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The Behavioral Response of Komodo Dragons (*Varanus komodoensis* OUWENS, 1912) During Mating and Nesting Periods towards Tourist Presence in Loh Buaya, Komodo National Park

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Abstract

It has been recognized in many studies that wildlife tourism practices might generate a negative impact on wildlife, particularly during the reproductive period. Some wildlife may lower their sensitivity towards tourist presence, for instance in Komodo. Understanding to what extent habituation occurs in Komodo would be necessary for tourism management in Komodo National Park (KNP). Therefore, this study aimed to identify the response of Komodo to tourist presence during mating and nesting activities. The observation was conducted in Loh Buaya, which is one of the tourism sites in KNP. Komodo's responses were divided into (1) avoidance; (2) neutral; and (3) aggressive under categorized stimulus: tourist number (i.e., < 5 persons; 5-10 persons; and > 10 persons) and distance (i.e., < 5 m; 5-10 m; and > 10 m). Correlation analysis was performed to identify any influences on mating and nesting activities. Our results revealed that Komodo inhabiting tourism facilities have been habituated to tourist presence. Different tourist frequencies did not influence Komodo mating activities ($r(20)= 0.036$, $p=0.873$), the nest preparing activity (i.e., digging proportion; $r(22)= 0.054$, $p=0.803$) and the guarding activity (i.e., nesting proportion; $r(22)= 0.314$, $p=0.135$). Nevertheless, our results indicated possible impacts due to tourism activities and its supporting facilities, such as dominated mating pairs, threats to female reproductive success, and human-Komodo conflicts. Therefore, habituation evidence must be carefully considered in order to develop more corresponding strategies and achieve sustainable tourism practices.

Keywords: *wildlife tourism, Komodo, reproductive behavior, habituation*

1. Introduction

Interaction between humans and wildlife has occurred for a long time. It could come up with consumptive activities, e.g., hunting, or non-consumptive activities, such as tourism [1]. Tourist motivation for visiting nature could be varied and not limited to observing wildlife, for instance, visitors' activities in Bako National Park were mostly related to trekking, enjoying nature scenery, observing wildlife, experiencing a relaxing environment, and taking nature photographs [2]. Nevertheless, in wildlife tourism, which makes wildlife encounters the main product, tourist satisfaction might be greatly influenced by the quality of their experience generated from the interaction with wildlife [1]. Many managers would come up with some strategies to improve the outcomes by building trekking tracks [3], watch towers, artificial water holes [4], and wildlife feeding [4–6].

The impacts of tourism activities on wildlife have been reported in many studies, particularly during the breeding seasons. Animal reproductive activities become a highly interesting attraction for tourists, yet wildlife may experience great pressure [7]. Human visits during the early incubation period resulted in a lower nesting success rate in Common Eiders compared to late period visits [8]. Furthermore, human presence may force wildlife to exhibit antipredator behavior, which may reduce their body conditions [9,10] and cause behavioral changes [11]. In the study of the Iberian rock lizard, antipredator behavior caused the male individuals to spend more time in refuge and ultimately lose their mating opportunities [12].

In order to offset the cost due to antipredator behavior, some wildlife could adjust their response through habituation.

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Muting the antipredator behavior by lowering their sensitivity may provide benefits for wildlife. Habituated individuals can relatively improve their body conditions [13] and maintain their reproductive success [11]. Nevertheless, habituation does not always come with positive consequences, such as human-wildlife conflict [14,15]. Regardless of the benefit and cost to wildlife, habituation sometimes becomes a desirable result in wildlife tourism practices [1,13,16].

In general, wildlife might be forced to decrease their sensitivity level due to the absence of alternative habitats [17] or because the benefit provided exceeds the cost [7]. Habituation may differ between species or individuals based on genetic and learning abilities to specific stimuli or environmental conditions [14,18]. Individual characteristics, such as gender, may influence the rate of habituation [19]. Moreover, the degree of stimulus will also influence the wildlife sensitivity level [11]. Therefore, with these varying factors and results in the habituation process, more comprehensive information would be necessary to draw the conclusions in the wildlife response to human presence.

