our team attempted to avoid physical contact. Due to the challenge posed by vigilance sampling, we generally attempted to approach to between 5 and 15 m before sampling behavior.

We collected behavioral data on the monkeys using continuous focal animal samples lasting two minutes. This duration was chosen on the basis of an earlier study of vigilance at this site [Treves et al., 2001]. Longer sampling intervals led to more aborted samples because movements in the forest canopy often conceal the focal animal, while shorter samples truncated bouts of scanning and thereby distorted estimates of bout length and total time spent scanning [Treves, 1998]. Focal animals were chosen haphazardly rather than by a predetermined routine because of the need to see the eyes of the focal animal clearly for identification [Treves et al., 2001]. As a result, individual animals were sampled unevenly and repeatedly throughout the day. Statistical treatment of this non-independence is detailed below.

We recorded the activity of the animal, its identity and several response variables expected to change with the presence of humans. Time spent vigilant, distance to the observer, and height in the forest canopy (in meters) were estimated. Interindividual proximities of the monkeys were recorded as the number of associates in three nonexclusive distance categories: < 2 m, within 2-5 m and within the same tree. We also recorded all occurrences of loud calls (roars) by the focal group, including apparent stimulus, number of roar syllables produced and the duration of the entire bout. The onset of distant (non-focal) monkey roars was noted as were other events that might affect monkey behavior, e.g., conspicuous social interactions, anthropogenic disturbances, etc. All visual encounters between monkeys and tourists were recorded. We noted auditory contacts but could not be sure of recording dog barks, vehicles or auditory contact with humans on all occasions. Therefore, we analyzed only the response to visual encounters with humans. For visual encounters, we noted the start and end time to obtain duration, the number of tourists and guides, and the name(s) of the guide(s) whenever possible. The type of tour was designated by identifying the guide (mass, lodge, or unguided) based on our intensive study of tour operations [Grossberg et al., 2003]. Also, we noted and ranked the intensity of any encounter, based on behavior of humans toward the monkeys, as follows:

- 0 = NONE (no member of tourist party appears to detect the monkeys)
- 1= OBSERVE (member(s) of the tourist party notice(s) the monkeys and observe(s) them only)
- 2= MILD (discreet, brief attempt to elicit a response from the monkeys)
- 3= MODERATE (loud or lengthy attempt to elicit response)
- 4= INTENSE (loud and lengthy attempt to elicit response or vigorous use of branches or missiles to gain monkeys' attention)
- 5= CONTACT (physical contact between human and monkey or transfer of food)

We identified MILD, MODERATE or INTENSE attempts to elicit a response as any of the following human behaviors done while watching the monkeys: (i) vocalizations or speech emitted louder than conversational tones and directed to the monkeys rather than fellow tourists; and (ii) the use of missiles or shaking of vegetation in the general direction of the monkeys. With these criteria, we probably underestimated disruptions to the monkeys. That is because some behavior we did not score as 2, 3 or 4 might still appear to the monkeys to be directed toward them (e.g., one tourist beckoning loudly to another while standing beneath a monkey). However, we felt we were accurately measuring the tourists' intentions to interact with the monkeys. Admittedly, there is some subjectivity in assigning a behavior to MILD, MODERATE or INTENSE, but the major distinction of concern is between interactions scored 0-1 and higher-ranked interactions. For the purposes of analysis, we treated the most intense human behavior in a given encounter as the attribute of the entire encounter.

There are three sources of error in our attempts to relate monkey behavior to the actions of tourists. First, we did not record the exact timing of tourists' attempts to interact with monkeys, because these were typically brief and intermittently repeated. As a result, we assume that the human behavior recorded within one encounter characterizes the entire encounter regardless of when it occurred. Hence, error arises when the behavioral sample precedes the tourists' attempt to elicit a response from the monkeys. Because the median encounter lasted six minutes and our behavioral samples lasted two minutes, this is a rare and conservative error that reduces our sensitivity to tourist-related disruptions of monkey behavior. The second error is similar in that we did not identify the individual monkey(s) subjected to human influence. We believe this is insignificant because these small monkey groups were generally dispersed over less than 30 m [Arrowood et al., 2003], so all monkeys were likely to detect conspicuous tourist behavior. The third potential error concerns aftereffects of tourist encounters. For analyses, we assumed that a sample taken after the departure of a tourist party was the same as one taken before the arrival of that party (i.e., baseline = no tourist present). If the monkeys' responses to disturbances linger after tourist departure, our method will fail to detect an effect of tourists, or minimize that effect. This is a conservative type of error but may be particularly relevant to monkey vigilance, which has been shown to reflect potential threats for 30 minutes or more after the threat has vanished [Treves, 1999].

