

## OBSERVATION OF A FATAL DOG ATTACK ON A JUVENILE LONG-TAILED MACAQUE IN A HUMAN-MODIFIED ENVIRONMENT IN SINGAPORE

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**ABSTRACT.** — Direct observations of predation on primates are rare, in part because the presence of observers deters potential predators. We observed domestic dogs (*Canis lupus familiaris*) kill and take away a juvenile long-tailed macaque (*Macaca fascicularis*), presumably for consumption, in Singapore’s Bukit Timah Nature Reserve. We describe the event and reaction by group members in detail. We also compare our observation to reported accounts of predation on long-tailed macaques. In doing so, we discuss factors that increase predation risk for long-tailed macaques in anthropogenic environments. Dogs may not be important predators of primates in natural habitats, but currently they are important predators of long-tailed macaques in anthropogenic environments. This is because a large proportion of long-tailed macaques now live near humans. Anthropogenic environments differ from the forest environments to which long-tailed macaques are most adapted. Compared to forests, anthropogenic environments are more open, contain novel structures, and require more terrestrial locomotion. These differences pose novel ecological challenges that increase macaques’ susceptibility to predation by dogs. Features of primate juvenility leave young macaques especially vulnerable to dog predation. Young macaques have a small body size and frequently play, which reduces their vigilance to predators. In sum, greater exposure to anthropogenic environments increases the risk of long-tailed macaques—especially juveniles—to predation by dogs.

**KEY WORDS.** — *Macaca fascicularis*, *Canis lupus familiaris*, predation, prey, juvenile, Singapore

### INTRODUCTION

Predation may be a key selection pressure for primate sociality (Alexander, 1974). Larger groups, for example, detect predators at greater distances (van Schaik et al., 1983). Relatively little is known, however, about what occurs during and after predation events. Direct observations are unfortunately rare in the literature (Isbell, 1994), perhaps because many predators avoid humans, including scientists (Cheney & Wrangham, 1987). Although difficult to collect en masse for publication, observations of rare events such as predation are important for understanding primate behaviour. Here, we report an observed fatal attack on a long-tailed macaque by domestic dogs in Singapore and the immediate social aftermath.

Long-tailed macaques (*Macaca fascicularis*) are a forest edge-dwelling species that regularly utilise human habitats (Gumert, 2011). One of the most abundant and widespread non-human primate species, they are among the most studied macaque species in the wild. Nevertheless, accounts of predation on long-tailed macaques are rare. First-hand information from observation, necropsy, and remains found in predator faeces indicate that successful predators of wild long-tailed macaques include the false gharial (*Tomistoma schlegelii*) (Galdikas & Yeager, 1984), reticulated pythons (*Malayopython reticulatus*) (van Schaik et al., 1983), and domestic dogs (*Canis lupus familiaris*) (Hock & Sasekumar, 1979), among other predators. Table 1 summarises documented instances of predators killing long-tailed macaques from primary literature. The table includes only accounts of killing by non-human predators.

Anderson (1986) lamented the lack of details in reports of observed predation events, so we provide a detailed account that includes information relevant for researchers of diverse interests. We then relate our account to theory by discussing factors that increase the risk of long-tailed macaque predation by dogs. We also address features of anthropogenic habitats and aspects of juvenility that increase susceptibility of long-tailed macaques to dog attacks.

As part of a project focusing on social behaviour, CMR and MDG began in Sep.2009 to collect data on a group of long-tailed macaques in Singapore’s Bukit Timah Nature Reserve. This 163-ha nature reserve includes mostly areas of secondary forest, with fragments of primary coastal hill dipterocarp forest, contains hiking and mountain-biking trails (National Parks Board Singapore, 2009), and has apartments and condominiums adjacent to it. The macaque

Table 1. First-hand, confirmed incidences of predators killing long-tailed macaques (*Macaca fascicularis*). Instances included in the table were either observed first hand by researchers, or inferred from necropsy remains or group composition. It excludes reports about macaques merely reacting to the presence of predators, reports in which macaques were injured but not killed, and secondhand reports from untrained observers to researchers.

