

**HUMAN-MACAQUE INTERACTIONS ON SON TRA PENINSULA,
DA NANG CITY: MANAGEMENT IMPLICATIONS
FOR SUSTAINABLE COEXISTENCE**

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Abstract. This study examines the dynamics of human-macaque interactions on the Son Tra Peninsula, focusing on the influence of visitor and primate characteristics. Statistical analysis revealed that interaction distances predominantly ranged between 2 and 3 meters, suggesting a high degree of habituation within the population. A critical disparity was observed between visitor groups, as domestic visitors provisioned macaques with anthropogenic food significantly more frequently than international visitors ($\chi^2 = 22.123$, $p < 0.001$). Among the primates, immature macaques were identified as the most active and bold age group, consistently displaying higher interaction intensity than adults or infants ($F = 67.75$, $p < 0.05$). Spatial analysis confirmed that Troop 8 and Troop 3 are the most habituated groups, often engaging in high-intensity proximity behaviors. These findings highlight the urgent need for demographic-specific management interventions to mitigate the risks of disease transmission and primate dependency on anthropogenic food.

Keywords: human-macaque interactions, *Macaca mulatta*, provision, Son Tra, Da Nang.

1. Introduction

Human-macaque interactions are emerging as a pressing environmental and social issue globally, especially in Asia. A primary driver of behavioral modification and increased conflict is human provisioning. This provisioning manifests in diverse forms: roosted in

religious beliefs and cultural traditions—where macaques are often regarded as sacred entities, as well as tourism activities and recreational habits in conservation areas or urban parks. Research by [1] indicates that in urban areas of India, human feeding (79.4%) and improper food waste disposal (57.4%) are the main factors attracting macaques into human-dominated landscapes. Similarly, in Singapore, research [2] found that up to 90% of long-tailed macaque behaviors directed at humans were the result of human provocation, mainly through feeding or bringing food into macaque habitats. In response, Singaporean authorities imposed fines of up to US\$4,000 for provisioning; subsequent surveys revealed that 79.2% of the public perceived the ban as effective, despite skepticism regarding its consistent enforcement. In India and Sri Lanka, authorities also prioritized banning feeding in public places and temples to minimize the concentration of macaque troops. However, [3] noted that fining people for feeding macaques varied significantly across different cultural contexts [4] emphasized the importance of implementing awareness programs for both residents and tourists. These initiatives should highlight that provisioning ultimately harms macaques by inducing behavioral shifts, increasing disease susceptibility, and necessitating lethal management following aggressive encounters. Furthermore, [5] suggested that prominent signage and behavioral guidelines at tourist sites are essential for helping visitors recognize gestures that may inadvertently provoke attacks.

In Vietnam, while human–macaque conflict is frequently documented in media reports, empirical research on these interactions remains limited. On the Son Tra Peninsula, Da Nang, the rhesus macaque (*Macaca mulatta*) is not only threatened by hybridization with other congeners of the genus *Macaca* [6], but is also impacted by human activities such as hunting, trapping, habitat loss, and behavioural changes associated with food provisioning by tourists [7], [8]. Therefore, this study characterizes the dynamics of human macaque interactions in Son Tra, Da Nang; to elucidate their underlying causes and facilitate evidence-based solutions for sustainable coexistence.

2. Content

2.1. Materials and methods

From April 2024 to June 2025, the study was conducted on the Son Tra Peninsula, Da Nang City, with a total of 120 field observation days. Daily observations were conducted between 07:00 and 18:00 at sites characterized by frequent human–macaque contact. The researcher monitored the first macaque troop encountered, recording all behavioral interactions until the contact ceased.— Once human–macaque interactions concluded, the researcher relocated to identify and observe subsequent troops. This sampling protocol ensured that observations focused on active interaction bouts throughout the day. In total, interactions were documented across nine distinct troops at nine separate locations (Table 1, Figure 1).

Scan sampling (2-min scans conducted at 15-min intervals) was used to record as many individuals as possible across different age–sex classes within each focal troop [9], [10]. The following variables were recorded, including troop identity, age, and sex class (Table 2), type of interaction, food type, distance between humans and macaques during interactions, time of arrival and departure, and the nationality of the interacting person.

The ethogram and data protocols were adapted from established frameworks: interaction scoring followed [11], while behavioral intensity and interaction classification were based on [12] (Table 3). Food resources were categorized as natural or anthropogenic according to [13], [14]. Age–sex categories for *M. mulatta* were defined (Table 2) following the criteria established by [15]–[17].