The world's largest living lizard, the Komodo (*Varanus komodoensis* OUWENS, 1912), has a very limited distribution in five islands in the East Nusa Tenggara region, four of which are within the Komodo National Park [20–22]. Komodo National Park (KNP) is one of the conservation areas intended to protect the well-known lizard population and their natural habitat. The tourism practice with Komodo as the main attraction has grown steadily since the establishment of KNP in the 1980s [4]. According to the Bureau of Statistics [23], total number of visitors in KNP increased from 68,000 (2015) to 178,683 (2018) individuals/year. Furthermore, the peak season for visitors was July-August, which also happens to be Komodo dragon reproduction season [24]. The mating and nesting activities might be highly attractive for visitors to observe, yet it was also the most sensitive period for the Komodo population.

Komodo habituation to visitors has been discussed in a previous study. It was reported that the Komodo inhabiting the high human activity areas were less sensitive (or habituated) [25]. Despite an extensive examination of human activity's impact on the population, the discussion of Komodo's habituation was limited to direct responses, with no extension to other behaviors such as mating and nesting. According to Auffenberg [24], Komodo will exhibit aggressive behavior during mating and nesting activities. Therefore, understanding the Komodo response to tourist presence during those times may provide more information about the extent of habituation.

This study aimed to identify the Komodo's response to tourist presence during mating and nesting activities. The response would be assessed under different tourist numbers (i.e., low, moderate, and high) and distances (i.e., near, moderate, and far). In particular, we would like to identify whether there were certain numbers or distances that could possibly terminate mating and nesting activities. Furthermore, the relationship between the stimulus and reproductive behavior would be assessed to determine the influence of tourist presence. Ultimately, it may provide extensive information regarding the habituation of Komodo.

2. Methodology

2.1 Description of Study Area

This study was conducted at a tourism area in Loh Buaya, Rinca Island, Komodo National Park (Figure 1). The ecosystems in that area were dominated by deciduous monsoon forest and savanna grassland. The climate consists of a long-dry season in March-November and a short-wet season in December-February [21,24]. Six nests had been observed in this study, but one of those was different from the last study reported by Jessop et al. [26].

Mating observation was conducted around the Tourism Supporting Facility Area (TSFA) such as the barrack, kitchen, café, guest house, and office. Meanwhile, a nesting observation was performed on a potentially active nest. According to a previous study, the active nests of Komodo are usually located under ≤ 25% of vegetation canopy coverage [27]. In order to carry out our research design, the observed nest should be located under 10 meters with the tourism track. It was determined by komodo's ability to clearly distinguish a person from another object at six meters [24]. Therefore, there were only two possible nests that meet the criteria, which were LBM1 (i.e., Loh Buaya Mount-Nest) and LBM2 (Figure 2).

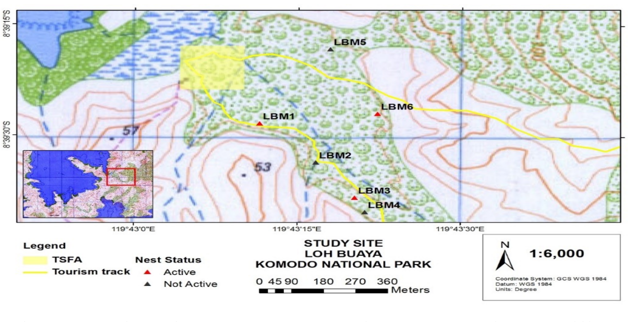

Figure 1. Map of study area in Loh Buaya that shows TSFA (Tourism Supporting Facility Area that consists of barac, cafetaria, kitchen, guest house, office, and other facilities), nest distribution (red: active nest and dark: not active nest) and its relative distance to tourism track.

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Figure 2. Observed Komodo's Nest (A) LBM1 and (B) LBM2.

LBM1 and LBM2 are mount-type nests and located in a deciduous monsoon forest. The average solar radiation intensities were 90.97 (SE) 1.52 Lux (LBM1) and 90.20 (SE) 1.30 Lux (LBM2). Due to the direct exposure to an open area (> 75% of total surrounding cover), LBM1 is likely to experience higher pressure than LBM2.

2.2 Behavior Observation

This study was conducted at a tourism area in Loh Buaya, Rinca Island, Komodo National Park (Figure 1). The ecosystems in that area were dominated by deciduous monsoon forest and savanna grassland. The climate consists of a long-dry season in March-November and a short-wet season in December-February [21,24]. Six nests had been observed in this study, but one of those was different from the last study reported by Jessop et al. [26].