S/No.	Predator	Source	Locality	Reference	Notes
1.	false gharial ( <i>Tomistoma schlegelii</i> )	Direct observation	Indonesia	Galdikas & Yeager (1984)	Juvenile macaque
2.	reticulated python ( <i>Malayopython reticulatus</i> )	Direct observation	Indonesia	van Schaik, van Noordwijk, Warsono, & Sutriano (1983)	Juvenile macaque
3.	Komodo monitor ( <i>Varanus komodoensis</i> )	Remains in Komodo monitor faecal pellets	Indonesia	Auffenberg (1981)	Canines in pellets indicate at least 2 adult macaques
4.	leopard ( <i>Panthera pardus</i> )	Remains in leopard faecal	Indonesia	Seidensticker, Suyono, & Thomas (1980)	Ten instances, including "teeth of old and young individuals," (p. 63)
5.	tiger ( <i>Panthera tigris</i> )	Remains in tiger faecal	Indonesia	Seidensticker, Suyono, & Thomas (1980)	Two instances
6.	Philippine eagle ( <i>Pithecophaga jefferyi</i> )	Direct observation	Philippines	Kennedy (1977)	Prey described only as a monkey; <i>M. fascicularis</i> only native monkey
7.	Philippine eagle	Undigested monkey in eagle's stomach	Philippines	Clemens (1907)	Prey described as monkey; <i>M. fascicularis</i> only native monkey
8.	Philippine eagle	Observation of eagle pair's nest	Philippines	Gonzales (1968)	Three monkey carcasses brought to nest
9.	estuarine crocodile ( <i>Crocodylus porosus</i> )	Direct observation	Malaysia	Otani, Tuuga, Bernard, & Matsuda (2012)	Adult male macaque
10.	domestic dog ( <i>Canis lupus familiaris</i> )	Examination of deceased juvenile	Malaysia	Hock & Sasekumar (1979)	Juvenile macaque
11.	domestic dog	Inferred from group composition and dog-macaque overlap	Thailand	Gumert, Hamada, & Malaivijitnond (2013)	Likely multiple incidences focused on infants and juveniles
12.	domestic dog	Direct observation	Singapore	Ridley (1895)	Author's pet terriers killed a macaque
13.	domestic dog	Direct observation	Singapore	this paper	Juvenile macaque

group had approximately 55 members, which is within the range of groups given access to human food (van Schaik et al., 1983; Fooden, 1995). As part of that project, CMR was collecting faecal and scan samples of adult individuals (all of whom were individually identified) and was in the process of identifying the juvenile macaques in the group. It was on one of these data collection outings that a fatal dog attack on a macaque was observed.

## OBSERVATION

On 10 Feb.2010, at 1235 hours, CMR and MDG, along with visiting researcher Ronald Noë, were watching the group forage. Two-thirds of the macaques were in the trees and the remainder on the ground, along the Bukit Timah Nature Reserve Chestnut Mountain Biking Trail, situated on the edge of the forest approximately 15 m behind an apartment building. Without forewarning three large feral dogs ran silently towards the macaques, passing within 2 m in front of the researchers. Apparently unaware of the dogs, the macaques did not respond until the dogs were about 3 m from the closest group members. At that point, multiple macaques began alarm calling and most darted into the trees. Last on the ground were three juveniles. A dog caught and killed one of them. The other two juveniles sprung into the trees, narrowly evading the remaining two dogs that had rushed towards them. Within a minute of biting the juvenile to death, the dogs abandoned its body without consuming any of it. Two dogs ran west down a hill and out of sight behind the apartment building. The dog that had killed the macaque ran northeast toward the nearby Hindhede Quarry.

