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DIET PREFERENCE AND ACTIVITY OF ASIAN WATER MONITOR AT CHAGAR HUTANG TURTLE SANCTUARY

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Abstract: Excessive sea turtle nest predation is a problem for conservation management of sea turtle populations. For green turtles (Chelonia mydas) nesting at Chagar Hutang beach, Redang Island in Malaysia, Asian water monitor lizards (Varanus salvator) are nest predator. To help deter water monitors from attacking nest, plastic mesh is placed on top of sea turtle nests, although this is not always successful in preventing predation. Due to human food waste is frequently dumped near sea turtle nesting area, no studies have documented the if Asian water monitor lizards are attracted by human food waste at Chagar Hutang beach. This study assessed the prevalence of Asian water monitors on the sea turtle nesting beach using passive track-count plots (2×1m) every 50 m along the beach 5-10 m above the high tide mark in the area used by sea turtles to construct their nests. Results indicated Asian water monitors were the only vertebrate nest predator at Chagar Hutang and were widely distributed along the beach and had a Passive Activity Index (PAI) of 1.25. The stomach contents of 20 Asian water monitors were examined by stomach flushing, and 76.8% of stomach contents were human food wastes, 21.2% were turtle egg and hatchling and only 1% were from other natural food sources. This study suggests human food waste attract Asian water monitor to Chagar Hutang beach and that this may result in water monitors visiting sea turtle nests at a higher rate compared to a situation if human food waste was not available.

Keywords: Asian water monitor, diet, sea turtle, sustainability, South China Sea.

Introduction

Human activities can affect species' behaviour, activity and richness (Marzluff & Neatherlin, 2006; McDonnell, 2007; Yasuda & Tsuyuki, 2012). The overlapping in space use between human and wildlife may lead to changes in animal behaviour, life history and population size (Marzluff & Neatherlin, 2006; Yasuda & Tsuyuki, 2012), and therefore human disturbance has become a problem in managing wildlife. Food subsidies from humans had become one of the main factors driving the changes in ecosystem (Oro *et al*., 2013). For example, dingo (*Canis lupus dingo*) foraging near mining sites in Northern Australia, had a diet consisting of more than 60% human food waste (Newsome *et al*., 2014). In Israel, human food waste has increased red foxes (*Vulpes vulpes*) population size and resulted in increased predatory pressure on two gerbils species (Shapira *et al*., 2008). Therefore, when considering management of prey populations, it is important to understand if human activities result in increases in predators' population size and as a consequence, cause increased predation on prey species that might result in a decrease in prey population size.

Asian water monitors, *Varanus salvator* are carnivorous scavengers and are widely distributed throughout South and Southeast Asia (Koch *et al*., 2007). The diet of Asian water monitor includes insects, crustaceans, fish, reptiles, reptile eggs, birds and small mammals (Smith, 1932; Gaulke, 1991; Traholt, 1997). In addition, scavenging on carcasses is a major part of their foraging behaviour (Traholt, 1994b). This species is often encountered in human settlements (Kulabtong & Mahaprom, 2014). Because human food waste is easily obtained by Asian water monitors, some Asian water monitor populations have changed their foraging behaviour and started to rely on human food waste as their main source of nutrition in areas inhabited by humans (Traholt, 1994a; Uyeda, 2009). For example, the presence of human food subsidies increased Asian water monitor density and therefore their intraspecific encounter rate, which resulted in the formation of dominance hierarchy behaviour between individuals on Tinjil Island, Indonesia (Uyeda *et al*., 2015). Traeholt (1997) also reported that Asian water monitors decreased their home range size when tourist visitation rate was increased. However, no study has investigated how local increases in Asian water monitor density associated with the supply of human food waste may affect their natural prey populations.

