Short Communication

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Komodo Dragon Predation on Crab-Eating Macaques at the Rinca Island's Visitor Centre, Indonesia

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Macaca fascicularis · *Varanus komodoensis* · Predator-prey relationship · Prey consumption · Spatial arrangement

Abstract
We investigated the proportion of crab-eating macaques in the diet of Komodo dragons and quantified the spatial habitat use between the species as a proxy for predation threat and in relation to prey availability due to ecotourism. In 2013, in Loh Buaya valley of Rinca Island, Komodo National Park, we conducted macroscopic identification of hairs, claws, dentition and osteological remains of consumed prey. For habitat use, we quantified the use of vertical strata by macaques through focal animal sampling. For Komodo dragons in the valley, macaques were a significant component of their diet (20.7%), ranking second after rusa deer (58.6%); the proportion of macaques we observed in the diet is much higher than in previous studies. An increased use of the forest floor by macaques at this site may increase their vulnerability as a prey species, especially in the daytime when tourist presence impacts the availability of other favoured prey species.

Introduction

The crab-eating macaque (*Macaca fascicularis*) is widely known to survive in diverse regions and ecosystems throughout South-East Asia [Ong and Richardson, 2008]. Macaques are hunted by humans [Eudey, 2008] and are sometimes attacked by domestic animals [Riley et al., 2015]. This primate has increasingly become part of the diet of various predators, including crocodiles [Auffenberg, 1981; Galdikas and Yeager, 1984], tigers, leopards [Van Schaik et al., 1983], and Komodo dragons *(Varanus komodoensis)*.

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Notably, amongst predators of *M. fascicularis*, Komodo dragons are opportunistic, preying on almost any species they come across, as well as on carrion [Auffenberg, 1981; Jessop et al., 2006]. The dietary role of *M. fascicularis* for the dragons remains ambiguous; it can be either a minor food source compared with ungulates (e.g., rusa deer, *Rusa timorensis*, and water buffalo, *Bubalus bubalis*) [Auffenberg, 1981; Ciofi and De Boer, 2004] or a substantial dietary component [Murphy et al., 2002]. Reports of crab-eating macaque predation by dragons are limited to Flores Island [Auffenberg, 1981] and rarely reported for Rinca Island, where observational wildlife tourism occurs [Walpole, 2001].

The presence of tourists has been reported to affect the activities of wildlife [Marchand et al., 2014] and this may apply in Komodo National Park, notably in Loh Buaya valley, Rinca Island. Crab-eating macaques that have adapted to humans, including tourists [Eudey, 2008], may be especially available as prey for the dragons. While dragons are opportunistic predators, they might adjust their dietary preference in favour of macaques due to the monkeys' greater abundance compared to ungulates or other favoured species in the valley. We explore the relative proportion of *M. fascicularis* in the diet of dragons. Secondly, since the macaques are semi-terrestrial on other islands [Richter et al., 2013], we aim to find the degree of terrestrial overlap between the macaques and dragons to quantify Komodo dragon-macaque predation opportunity. We further investigate whether spatial segregation and arboreal strata preference among macaque sex and age classes [Girard-Buttoz et al., 2014] are present in the *M. fascicularis* in Loh Buaya valley as a potential predation risk variable that may influence population dynamics.

Methods

We conducted fieldwork from May to June 2013 (5 weeks) in Loh Buaya (119.713–119.736° E, 8.648 to –8.666° S) on Rinca Island, Komodo National Park, Indonesia. Loh Buaya is a wide valley on Rinca Island (279.36 ha), consisting of a tropical dry forest gallery, surrounded by savanna hills inhabited by both *M. fascicularis* and Komodo dragons. To explore whether *M. fascicularis* in the Loh Buaya valley is a readily available food resource for the dragons, we observed one troop of 50 individuals (12 adult males, 16 adult females, 15 juveniles, and 7 infants).