Data from the field sheets were transcribed and categorized into a digital database of discrete variables for statistical analysis. All data processing, analysis, and visualization were performed in R version 4.5.2 [18]. Statistical procedures followed the methodologies described by [18], ensuring consistency in data handling and interpretation.

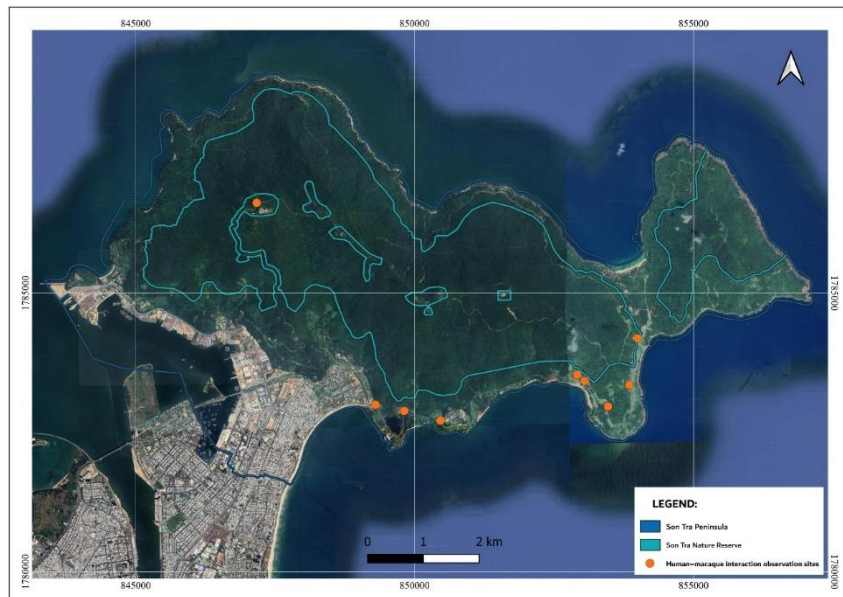


Figure 1. Map of human-macaque interactions study sites on Son Tra Peninsula, Da Nang, Vietnam

Table 1. Locations and site characteristics of the 9 macaque troops engaging in human macaque interactions

Troops	Site characteristics	Coordinates
1	Le Van Luong Street and the shrine at the beginning of Hoang Sa Road.	16.102127 N, 108.264909 E
2	The section at the start of Hoàng Sa Road near the entrance to Ho Xanh (Green Lake).	16.101068 N, 108.269692 E
3	The stretch on Hoang Sa Road before reaching Linh Ung Pagoda, where there are two scenic viewpoints along the roadside, and morning vendors often set up stalls.	16.099408 N, 108.275732 E
4	The three-way junction in the middle of Hoang Sa Road has a right turn leading down to the beach.	16.105458 N, 108.299985 E

5	The section on Hoang Sa Road, where there is a bridge with a stream flowing across.	16.106461 N, 108.298752 E
6	A section on Hoang Sa Road marked by the road sign “300 m, 4823+GG3, Son Tra, Da Nang”.	16.101250 N, 108.303809 E
7	The stretch on Hoang Sa Road with a bare mountainside and a bougainvillea tree.	16.104667 N, 108.307439 E
8	The dual-carriageway section near the InterContinental.	16.112235 N, 108.308939 E
9	Near the Son Tra Radar Station and the paragliding launch site.	16.135134 N, 108.245534 E

Table 2. Morphological identification for *Macaca mulatta* ([15]-[17])

Age/Sex Group	Pelage & Facial Features	Sexual / Genital Characteristics	Morphometrics (Approximal Weight & Length)
Infant (< 6-7 months)	Crown hair is parted by a midline bare area. Pelage is thin, fine-textured, and darker than adults (pale to dark brown). Face skin is purple at birth, turning pale pink within 5 minutes, and then buffed by 2 months.	No external sexual differentiation visible by size or secondary traits.	Weight: ~1.1–1.2 kg. Head & body length: ~230 mm. Large ears relative to head size.
Juvenile (7 months to ~3 years)	Coronal parting disappears by 6 months. Pelage becomes similar to that of adults in color and texture. Face remains buffy/yellowish.	Sexes are difficult to distinguish based on external size or morphology and can only be reliably determined from the genital organs.	Weight: ~2.5–4.1 kg. Head & body length: ~300–350 mm.
Subadult Female (3–4 years)	Pelage becomes sleeker; the contrast between the yellowish-gray upper back and reddish-orange lower back begins to define.	Sexual skin starts showing cyclical changes in color and slight swelling. Growth rate slows compared to males after age 3–4.	Weight: ~4.5–6.6 kg. Head & body length: ~390 mm.
Subadult Male (3–6 years)	Pelage becomes thicker. The body becomes noticeably more muscular	Permanent canines begin to erupt. Testes begin to descend and enlarge significantly.	Weight: ~4.4–6.2 kg. Head & body length: ~350–430 mm.