Water monitor lizards predate 30-35% of unprotected sea turtle nests at Chagar Hutang beach, Redang Island, Malaysia (SEATRU, unpublished data), although the predation rate can be reduced to 2-5% if the nests are protected with plastic mesh (SEATRU, unpublished data). Water monitors appear to have an usually high density at this location, and no quantitative study of monitor lizard activity or behaviour has been conducted at this important nesting beach. Therefore, the aim of our study was to quantifying Asian water monitor activity and diet on the sea turtle nesting areas during the nesting season at Chagar Hutang beach. We used two methods to achieve this aim. Firstly, we used passive track-plots to quantify general activity levels of Asian water monitors in the area where sea turtles construct their nests. Secondly, we used stomach flushing to examine the stomach content of Asian water monitors to discover what they had been eating.

Material and Methods

Study Area

Redang Island is located off the east coast of Peninsular Malaysia (5° 44' – 5° 50' N, 102° 59' – 103° 05' W). Our study was conducted at the 350 m long Chagar Hutang beach at the northern end of Redang Island (Figure 1). Chagar Hutang beach supports nesting of green turtles (*Chelonia*

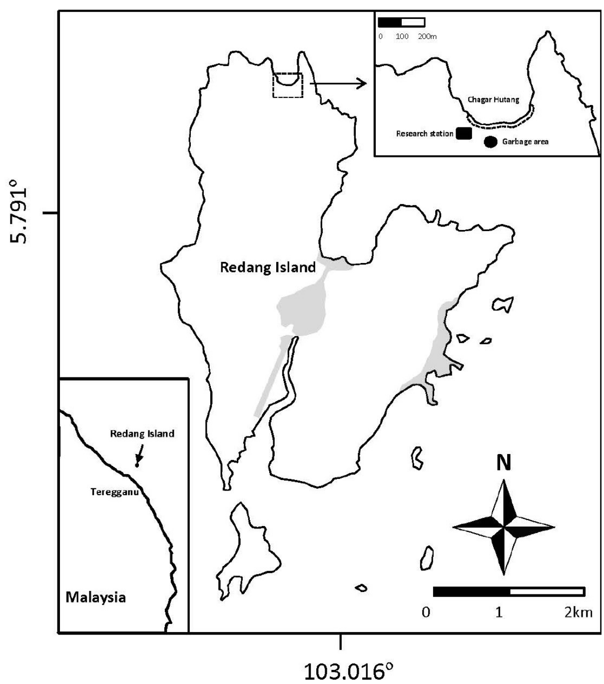

Figure 1: Location of study site, Chagar Hutang beach, Redang Island

mydas) and hawksbill turtles (*Eretmochelys imbricata*), with the peak nesting season between May and August (Chan, 2010). Sea Turtle Research Unit (SEATRU) of Universiti Malaysia Terengganu has been conducting research and conservation activities at this site since 1993. Several rangers and volunteers are present at Chagar Hutang research station during the sea turtle nesting season (April to October), but the beach is uninhabited by humans during the Monsoon season (November to March). Food waste is dumped into a pit dug approximately 50 m away from the research station and 100 m above the high tide line (Fig. 1) at least twice per day, usually in the morning and evening.

Passive Track-plots

We used passive track-plots (Lei & Booth, 2017a) to estimate relative activity of predators during the sea turtle nesting season from July-2017 to September-2017 for seven days each month. Seven passive track-plots (2 m x 1 m) were spaced 50 m apart along the length of the beach 10-20 m above the high tide mark in the region where most sea turtle nests are constructed. Each plot was marked by sticks placed at each corner of the plot and the plot's location was recorded with a handheld GPS. Each plot was inspected daily during the afternoon (weather permitting), and the number of water monitor lizard tracks were counted. After reading, plots were resurfaced using a rake to obliterate tracks, ensuring the same tracks were not recorded on subsequent days. The activity of predators was quantified using the passive activity index (PAI) (Engeman & Allen 2000)

$$PAI = \frac{1}{d}\sum_{j=1}^{d}\frac{1}{Pj}\sum_{i=1}^{Pj}Xij$$

where the Xij value represents the number of tracking plot tracks by an observed species at the ith plot on the jth day; d is the number of days of inspection, and Pj is the number of plots contributing data on the jth day.