Mating activities were observed using the Focal sampling method and limited to the pairs that were observed mating around TSFA. Those pairs would be categorized into resident and visitor pairs. The resident pairs (i.e., both male and female individuals) were distinguished by their regular presence around TSFA. All individuals were firstly identified by their natural marks, such scars [28]. Copulation duration and interval (i.e., pre-copulation and post-copulation) were recorded during observation. When one of the two individuals left the TSFA, the observation would come to an end.

A similar method was also performed for nesting observation. The observations were limited from pre-egg laying phase to the first week of the post-egg laying phase. This period was thought to be the most vulnerable to disturbances [8]. A single female individual from either LBM1 or LBM2 would be continuously observed for 12 h (i.e., 06.00-18.00) based on Komodo's daily active period [24]. The observation will be focused on single female individual that was firstly recorded to starting her nesting activity. Duration of other nesting activity, including resting would be recorded during this observation.

2.3 Assessment of Response Toward Tourist Presence

The direct responses were divided into three categories: (1) Avoidance, i.e., Komodo stop the activities and run away from tourists, which results in a broken mating pair or nest abandonment; (2) Neutral, i.e., Komodo continue the mating or nesting activities; and (3) Aggressive, i.e., Komodo stop the activities and run toward tourists in an aggressive course.

The tourism stimuli were categorized by the number of tourists in one group and observation distance. The management of Komodo National Park has decided that one guide will accommodate a maximum of five visitors in a single group. It is also possible that a single group will have more than 5 participants and will be led by more than one guide. Therefore, this threshold was used to define the number of tourist categories: low (i.e., < 5 persons in a group); moderate (i.e., 5-10 persons in a group); and high (i.e., > 10 persons in a group). The observation distance was also classified as close (5 m), moderate (5-10 m), and far (> 10 m). That was based on Komodo's ability to clearly recognize an object at 6 meters [24]. Under the conditions where multiple groups occurred, the total number of visitors, which was then calculated into tourist frequency (i.e., visitors/minute), and the nearest distance would be recorded.

2.4 Statistical Analysis

Differences in mating activity (i.e., pre-copulation, copulation, post-copulation, and total mating) between resident and visitor pairs were analyzed using a t-test. If the data could not meet the parametric test assumptions, then the Mann Whitney U test would be performed [28]. Similar methods were used to analyze differences in nesting activity (i.e., digging activity, other nesting behavior, total nesting, and foraging) between the pre-egg laying and post-egg laying phase. Furthermore, the Chi-square test will be used to examine the difference in Komodo's response to all stimulus categories. Furthermore, the Pearson's correlation test will be used to determine any impact of tourist presence on mating behavior. It aimed to see the relationship between visitor frequency and mating proportion (i.e., copulation behavior/mating interval). Similar methods were used to investigate the effect of visitor frequency on nesting behavior. We tried to identify whether the visitor frequency influences nest-preparing behaviors (i.e., digging/other nesting behaviors) as well as nest-guarding behaviors (i.e., nesting/foraging). The R program (R GUI version 4.0.4, assisted by R Studio version 1.4.1106) was used for all statistical analysis.

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3. Results and Discussion

3.1 Mating Behavior

Two pairs, which are resident (i.e., ♂1 and ♀1; Figure 3 A and B) and visitor (i.e., ♂5 and ♀4; Figure 3 C and D), were observed mating around TSFA during this study (Table 1 & Figure 4). The resident pair was observed mating 13 times in two consecutive days and visitor only mating nine times in a single day. The resident pair exhibited a longer duration of total mating (U= 84.5, p= 0.044), pre-copulation (U= 88, p= 0.022) and post-mating (U= 94, p= 0.019). Nevertheless, copulation duration was not significantly different between those pairs (U= 45.5, p= 0.396).