	than that of females after 4 years of age.		
Adult Female (> 4-5 years)	Pelage is lustrous in prime condition. The lower back is conspicuously more erythristic (burnt orange) than the upper back.	Broadly distributed sexual skin undergoes intense cyclical swelling and reddening during the mating season.	Weight: Species average 5.34 kg. Head & body length: ~440 mm.
Adult Male (> 6 years)	Sleekest pelage, especially in dominant individuals. Facial skin is reddish with unpigmented white upper eyelids. The alpha male typically carries his tail raised in a question-mark shape while moving.	The glans penis is blue-black. Possesses very large permanent canines. Sexual dimorphism is fully realized; males are ~13% longer and ~44% heavier than females.	Weight: Species average 7.70 kg. Head & body length: ~480 mm.

Table 3. Classification and scoring of human macaque interaction intensity levels

Interaction	Rank	Notes
A person stands near the macaques without looking at them or performing any action directed toward them.	1	Causes minimal disturbance to the macaques.
A person watches the macaques, records videos, or takes photographs.	2	Causes mild disturbance to the macaques.
Pointing at the macaques, calling them, waving, or speaking to them.	3	Causes noticeable disturbance and attracts the macaques' attention to the person.
Shaking trees, making threatening gestures, wagging fingers at the macaques, or throwing light objects toward them without making contact.	4	Elicits strong attention from the macaques but does not substantially alter their behaviour; individuals typically resume previous activities after the interaction.
Releasing a dog to chase the macaques or pretending to strike them.	5	Forces macaques to interrupt ongoing activities and adopt vigilance or avoidance responses toward humans.

Throwing objects that lightly hit the macaques, or gently poking them with sticks, poles, or other objects.	6	Represents a low risk of human-to-macaque pathogen transmission and exposure to potentially harmful objects.
Throwing objects forcefully, poking the macaques strongly, or direct physical contact by hand (e.g., hitting or petting).	7	Represents a moderate risk of human-to-macaque pathogen transmission and exposure to potentially harmful objects.
Feeding macaques with natural food items.	8	Represents a high risk of pathogen transmission and increases the likelihood of behavioural alteration associated with anthropogenic food provisioning.
Feeding macaques with artificial or processed foods.	9	Represents a high risk of pathogen transmission and promote dependency on humans, as such foods are not naturally available in the environment.
Spitting at macaques and contaminating them with saliva.	10	Represents a very high risk of transmitting human pathogens.

2.2. Results and discussion

2.2.1. Results of human-macaque interactions

Statistical analysis of the nine observed macaque troops identified Troops 8, 3, and 1 as having the highest interaction intensities on the Son Tra Peninsula. Troop 8 exhibited the most pronounced habituation; raw data indicated consistent high-intensity interactions, frequently scoring 9 on a 10-point scale. A one-way ANOVA confirmed significant differences in interaction intensity across the nine troops $F(8, 7231) = 25.6$; $p = 2e^{-16} < 0.001$; $N = 7240$) (Figures 2 and 3). Subsequent post-hoc analysis using the Tukey Honest Significant Difference (HSD) test graph analysis also showed that Troop 8 had significantly stronger interaction intensity than Troop 1 (adjusted p-value $\approx 0.00000001 < 0.05$), proving that it is one of the most highly habituated troops. Similarly, Troop 3 displayed consistently high interaction levels (median score of 9) and a high frequency of occurrence during observation periods, suggesting a strong reliance on anthropogenic food sources. Troop 1 showed comparable patterns, frequently occupying tourist hotspots with interaction scores ranging between 8 and 9. Notably, while troop 7 was encountered less frequently, it was the only group in the data with a record reaching the maximum intensity level of 10. This indicates that, despite lower encounter rates, specific individuals within Troop 7 exhibit extreme interaction behaviors.