Within a couple minutes of the dogs leaving, adult male macaques made what appeared to be a perimeter in the trees at a radius of about 5 m around the deceased juvenile. Group members made alarm calls for about 20 min. The researchers failed to identify the deceased macaque or collect a biological sample for genetic analysis because attempts to approach the body resulted in the adult males lunging, grunting, and baring their teeth. To avoid further disturbing the agitated group, the researchers left at approximately 1330 hours.

When the researchers returned at 1445 hours, the group resumed alarm calling. Between 1330–1445 hours, one of the dogs had returned and moved the deceased macaque from the bike path to about 10 m into the forest. There the dog that had killed the macaque lay with the body between its paws (Fig. 1). At 1505 hours, the dog stood and walked away, leaving the body behind (Fig. 2). The group continued alarm calling for about two minutes after the dog moved out of sight. Two researchers then departed. The other (CMR) remained to observe the group.

Soon thereafter, some group members approached the body. Uma, the 14th-ranked adult female (out of 15), moved repeatedly back and forth between a tree and the body. She would stop about 1 m from the body, stare at it, then climb the tree again. The third-ranked adult female, Keira, remained on the tree branch directly above where the dog had killed the macaque, staring at the spot on the ground where the body had been before the dog moved it. Both females periodically made distress coos. Three juveniles, together, approached the body to within about 3 m and then stopped. At that distance for several minutes, they expressed silent-bared-teeth displays towards the body, teeth-chattered, screamed, mounted one another, and embraced one another. Then while two of the juveniles moved away, the other inched slowly toward the body, reached out, touched it, pulled its hand away quickly, and ran back to the other two juveniles.

Over the next two hours, the two adult females mentioned above continued to gaze at the body periodically. Other group members resumed foraging in the trees and on the ground. The group maintained a loose perimeter around the body. At 1715 hours, the same dog reappeared, causing the macaques to alarm call again. The dog picked up the body of the macaque and departed, heading back towards the quarry carrying the body of the deceased macaque in its mouth. The entire group stayed by the location at least five hours after the event began—longer than they would remain in one place on an ordinary day.

We reported the observed event to the local authorities, the National Parks Board of Singapore (NParks). NParks officers investigated the area and reported finding a “dog nest” approximately 20 m from the site of the killing. In Singapore, owing to concerns about danger to people, feral dogs are sometimes trapped and rehomed or culled (Tan, 2011). In this case, however, the officers decided not to trap the dogs. The researchers saw these specific dogs in the area only one more time after the event.