Table 1. Mating and nesting behavior of Komodo

No	Behavior	df	Duration (minute)			
			Min	Max	Avg	± SD
Mating Behavior						
1	Pre-Copulation	21	1	46	12.82	13.84
2	Copulation	21	2	10	4.36	2.14
3	Post-Copulation	19	0	65	18.63	15.59
4	Total Mating	21	6	99	33.27	25.04
Nesting Behavior						
1	Digging	23	0	642	98.04	146.76
2	Other nesting behaviors	23	0	684	293.42	241.62
3	Total Nesting	23	0	716	391.46	236.74
4	Foraging	23	0	725	290.50	234.72

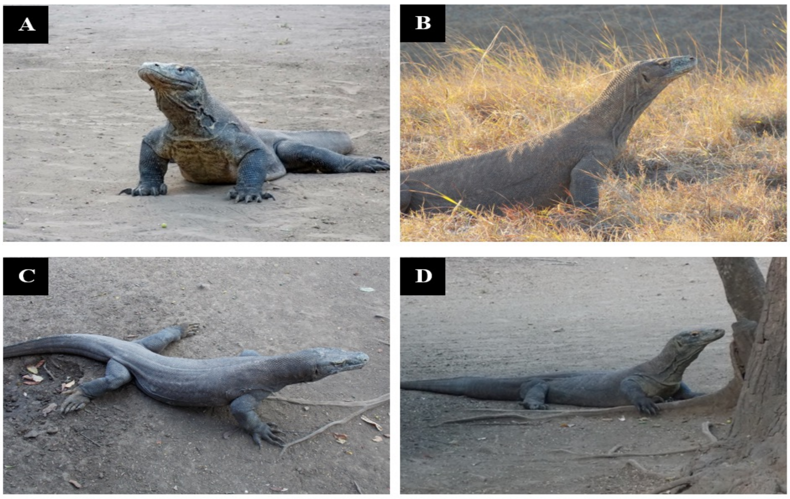

Figure 3. Focal Individuals (Resident pair: (A) ♂1 (Johnson) and (B) ♀1 (Jessica). Visitor pair: (C) ♂5 (Jeremy) and (D) ♀4 (Jane)).

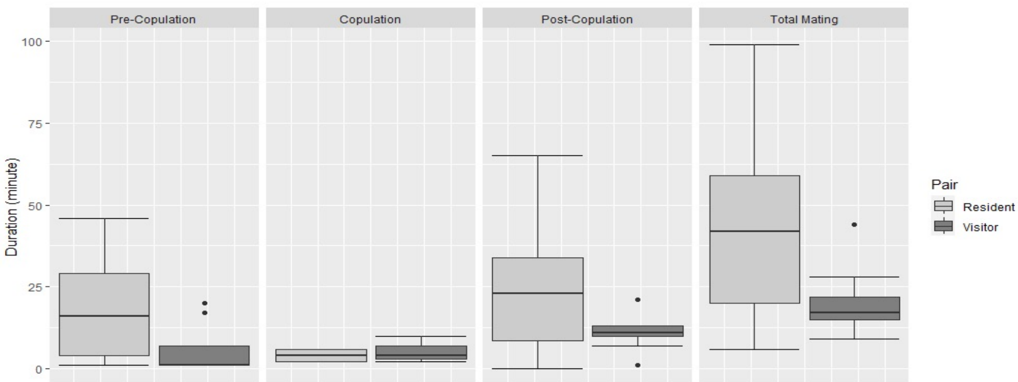

Figure 4. Komodo mating behavior.

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3.2 Nesting Behavior

During our fieldwork, we recorded that three of six Komodo nests were active, which were LBM1, LBM3, and LBM 6 (Figure 1). The active nest was distinguished by the presence of female individual during the nesting period. Nevertheless, the observation was carried out at LBM1, since it met with the given criteria. Individual ♀1 was observed nesting at LBM1 in 21 days after the last mating with ♂1. Nevertheless, she was also spotted mating with another male individual the day before it, but the data was not included in the analysis. Nesting activity became more intensive on day 6th and carried on for another 12 days until eggs were laid. There was a different in nesting activity between preparation and guarding phase (Table 1 & Figure 5). Total nesting (U= 30, p= 0.032) and other nesting behaviors (U= 11, p= 0.001) were significantly higher during the post-egg laying period. On the other hand, digging (U= 86.5, p= 0.044) and foraging (U= 94.5, p= 0.028) were recorded significantly lower in that period.