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Troop	8	1909	238.57	25.6	<2e-16 ***
Residuals	7232	67391	9.32		

Figure 2. The Tukey honest significant difference test graph analysis between macaque troops

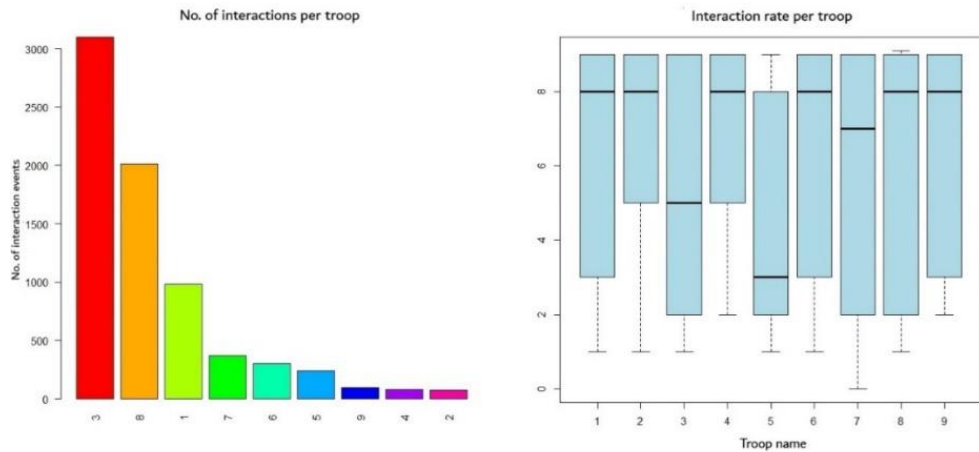


Figure 3. Interaction levels of macaque groups in Son Tra

Human-macaque interactions exhibited distinct bimodal peaks, occurring primarily between 09:00–11:00 and 15:00–17:00 (Figure 4).

The relationship between the two sexes of the macaques interacting with humans and the types of food the macaques were provisioned, processed anthropogenic food (hereafter referred to as “artificial food”) was more prevalent than natural food sources is shown in Figure 5, which indicates that the column representing female individuals interacting with humans for food is larger than the column representing male individuals. A chi-square test confirmed that this sex-based difference in interactions for food was statistically significant ($\chi^2 = 9.761$, $df = 1$, $p\text{-value} = 0.001783$).

