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Sexual bias in probe tool manufacture and use by wild bearded capuchin monkeys

Tiago Falótico*, Eduardo B. Ottoni

Department of Experimental Psychology, Institute of Psychology, University of São Paulo, Av. Prof. Mello Moraes, 1721, Bloco F, Sala 2, Cidade Universitária São Paulo 05508-030, Brazil

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ABSTRACT

Here we examine data from a two-year research on the use of sticks as probes by two groups of wild capuchin monkeys (*Sapajus libidinosus*) in Serra da Capivara National Park (PI), Brazil. The use of sticks as probes is not usually observed among wild tufted capuchin (*Sapajus* spp.) populations, having been reported as a customary behavior only in SCNP groups. Probe tools are used to access small prey (insects or lizards) in rock cracks or tree trunks, or honey from wasps' nests, and also to poke toads and poisonous snakes. Probe use is, so far, the only known case in which wild capuchins modify objects used as tools: branches are trimmed off, and tips, thinned. Tool preparation episodes involved up to four modification steps. Contrary to the stone tools used to crack hard nuts, probe tools don't present any weight constraint for use by females, but there is nevertheless a strong male bias (97%) in the occurrence of probe tool use. There are also no diet biases that could explain this difference. Although males hunt more often than females, the latter main prey items are lizards, which are also the main targets of probe tool use. One possibility is that females may have fewer social opportunities to learn about probe tools.

1. Introduction

Tool use is widespread in bearded capuchin monkeys (*Sapajus libidinosus*, previously *Cebus libidinosus* – see Alfaro et al., 2012) living in savannah-like and semiarid environments (Ottoni and Izar, 2008). Their most common tools are stones used as "hammers" to crack open hard-shelled fruits, seeds, and nuts (Ferreira et al., 2010; Fragaszy et al., 2004; Ottoni and Izar, 2008; Spagnoletti et al., 2012). Others species of the genus (*Sapajus xanthosternos* and *Sapajus flavius*) also use stone tools to open hard shelled fruits (Canale et al., 2009; Ferreira et al., 2009), but the only wild groups of *S. libidinosus* known, to date, to regularly use stone tools for other purposes are those from the Serra da Capivara National Park (SCNP) population. In this location, bearded capuchins of at least two groups were previously known to use stones not only to crack or smash fruits and seeds, but also to dig for roots, underground storage organs, and spider nests (Mannu and Ottoni, 2009; Moura and Lee, 2004). Most tools are used to obtain food, but there are exceptions, like stone banging in threatening displays (Moura, 2007), and throwing stones as a part of females' sexual display (Falótico and Ottoni, 2013).

The use of probe tools is reported in several primate species under captivity, mostly in experimental situations (Shumaker et al., 2011), but is less frequent in the wild. Among chimpanzees, the use of probes to obtain food is customary in several populations, especially in the predation of social insects. Army ants' dipping consists in placing a stick on the ants and the consumption of the insects that climb/grab it (McGrew, 1974; Nishida and Hiraiwa, 1982). There are variations in this behavior depending on the species predated; if the ant species is more aggressive, the tools are longer and the processing technique is different (Humle and Matsuzawa, 2002). There is also the sequential use of probe tools to obtain food by some groups: chimpanzees from Goualougo Triangle (Congo) use a thick stick to perforate the termite nests and then a slender and longer stick to "fish" the insects (Sanz et al., 2004), and chimpanzees from Loango National Park (Gabon) use a similar tool set to dip for honey in bee nests (Boesch et al., 2009). Some wild populations of Sumatran orangutans use sticks to access seeds from the *Neesia* fruit, and others use stick probes to extract social insects and their products from tree holes (Van Schaik et al., 1996; Van Schaik and Knott, 2001).

Captive tufted capuchin monkeys in experimental settings use probes to push a reward out of a tube (Visalberghi et al., 1995;

* Corresponding author. Tel.: +55 11 3091 1926, +55 11 99711 1849 (mobile).
E-mail address: tfalotico@gmail.com (T. Falótico).

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Visalberghi and Limongelli, 1994), and also modify and combine probe tools when the probes were presented tied together, or cut in pieces that needed to be inserted sequentially (Visalberghi and Trinca, 1989). In other experiments where capuchin monkeys had to probe for molasses in a box, they solved the problem by making and using probes with the material provided, wooden dowel and freshly cut branches from shrubs (Westergaard and Fragaszy, 1987). Similar behaviors were observed in semi-captive and semi-free animals in experimental settings (Aquino and Ottoni, 2001; Perondi et al., 1995).