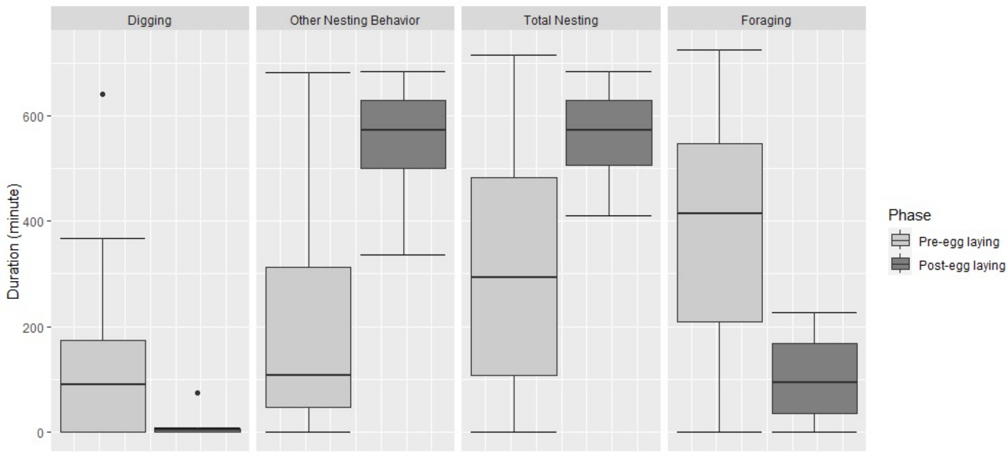

Figure 5. Komodo nesting behavior.

3.3 Komodo Response Towards Tourist

Both resident and visitor pairs exhibited neutral responses in all stimulus categories (Table 2). The highest number of visitors was 40 persons with the closest distance was 3 meters. The average tourist frequency was found to be significantly higher in the resident (6.08 ± (SE) 0.98 tourists/minute) than visitor pairs (1.76 ± (SE) 0.61 tourists/minute; U=1895, p=0.001). The resident pair was observed mating more frequently than the visitor pair around the study area. It increased the possibility of multiple tourist groups occurring and affected the average tourist frequency. In addition, different tourist frequencies did not influence Komodo mating activities ($r_{(20)}$= 0.036, p=0.873; Figure 6). All the stimulus categories and pairs were not analyzed separately due to the limited data available.

Table 1. Komodo response towards tourist presence during mating and nesting activities

Parameters	Mating Response				Nesting Response			
	N	1	2	3	N	1	2	3
Less than 5 persons								
< 5 m	32	0	32	0	30	0	30	0
5-10 m	28	0	28	0	204	0	204	0
>5 m	1	0	1	0	11	0	11	0
5 – 10 persons								
< 5 m	15	0	15	0	9	0	9	0
5-10 m	22	0	22	0	119	0	119	0
>5 m	0	0	0	0	14	0	14	0
More than 10 persons								
< 5 m	6	0	6	0	3	0	3	0
5-10 m	6	0	6	0	45	0	45	0
>5 m	1	0	1	0	4	0	4	0

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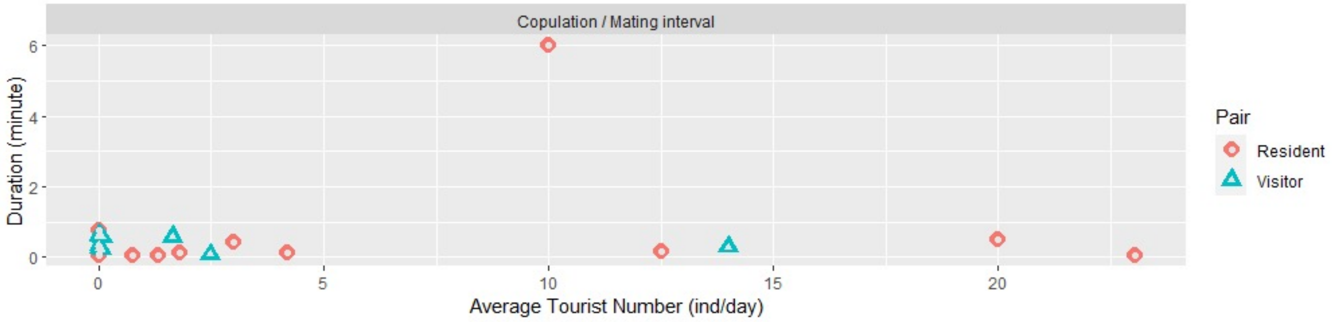

Figure 6. Relationship between Komodo mating behavior (i.e., copulation proportion) and tourist frequency

