ZOOLOGIA 31 (5): 516–519, October, 2014
http://dx.doi.org/10.1590/S1984-46702014000500012

SHORT COMMUNICATION

Tool use in urban populations of capuchin monkeys *Sapajus* spp. (Primates: Cebidae)

Lucas M. Aguiar[1,4], Raphael M. Cardoso[2], Janaína P. Back[1], Eduarda C. Carneiro[2], Adriane Suzin[1] & Eduardo B. Ottoni[3]

[1] *Instituto Latino-americano de Ciências da Vida e da Natureza, Universidade Federal da Integração Latino-Americana. Avenida Tancredo Neves 6730, Fundação Parque Tecnológico de Itaipu, Bloco 6, 85867-970 Foz do Iguaçu, PR, Brazil.*
[2] *Universidade Federal de Goiás, Regional Jataí. Rodovia BR 364, km 195, 3800, Cidade Universitária, 75801-615 Jataí, GO, Brazil.*
[3] *Departamento de Psicologia Experimental, Instituto de Psicologia, Universidade de São Paulo. Avenida Professor Mello Moraes 1721, Bloco A, Sala E-10, Cidade Universitária, 05508-030 São Paulo, SP, Brazil.*
[4] *Corresponding author. E-mail: lucas.aguiar@unila.edu.br*

ABSTRACT. Capuchin monkeys, *Sapajus* Kerr, 1792, are known for their flexible behavior, including tool use, and their ability to survive in urban forests. We observed capuchin juveniles using wood as hammer and anvil and different materials as sponges (four tool-use events) in two geographically distinct urban populations in Brazil, in 2012: two in Goiânia, Central Brazil and two in Foz do Iguaçu, Southern Brazil. In Goiânia, a male used a detached tree branch as a hammer and a buttress root as an anvil to pound a seed of *Terminalia* Linnaeus. Another male used a small branch with leaves as a dipping tool to access water inside a tree trunk hole. In Foz do Iguaçu, the capuchins used a small branch and a piece of bread to obtain water by dipping them into tree trunk holes. This latter event might be interpreted as a case of self-control, with a familiar food item used as a tool to reach a resource that is difficult to access otherwise. Our observations contribute to the knowledge on the tool-kit of capuchins and we propose that these urban populations should be conserved for scientific evaluations of behavioral flexibility in non-human primates.

KEY WORDS. Animal self-control; behavioral flexibility; food provisioning; urban wildlife; values of nature conservancy.

Capuchin monkeys, *Sapajus* Kerr, 1792, are extractive foragers, and their behavioral flexibility allows them to inhabit a variety of habitats, including forest fragments within many Brazilian cities (Fragaszy *et al*. 2004). Although anthropic environments can provide some advantages to animals (e.g., partial food provisioning, low predation risk and increased free time), they also impose new challenges (Lowry *et al*. 2013, Sol *et al*. 2013). For example, in anthropic forest fragments, capuchins must adjust their foraging patterns by exploring new feeding resources (artificial or exotic foods) (Visalberghi & Addessi 2003). At the same time, they have to cope with stressful situations, such as crowding, roadkill, electrocution, intoxication, and conflicts with humans. Behavioral flexibility is widely believed to be one of the mechanisms by which animals deal with these challenges (Sol *et al*. 2013). Tool use, an example of flexible behavior found among capuchin monkeys (Fragaszy *et al*. 2004), has been documented in some urban populations (Rocha *et al*. 1998, Ottoni & Mannu 2001).

Habitual tool use by wild capuchins has been increasingly documented in the last decade (Ottoni & Izar 2008). Most accounts concern *Sapajus libidinosus* Spix, 1823, a species that inhabits savannah-like environments in Brazil, and describe the use of tools for food extraction (sensu Bentley-Condit & Smith 2010), for instance stones for digging tubers, and pounding tools for cracking open encapsulated fruits (Moura & Lee 2004, Mannu & Ottoni 2009, de Moraes *et al*. 2014). In addition, the tool-kit used by *S. libidinosus* comprises tools of other categories, such as utensils to transport resources, including probes (Mannu & Ottoni 2009), and for communication (Falótico & Ottoni 2013). The use of probes was also observed in a group of blond capuchin monkeys (*Sapajus flavius* Schreber, 1774) inhabiting a forest fragment in the Atlantic Forest Domain (Souto *et al*. 2011).