Wild capuchin monkeys often hunt small vertebrates (Butynski, 1982; Fedigan, 1990), as well as a variety of invertebrates (Izawa, 1979). Several invertebrates nest in small spaces in tree trunks, and small vertebrate prey (e.g. lizards), when chased, may hide in rock cracks or tree holes, escaping the monkeys' direct reach. The only population with known customary use of probe tools to deal with this problem is found in the Serra da Capivara National Park (SCNP)(Mannu and Ottoni, 2009; Moura and Lee, 2004; Ottoni and Izar, 2008), but no detailed description of this behavior has been done. Another long term study on capuchin monkeys in a similar environment 300 km apart from SCNP never reported probe tool use (Spagnoletti et al., 2012). The only other report of a similar behavior involves just a few episodes ($N = 8$) of termite nest probing by a non-typical group (four adult males, one adult female, and one male juvenile) of *S. flavius* in the Atlantic forest (Souto et al., 2011).

Here we describe in detail the customary manufacture and use of stick probes to cast out prey from hiding places, and to dip honey from bee/wasp hives, by two, not previously studied groups of *S. libidinosus* in the SCNP. We also report the use of sticks to threaten potentially dangerous animals.

2. Methods

2.1. Study site

Research was conducted in Serra da Capivara National Park (SCNP; Piauí state, northeastern Brazil). The park is located at the geoclimatic domain of the *Caatinga*, semi-arid climate, with a mosaic of xerophytic vegetation and patches of deciduous forest at narrow wetter valleys surrounded by high cliffs. The rainfall is very concentrated in the short wet season, from November to March. The study area is the Boqueirão da Pedra Furada, in the southeast border of the park (limiting coordinates: North: 8°49′S, 42°33′W; South: 8°50′S, 42°33′W; East: 8°50′S, 42°32′W; West: 8°50′S, 42°34′W).

2.2. Study groups

We observed two partially sympatric groups (Supplementary map 1) of capuchin monkeys (*S. libidinosus*). The Pedra Furada (PF) group had, in the beginning of the study, 45 individuals, and the Bocão (BC) group, 27 individuals. The two groups sometimes met and foraged in the same area for minutes or hours, but never had agonistic encounters (occasional agonistic episodes occurred between some individuals, but never included the whole groups). The park staff provisioned both groups during the dry seasons. The provisions consisted of fruits (three to four times a week) and dry corn (every two weeks). The corn was meant for other animals on the park, but monkeys also ate it.

2.3. Observation method

During the daily following of the group we registered all occurrences of tool use (as defined by Shumaker et al., 2011) with the help of a field assistant, by All Occurrences sampling (Altmann, 1974).

Tool use behaviors were registered by voice and/or by video. The monkey and its target prey were identified when possible. An individual was counted as an observer when it was within 1 m from the tool user and oriented towards it.

Table 1
Levels of stick tools modification.

No. of modifications	Description
0	No modifications of the tool.
1	The tool was detached or was modified once (tip cut, lateral branches removed or thickness reduction by bark removal).
2	The tool was detached and underwent one more modification, or was taken already detached, but underwent two subsequent modifications.
3	The tool was detached and underwent two more modifications. Or was taken already detached, but underwent three subsequent modifications.
4	The tool was detached by the user and underwent three more modifications.

When probe tool use events were observed from the very beginning (68.9% of the events) we registered the manufacturing of the tools: where the monkey got the stick, how many modifications were made and which end was used for probing. We classified these tools in to four categories, according to the number of modifications (Table 1). Stick tools were collected and measured (length and thickness) when possible.

The research in the SCNP was previously approved by IBAMA/ICMBio (authorizations 037/2007/DIREC and 14825-1), adhered to the ASAB/ABS Guidelines for the Use of Animals in Research, and followed all ethical guidelines for animal research of the Institute of Psychology-USP.

3. Results

The groups were systematically followed for 20 days per month, from initial visual contact in the morning until the end of the day or the loss of contact with the group. The data from PF group were collected for 23 months (Sep/2007–Jul/2009), and from BC group, for 12 months (Mar/2008–Feb/2009), with 1290.23 h of contact time with the PF group and 426.36 h with the BC group.

We registered 480 episodes of probe tool use for both groups, and collected the probes used in 177 episodes; the average length of the probes was 27.94 ± SD 14.97 cm (min. 6.5 cm; max. 98.2 cm). The average thickness was 4.67 ± SD 1.19 mm. There were no significant differences between the two study groups in the length (Mann–Whitney, $p = 0.334$) and thickness of the tools (Mann–Whitney, $p = 0.437$).

There was also no statistical difference in length (Mann–Whitney, $p = 0.85$), or in thickness (Mann–Whitney, $p = 0.837$) between the probes used by these groups and by the other two studied by Mannu and Ottoni (unpublished data).

The targets of the probing behavior were the hiding places of small lizards (mostly *Tropidurus* ssp.) and arthropods, or honey from bees' and wasps' nests (Table 2).

Table 2
Targets searched with probe tools.

Target	Events	Frequency (%)
Lizards (rock cracks)	191	39.79
Trunk holes[a]	181	37.71
Carpenter bee nests	85	17.71
Wasp nests	3	0.62
Termite nests	11	2.29
Spider nests	4	0.83
Others	5	1.04
Total	**480**	**100**

[a]Target unseen, probably arthropods/honey.