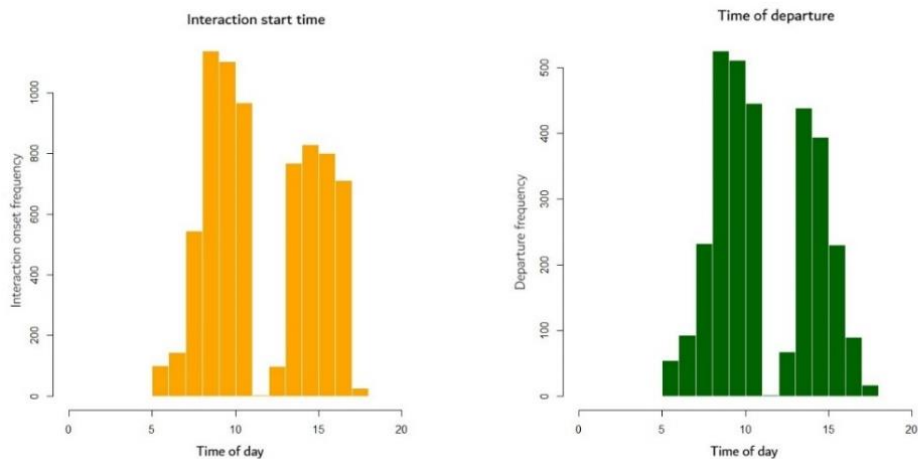


Figure 4. Time of day for macaque-human interaction

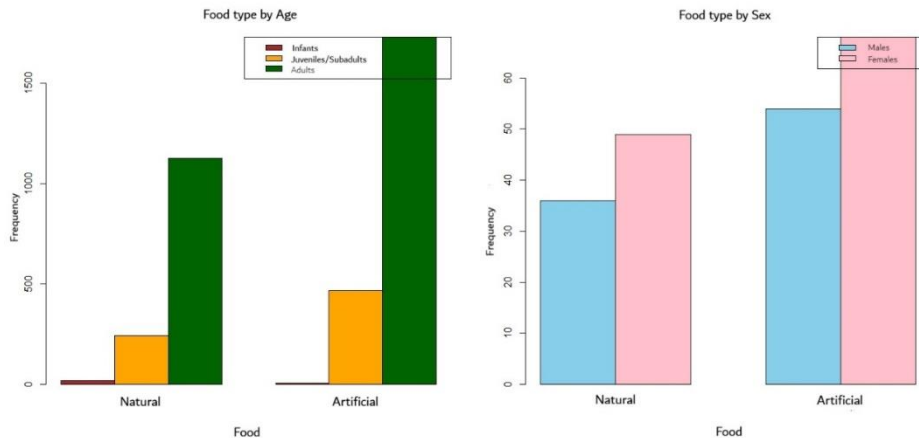


Figure 5. Sex-based differences in macaques and the types of food consumed during human provisioning

Regarding age, Figure 6 shows that immature macaques interacted with humans more frequently and with greater intensity than adults, while infants exhibited minimal interaction. A one-way ANOVA confirmed that these differences across age groups were statistically significant (F value = 67.75; $Pr(>F) < 0.05$). This suggests that younger, independent individuals are the most active participants in anthropogenic interactions.

To verify these results and address the ordinal nature of the interaction intensity scale (1–10) and the non-normal distribution of behavioral data, the study employed a Kruskal-Wallis rank sum test. The test yielded highly significant results ($\chi^2 = 131.06$; $df = 2$; $N = 7240$; $p < 2.2 \times 10^{-16}$), confirming that age is a significant predictor of interaction behavior and suggesting that habituation follows a distinct ontogenetic trajectory. To further quantify these differences on a latent scale of boldness, a Cumulative Link Model (CLM) with a logit link function was utilized, providing estimated marginal means (emmeans) that rank the age groups by their proactive interaction tendencies. According to the CLM output ($N = 7240$), juveniles/subadults exhibited the highest latent mean boldness score of 0.921 ± 0.09 (SE), followed by adults at 0.531 ± 0.08 (SE), while infants remained at a significantly lower baseline of -1.210 ± 0.20 (SE). This hierarchy indicates that the juvenile cohort represents the most highly habituated demographic, likely driven by a combination of reduced natural caution and social learning.

The nuances of these age-based disparities are most clearly articulated through pairwise comparisons via Dunn's test (with Benjamini-Hochberg adjustment), which pinpoints the specific intensity of the differences between each group. The statistical divergence was most pronounced when comparing juveniles to infants ($Z = 10.73$; $p < 0.001$), reflecting the minimal interaction displayed by dependent infants. Crucially, the significant gap between juveniles and adults ($Z = 6.64$; $p < 0.001$) statistically corroborates the observation that younger macaques are significantly more daring and persistent than mature individuals. These findings are consistent with the initial one-way ANOVA results ($F(2, 7237) = 67.75$; $p < 0.001$), confirming that the "daring" behavior associated with close-range food solicitation is predominantly a juvenile trait. Consequently, management interventions should prioritize the juvenile demographic,

as their current lack of caution and high reliance on anthropogenic food sources pose the greatest long-term risk for permanent behavioral alteration and intensified human-wildlife conflict within the reserve.

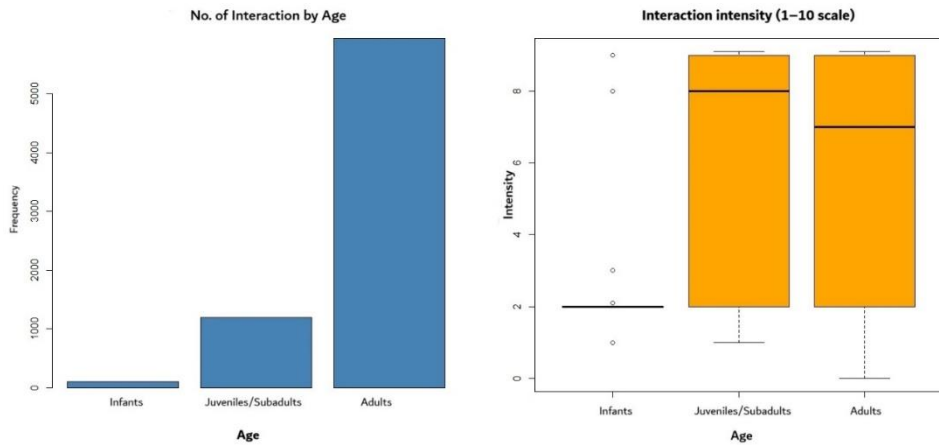


Figure 6. Differences in macaque age when interacting with humans

Regarding spatial proximity and individual characteristics, statistical analysis shows that macaques are mostly 2 to 3 meters away from humans. However, closer approaches (0.5–1.0 meters) were frequently observed during direct anthropogenic provisioning (Figure 7). In particular, injured individuals exhibited a higher propensity to approach humans, likely as a strategy to secure easily accessible food resources.

