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Comments/Reflections

Stone-tool-assisted hunting by a wild monkey (*Macaca fascicularis aurea*)

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Abstract
We report anecdotal evidence for stone-tool-assisted hunting by a non-human primate. Wild Burmese long-tailed macaques (*Macaca fascicularis aurea*) in Laem Son National Park, Thailand, regularly consume crabs, processing them both with and without stone pounding tools. However, stone-tool-assisted capture of crab prey, prior to the processing for consumption, has yet to be reported. We observed a tool-using episode as part of the hunting process, and provide video evidence confirming Burmese long-tailed macaques as the first known non-human primate to hunt and subdue other animals with the aid of stone tools.

Keywords
Macaca fascicularis aurea, long-tailed macaque, crab-eating macaque, stone hammer.

1. Introduction

Macaca fascicularis is most commonly described today as the long-tailed macaque, a phenotypic rather than behavioural classification. However, they have previously been known as 'crab-eating macaques', a typical English

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name applied to *M. fascicularis* across its southeast Asian range in the 19th and 20th century. The shoreline habitat of some *M. fascicularis* groups — making them amenable to observation from passing boats — and the fact that they do prey on crabs among other plant and animal foods, led to an early emphasis on this dietary feature.

For example, Lydekker (1893) notes in *The Royal Natural History* that: "What induced the ancestors of this monkey to forsake the usual simian food and take to a diet of crabs and insects it is difficult to conceive... Be that as it may, there is no doubt whatever as to the crustacean-devouring proclivities of this species".

In coastal and swamp areas, the common subspecies (*M. f. fascicularis*) are widely reported to hunt and consume crustaceans as prey (Fooden, 1995), without the use of tools to process them for consumption. Their behaviour involves stalking, catching, killing, and extracting meat from within the hard chitinous exoskeleton. The Burmese subspecies (*M.f. aurea*) is more-or-less the same in this respect, except that they are known to use stone tools for the extraction process (Gumert & Malaivijitnond, 2012).

Around the time that Lydekker was compiling his reference work, Carpenter (1887) penned the first western report of another unusual behaviour of *M. fascicularis* in the Mergui Archipelago, off the Myanmar coast. He regularly saw these macaques opening intertidal oysters using stone tools, a fact scientifically confirmed some 120 years later by Malaivijitnond and colleagues (2007) in the same region. Carpenter didn't report stone tool use on crabs, but the later study found broken swimming crab (*Thalamita sp.*) remains that the monkeys had placed on a substrate (anvil) stone and then pounded with a handheld stone hammer. The tool-using macaques were assigned to the *M. f. aurea* subspecies (Bunlungsup et al., 2016).

A more comprehensive survey of islands in Laem Son National Park, Thailand, by Gumert & Malaivijitnond (2012) found evidence for a further three crab species cracked by the macaques using stone tools: mottled sally-light foot (*Grapsus albolineatus*), orange mud crab (*Scylla olivaceae*), and the stone or thunder crab (*Myomenippe hardwickii*). From direct observations and recovered remains, the macaques were found to eat crabs both without and with the use of stone tools, with the latter particularly focused on cracking resistant claws. To date, therefore, we have consistent long-term descriptive and archaeological data on stone tool use for crab processing by the monkeys also known as crab-eating macaques.

Figure 1. Judas (*Macaca fascicularis aurea*) versus the crab (*Scylla olivaceae*; circled), Piak Nam Yai, Thailand. Still image from Supplementary Video 1 in the Appendix at 10.6084/m9.figshare.19960160.

However, the process of tool-assisted crab capture and processing has not been fully described. Typically crab capture and consumption activity involves fairly uneventful — though purposeful and skilful — grabbing and biting or striking of the crab to kill and consume it, without the aid of tools. Here, we describe and present video evidence for a more confrontational capture, in which a male long-tailed macaque attempts to avoid injury from, and subdue, a large crab (Figure 1; Supplementary Video 1 at 10.6084/m9.figshare.19960160). The macaque uses a stone tool as a weapon in this encounter, making it the first documented evidence for stone-tool-assisted hunting and prey incapacitation by a non-human primate.