Statistical Methods

To assess behavioral changes during encounters with tourists, we sought control over other factors that alter daily behavior. Thus, we discarded samples of infant behavior, samples taken of adults and older juveniles when younger animals were behaving conspicuously from the perspective of the observer, i.e., playing, vocalizing, or moving quickly, and samples taken when another group of monkeys was visible or audible. All of these affect vigilance and inter-individual proximity in this species

Table I. Exposure to tourism for black howler groups of Lamanai Reserve.

		Visual encounters with tourists *				
Group	**Contact hours 1999-2001**	**Total**	**Rate per hour**	**Duration (min) average**	**Party size average**	**Exposure**
ALT	1133.8	14	0.05	4.2	6.0	low
MAS	154.2	48	0.39	7.1	9.9	high
OBO	782.4	329	0.85	8.4	9.7	high
QUA	955.7	15	0.15	5.1	3.7	low
THR	318.2	7	0.62	11.6	10.0	high
Others	500.9	13	0.03	*	*	low
Total	3845.2	426				

* details of tourist parties were collected only during Jan-Aug 2000

[Treves et al., 2001, 2003]. We also discarded records from those monkeys sampled <5 times and then we tested for interobserver differences over the remaining samples. Seven researchers collected most of the data. Interobserver training preceded data collection for each researcher, and was tested midway through the study; systematic differences between observers exceeding 2 m (for measures of distance) or 2 seconds (for measures of time spent vigilant) were eliminated by further training. One researcher's vigilance data were significantly different from the others and discarded. The remaining 6 researchers' data did not differ significantly in the measure of time spent vigilant (Kruskal-Wallis $H=6.76$, $p=0.24$), the most difficult behavioral data to collect. Thus we pooled 6 researchers' data to yield 885 samples collected for the analysis of response to tourists.

We were concerned with documenting consistent responses of monkeys to human disturbance, hence we treated individual monkeys as independent. Treating groups as the replicate would have obscured differences between individuals and age-sex classes without shedding light on individual responses to stimuli that are experienced by all. Tourist parties were also treated as independent events so some individual monkeys contributed more than one sample to a test if they were exposed to more than one tourist party. But for each condition (e.g., party size of 7), each individual monkey contributed a single average score. Significance was set at $p \leq 0.05$. We used multivariate linear models when the assumption of constant variance was met; otherwise nonparametric tests. The sample size (individual monkeys' averages) is delineated for each test and the test itself described below, the first time it is used.

RESULTS

We recorded 426 visual encounters between monkeys and tourists. Encounters were not evenly distributed among monkey groups (Table I). Based on the frequency of encounters with tourist parties, the duration of these encounters and the average number of tourist parties, we classified ALT and QUA as low exposure groups, and MAS, OBO and THR as high exposure groups. Neighboring groups observed in the main tourist areas were classified as high, by analogy to their neighbors, while all other groups were coded as low.

Tourist Parties and Their Efforts to Interact With Monkeys

In 91 encounters (21.4%), the tourists did not appear to detect the monkeys (rank = 0), while in 277 (65.0%), the tourists simply observed the monkeys (rank = 1). Of the remainder, we recorded 26 mild (rank = 2), 25 moderate (rank = 3), and 7 intense (rank = 4) attempts to elicit a response from the monkeys (jointly 13.7% of total). Two attempts to feed monkeys were unsuccessful and ranked as INTENSE. Physical contact between tourists and monkeys (rank = 5) was observed twice outside of systematic sampling. We also recorded the guides' interactions with the monkeys in 223 cases. Guides did not appear to detect the monkeys in 19.3% of encounters. They observed them in 71.7% of encounters, and tried eliciting a response (rank = 2-5) in 9.0% of encounters. Although guides and tourists did not differ in intensity of interaction

Table II. Attributes of four types of tours at Lamanai Reserve, Belize.