Individual ♀1 exhibited a neutral response in all stimulus categories during pre-egg laying and post-egg laying phase (Table 2). During the nesting observation, the highest number of tourists was 35 persons with the closest distance was 5 meters. The average tourist frequency for the pre-egg laying (4.13 ± (SE) 0.29 tourists/minute) was significantly lower than the post-egg laying (5.83 ± (SE) 0.11 tourists/minute; U=1476, p=0.003). Individual ♀1 was recorded to spend more time around the nest during post-egg laying phase. Therefore, multiple groups were more likely to occur, which increased the average tourist frequency. Furthermore, different tourist frequencies had no influence on nest preparation activity (i.e. digging proportion; $r_{(22)}$= 0.054, p=0.803; Figure 7) and guarding activity (i.e. nesting proportion; $r_{(22)}$= 0.314, p=0.135; Figure 7). All the stimulus categories and nesting phases were not analyzed separately due to the limited data available.

Figure 7. Relationship between Komodo nesting behavior and tourist frequency. (A) Digging proportion and (B) Nesting proportion

Both resident and visitor pairs appeared to be already habituated to tourist presence. All the mating events were not influenced by the tourist's presence (i.e., there was no evidence in broken mating pair). Moreover, different tourist stimulus categories did not seem to cause the mating duration shorter or longer. Nevertheless, according to our observations, mating occurred more frequently under the low tourist frequency. Unfortunately, we could not make any clear judgements regarding the relationship between mating frequency and tourist numbers due to the limited data available.

Furthermore, we were unable to determine whether the lower mating occurrence on visitor pairs was due to their lower habituation level when compared to resident pairs. We recorded that the visitor pair performed mating only on a single day around the TSFA. According to the data, the pair exhibited no response toward tourist presence during mating. We

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assumed that the mating occurred when the male individuals extended their home range during the reproductive period and overlapped with the female [29]. It has been reported in a previous study that mating in Komodo often take place near carcass [24]. Therefore, human activities in the TSFA may attract Komodo to aggregate [25]. Without the presence of the dominant resident male, other individuals, particularly the subordinate male or visitors, could have an opportunity to mate around the TSFA [30].

The resident exhibited a longer duration in mating activities (i.e., pre-copulation and post-copulation) than the visitors. Mating duration in Komodo could be influenced by the male's experience. A younger male individuals take longer mating time than a more experienced older male individuals [24]. The longer mating duration in the resident pair might be influenced by a high individual density around the TSFA which could increase the competition among male individuals. It has been reported in the previous study that Komodo were attracted to tourism facilities, particularly the kitchen [25]. With a male:female ratio that is skewed toward male (i.e., 3.3:1), the competition will be on the male individuals to find a mating partner [24,30]. Our observations supported this suggestion. All the resident pair mating activities were occurred in the middle of individual aggregation around the TFSA. There were almost 15 occurrences of mating disturbances recorded during the mating observation.

Moreover, a high frequency of interaction among resident individuals due to aggregation may also influence female receptivity. According to Auffenberg [24], female individuals would tend to exhibit aggressive behavior toward male individuals. Bigger male individuals ofter attack smaller individuals, including females, while eating a carcass in aggregation. Mating rejection by females may also be affected by their receptive period, which could be different among individuals [30,31]. Nevertheless, female individuals will finally accept mating to avoid a bigger cost generated from male coercion [32]. Unfortunately, our observations could not distinguish the receptive period of the female resident during mating activities.

Human disturbance during the nesting period often leads to some unfavorable consequences, such as nest abandonment [8]. Nevertheless, such evidence was not detected on our focal female. Individual ♀1 did not abandon her nest during tourist visits in both phases. During preparation phase, high tourist frequency did not interfere digging activity. Moreover, it also did not seem to have any influence on nesting behavior during the guarding phase. Unfortunately, less habituated females were not covered by this study, which might prefer to avoid nesting in disturbed areas [17].

Low availability of suitable nest might turn the habituation as a preferable way for individual ♀1 in order to depress the cost, otherwise more energy should be spent for exploring other potential nests outside the disturbed area [7,8,17,33]. Nevertheless, adverse consequences might remain to emerge. Our camera trap results indicated that the LBM1 had experienced the highest pressure from egg predators due to its surrounding openness compared to the other more isolated active nests (e.g., LBM3 and LBM6). Opening habitat is often implemented in tourism practice, and it has been reported that this could potentially increase nest predation [11,34]. Furthermore, it might threaten the body condition of individual ♀1. However, the limited nest available and food attraction (i.e., attracted by food smells around kitchen and feeding attraction) seemed to overcome the cost. Nonetheless, long-term effects may occur, jeopardizing the reproductive success of Komodo dragons.