2. Methods

The video described here was taken just before 6pm on 23 May 2012, on the northeast intertidal zone of Piak Nam Yai island, Laem Son National Park, Thailand. The event occurred during a low, evening spring tide that exposed the mangroves floors and mud flats of the island. During this time, a group of macaques was opportunistically foraging amongst the diversity of prey in the temporarily available environment. It was filmed by hand (by MH) on a Sony Handycam from an unanchored boat offshore, which has added movement to the camera, later minimised using Apple iMovie software. The

adult male macaque involved is Judas (Jd), at the time a member of the Mangrove group on Piak Nam Yai (Gumert et al., 2013). The crab was a mud crab, *S. olivaceae*.

3. Description

Prior to the start of the video segment, Jd was observed at a distance carrying the captured crab from the tidally exposed mudflats of Piak Nam Yai directly to the location where the video takes place (see Figure A1 in the Appendix at 10.6084/m9.figshare.19960160). The actual capture was not seen, but Jd did not stop or use tools from the time he was first observed to the time he reached the video location.

At the beginning of the video, Jd is in the process of manipulating what appears to be a fatigued or stunned orange mud crab. He carefully manipulates the crab bimanually, withdrawing each hand in avoidance when verging on contact with the crab's pincers. Despite apparent effort to avoid being pinched, he is glancingly nipped on the left hand. Jd drags the crab towards a raised gap under a very large basalt stone that he is standing over. He adjusts the raised area of the stone with his left hand. Although it is not captured in the video, it is possible that Jd has earlier positioned the large stone in preparation for a strike, since the stone is first seen at an unnatural angle and Jd's left foot may be holding down the other end. We suggest that preparatory tool behaviour should be assessed in future work building on this anecdote.

Jd is battling to keep the crab flat on its carapace, with the crab's abdomen exposed upwards. Jd eventually forces the crab under the stone. He immediately picks the stone up bimanually and strikes the crab. Using a pound hammering action, Jd hammers the face of the stone downwards, favouring his right arm. The strike fails to connect fully, as the crab struggles and evades the full impact of the stone. Jd seizes the crab bimanually, then secures the crab in his left hand and readies his right hand on the stone. The crab rights itself, and Jd rolls the crab back onto its carapace. The crab continues to struggle to right itself.

Jd restrains and inverts the crab with two hands, following which he scans his surroundings (note that crab collection often attracts attention from other macaques). The crab appears to be tiring. Jd pins the crab with his left hand, restraining it. The crab tries to break away a few times, but Jd restrains it each time. Eventually, with the crab pinned in place, Jd quickly removes

his left hand restraining the crab, to pick up the stone and strike the crab bimanually. Again, he favours his right hand during the hammer strike. The face of the stone solidly connects onto the fully exposed abdomen. The crab is immobilized and potentially dead. Jd collects the crab with left hand and shifts to a bimanual inspection of it. He transfers the crab back to his left hand and carries it away from the stone weapon. The fact that Jd takes the crab away for consumption confirms that this stone tool was part of the hunt and not used for meat extraction.

Following the video, Jd took the motionless but intact crab several metres away and sat down to eat it (Figure A2 in the Appendix at 10.6084/m9.figshare.19960160). He did not further use tools on the crab, instead tearing it apart with his teeth and hands and eating it piece by piece. The subduing phase was therefore the only part of the hunt that involved a tool of any kind.

Although this specific kind of observation was never noted before, the crab predation proclivities of Jd did not seem to differ from the general population of macaques on Piak Nam Yai. From scan sampling across Piak Nam Yai's 9 groups in 2011 by MDG, Judas was recorded once eating a crab, out of 23 scans where he was engaged in feeding activity. This finding was equivalent to the overall proportion found across 142 individuals, where 4% of scans with identifiable food were crabs. Jd therefore was no more or less focused on crab predation than other macaques on Piak Nam Yai. The videoed event we have presented here was the only time Jd was recorded using a stone to pound a crab, although he was regularly observed to use stone hammers to pound open unattached shellfish on stone anvils, and less often stone axe hammers to break open oysters attached to tidally-emergent boulders. The stone tool used in the video was amongst the largest of stones used by Jd or any other macaque on Piak Nam Yai. Although never collected and measured, the stone tool used in this case appeared to be at least the size of the heaviest macaque tools ever measured in systematic surveys of the island, which were approximately 2.5 kg.