	Encounters with black howling monkeys				
Type of tour	**N**	**N of tourists (mean ±sd)**	**Duration (min) (mean ±sd)**	**Ranked intensity (mean) tourist**	**Ranked intensity (mean) guide**
lodge	41	5.4 ± 3.0	10.1 ± 12.7	0.9	0.9
mass	191	13.7 ± 10.3	9.5 ± 10.6	1.2	1.1
no guide	86	3.4 ± 3.3	6.3 ± 8.6	0.8	-
unknown	108	5.8 ± 2.6	5.9 ± 6.3	1.0	0.8

(average rank of guides compared to tourists: Mann Whitney U test, Z = -0.21, p = 0.88), they did differ in the likelihood of an elicit (rank 0-1 versus rank 2-5 assuming equal probability of the two categories: df = 1, χ^2 = 11.11, p = 0.025). Tourists were more likely to attempt to elicit a response or to do so more intensely than guides when pooling across parties and encounters.

Mass tours were the most frequent type and brought the most people to Lamanai [Grossberg et al., 2003]. A large proportion of tours could not be classified because

Table III. Loud call (roar) production between 0500-1900 by black howling monkeys of Lamanai Reserve, Belize from Jan 2000 - Mar 2001.

		Roaring	Effort			Rates		
Group	**Tourism exposure**	**Observation time hours**	**bouts**	**syllables**	**minutes**	*****	******	*******
ALT	low	277.6	83	2548	725	0.30	3.51	8.73
MAS	high	118.4	41	1599	921.5	0.35	1.74	22.48
OBO	high	385.4	74	2151	876	0.19	2.46	11.84
QUA	low	101.1	18	360	233	0.18	1.55	12.94

* bouts per observation hour (measures frequency of loud call initiation)
** syllables per minute of roaring (measures frequency of call production in bouts)
*** minutes of roaring per bout (mean bout length)

Table IV. Black howling monkey responses to humans.

	Humans present				
		Tourists + Researchers			
Monkey behavior	**N of researchers (2-5)**	**N of humans 3-62**	**Encounter duration <30 min**	**Encounter duration ≥30 min**	**Humans try to elicit response from monkey**
Avoid observer	+	+	+	NS	+
Climb higher	NS	†*	NS	NS	+
Scatter	NS	+	+	NS	NS
Cluster		NS	NS	+	NS

+ = significant at $p < 0.05$, NS = Non Significant
†* sex-specific response by monkeys (see Results)

researchers did not recognize a guide or recorded inadequate information. Probably most unidentified tours were mass tours or unguided tours because there were only 3 Lodge guides and they were known personally to our team. The four types of tours differed significantly in number of tourists per party (Table II: Kruskal-Wallis non-parametric ANOVA to compare mean ranks: $H = 18.33$, $p < 0.0001$), and in duration of encounter with the monkeys ($H = 22.45$, $p < 0.0001$). They also differed significantly in the intensity of interaction between tourists and monkeys ($H = 17.77$, $p = 0.0005$). Tours without guides had the lowest average intensity of interaction with the monkeys (Table II) because many of them did not detect the monkeys (40%) compared to the two types of guided tours (17.3%). Excluding encounters in which tourists did not detect the monkeys, Lodge tours were the most discreet (median interaction rank = 1.1) with mass and unguided tours equally disruptive (medians = 1.4, 1.3 respectively; $H = 6.63$, $p = 0.036$).

Twenty-five guides could be compared and they differed significantly in average intensity of behavior toward the monkeys ($H = 52.5$, $p = 0.0007$). Part of the difference between guides was explainable by the type of tour (mass versus lodge: Mann Whitney U test $Z = 1.91$, $p = 0.07$). This difference was significant when one of the Lodge guides was excluded ($Z = 2.79$, $p = 0.0053$); we do this only to emphasize how interindividual variation among the guides could obscure variation among tour types.