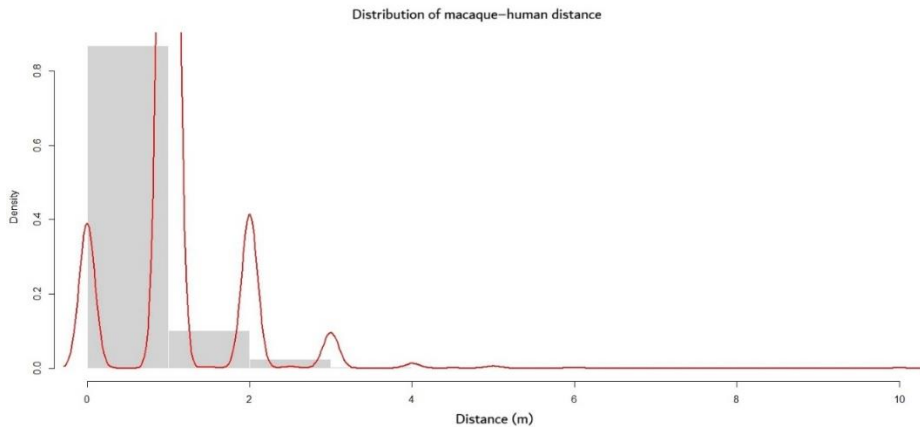


Figure 7. Interaction distance between macaques and humans

When analyzing whether Vietnamese or foreign people interacted more with macaques, the results showed a very clear statistical difference between the two groups of visitors interacting with macaques (Vietnamese and foreign visitors, Figure 8). In which, $\chi^2 = 22.123$, $df = 1$, $p\text{-value} = 2.558e^{-06}$. Comparative analysis of visitor demographics revealed a significant disparity in interaction patterns between domestic and international visitors (Figure 8, $\chi^2 = 22.123$, $df = 1$, $p\text{-value} = 2.558e^{-06}$). This variation reflects distinct behavioral tendencies between the two cohorts; domestic visitors were significantly more proactive in provisioning macaques, primarily utilizing artificial food sources. The high statistical significance of this result ($p=0.000002558$) underscores that

anthropogenic feeding is a culturally-mediated behavior that must be addressed within the tourism management framework of the Son Tra Peninsula.

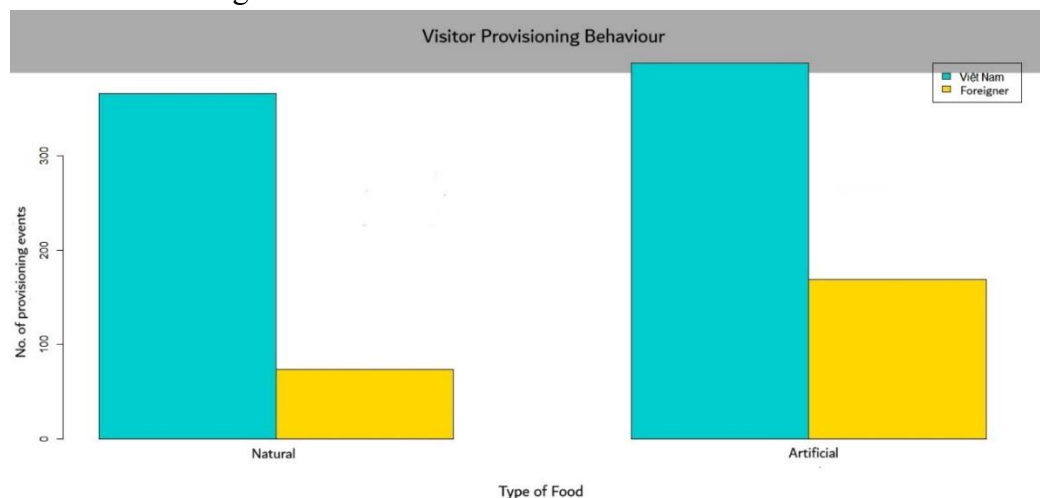


Figure 8. Differences between Vietnamese and foreign visitors in macaque provisioning and the types of food provided