We assessed the Komodo dragons' consumption of *M. fascicularis* by opportunistically collecting dragon faeces on existing paths in the valley following the method of Chua et al. [2016], as the dragons utilize these tracks. We conducted faecal pellet analysis to investigate the remaining food items of dragons. This method has been used to investigate the diet of predators [Hoppe, 1984; Maheshwari, 2006; Aryal and Kreigenhofer, 2009; Sharbafi et al., 2016], including the Komodo dragon [Auffenberg, 1981]. We broke down the faeces and washed them with running water over a <1-mm mesh sieve, and then sun-dried the remains. We conducted macroscopic identification of hairs, claws, dentition and osteological remains of consumed prey. The remains were classified at a species level if possible, otherwise at the level of class.

We used instantaneous focal animal sampling [Altmann, 1974] to record the vertical distribution of the macaques. Observations started at 6:30 a.m., when the troop commenced its activities, ceasing at 5:00 p.m. when the troop returned to its sleeping sites. We set the time sampling unit at 5 min.

The Komodo dragon is a terrestrial predator [Auffenberg, 1981; Murphy et al., 2002], thus we categorised the macaque's spatial use through their relative position from the forest floor, i.e., forest floor (position 1), tree trunk (position 2), lowest branch (position 3), mid crown (position 4), and top crown (position 5). We performed a χ^2 test of independence to examine the vertical spatial use by the macaques.

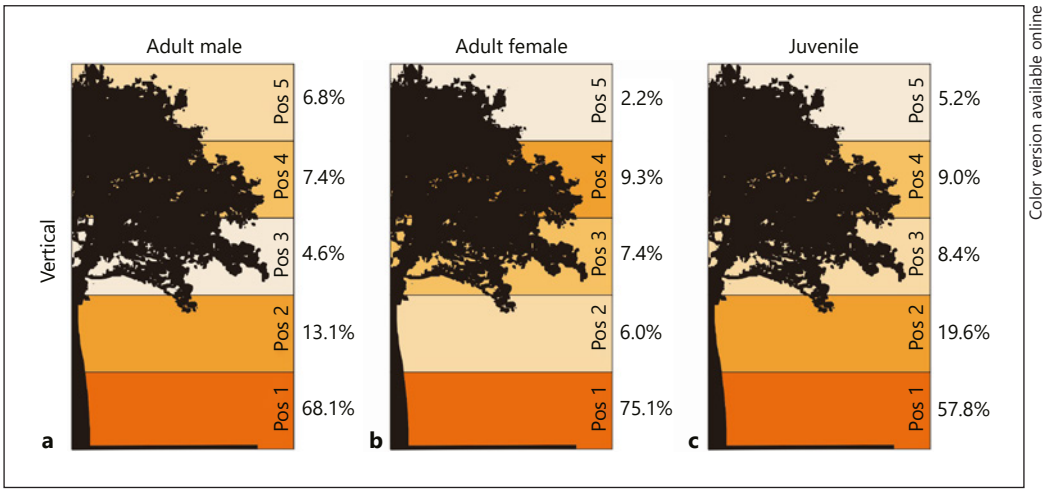

Fig. 1. Vertical space utilization patterns by *M. fascicularis* in Loh Buaya valley. Darker colour indicates a higher proportion of spatial use (positions 1–5 explained in text).

Table 1. Pearson χ^2 test of goodness of fit of the horizontal and vertical position of *M. fascicularis*

Category	χ^2	df	Sig. code
Vertical position	1,538.600	4	***
Vertical – adult male	538.270	4	***
Vertical – adult female	700.370	4	***
Vertical – juvenile	348.790	4	***

*** $p < 0.001$.

Results

We found 29 Komodo dragon scats, containing various prey species. We found the following taxa in scats, showing number and percent: rusa deer, $n = 17$ (58.6%); *M. fascicularis*, $n = 6$ (20.7%); vipers and other snakes, $n = 3$ (10.3%); small mammals, $n = 2$ (6.9%); bird eggs and feral pig, $n = 1$ for both (3.4%). We also confirmed cannibalism [Auffenberg, 1981] at Loh Buaya from a claw of a dragon in one scat.