There were strong correlations between the number of tourists, the duration of an encounter with monkeys, and the intensity of interactions with monkeys. Not surprisingly, behavior of a given tourist party towards monkeys was very similar to the behavior of that party's guides (Spearman rank correlation $r_s = +0.67$, $p < 0.0001$). Both increased slightly with the duration of the encounter ($r_s = +0.36$, $r_s = +0.29$, both $p < 0.0001$), probably because parties that did not detect the monkeys (rank = 0) passed through the area quickly. More surprising, the number of tourists was not correlated with the intensity of interaction between monkeys and guides ($r_s = 0.03$, $p = 0.68$), but was for interactions between monkeys and tourists ($r_s = +0.23$, $p < 0.0001$). The duration of an encounter and the number of tourists in a party were also positively correlated with each other ($r_s = +0.24$, $p < 0.0001$). It appeared that the duration of an encounter predicted the intensity of tourists' interactions with monkeys independently of the number of tourists in that party (residual of duration regressed on number of tourists versus intensity: $r_s = +0.33$, $Z = 6.33$, $p < 0.0001$). However, the increased intensity of interactions with monkeys associated with larger tourist parties and longer-lasting encounters might simply have reflected higher probabilities of detecting the monkeys. We excluded interactions without detection (rank = 0) and reanalyzed the above relationship. All three predictors (number of tourists, duration of encounter, and their residuals) persisted as significant predictors of the intensity of interaction with monkeys. In short, larger tourist parties and longer encounters were both associated with more intense efforts by tourists to elicit responses from the monkeys.

Responses of Monkeys to Humans

Monkeys rarely responded vocally to tourists. In 72 interactions that involved more than simple observation (rank > 1), the monkeys responded vocally to the humans in only 5 cases (6.9%). In two of these, an adult male responded with a grunt only. This vocalization has been observed in three contexts: when an adult male is building up to a roar; when any individual is behaving aggressively; and when an adult of either sex is attempting to direct group movement [unpublished data]. There were two additional cases of a roar following tourists' actions, but these were coincident with another monkey group being in visual contact. For the sake of comparison, when dogs barked < 50 m away, an adult male monkey roared in 58% of cases (N = 31). Hence, in general, vocal behavior of the monkeys did not appear to be significantly affected by tourism. The groups exposed to high levels of tourism (OBO and MAS) did roar for more minutes than the other two study groups but rates of loud calling were not consistently higher (Table III). Nor was the roaring male joined by vocalizing associates more often in the high-exposure groups (ALT 40% of bouts compared to MAS 66%, OBO 89% and QUA 93%: $df = 3$, $\chi^2 = 6.1$, $p = 0.11$). Females and subordinate males were more likely to join the roaring male in tense situations (e.g., close intergroup encounters [unpublished data]).

To detect more subtle responses to human disturbance, we analyzed vigilance, interindividual proximity, distance between observer and focal monkey, and the monkeys' heights above the ground. We began by assessing the effect of researchers to understand the effects of tourists on the monkeys. Hereafter, we use the term "observer" to refer only to the researcher collecting the behavioral records in question (not companion researchers or tourists).