The differences observed among tool-kits of capuchins from different populations illustrate their flexibility in tool use. Although genetic and ecological factors may contribute to the development of tool use behavior (Meulman *et al*. 2013), the social environment appears to provide a basis for naive capuchins to learn technical skills (Fragaszy *et al*. 2013).

Here we report the use of tools by capuchins from two urban populations in geographically distant locations in Brazil, with two different purposes: first, to pound seeds with a wooden hammer and anvil and second, to obtain water inside tree trunk holes using different kinds of sponges. The use of

dipping tools to obtain water from cavities in trees is rare in primates (Tonooka 2001). Our observations may also indicate a case of animal self-control in a non-captive context, namely the abdication of an immediate opportunity to consume resources in favor of using a tool to later obtain other valuable resources (Evans & Westergaard 2006). To date such behavior had only been observed in captive capuchins (Evans & Westergaard 2006, Judge & Essler 2013).

Our observations took place in two urban parks in Brazil: Areião Municipal Park (16°42'18.4"S, 49°15'16.1"W), 14 ha large, in the city of Goiânia (Central Brazil, Cerrado Domain) and the Jardim Ipê Forest (25°28'56.1"S, 54°33'55.9"W), 3.5 ha large, in the city of Foz do Iguaçu (Southern Brazil, Atlantic Forest Domain). In both areas, capuchins are semi-free ranging and are provisioned weekly, although they can also forage for resources in the forest and consume human leftovers. Both areas are open to the public and humans frequently feed the capuchins. Contrasting with the Foz do Iguaçu Park, where water is more limited, water sources are continuously available in the Goiânia Park (a stream and a lake). Stones that are large and hard enough to be used as hammers and anvils are unavailable in both locations.

A native population of *S. libidinosus* has been living in the Goiânia Park at least since 1938, when the reserve was created. Today, this population consists of three groups. There have been local accounts of these monkeys using probes, which we aimed to ascertain. Capuchins from different groups were observed from August to November 2012, three days a week, at different hours (8:00-11:00 or 13:00-16:00 h) of the day, adding up to a total of 126 h in 52 days. Tool use was observed in two distinct groups: one of 24 individuals [13 adults (five males and eight females), two subadults, four juveniles and one infant], and another of 34 individuals [13 adults (three males and 10 females), four subadults, eight juveniles and one infant)].

In Foz do Iguaçu, tool-use events were registered during a social behavior study of a group of 17 individuals (J.P. Back, unpubl. data) that inhabit the forest [six adults (one male and five females), three subadults, three juveniles and five infants]. Although *Sapajus nigritus* (Goldfuss, 1809) occurs naturally in this region, the coats of individuals in this group are blond and they rather resemble *Sapajus cay* (Illiger, 1815). Therefore, they are here referred to as *Sapajus* sp. (Lynch-Alfaro *et al*. 2014). According to local people, these capuchins have lived there for 30 years, and are most likely introduced. The group was observed for three days each month between 7:00 and 17:00 h from January 2012 to June 2013 for a total of 530 hours.

We followed the definition of tool use by Shumaker *et al*. (2011). We considered as a tool-use event the usage of an object to obtain a resource until the abandonment of that object. These events were counted using the all-occurrences sampling method (Altmann 1974), and were recorded and described *ad libitum* in a field notebook.

We observed four tool-use events: two events in Goiânia (1.6 event/100 h) and two in Foz do Iguaçu (0.4 event/100 h). All tool-use events were observed in 2012 and were performed by juveniles. In all cases, no other individual was within five meters of the subject.

The first event was recorded in Goiânia (September 7th, at 9:47 h): a male juvenile on the ground used a detached tree branch as a hammer and a buttress root as an anvil to pound an encapsulated seed of *Terminalia* L. (Fig. 1). One of us (E.C. Carneiro) became aware of this behavior when it was already being performed, and for this reason we did not record its duration. We were also unable to verify whether the use of this tool was successful because the animal abandoned the site carrying the seed. The second event (September 12th, 14:58-15:00 h), also in Goiânia, took place in the canopy, ten meters above ground: another male detached a small branch with leaves from a tree of an undetermined species and dipped it into a tree trunk hole (Fig. 2). The capuchin left the branch inside the hole for three seconds and then kneaded the leaves with two hands and sucked them. Subsequently, it moved one meter away and discarded the branch.