2.2.2. Discussion

The level of interaction with humans of each macaque troop varies, potentially influenced by its home range and its overlap with human activity zones. Troops whose territories are frequently visited by humans tend to interact more, and vice versa [2], [3]. Troop 8 is found near Linh Ung Pagoda, a spatial overlap with significant interaction. Troop 3 is found along the roadside near Linh Ung Pagoda, proximal to a roadside establishment situated at a scenic viewpoint, attracting many visitors for food and photography. Troop 1 is frequently seen on Le Van Luong Street and at the shrine at the beginning of Hoang Sa Street, where they often enter people's homes to forage and eat offerings from the shrine. Furthermore, Troop 7 is often seen near the InterContinental Resort, an area with many tourists and street vendors. These locations represent critical interfaces where high human accessibility and abundance of unsecured waste facilitate frequent inter-species contact.

The temporal distribution of human–macaque interactions during the morning and afternoon aligns with the diurnal activity peaks of both residents and tourists on the Son Tra Peninsula. As these macaque populations remain primarily free-ranging and continue to forage within the forest, they appear to opportunistically exploit human presence to secure energetically dense food resources.

However, feeding macaques primarily with artificial food can cause digestive problems for the macaques due to changes in microbial richness compared to individuals living in their natural environment. Furthermore, these close-contact interactions facilitate the zoonotic transmission of parasites and bacteria between humans and wildlife [19]. The higher proportion of artificial food compared to natural food may be due to tourists commonly bringing packaged food due to their transportability and ease of handling.

The observation that injured individuals appeared to approach humans more closely to obtain food represents a novel finding not previously documented in the literature. Previous studies suggest that adult males tend to approach humans more closely and intensely due to their social dominance and protective roles within the troop [20], [21]. One possible explanation is that these injured individuals had already developed pre-existing foraging habits in proximity to humans, which may have increased their risk of accidents leading to injury. Domestic visitors tended to interact indirectly by throwing food, whereas international visitors primarily engaged in passive observation and photography. These behavioral variations may reflect broader cultural differences in wildlife perception [22] or varying levels of habituation to macaque presence [5]. Domestic visitors, possessing greater familiarity with the species, may also possess specific local ecological knowledge regarding which actions are less likely to provoke aggressive responses from the macaques.

3. Conclusions

In conclusion, human-macaque interactions at Son Tra are driven by a complex interplay of visitor behavior and primate life-history stages. The high frequency of feeding by Vietnamese tourists indicates a substantial reliance on anthropogenic food sources within specific troops, notably Troops 3 and 8, which emerged as the most highly habituated and potentially high-risk groups. Immature individuals represent the priority demographic for management intervention, as their heightened boldness may lead to long-term behavioral shifts. Interaction distances consistently falling below 3 meters pose severe risks for zoonotic pathogen transmission and physical injury. Furthermore, the observation that injured individuals maintain closer human proximity suggests an adaptive foraging strategy to mitigate physical limitations. Management efforts must prioritize the strict enforcement of "no feeding" regulations, particularly targeting Vietnamese tourist hubs. Communication strategies should be tailored to different nationalities to address the varied ways they interact with the macaques. Continuous monitoring of the most habituated troops, such as Troop 3 and Troop 8, is imperative to track the progression of habituation and mitigate escalating aggression. Finally, further longitudinal research is required to evaluate the nutritional and physiological impacts of anthropogenic diets on the long-term health of this macaque population.

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Ethics statement. All research protocols reported in this manuscript complied with Vietnam's legal framework for wildlife protection, specifically Government Decree 06/2019/NĐ-CP and its amendment Decree No. 84/2021/NĐ-CP. The study also adhered to the American Society of Primatologists (ASP) Principles for the Ethical Treatment of Non-Human Primates. The study was strictly non-invasive and observational, involving

no physical contact, laboratory manipulation, or biological sampling of animals. Regarding human subjects, data collection was limited to recording observable demographic characteristics, such as nationality, at public interfaces. No personal identifying information was collected, and no direct interactions occurred between researchers and the visitors observed, ensuring anonymity. All procedures were approved and conducted under Contract No. 03/HD-SKHCN with the People's Committee of Da Nang city.

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