

Tool use in wild spider monkeys (*Ateles geoffroyi*)

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Abstract Tool use has been observed in a variety of primate species, including both New and Old World monkeys. However, such reports mainly address the most prodigious tool users and frequently limit discussions of tool-using behavior to a foraging framework. Here, we present observations of novel and spontaneous tool use in wild black-handed spider monkeys (*Ateles geoffroyi*), where female spider monkeys used detached sticks in a self-directed manner. We introduce factors to explain *Ateles* tool-using abilities and limitations, and encourage the synthesis of relevant research in order to gain insight into the cognitive abilities of spider monkeys and the evolution of tool-using behaviors in primates.

Keywords Tool use · *Ateles geoffroyi* · Cognition

Introduction

Tool use has been reported in a variety of primates, including both New and Old World monkeys (Beck 1980; Urbani and Garber 2002; Panger 2007). However, the

literature mainly addresses the most prodigious tool users, particularly chimpanzees (*Pan troglodytes*), orangutans (*Pongo pygmaeus*), and capuchin monkeys (*Cebus* sp.), and often limits discussions of tool-using behavior to a foraging or feeding framework (van Schaik et al. 1999; Urbani and Garber 2002). Such an emphasis overlooks the cognitive aspects of tool use in solving problems unrelated to food. Unlike foraging-related challenges, self-directed and social tool use are less constrained by outcome, which may provide greater opportunity for innovation and creativity. Here, we present evidence of tool use in wild black-handed spider monkeys (*Ateles geoffroyi*), where on three occasions females used detached sticks to scratch themselves.

Our observations are unique, as this type of tool use is absent in the published literature for *Ateles*. Employing tools for body care or comfort has been observed in other wild nonhuman primates (*Macaca radiata*: Sinha 1997; *Pan paniscus*: Hohmann and Fruth 2003; *Pan troglodytes*: Goodall 1970; Nishida and Nakamura 1993; *Pongo pygmaeus*: Galdikas 1982), primates living in urban areas or captivity (*Leontopithecus rosalia*: Stoinski and Beck 2001; *Macaca fascicularis*: Watanabe et al. 2007), and in non-primate animals (*Elephas maximus*: Hart et al. 2001). Such behaviors fit Beck's (1980) definition of tool use: "the external employment of an unattached environmental object to alter more efficiently the form, position, or condition of another object, another organism, or the user itself when the user holds or carries the tool during or just prior to use and is responsible for the proper and effective orientation of the tool." We might predict that *Ateles* is capable of using tools given that cognitive measures generally correlating with this behavior (e.g., neocortex ratio, encephalization quotient) are similar among *Ateles* and well-known tool users (Jerison 1973; Kudo and Dunbar 2001; Panger 2007). Moreover, spider monkeys are highly

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frugivorous (Carpenter 1935), exhibit a fission–fusion social system (Chapman 1990), and have slow life history patterns relative to body size (Chapman and Chapman 1990), all of which are thought to be associated with the evolution of cognitive complexity (Milton 1981; Barrett et al. 2003; Aureli et al. 2008).

Methods

The study was conducted at El Zota Biological Field Station (10°57.6'N, 83°75.9'W) in northeastern Costa Rica. This private reserve hosts a spider monkey population sympatric with mantled howling monkeys (*Alouatta palliata*) and white-faced capuchins (*Cebus capucinus*). El Zota consists of approximately 10 km² of lowland tropical wet and swamp forest (Holdridge et al. 1971), including several small plots of *Gmelina arborea*, *Hyeronima alchornoidea*, and *Musa* sp. monoculture. The region averages approximately 4000 mm of rainfall annually and lacks a pronounced dry season (Sanford et al. 1994).

Data were collected during two concurrent studies on the spider monkey communities at El Zota. A total of 169 contact hours were accumulated by the authors over the course of seven months between May 2005 and August 2006. Observations of tool use were recorded ad libitum.

Results

Three stick tool use events were documented in two spider monkey communities, known as Ceiba and Pilón, during the study period. In addition, observer-directed branch dropping events, which fit Beck's (1980) tool use definition, occurred on numerous occasions but were not systematically recorded. All branch-dropping events appeared to have been a response to observer presence.

Case 1

On 4 June 2005 at 11:27 hours, SML observed an adult female of the Ceiba community holding a small, leafy branch in her hand, which she used to scratch her thoracic and abdominal regions. The subject was part of a mixed-sex subgroup of at least eight individuals.

Case 2

Later that day, SML encountered a mixed-sex subgroup of at least six individuals within the Ceiba community. At 15:56 hours, an adult female used a stick, lacking side branches and leaves, to scratch her left axilla region. She

chewed the tool tip between scratching bouts. It could not be determined whether this female was the same individual from the first case.

Case 3

On 21 June 2006, MAR observed a party of at least four individuals of the Pilón community. At 15:59 hours, a juvenile female used a stick to scratch her anogenital region and the underside of her tail. Before using the tool, she chewed the distal tip and applied this end to her body.