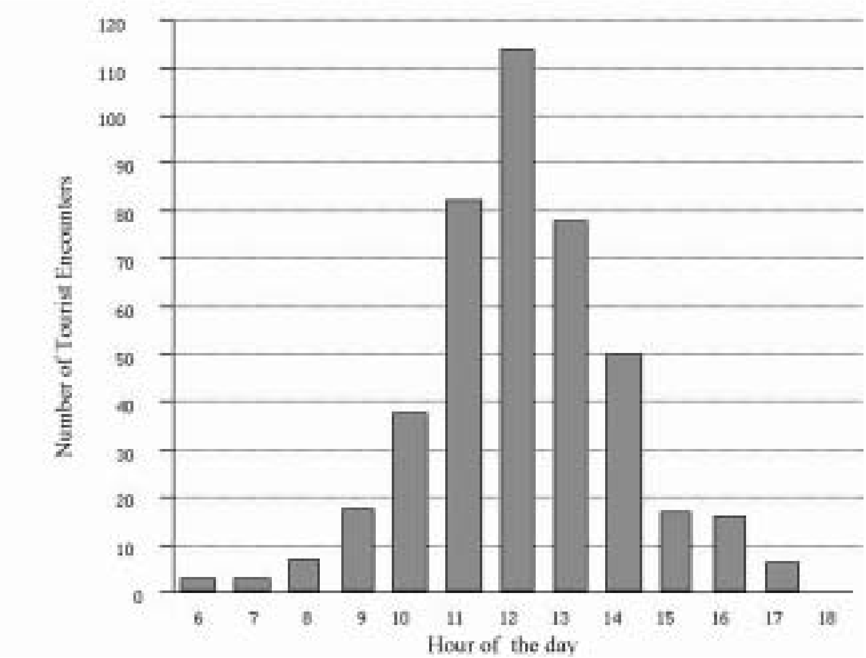

Figure 3. Diurnal distribution of tourist party encounters with monkeys from Jan-Aug 2000.

In the absence of tourists, increasing the number of researchers was associated with greater distances between the observer and the focal monkey (N = 67 average scores taken from 23 individual monkeys under conditions of 1, 2, 3, 4 or 5 researchers, $r_s = +0.28$, $p = 0.021$). This distancing between focal monkey and observer occurred with little or no increase in height above the ground ($r_s = +0.20$, $p = 0.11$). Both male and female monkeys were sampled further from the observer, but considering the sexes separately, we saw another response to the number of researchers (Table IV). Male monkeys (N = 12 individuals contributing 35 average scores) were observed with more associates within 2-5 m ($r_s = +0.39$, $p = 0.022$) while females (N = 11 contributing 32 average scores) showed the opposite tendency ($r_s = -0.26$, $p = 0.14$). Indeed, females had significantly fewer associates in the same tree ($r_s = -0.38$, $p = 0.032$), while males retained the same number ($r_s = 0.12$, $p = 0.47$). These results suggest that the monkeys moved away from the observers rather than the converse, and that adult males were a focus of aggregation, while females disaggregated.

Separation between observer and focal monkey was most different between 1-2 researchers (N = 36 values, 12.3 ± 2.1 m) and 3-5 researchers (N = 31 values, mean = 14.1 ± 2.9) (Mann Whitney Z = 2.73, p = 0.0064). Therefore, for the remaining