In Foz do Iguaçu, we observed the use of two different tools for dipping into tree trunk holes of the forest understory (approximately two meters above ground): 1) a small piece of bread provided by humans (January 7th, 14:45-14:51 h) and 2) a small branch with leaves picked up from the ground (September 6th, 16:21-16:22 h). During both events, the animal sucked the object repeatedly after multiple insertions into the cavities. During the first event, the capuchin ate the bread after dipping it and sucking from it five times. During the second event, the capuchin left the branch after drinking from it three times. It was not possible to identify the juveniles in Foz do Iguaçu, and therefore they may have been performed by the same individual or not.

Tool use was a rare behavior at our study sites compared with other sites (e.g., Phillips 1998, Mannu & Ottoni 2009), but we observed differences in tool-use behavior in both areas. In Goiânia, tool use can be split into two categories: food extraction and resource transportation (here: water). In Foz do Iguaçu, we only observed one of those categories, resource transport, but two different techniques were employed: the use of a natural item from the forest (branch) and of a man-made food item (bread). This may indicate a temporary transition of a familiar food item into a dipping tool, as discussed below.

Capuchins can maintain the use of tools through social learning, and adult individuals tend to be more skilled users (Ottoni *et al*. 2005). However, we only observed tool use by juveniles at our observation sites, and adults were not involved. The observed categories of tool use are common among capuchin juveniles (Phillips 1998, Mannu & Ottoni 2009) and have been associated with their great learning capacity, propensity for innovation and flexible behavior (Kummer & Goodall 1985). Lowry *et al*. (2013) noted that juveniles can express a greater foraging plasticity in urban environments, and tool use can be considered as a foraging strategy (Bentley-Condit & Smith 2010).

Figures 1-2. Capuchin monkeys, *S. libidinosus*, from Goiânia using tools: (1) a juvenile using a wooden hammer and anvil to open a *Terminalia* sp. seed; (2) a juvenile inserting a small branch with leaves into a tree trunk hole to obtain water.

In Goiânia, a capuchin used a hammer and anvil in a feeding context. According to Fragaszy *et al*. (2013) these are complex tools for animals and require practice. Young capuchins can combine non-stone items for pounding (Mannu & Ottoni 2009), as observed by us where stones are not available. Thus, the use of wooden hammer and anvil suggests a pounding technology analogous to the more common lithic tools observed at other sites, since the basic principles of tool use can be applied to both organic and inorganic materials (Westergaard & Suomi 1994).

The urban capuchins used dipping tools as sponges but in a simpler fashion than other capuchin populations, which perform object modifications (Phillips 1998, Mannu & Ottoni 2009). The use of bread as a tool by a capuchin was noteworthy and the bread was only consumed after repeatedly using it as a sponge for drinking water, suggesting that the user is capable of self-control (Evans & Westergaard 2006). Apparently, the capuchin was able to postpone the immediate consumption of a food item to access water, which is a scarce and valuable resource in this urban forest. The use of food as a tool, including bread, has been recorded for captive capuchins (McGrew & Marchant 1997), and our observations indicate that capuchins in a non-captive context share this ability. Alternatively (but not to the exclusion of the first explanation), it is possible that the capuchin meant to soften the bread instead of using it as a tool. However, the action pattern and the repetition of combined insertion and drinking indicate that the bread was used as a tool.

Our observations were made on semi-free ranging and partially provisioned monkeys, a situation that can interfere with the foraging behavior of the species (Lowry *et al*. 2013). However, it is difficult to evaluate these influences on the urban capuchins from Goiânia because wild populations of *S. libidinosus* frequently use tools. Yet, the continuous availability of food and water suggests that these animals live with a surplus of time and energy, and that the observed tool use behavior could result from the opportunistic habits of the species (Haslam 2013). Anthropic food are abundantly available to the capuchins in Foz do Iguaçu, while water sources are scarce, which could explain the self-control and opportunistic habit of using a common food item as a tool.