All age classes of macaques disproportionally used vertical positions; they used the forest floor more often than arboreal positions, whilst using the tree crown least (Table 1). Among all age categories, adult females exploited the forest floor at the highest frequency (75.1%). Adult males and juveniles used the forest floor in a similar proportion. Adult males more frequently exploited the top crown compared to juveniles (Fig. 1).

Discussion

Our study is the first to report on the Komodo dragon's consumption of *M. fascicularis* and we found evidence of cannibalism by Komodo dragons on Rinca Island, as reported by Auffenberg [1981]. Our findings confirm that the dragons still consume ungulates, i.e., rusa deer, as their primary prey [Auffenberg, 1981]. Crab-eating macaques constituted the second most frequently consumed prey, appearing in around one fifth of all faecal samples. The macaques used the forest floor to a great extent, causing spatial overlap with the dragons, providing the dragons with increased opportunity to predate on macaques. The high presence of adult females exhibiting terrestriality (75.1%) sympatrically with Komodo dragons implies increased predation risk, with potential impacts on macaque population dynamics within the study area if predation continues.

Our finding that *M. fascicularis* is the second most frequently consumed prey item in the Loh Buaya valley confirms that, as an opportunistic predator, Komodo dragons consume a diverse prey size to fulfil their metabolic needs [Sinclair et al., 2003]. The Komodo National Park management authority attempts to attract tourists to the valley, plausibly limiting the dragons' access to ungulates in this area, due to the ungulates' avoidance of human presence. During our observations, we did not see any ungulates other than rusa deer (*R. timorensis*) and feral pigs (*Sus scrofa*), which were nocturnally active in the visitor centre. Our observations showed that the macaques were relatively well adapted to the presence of visitors, more so than other prey species in the valley. The macaques successfully occupy disturbed habitats including tourism areas [Eudey, 2008; Peterson and Riley, 2013] and can cope with the tourists' presence and activities [Biquand and Gautier, 1994; Fuentes et al., 2007]. The macaques' ability to persist in tourist-dominated areas sympatrically with Komodo dragons [Fuentes et al., 2007] increases their predation risk due to their relative abundance compared to other prey species (i.e., water buffalo and feral pigs), which actively avoid tourist-occupied areas. Their absence thus negates their availability as a food source for Komodo dragons.

We anecdotally observed that the macaques travelled terrestrially in the salt field, mangrove and low-land gallery forest. This higher proportional use of the forest floor by macaques (Table 1) indicates that the primates' spatial distribution overlaps with that of Komodo dragons. Contrastingly, other sympatric prey species are not available diurnally in the valley because of tourist presence. Since the Komodo dragon is an ambush predator, with juveniles and infants occupying trees [Auffenberg, 1981], further study on arboreal distribution in both species will provide valuable insight into the predator-prey relationship and spatial overlap between the Komodo dragons and the macaques in this valley.

The Komodo National Park prioritizes the management of the Komodo dragon population and focuses its efforts on only 3 prey species, i.e., rusa deer, feral pigs and water buffalo [Auffenberg, 1981; Jessop et al., 2006; Ariefiandy et al., 2013; Laver et al., 2017]. The management rarely considers the population dynamics of *M. fascicularis* as an alternative but substantial prey for the dragons. As the presence of visitors and poaching [Ariefiandy et al., 2013] on the Island likely have impacted the availability of primary sources of prey for Komodo dragons, park management should consider macaques as alternative prey as shifting predation rates have the potential to impact local population stability. Additionally, using distance sampling [Buckland

et al., 2001; Ariefiandy et al., 2013], as utilized for other prey species, to monitor population dynamics of the macaques will provide valuable ecological information and aid in the management of *M. fascicularis* populations.

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Disclosure Statement

We understand *Folia Primatologica's* declaration of interests and declare that we have no competing interests.

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