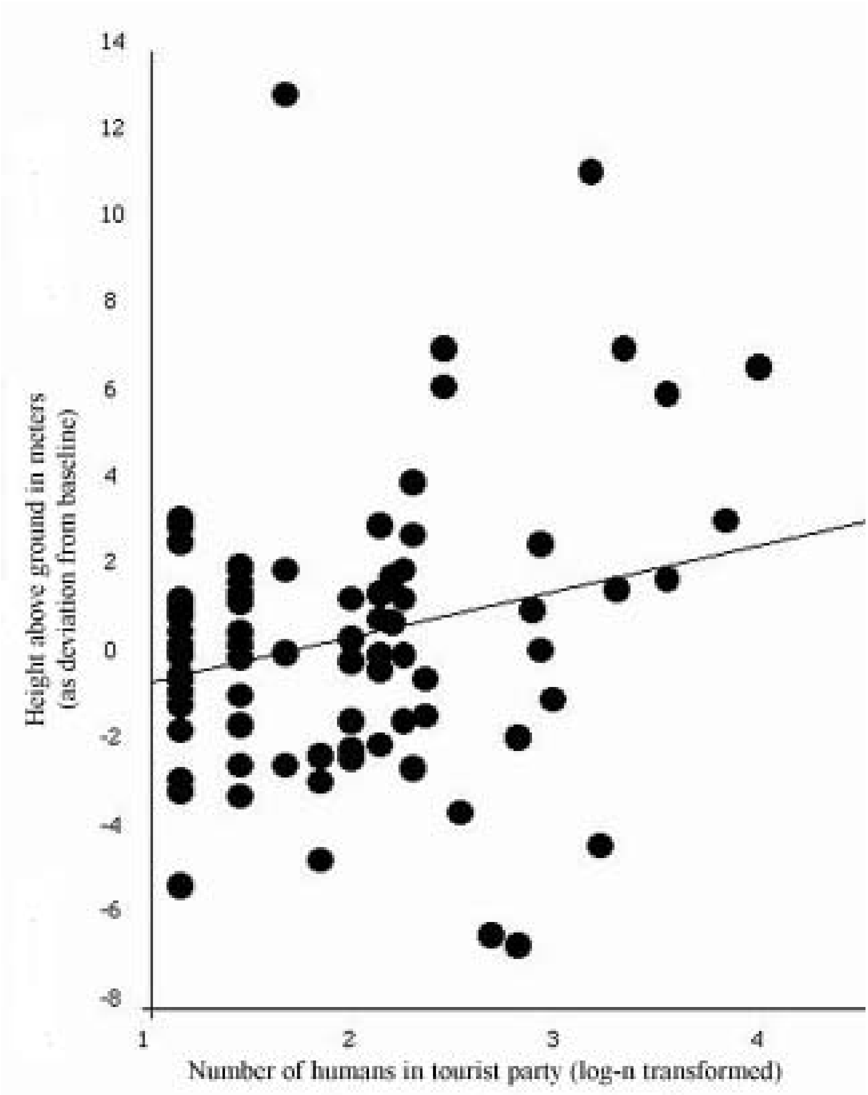

Figure 4. Change in the use of height by the monkys in relation to tourist encounters. The y-axis denotes height above the ground during encounters with tourists subtracted from the baseline height with 1-2 researchers and no tourists. Each point is an average for an individual monkey (n=18 monkeys, 79 averages). The regression line was forced through the origin to identify the tourist party size at which monkeys begin to climb higher in the trees (>14). For analysis however, the intercept was included in the regression model.

analyses, we treated samples taken with 1-2 researchers (and no tourists) as baseline from which to consider all other conditions. Baseline samples could be collected at any time of day - the sole criterion was no tourists and < 3 researchers visible. A potential confound for comparisons of baseline behavior to that seen when tourists were present was the timing of samples because 95.6% of tourist parties (N = 432) visited Lamanai between 9 am and 4 pm with a peak around midday (Figure 3). If the diurnal distribution of our baseline samples differed from the diurnal distribution of tourist parties, we might confuse the effect of tourism with an effect of time of day such as temperature or activity level. To assess this potential confound, we used a Kolmogorov-Smirnov test to identify any differences between the diurnal distribution of baseline samples and that of samples collected when tourists were present (N = 14 hours in the day, maximum difference = 0.29, $\chi^2 = 2.29$, p = 0.64). The result was the same for the groups exposed to low tourism (max = 0.29, p = 0.64), and those exposed to high tourism (max = 0.32, p = 0.34). Thus our baseline samples were drawn from the same times of day as our samples with tourists visible.

Eighteen monkeys contributed 79 average scores to test if behavior with > 2 humans (researchers + tourists) differed significantly from that seen with 1-2 researchers (baseline). All monkeys were tested jointly with a one sample sign test. The number of associates within 2 m and within the same tree decreased from baseline levels for a majority of the monkeys (62.0%, p = 0.0071, and 65.8%, p = 0.0066, respectively), indicating greater dispersion or scattering of monkeys when > 2 humans were present. In 64.5% of cases (p = 0.013), monkeys were further from the observer when > 2 humans were present. Among males, 67.4% of samples were collected higher off the ground when > 2 humans were present (p = 0.032; Table IV).

We also tested for a simple linear relationship between the number of humans present and changes in monkey behavior. We treated each tourist party as an independent event here. Because of the sex differences and possible effects of long-term exposure to tourism, we employed a multiple regression with two interaction terms (sex and exposure) to assess the relationship between number of humans (*ln*-transformed to meet the assumption of constant variance) and each of the response variables. The multiple regression models explained little or no variation in the behavioral responses. The only significant effect of increasing numbers of humans was seen in the monkeys' height above the ground (N = 79, $r^2 = 0.16$, F = 4.67, p = 0.0048). Controlling for sex (t = 2.14, p = 0.0036: males were seen higher than females) and exposure to tourism (t = -2.12, p = 0.038, low exposure groups were seen higher than high-exposure groups), monkeys went higher in the trees as more humans were present (4 ± 3 m higher: t = 2.87, p = 0.0054; Figure 4). Compared to baseline, parties with more than 14 tourists triggered the greatest increases in heights.