Discussion

Our observations demonstrate that at least two individuals in different communities use stick tools at El Zota, which provides conclusive evidence of spontaneous tool use in wild spider monkeys. This record draws attention to existing—although often unacknowledged—spider monkey tool use observations consisting of branch dropping (Carpenter 1935) and fur rubbing (Campbell 2000; Laska et al. 2007). Branch dropping or throwing is classified as tool use if the branches are intentionally directed at the recipient in order to change their behavior (Beck 1980). However, diagnosing direction and intent may be ambiguous. Consequently, this behavior has been excluded from some discussions of tool use (Panger 1998). Fur rubbing, the action of rubbing aromatic substances on the body, qualifies as tool use but is generally limited to discussions of self-medication or olfactory communication (Campbell 2000; Laska et al. 2007). In addition to variation in how researchers conceptualize tool use, the rareness of tool-use reports for *Ateles* may be a consequence of overall observation time, as *Ateles* is understudied relative to other tool using primates.

For the events observed in this study, each individual scratched a region of the body that was accessible without the aid of a tool. Therefore, these tools did not exclusively function as extensions of the body. We propose that tool function is related to mechanical or chemical properties of tools, or olfactory communication. Recent accounts of novel tool use in primates indicate that differences in local environment and consequent behavioral variation are important aspects to consider in the evolution of tool use (Breuer et al. 2005; Pruett and Bertolani 2007). At El Zota, tool function may also be associated with environmental context. Most long-term research on spider monkeys has been conducted in tropical moist or dry forests, but the wet forests at El Zota receive more annual precipitation. This wetter environment may lead to a higher prevalence of skin irritants caused by ectoparasites (Wolda and Galindo 1981) or fungi (Lupi et al. 2005), thereby provoking spider

monkeys to use tools for body care. Alternatively, stick scratching may simply be a cultural variant of scratching behavior (Whiten et al. 1999). Itch relief may be the immediate explanation for this behavior and, under this assumption, stick tools may serve a mechanical or chemical purpose. In two of the three events reported here, individuals modified the distal end of the tool, resulting in a frayed edge that may have provided more relief and comfort during scratching. Modifying the tip might also be related to the chemical properties of the selected plant, as research on fur rubbing and self-medication indicates that some primates select plants or invertebrates with chemical properties for this reason (Valderrama et al. 2000 and references therein). Tool use could play a role in olfactory communication, as some portions of the body affected by scratching contain scent-producing glands. Campbell (2000) argues that spider monkeys at Barro Colorado Island rub a mixture of crushed leaves and saliva on the sternal region and rub this area on a substrate to chemically communicate with conspecifics. In this study, substrate rubbing was not observed but perhaps scratching behaviors stimulate scent glands and contribute to olfactory signals in an undetermined way. Clearly, more information on this behavior and the tools used are required in order to understand the proximate mechanisms, the prevalence of tool use within and between *Ateles* populations (sensu Whiten et al. 1999), and how such behavior is acquired.

Generally, tool use within primates is thought to be rare (Panger 2007). Tool use in *Ateles* is significant because this genus is lacking in some, but not all, behavioral and morphological traits associated with this behavior. van Schaik et al. (1999) proposed several conditions under which tool use, excluding object throwing (e.g., branch dropping), is likely to have evolved: opportunity to better exploit foods with tools, cognitive ability to socially acquire and transmit tool use techniques, and effective manual dexterity for handling tools. *Ateles* brain morphology fits the general pattern among primate tool users. Panger (2007) reviewed common measures of cognition and found that larger brain sizes, expressed as the neocortex ratio and encephalization quotient, are associated with tool use in primates. *Ateles geoffroyi* has a neocortex ratio similar to *Cebus apella* and *Macaca radiata* (Table 1 in Kudo and Dunbar 2001), and an encephalization quotient equivalent to *P. troglodytes* (Table 16.3 on page 392 of Jerison 1973; but see also page 13 of Stephan et al. 1988). Moreover, some researchers suggest there is a relationship between fission–fusion dynamics and enhanced cognition (Barrett et al. 2003; Aureli et al. 2008). Recent evidence supports this prediction in *Ateles*, *Pan*, and *Pongo* (Deaner et al. 2006; Amici et al. 2008). However, we would not expect to observe a large tool-use repertoire in spider monkeys, given that their diet does not rely on extractive foraging techniques (Russo et al.

2005) and manual dexterity is limited by their hand morphology. Primates that use tools to extract food items typically exhibit great manual dexterity (Parker 1973; Jouffroy 1993); i.e., independent movement of all five digits and flexibility of the hallux. The spider monkey, a semibrachiator, has long, hook-like phalanges and a reduced or absent hallux. Such morphology facilitates suspensory travel but limits the ability to grasp or grip objects (Jouffroy 1993; Napier 1956). Thus, for spider monkeys, locomotion adaptations may constrain tool use.

Theoretical discussions for the evolution of tool use that exclude nonforaging contexts fail to predict such behavior for spider monkeys. While caution should be employed when drawing conclusions about cognitive abilities from anecdotal evidence of rare or understudied behaviors, anecdotes should not be dismissed due to their rarity (Bates and Byrne 2007) or in the case of tool use for their lack of association with food resource acquisition (McGrew 1992). While the use of tools by nonhuman primates to procure food is often considered a hallmark of cognitive ability, solving social and self-related problems with tools, irrespective of taxon, is also a notable display of cognitive innovation. Reporting and synthesizing all observations of tool use and function may provide new directions for investigating the cognitive abilities of spider monkeys and the evolution of tool-using behaviors.

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