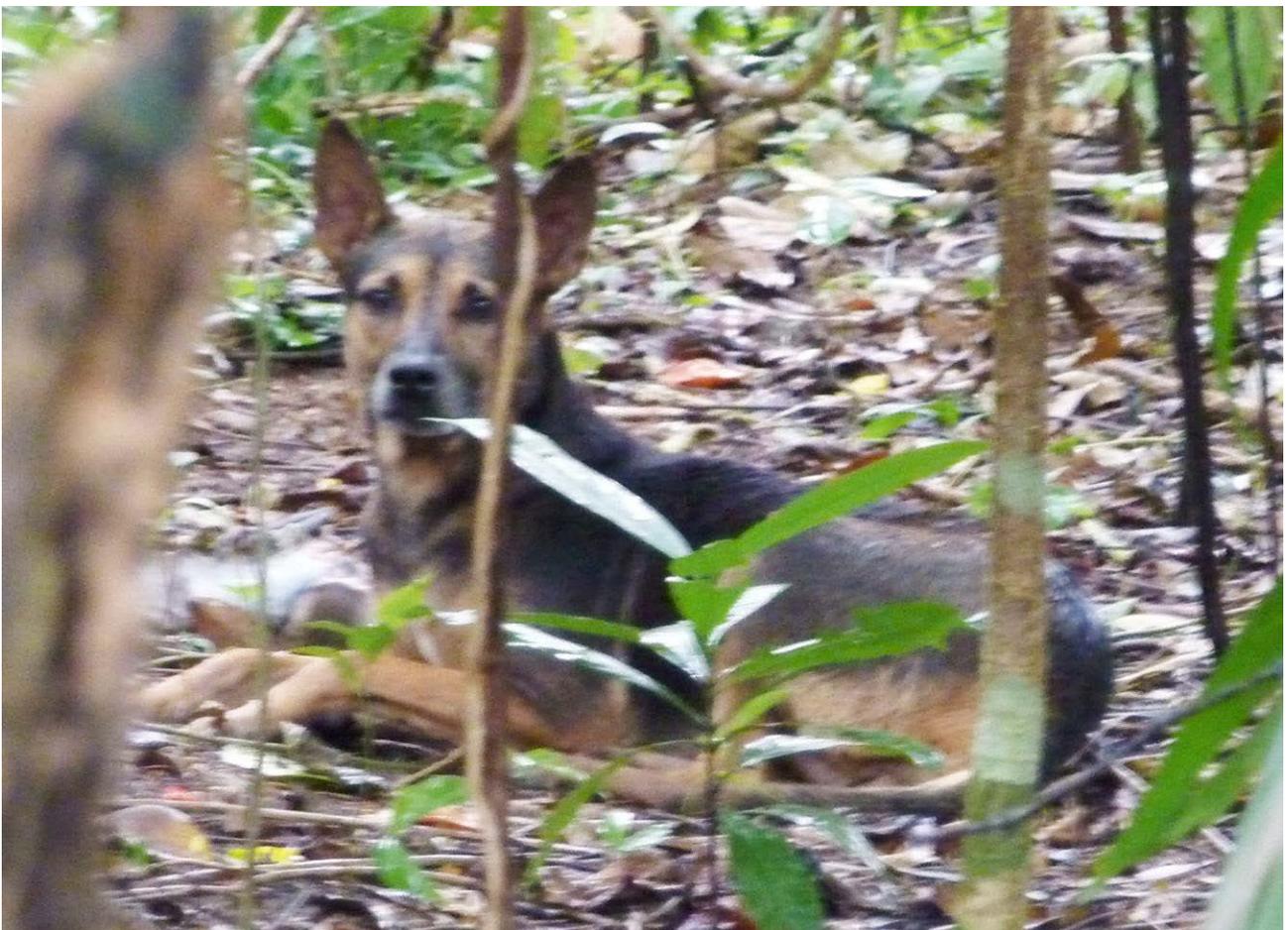


Fig. 1. Dog and the juvenile macaque it killed. (Photograph by: Crystal M. Riley).



Fig. 2. Temporarily abandoned body of juvenile macaque. (Photograph by: Crystal M. Riley).

## DISCUSSION

Many aspects of the observed event are notable. Regarding the aftermath, macaques responded differently depending on their demographics. Adult males took what looked like a protective stance. Two adult females seemed especially concerned about the dead macaque; perhaps they were relatives. Three juveniles acted curious but scared regarding the dead body. However, our discussion identified elements of the event that might be considered typical and shows how they relate to key themes in literature. The three feral dogs were undeterred by humans nearby. The event occurred on a man-made bike path with a fence on one side, an evolutionarily-novel context for macaques. The individual killed was young and interacting with other juveniles and therefore particularly vulnerable to predation. We consider these interrelated topics in turn.

***Dogs are important predators of long-tailed macaques in human-modified environments.*** We witnessed a dog kill, but not eat, a macaque—but canid predatory behaviour suggests the dog likely consumed it later. The consumption of prey is an important aspect of predation, which is broadly defined as “an organism killing another organism for nutritional purposes” (Bengston, 2002: 289). Some predators, particularly canids, take prey to a secluded location before consuming them (Fox, 1969; Fox, 1971). Based on such patterns of canine behaviour following the killing of prey, we assume the dog later ate some portion of the macaque in the event we observed. The dog moved the macaque away from where it was killed, possibly because the dog was uncomfortable consuming the macaque in the researchers’ presence. Given the later discovery of a “dog nest” 20 m away, it seems likely that the dog carried the macaque there (a known location secluded from people) to eat it. There is evidence of dogs killing animals and not eating them (e.g., Coppinger & Coppinger, 2001); however, those reports were by dog owners. Feral dogs obtain their own food so they seem unlikely to kill prey simply to abandon it. Thus we conclude that what we observed was a predation event. This is consistent with other published accounts that refer to dogs killing wildlife as predation, despite the researchers not observing the dogs consuming their kills (e.g., Young et al., 2011). Even if the dog abandoned its kill, the evolutionary effect is the same for the deceased individual. As Bengston (2002) pointed out, “The central aspect of the definition of predation is that it kills the victim” (p. 289).