We assessed whether or not the duration of an encounter with tourists affected the behavior of the monkeys. Samples from 11 monkeys exposed to 47 different tourist parties were examined for this test. Linear analysis of duration (x-axis) versus change in behavior over baseline (y-axis) yielded no significant relationship. Inspection of the scatter-plot revealed a nonlinear trend which we explored by dichotomizing durations at 30 minutes (exploiting a natural gap in the distribution of duration). Encounters of < 30 minutes duration were more likely to lead to scattering (number of associates decreased within 2 m for 82.9% of monkeys, p = 0.0001, and decreased within the same tree for 79.0% of monkeys, p = 0.0005). By contrast, encounters ≥ 30 minutes were associated with reduced distance between observer and monkey (88.9%: p = 0.039; Table IV). To control for the correlation between number of humans and length of encounter, we used a multiple regression incorporating sex, exposure to tourism, *ln*(number of humans), and *ln*(duration). A weak effect of duration was found on the number of associates in the same tree ($r^2 = 0.07$, F = 4.47, t = 2.11, p = 0.040), indicating that lengthy exposure to a tourist party led the monkeys to reaggregate somewhat (Table IV).

Next, we assessed the effect of the behavior of the tourists on the behavior of the monkeys. Eleven monkeys provided 41 samples for this test. Because the intensity of encounters between tourists and monkeys was a ranked variable, we ran a simple Spearman's correlation without controlling for the effects of number of humans or duration of encounter. Under these conditions, the more intense interactions prompted the monkeys to move away from the observer ($r_s = +0.38$, p = 0.016) and higher off the ground ($r_s = +0.42$, p = 0.0085).

DISCUSSION

Black howling monkeys at Lamanai Reserve behaved differently when > 2 humans were visible. Visual encounters with humans altered the monkeys' use of microhabitat and interindividual proximity. In particular, the number of tourists, duration of the encounter, and behavior of tourists influenced the response of the monkeys. When > 2 researchers were present without tourists, monkeys moved further from the observer without moving higher in the canopy. Also, the monkeys appeared to approach male associates and move away from female associates when more researchers were present. The monkeys responded differently to tourists than they did to researchers. When tourists were visible, the monkeys increased interindividual distances (scattered), moved away from the observer, and climbed higher in the trees. This avoidance increased when tourists tried to elicit responses from the monkeys. Most responses to humans reduced the observability of the monkeys, and, therefore, the quality of wildlife viewing for the tourists. However, monkeys reaggregated when encounters were protracted to > 29 minutes and the presence of > 2 researchers also led to some clustering around adult males. These responses could improve the quality of wildlife viewing.

We found little or no evidence for habituation to tourism. Those monkey groups exposed to high levels of tourism still scattered and moved up and away from humans, despite years of exposure and thousands of tourists passing. Although none of the monkeys engaged in risky evasive behavior, they consistently changed their positions when tourists were visible. Perhaps the occasional intense effort by a tourist to elicit a response, or some other anthropogenic disturbance prevents habituation, or past selection for avoidance of potential threats has hard-wired the observed self-protective responses. We found no evidence for changes in vigilance but vigilance patterns display multifactorial determinism and we caution against premature conclusions about vigilance patterns in response to tourism.

Implications for Primate Conservation

From an ecological viewpoint, the short-term behavioral changes observed in our study are not dangerous to the monkeys. They do, however, raise the daily cost of living as follows. Moving away from perceived threats and climbing higher expends energy, and can do so significantly if repeated often. If the monkeys are unable to compensate for energetic losses, one would expect lower birth rates, lower birth weights, or slower maturation. Higher rates of infant mortality in the groups exposed to high levels of tourism have been observed (0.04 deaths per female-month versus 0.02 for groups with low exposure [Treves et al., unpublished data]); these are consistent with the short-term energetic costs and opportunity costs observed here, but clear evidence of causation is not yet available. The observed changes in behavior also hint that monkeys used less preferred resting and foraging sites when humans were visible. This may entail delays in resting or accessing high-quality resources. Bolder animals who avoided tourists less would be at an advantage. In this population, the female black howling monkeys were not as bold, judging from the involvement of young adult and subadult males in every observed case of physical contact with humans (including researchers, N = 8).