Animal capture

During the 2018 turtle nesting season (15th August to 1st September), adult Asian water monitor lizards were captured using noose and pole, or in wire-mesh cage traps baited with chicken carcasses housed inside wire mesh that prevented Asian water monitor lizards from eating the bait. Once caught, the snout-to-vent length and total length of the Asian water monitor lizard was measured with a flexible fiberglass measuring tape (±1 cm), mass was recorded by a hanging digital scale (±0.01 kg), and the sex determined by squeezing the tail base to evert the hemipenis of males or examining the thickness and scales at the tail base (Auffenberg *et al*., 1991). Most of the male monitor lizards exposed their hemipenes when the base of the tail was squeezed. If the hemipenes were not everted by squeezing, a blunt probe was inserted into the cloaca to make sure no hemipenes were present (Lei & Booth, 2018).

Diet analysis

The stomach of each Asian water monitor lizard was flushed within 1 hour of capture. This involved inserting a plastic tube (diameter 10mm) down the esophagus into stomach. Fresh water (2-3L) was then pumped into stomach using an aquarium pump (Hasbur FP-9025). Flushed water was filtered through 2mm mesh. All material flushed from stomach was separated and examined immediately. Any content apart from human food wastes (e.g. rice, noodle, cooked meat, cooked vegetable and chopped bones), turtle eggs, turtle hatchlings and other food were identified to the closest taxa. Each constituent of stomach content was weighted by an electronic scale and volume was measured by adding stomach content with a known volume of water in a graduated volumetric measuring cylinder, and then the volume of water subtracted from the reading.

Samples were quantified for percentage frequency of each food type from the total sample and the mean of the percentage volume of each food type from each sample. This information was used to calculate an index of relative importance (IRI), as modified by Bjorndal *et al*. (1997) from the original index developed by Pinkas (1971) and Pinkas *et al*. (1971)

$$IRI = 100(FiVi / \sum_{i=1}^{n}(FiVi))$$

where F = percentage frequency of occurrence, V = percentage volume, n = number of food types, and i = food type.

Results

Passive track-plots

Passive track-plots revealed that Asian water monitor lizards were the only vertebrate predator on the beach there sea turtle nests are located Chagar Hutang beach. During the nesting season, 7 plots were monitored for 21 days with 184 Asian water monitor lizard occurrences recorded. The mean daily PAI was 1.25 ± 0.13. In July, August and September, the average daily PAIs were 1.24 ± 0.18, 1.16 ± 0.2 and 1.35 ± 0.29 respectively. ANOVA indicated no difference ($F_{1,2}$ = 0.836, P=0.769) in PAI between months.

Diet

We sampled stomach contents of 20 adult Asian water monitor lizards, 70% (14)of them were males. The average SVL of all individuals was 53.6 ± 1.79 cm. Only 5 different types of food items were flushed from stomachs of Asian water monitor lizard at Chagar Hutang (Table 1). There was no significant difference (P=0.953) between biomass and volume between food types. Biomass, volume and index of relative importance indicated the diet of Asian water monitor lizard consisted mainly of human food waste (IRI = 84.54). The reminder of the diet includes turtle egg, turtle hatchling, crab and lizard egg. Turtle egg represented a large proportion of the remaining diet (IRI = 14.14), nine of the 20 Asian water monitor lizards had turtle eggs flushed from their stomachs, indicating turtle eggs were frequently consumed by Asian water monitor lizards. Prey groups representing less than 5% included turtle hatchlings, crabs and lizard eggs.