Finally, tool use behavior is absent in the majority of other species of *Sapajus*, especially in forested environments (Ottoni & Izar 2008). There are only four sites in the Atlantic Forest Domain where capuchins were observed using tools (this study, Rocha *et al*. 1998, Ottoni & Mannu 2001, Souto *et al*. 2011), three of which are urban forests. Monkeys in urban forests are often more accessible for primatological field studies and urban populations of tool using capuchins can be viewed as scientific subjects for accessible studies of primate behavior. In addition to surveying tool-use techniques by capuchin populations, we encourage environmental administrators, managers and scientists to use the so-called Ecologistic-Scientific Human Value of Nature (Kellert 1993) as a motivation to better protect these animals in cities.

Our observations contribute to the knowledge on the tool-kit of capuchins and we propose that these urban populations should be subjected to scientific evaluations. Standardized field studies will help to catalog, compare and contextualize the social and ecological significance of the tool-kit of these urban monkeys, while providing a better understanding of animal behavioral flexibility and interactions with humans.

ACKNOWLEDGEMENTS

LMA, JPB and AS are grateful to the PROBIC/UNILA, Fundação Araucária, and Foz do Iguaçu City Hall. RMC and ECC thank CNPq and the Goiania City Hall. EBO thanks FAPESP and CNPq. We also thank Phyllis C. Lee, editors, and two anonymous reviewers for their helpful comments.

LITERATURE CITED

Altmann, J. 1974. Observational study of behavior: sampling methods. **Behaviour 49** (3): 227-267.

Bentley-Condit, V.K. & E.O. Smith. 2010. Animal tool use: current definitions and an updated comprehensive catalog. **Behaviour 147** (2): 185-221. doi: 10.1163/000579509X12512865686555

de Moraes, B.L.C.; A.S. Souto & N. Schiel. 2014. Adaptability in stone tool use by wild capuchin monkeys (*Sapajus libidinosus*). **American Journal of Primatology 76**: doi: 10.1002/ajp.22286

Evans, T.A. & G.C. Westergaard. 2006. Self-control and tool use in tufted capuchin monkeys (*Cebus apella*). **Journal of Comparative Psychology 120** (2):163-166. doi: 10.1037/0735-7036.120.2.163

Falótico, T. & E.B. Ottoni. 2013. Stone throwing as a sexual display in wild female bearded capuchin monkeys, *Sapajus libidinosus*. **PLoS One 8** (11): 1-6. doi: 10.1371/journal.pone.0079535

Fragaszy, D.; E. Visalberghi & L.M. Fedigan. 2004. **The Complete Capuchin, the biology of the Genus *Cebus*.** Cambridge, Cambridge University Press, XX+356p.

Fragaszy, D.; D. Biro; Y. Eshchar; T. Humle; P. Izar; B. Resende & E. Visalberghi. 2013. The fourth dimension of tool use: temporally enduring artefacts aid primates learning to use tools. **Philosophical Transactions of the Royal Society B 368** (1630): 1-10. doi: 10.1098/rstb.2012.0410

Haslam, M. 2013. 'Captivity bias' in animal tool use and its implications for the evolution of hominin technology. **Philosophical Transactions of the Royal Society of London B 368** (1630): 1471-2970. doi: 10.1098/rstb.2012.0421

Judge, P.G. & J.L. Essler. 2013. Capuchin Monkeys Exercise Self-control by Choosing Token Exchange Over an Immediate Reward. **International Journal of Comparative Psychology 26** (4): 256-266.

Kellert, S.R. 1993. The biological basis for human values of nature, p. 42-69. *In*: S.R. Kellert & E.O. Wilson (Eds). **The Biophilia Hypotheses.** Washington, D.C., Island Press, XX+496p.