For those aiming to reduce disturbances caused by tourism, the short-term behavioral disruptions we document here are sufficient cause for action. Others, more concerned with the viability of the population, may want to weigh disruptions to 3-4 groups and possible depression of reproductive performance against the direct and indirect benefits of tourism to the population of Lamanai as a whole. To do so, however, one needs to track revenue from tourism at Lamanai to actual conservation action and the attitudes and activities of the local community. Although a complete treatment of this subject is beyond the scope of the present paper, a preliminary study indicates that little or no revenue goes directly to standard conservation activities in the Lamanai area (e.g., guarding, environmental education, habitat restoration, etc. [Grossberg et al., 2003]).

CONCLUSION

Implications for Ecotourism Management

Our study offers several suggestions for those aiming to reduce tourist disturbance to howling monkeys or other primates, and those who would increase tourism revenues to local communities. The key finding is that the least disruptive tours of wild monkeys will be those led by discreet guides, consisting of a small number of discreet tourists, and making no effort at interaction or close physical proximity to the animals. In quantitative terms, tourist parties with < 15 individuals would appear to be optimal, judging from the monkeys' changes in height (Figure 4). Also, encounters with monkeys that lasted more than 29 minutes improved wildlife viewing opportunities because monkeys scattered initially and later reaggregated in one or a few trees.

Small Tourist Party Size Improves Observability of Monkeys

Reducing tourist party sizes is typically recommended by ecotourism studies. We repeat these calls, but acknowledge that recommending smaller tourist parties will probably not please most mass tourism companies. Nevertheless, the recommendation is in the best interests of the tourists and monkeys. Managers and conservation groups should work to persuade tour companies of the need to divide their large parties into smaller ones. One means to reduce party size and encounter duration without increasing tour company operating costs would be to train and recruit locals to assist in leading smaller parties on site, without pay. Several tour operators voluntarily adhere to this system currently by requesting the help of the on-site representative of the Ministry of Tourism. If tourists are informed why these guides are employed without salaries, the tourists may be willing to make contributions to the local, on-site guides in the form of tips or donations, while at the same time receiving a concise lesson in wildlife viewing. The majority of visitors to Lamanai expressed an interest in seeing more monkeys [Grossberg et al., 2003], so our proposal may be economically self-sustaining at a site like Lamanai. Moreover, some tourists expressed frustration at the monkeys' lack of activity or concealment, perhaps unaware that they were partly to blame. Well-trained guides can explain the behavior of the monkeys and give tourists the motivation to remain discreet for 29 minutes or more. There are sufficient other attractions on most tourist trails to occupy a party for 20-30 minutes while the monkeys habituate to the humans. These conjectures will require deliberate testing, however.

Guides Are Essential to Howling Monkey Tourism

Forty percent of tours without guides did not detect the monkeys, as opposed to 17.3 % of guided tours. Furthermore, tourists without guides were more likely to disrupt monkey activities once detected. The managers of Lamanai should find a way to unite local, trained guides with the large, unguided parties entering the Reserve. Prohibitions on unguided parties with > 14 tourists may be necessary. However, tourists did not always model their behavior on that of guides, so some education aimed directly at tourists will be needed in addition to training guides. A welcoming billboard indicating the presence of an endangered species coupled with multilingual instructional signs along trails would be a first step.

Guide Training

Guides failed to detect observable monkeys in almost one-sixth of encounters. This is a missed opportunity often caused by the guide rushing the tourists through a preset timetable. When monkeys were detected, some guides were discreet and provided accurate environmental information while others did not [Grossberg et al., 2003]. For example, the two best-studied ecolodge guides were not consistent: one had the lowest observed rank of interaction (least disruptive to monkeys), while the other had the second highest ranking. This emphasizes the need for systematic training and supervision of guides.

Understanding tourists, their guides and the monkeys they encounter is a key area of research for the future. Such research holds the most promise for conservationists aiming to mitigate negative consequences of tourism and shape the behavior of guides. Both the monkeys and tourists share an interest in avoiding disruption. Because satisfied tourists are good for business, our recommendations mesh well with the goals of conservationists, tourists, and many tour operators.

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