In an overview of dog predation on primates, Anderson (1986) concluded that dogs are unimportant predators of primates generally; however, they might be important predators of long-tailed macaques. This is because both dogs and long-tailed macaques are commonly found around human settlements in Southeast Asia (Anderson, 1986). Moreover, long-tailed macaques on the ground (like the macaque reported in our observation) are more susceptible to predation by dogs than macaques in trees, and macaques utilising open spaces spend up to a quarter of their time on the ground—significantly more than when in the forest (Fooden, 1995). Long-tailed macaques therefore likely face increased susceptibility to dog attacks in open anthropogenic habitats as compared to in more forested environments.

Indeed, a literature review suggested that dogs are important predators of long-tailed macaques. Of 25 confirmed instances of long-tailed macaques being killed by a total of eight predator species (see Table 1), three were by dogs (12% of the total). This makes the dog the third most reported long-tailed macaque predator, after the leopard (10 instances, 40% of the total), and the Philippine eagle (five instances, 20% of the total). These estimates are imprecise, of course, owing to the aforementioned infrequency of researchers observing predation events. Our estimate of dog predation is likely low, for example, given the evidence of Gumert et al. (2013) that dog predation can significantly affect group composition.

In Singapore, stray dogs are a common and significant part of the anthropogenic environment. As of 2012, Singapore had an estimated 8,000 stray dogs (Tan, 2012), a substantially larger number than the long-tailed macaque population estimated at 1,900 individuals (Riley et al., 2013). Domestic dogs thus have potential to be a key predator of long-tailed macaques in Singapore and similar anthropogenic habitats where distributions of dogs and macaques overlap, as occurs regularly in Southeast Asia (Anderson, 1986). Macaques living in such environments risk death and injury due to predation by domestic dogs, but the mere presence of dogs as potential predators entails costs, including disruptions of group composition, habitat use, and group activity patterns (Anderson, 1986; Young et al., 2011; Gumert et al., 2013). A recent study found this to hold for long-tailed macaques on Piak Nam Yai Island in Thailand. Macaques there have been largely undisturbed by anthropogenic influence, but humans recently encroached on macaque habitat and introduced domestic dogs. Those dogs chase macaques, potentially disrupting their unique tradition of stone tool use (Gumert et al., 2013). Gumert and colleagues observed 15 interactions between dogs and macaques but did not directly observe predation. They noted, however, that macaque groups whose ranges overlapped with locations where dogs were seen most frequently had fewer juveniles and more regularly had younger animals disappear, suggesting predation. Furthermore, macaque groups whose ranges overlapped with those of dogs spent less time foraging on open shores. This may have been a response to dog predation because being on open shores made the macaques more vulnerable to dogs.

Long-tailed macaques living in modern anthropogenic habitats face challenges to which they were not necessarily adapted. Human-modified environments are generally more exposed and open, likely increasing terrestrial locomotion (Fooden, 1995). They also contain evolutionarily novel structures (e.g., buildings, roads, and fences) that would have no adaptive relevance to macaques' historical environments. Anthropogenic habitats indeed differ substantially from swamp or riverine forest habitats to which long-tailed macaques are most adapted (Gumert, 2011). This mismatch—between the novel ecological setting of a human-altered environment and macaque history of adaptation in less disturbed environments—might make long-tailed macaques more vulnerable to predator species such as dogs that are well adapted to human environments.