Human-wildlife interaction frequently results in conflict, such as an attack on humans, and the likelihood is higher in habituated wildlife [15,35,36]. Several cases of Komodo attack have been reported around the study site, but they have not been properly documented. During our observation, individual ♀1 was once spotted foraging into the ranger's facilities (i.e., barac). Therefore, it could be assumed that the human-Komodo encounter could take place in an undesired location. Without any proper facilities to treat the bite-wounds, it could have fatal consequences.

Even though our results showed that komodo exhibited a neutral response toward tourist presence, they might potentially take an aggressive course when the tourist was within closer range. As has been reported by Auffenberg [24], Komodo was often observed exhibiting ignorance behavior toward tourists up to 1-2 meters while they were around carcasses. During the observation, an aggressive response just occurred when the disturber (i.e., other Komodo individuals) came within a certain distance (i.e., 1 meter during mating and 2 meters during nesting). According to our data, the closest distance of the tourist while observing Komodo was still higher compared to the recorded proximity of disturber individuals. We believe that the unwanted interaction could possibly occur if the threshold was exceeded [37].

Misinterpreting the evidence of habituation may lead to an unwanted conflict between Komodo and tourists. Appropriate management should be implemented by the manager in order to achieve sustainable tourism practices. Therefore, several plans were proposed as follows:

1. Food attraction and feeding practices should be strictly regulated by the manager, as has been proposed in the previous study [25]. The rules of Who, When, and Where must be considered as a baseline in constructing the plan. Who: Feeding practice needs to be limited only for a certain type of visitor (i.e., those who has a special interest, such as researchers or documentary filmmakers) and was held under tight surveillance by the KNP manager. When: The practices could only be carried out for a certain period of time considering some adverse impacts that may follow, such as lowering body condition and decreasing the

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komodo's natural hunting ability. Where: Individual aggregation due to food attraction should be relocated out of TSFA for the purpose of avoiding unwanted interaction in an undesirable place. The baiting method was encouraged to be used in a preferable location, such as a forest. We believed that tourists would gain a greater experience by encountering Komodo in the wild rather than around TSFA.

2. Habitat modification was only conducted in insensitive areas, such as trekking tracks, baiting areas, or nest observation spots [1]. Clearing path along trekking track should be necessary due to the safety purposes towards unintentionally ambushing attack by komodo. Clearing habitat around the nest would not be encouraged due to the potential impact, as has been discussed above.
3. Tourist behavior should also be regulated to avoid unintentional conduct that could provoke the komodo to take an aggressive course [1,37]. A minimum distance between komodo and tourist should be established during their encounter. In addition, any sudden movement should also be prevented. Auffenberg [24] mentioned that komodo was not only sensitive to a chemical signal, but also a sudden motion. Moreover, the tourist number should also be regulated carefully. According to the study of the Nubian ibex in southern Israel, the species' tolerance increased with the number of humans present. Nevertheless, it would be a desirable outcome for a short period yet could lead to maladaptation in a long period [38].

Finally, tourist perception and knowledge of wildlife would be important and may become a key factor in establishing sustainable tourism practices [1]. Therefore, it should be taken into account by the KNP manager. Furthermore, multidisciplinary research will be encouraged in order to provide a more comprehensive picture.

4. Conclusion

Komodo, particularly those inhabiting the tourism area, have become habituated to the tourist presence during mating and nesting activities. Nevertheless, tourism activity should be managed carefully in order to avoid any negative consequences for both humans and Komodo. Our study suggested that the intensity of interaction between humans and Komodo should be limited. There must be a threshold for tourist numbers in order to avoid any further decrease in Komodo's tolerance level, which might lead to maladaptation. Direct interaction should be restricted to minimize any conflicts, such as an unintentional attack, that could possibly occur. Furthermore, habitat modification should avoid any sensitive areas, such as nests. The open access to the nest due to altered habitat could decrease a female Komodo's body condition and reproductive success. In the long term, it might jeopardize the species population viability. Finally, with a comprehensive plan by the manager, tourism activity in Loh Buaya could generate a positive impact for both the socio-economic aspect and the conservation of the Komodo population.

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