Discussion

Diet

Kulabtong *et al*. (2014) reported that Asian water monitor lizards in an urban environment in Thailand consumed 17 different prey items, which is more than three times the number found in the current study. The enormous difference in variety of food items may due to the limited prey abundance of prey items at Chagar Hutang beach, and therefore Asian water monitor lizards have become reliant on human food waste. Further study is required to compare the diet constitute between island and mainland populations of this species in Malaysia. Monitor lizards in general have good memories. For example, free-ranging yellow-spotted goannas (*Varanus panoptes*) were trained to learn not to eat cane toads (*Rhinella marina*) (Ward-Fear *et al.* 2016). In the current study, Asian water monitor lizards no doubt remember the location of the garbage pit, and thus exploit this food source to obtain high caloric return, and expend less energy searching for food than if they were active foraging for natural prey. Hence it

Table 1: The frequency of occurrence (F.O.) of each food item in stomach content from water monitor lizards (n=20), and their occupancy of the total mass, volume and index of relative importance (IRI)

	F.O	% of Total mass	% of Total volume	IRI
Human food waste	13	76.80	75.98	84.54
Turtle egg	9	17.50	18.49	14.14
Turtle hatchling	3	4.70	4.96	1.26
Crab	1	0.95	0.39	0.04
lizard egg	1	0.05	0.18	0.02

appears that access to an easily available supply of human food waste may be contributing to the apparent high density of Asian water monitor lizards at Chagar Hutang beach.

Throughout the course of our study, we did not observe/catch any hatchling or sub-adult Asian water monitor lizard foraging at Chagar Hutang beach. In addition, we did not observe any adult individuals in bipedal combat, biting, or wrestling. Therefore, the presence of human food waste may lead to the establishment of size-based dominance hierarchies in as has occurred in garbage concentrated area on Tinjil Island, Indonesia (Uyeda *et al*., 2015). In addition, Traeholt (1997) reported seasonal changes may alter Asian water monitor lizard foraging behaviour because of changes in food availability. Despite human subsidized food resources being frequency available during the turtle nesting season (human waste was dumped at least twice per day) at Chagar Hutang beach, seasonal changes may change Asian water monitor lizard foraging behaviour. Moreover, water availability also affects the behaviour of Asian water monitor lizards, as this species prefers habitats in close proximity to fresh-water sources (Auffenberg, 1981; Bennett, 1995; Gaulke & Horn, 2004). There are two natural fresh water creeks at Chagar Hutang beach, one at the eastern end of the beach and one at the western end of the beach, providingenough water resource for this species. In the current study, we speculate that garbage-feeding may attract more adult Asian water monitor lizards to the area, potentially result in an increased sea turtle nest visitation rate.

Activity

Based on the PAI analysis of track-plots, the activity of Asian water monitor lizards on the beach was relatively high compare to previous studies. Lei and Booth (2017) reported the PAI of two varanid species yellow-spotted goanna and lace monitor (*V. varius*) at Wreck Rock beach adjacent to Deepwater National Park, Australia was 0.313 and 0.150 in 2014 and 2015 respectively. Maulany (2012) reported that that olive ridley turtle (*Lepidochelys olivacea*) nests suffered 100% predation by Asian water monitor lizards at a beach adjacent to Alas Purwo National Park, Banyuwangi (East Java), Indonesia, where the PAI was 1.27 in 2009 and 1.41 in 2010. These PAI values are similar to those we recorded at our Chagar Hutang beach study site, suggesting that without placing mesh on top of nests and human beach patrols during the day when water monitors are active, recruitment of sea turtle hatchlings due to high nest predation would be significantly decreased.

Implications for Management

Although covering of sea turtle nests with plastic mesh and human beach patrols decreases water monitor predation of sea turtle nests at Chagar Hutang beach, we suggested human food waste should be dumped at a distance far from the sea turtle nesting area in order to decrease the water monitor visitation rate to the beach. . If unavoidably located in areas of turtle nesting area, human waste food should be buried and protected from Asian water monitor lizards digging into it by placing plastic mesh over the top (Lei & Booth, 2017b). More management strategies such as temporary removal of adult Asian water monitor lizards during the sea turtle nesting season could also be investigated in the future.

Conclusions

Human garbage is increasingly being dumped into the environment where it can have direct and indirect effects on animal populations (Polis et al., 1997). In this study, we found the diet of Asian water monitor consisted mainly of human waste food and their activity (PAI) was high on the turtle nesting dune, suggesting that human waste may attract Asian water monitors to Chagar Hutang beach at higher than natural density, and this results in a higher than natural levels of turtle nest visiting rate.

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