Through artificial and natural selection, humans transformed wolves into dogs. Dogs rapidly evolved traits to make them suitable to live near humans and in human environments (Coppinger & Coppinger, 2001). Macaques have likewise lived near humans for a long time (Gumert, 2011), and they too likely face selection pressures from humans and human environments (Gumert et al., 2011). Despite this, macaques (and other wildlife) probably have experienced less anthropogenic selection pressure than have dogs, and are less well suited to human-modified environments than are dogs. Therefore, they likely suffer a disadvantage relative to dogs in human-modified environments.

Macaques are not the only animals affected by sharing their habitat with dogs. Other wildlife is also at risk of predation and social disruption by dogs. A monkey that was presumed to be the last banded leaf monkey (*Presbytis femoralis*) in the Bukit Timah Nature Reserve in Singapore was killed by dogs (Yang & Lua, 1988). Singapore is home to many other mammals upon which feral dogs could potentially prey, such as civets, mousedeer, colugo, and squirrels. In addition to impacting wildlife through predation and altered behavioural patterns, dogs may also transmit pathogens to native wildlife and even to humans (Young et al., 2011).

**Juveniles are especially at risk for predation by dogs in human-modified environments.** A review of primate predation shows that for primates, including long-tailed macaques (van Schaik et al., 1983), infants and juveniles are at greater risk of being preyed upon than adults (Cheney & Wrangham, 1987), as smaller immature animals are more vulnerable than adults. Juvenile primates are less vigilant and less adept at detecting predators than adults (Janson & van Schaik, 1993). Galdikas & Yeager (1984) observed that young macaques were more careless and less vigilant than adults.

Play also entails increased predation risk for younger primates (Fagen, 1993). During social play immature primates focus attention towards conspecifics, which diminishes attention available for predator detection. Owing to increased vulnerability of the young, adults in many primate species are more vigilant near playing infants and juveniles (Fagen, 1993). In our observed event, the juvenile victim was close to two other juveniles, likely interacting with one another and therefore perhaps less aware of their surroundings. The environment was human-modified, so perhaps its openness or other features made it harder for adults to monitor and/or to rescue juveniles from danger.

We suggest that juvenile primates in anthropogenic environments with domestic dogs may be at especially high risk. This is because the effects of the human-modified ecology are compounded by the greater vulnerability of immature animals. For example, we observed an event on 13 Jan.2010 that demonstrated these factors. At Hindhede Place, just outside the Bukit Timah Nature Reserve, CMR and MDG saw a woman release her small pet dog from a fenced yard. The dog immediately chased a group of several immature monkeys that were playing in the street. These young macaques were unaware of the dog running at them, despite adult alarm calls. The dog ran directly towards an infant, picked it up in its mouth, and shook it. The adults immediately ran to the defence of the infant. During the mobbing one female jumped on the dog and bit it. The dog dropped the infant and retreated. The infant fled to a nearby gate, leapt, lost hold of the gate and fell to the ground, leapt again, and clung onto the gate at about a foot off the ground. The infant was then retrieved by an adult female—likely the infant’s mother—that had earlier bitten the dog. This event illustrates risks for young macaques: The dog went after the smallest individuals and play distracted young macaques from the threat.

The relationship between dogs and primates in human-modified environments is an underexplored aspect of commensal-living primates, such as long-tailed macaques. To better understand how human environments influence the behaviour and evolution of primates and other wildlife attracted to anthropogenic environments, we would do well to understand selection pressures in these habitats, such as enhanced vulnerability to predators. Dogs are indeed a significant predator of long-tailed macaques in human-modified environments, but to what degree are they a selective pressure? Future research can answer this question and improve our understanding of the role of human-modified environments on non-human primate evolution.

#### ACKNOWLEDGEMENTS

We thank the National Parks Board of Singapore for their assistance and support, and Crickette Sanz and Ronald Noë for their helpful comments on a previous version of this manuscript. This research was funded by a Tier One grant RG95/07 from Singapore’s Ministry of Education.

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