4. Discussion

Our use of the phrase 'stone-tool assisted hunting' may be contentious, but we believe it is appropriate. Hunting refers to any animal activity that involves chasing and subduing another animal to kill or injure it, which generally applies to crab capture by the Piak Nam Yai macaques, with or without

tool use. Further, while Judas' initial capture of the crab at Piak Nam Yai was not filmed, the recorded segment of the subduing phase is heavily dependent on his use of a large stone hammer. In this respect the macaque behaviour mirrors much human hunting, in which the initial stalk and chase may be done on foot, but a weapon (spear, club, knife, etc.) is then used to incapacitate or kill. The purpose of the hunting tool in both cases is to subdue the prey more quickly and safely than could be accomplished by the hunter alone. By using a stone tool, the macaque minimizes the time engaged in handling an active, potentially harmful opponent, reducing the risk of injury. The care shown by Judas in handling the crab, and the nip on his left hand while doing so, suggests that he is aware of and avoiding the potential threat.

'Tool-assisted hunting' has previously been applied to both non-human primate and dolphin tool use. In the former case, wooden tools are used by western chimpanzees (*Pan troglodytes verus*) to prey on lesser bushbabies (*Galago senegalensis*) at Fongoli, Senegal (Pruetz et al., 2015), and stone digging tools are used by bearded capuchins (*Sapajus libidinosus*) in Serra da Capivara National Park, Brazil, to flush out or access prey. In the chimpanzee case, the bushbaby is usually hidden and out of reach in a tree cavity, and once the prey is detected the chimpanzees make and use a thrusting spear to immobilize or kill it. The capuchins strike stones against crevices and other hiding places used by small prey such as lizards, and use stone tools to break up the soil as they dig for burrowing spiders, but they do not then use the stones to subdue their prey, which is caught and eaten by hand (Falótico et al., 2017a). In the dolphin case, they hold a protective sponge over their rostrum while scouring the seafloor for hidden and stationary fish, which they disturb and can then catch and eat (Patterson & Mann, 2012).

The macaque case is something of a blend of the chimpanzee and dolphin examples, with the stone tool used to end rather than start the hunt (as per the chimpanzees) but with the prey having greater scope for escape (as per the dolphins). Another potential case of tool-assisted hunting from the shores of Piak Nam Yai was the discovery of the smashed remains of a lizard (*Hemidactylus* sp.) underneath of a macaque tool (Gumert & Malaivijitnond, 2012). It is possible the stone was used during the capture process; however only the remains were observed.

Importantly, the targets of non-human animal stone tool use rarely fight back. These targets include nuts cracked by bearded capuchin monkeys (*Sapajus libidinosus*), white-faced capuchins (*Cebus capucinus imitator*),

western chimpanzees and long-tailed macaques, and slow-moving or immobile shellfish opened by capuchins and macaques (Shumaker et al., 2011; Haslam et al., 2016; Falotico et al., 2017b; Barrett et al., 2018). Non-primate examples include egg-cracking by Egyptian vultures (*Neophron percnopterus*), and shellfish pounding by sea otters (*Enhydra lutris*) (Carrete et al., 2017; Haslam et al., 2019). However, much human use of stone tools for subsistence also involves passive targets, including processing seeds, tubers, nuts and other plant foods, as well as bones, shells and carcasses. Human stone-tool-use for non-food tasks is also prevalent, but not relevant to our discussion here. At present, therefore, the use of stone tools to confront and subdue active, dangerous prey is only known among humans, and now long-tailed (crab-eating) macaques.

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Supplementary material

Supplementary Video 1. Judas (*Macaca fascicularis aurea*) hunting a crab (*Scylla olivaceae*) using a stone tool; 23 May 2012, Piak Nam Yai, Thailand. This video can be accessed in the Appendix at 10.6084/m9.figshare.19960160.

Figure A1. Judas (*Macaca fascicularis aurea*) transporting the captured crab from tidally exposed mudflats to the tool-use location seen in Figure 1 and Supplementary Video 1. Judas is circled, holding the crab in his right hand as he travels from right to left. This figure and the video can be accessed in the Appendix at 10.6084/m9.figshare.19960160.

Figure A2. Judas (*Macaca fascicularis aurea*; circled) consuming a claw of the subdued crab at a site several metres from the tool-use location in

seen in Figure 1 and Supplementary Video 1. He did not use tools at the consumption site, instead using hands and teeth to dismember the crab. This figure and the video can be accessed in the Appendix at 10.6084/m9.figshare.19960160.