Kummer, H. & J. Goodall. 1985. Conditions of innovative behaviour in Primates. **Philosophical Transactions of the Royal Society of London B 308** (1135): 203-214. doi: 10.1098/rstb.1985.0020

Lowry, H.; A. Lill & B.B.M. Wong. 2013. Behavioural responses of wildlife to urban environments. **Biological Review 88** (3): 537-549. doi: 10.1111/brv.12012

Lynch-Alfaro, J.W.; P. Izar & R.G. Ferreira. 2014. Capuchin monkey research priorities and urgent issues. **American Journal of Primatology 76**: doi: 10.1002/ajp.22269

Mannu, M. & E.B. Ottoni. 2009. The enhanced tool-kit of two groups of wild bearded capuchin monkeys in the Caatinga: tool making, associative use, and secondary tools. **American Journal of Primatology 71** (3): 242-251. doi: 10.1002/ajp.20642.

McGrew, W.C. & L.F. Marchant. 1997. Using the tools at hand: manual laterality and elementary technology in *Cebus* spp. and *Pan* spp. **International Journal of Primatology 18** (5): 787-810. doi: 10.1023/A:1026347913888

Meulman, E.J.M.; A.M. Seed & J. Mann. 2013. If at first you don't succeed. Studies of ontogeny shed light on the cognitive demands of habitual tool use. Philosophical **Transactions of the Royal Society of London B 368** (1630): doi: 10.1098/rstb.2013.0050

Moura, A.C.A. & P.C. Lee. 2004. Capuchin stone tool use in Caatinga Dry Forest. **Science 306** (5703): 1909-1909. doi: 10.1126/science.1102558

Ottoni, E.B. & M. Mannu. 2001. Semifree-ranging tufted capuchins (*Cebus apella*) spontaneously use tools to crack open nuts. **International Journal of Primatology 22** (3): 347-358. doi: 10.1023/A:1010747426841

Ottoni, E.B.; B.D. Resende & P. Izar. 2005. Watching the best nutcrackers: what capuchin monkeys (*Cebus apella*) know about others' took-using skills. **Animal Cognition 24** (8): 215-219. doi: 10.1007/s10071-004-0245-8

Ottoni, E.B. & P. Izar. 2008. Capuchin monkey tool use: overview and implications. **Evolutionary Anthropology 17** (4): 171-178. doi: 10.1002/evan.20185

Phillips, K.A. 1998. Tool use in wild capuchin monkeys (*Cebus albifrons trinitatis*). **American Journal of Primatology 46** (3): 259-261. doi: 10.1002/(SICI)1098-2345(1998)46:3<259::AID-AJP6>3.0.CO;2-R

Rocha, V.J.; N.R. Reis & M.L. Sekiama. 1998. Uso de ferramentas por *Cebus apella* (Linnaeus) (Primates, Cebidae) para obtenção de larvas de Coleoptera que parasitam sementes de *Syagrus romanzoffianum* (Cam.) Glassm (Arecaceae). **Revista Brasileira de Zoologia 15** (4): 945-950. doi: 10.1590/S0101-81751998000400012

Shumaker, R.W.; K.R. Walkup & B.B. Beck. 2011. **Animal tool behavior: the use and manufacture of tools by animals.** Baltimore, Johns Hopkins University Press, XX+304p.

Sol, D.; Dapiedra, O. & C. González-Lagos. 2013. Behavioural adjustments for a life in the city. **Animal Behaviour 85** (5): 1101-1112. doi: 10.1016/j.anbehav.2012.01.023

Souto, A.; A.B.C. Bione; M. Bastos; B.M. Bezerra; D. Fragaszy & N. Schiel. 2011. Critically endangered blonde capuchins fish for termites and use new techniques to accomplish the task. **Biology Letters 03**: 532-535. doi: 10.1098/rsbl.2011.0034

Tonooka, R. 2001. Leaf-folding behavior for drinking water by wild chimpanzees (*Pan troglodytes verus*) at Bossou Guinea. **Animal Cognition 4** (3-4): 325-334. doi: 10.1007/s100710100110

Visalberghi, E. & E. Addessi. 2003. Commentary to the article of Perry et al. Social conventions in wild white-faced capuchin monkeys: evidence for tradition in a neotropical primate. **Current Anthropology 44** (5): 259-260.

Westergaard, G.C. & S.J. Suomi. 1994. The use and modification of bone tools by capuchin monkeys. **Current Anthropology 35** (1): 75-77.

Submitted: 22.IV.2014; Accepted: 20.IX.2014.
Editorial responsibility: Diego Astúa de Moraes