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A Novel Food Processing Technique by a Wild Mountain Gorilla *(Gorilla beringei beringei)*

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Key Words
Gorilla · Food processing · Innovation · Uganda

Abstract

Innovation, the invention of new behavior, has been observed in wild primates only infrequently. The processing of thistle *(Cardus nyassanus)* has previously been described as being one of the most complex food processing techniques used by mountain gorillas *(Gorilla beringei beringei)*. We report a case of innovation in thistle leaf processing by a subadult female mountain gorilla in Bwindi Impenetrable National Park, Uganda. This technique involved rolling the thistle leaves into a ball between her palms prior to putting them in her mouth, as opposed to the standard method of folding leaves. All other weaned individuals (n = 13) were observed to use the standard method to process thistle leaves as described in Byrne et al. While the subadult female emigrated out of the research group 6 months after she had first been observed using the innovative technique, preventing observations of possible transmission within the group, it adds to the debate of whether food processing techniques used by gorillas are socially learned or not.

Introduction

Innovation, the invention of new behaviors or the use of established behaviors in novel circumstances, is a hallmark of intelligence and an important force of cultural evolution [Kummer and Goodall, 1985; Reader and Laland, 2001; van Schaik et al., 2006]. Primates are widely recognized as behavioral innovators, and this

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ability, as well as the capacity to learn from others, exhibits behavioral plasticity, and use of tools may have played a pivotal role in primate brain evolution [Reader and Laland, 2002]. Furthermore, innovation can significantly impact the fitness of primates by increasing foraging efficiency and facilitating ecological niche expansion and invasion [Byrne and Byrne, 1993; Reader and Laland, 2001; Day et al., 2003].

We expect innovation to occur most often in foraging contexts and in species that frequently encounter complex foraging tasks but lack specialized anatomy to accomplish them [Reader and Laland, 2002; Day et al., 2003]. Indeed, Reader and Laland [2001] found that nearly half of the recorded cases of primate innovation occurred in foraging contexts, and Day et al. [2003] found that species dependent on manipulative and explorative foraging tend to be less neophobic and more innovative than other species. However, because innovations are mainly adaptations to environmental conditions, which tend to remain stable over an individual's lifetime, observations of innovation in the wild are rare [Boesch, 1995; van Schaik et al., 2006]. The current observation, a novel food processing technique performed by a subadult female mountain gorilla *(Gorilla beringei beringei)* in Bwindi Impenetrable National Park, Uganda, represents an important addition to the few documented cases of behavioral innovation in wild primates.

The diet of mountain gorillas in the Virunga Volcanoes of Rwanda is largely comprised of foods that are difficult to process because of physical obstacles/defenses such as spines, stings and hooks [Byrne and Byrne, 1993; Byrne et al., 2001a, b]. For example, *Cardus* thistles are characterized by strong, woody spines that line the borders of the leaves, stems and petioles of the plant. To minimize contact between the sharp spines and the mouth and throat, thistles are thought to require the most complex processing of all foods in the diet of Virunga mountain gorillas [Byrne et al., 2001a, b]. The mountain gorillas of Bwindi Impenetrable National Park, Uganda, are geographically isolated from those of the Virunga Volcanoes. There is little dietary overlap between the two populations, but thistle *(Cardus nyassanus)* is an important food for both populations [Watts, 1984; McNeilage, 2001; Ganas et al., 2004; Robbins et al., 2006]. Thistle is less abundant in Bwindi than in certain areas of the Virunga Volcanoes [Watts, 1991; Nkurunungi et al., 2004] and, correspondingly, it constitutes a smaller proportion of the gorillas' dietary intake (Virunga Volcanoes, as much as 32% of biomass consumed [Watts, 1984]; Bwindi, consumed on 12% of days [Robbins et al., 2006]). While the techniques used to process thistle in Bwindi have not been systematically studied, the Bwindi gorillas use similar processing techniques to those in the Virunga Volcanoes [Robbins, pers. observation]. We describe here the occurrence of an innovative technique used to process thistle leaves in Bwindi and hypothesize about possible modes of transmission of the novel behavior to conspecifics.

Methods

Study Group

Only one group (the Kyagurilo group) of mountain gorillas in Bwindi Impenetrable National Park in southwestern Uganda (0°53'–1°08' N; 29°35'–29°50' E) is habituated for research purposes. The group has been fully habituated and observed regularly since August 1998 for stud-

ies of their behavior and ecology. The results reported here span the 11-month period from April 8, 2006 to March 8, 2007, during which we collected data on the group for approximately 4 h daily for 162 days. During this time, the Kyagurilo group consisted of 16–17 group members, including 1 silverback, 4 blackbacks, 6 adult females, 2–3 subadults and 2–3 infants. This research complied with research protocols of the Uganda Wildlife Authority and the Uganda National Council of Science and Technology and was done in accordance with the laws of Uganda.

Thistle Processing Techniques

Byrne et al. [2001a, b] describe the processing of thistle leaves as consisting of 6 stages: procurement of the plant or leaf, support of the plant, leaf detachment, accumulation of several items into a hand, removing debris from the leaf bundle and inserting the leaf bundle into the mouth, with only detachment of the leaf and insertion into the mouth as being obligatory. They further describe 72 distinctive 'elements' of these 6 stages. In general, detachment of the leaves can be done by either picking off the leaves from the stem with a 'pinch grip' of the thumb and index finger or by 'strip and detach': gripping around the midrib of the leaf and sliding the hand upwards to detach one or more leaves held between the thumb and index finger (e.g. 'strip-up' [Byrne et al., 2001a]). Next, the gorillas will often, but not always, further 'tidy up the bundle' before inserting it into the mouth by using a 'leaf fold', 'tuck fold' or 'stem fold', in which they use either their mouth or one or both hands to fold the thistle leaves lengthwise. This results in the bundle then being inserted into the mouth most commonly with the underside of the leaves being on the outside of the bundle and the spines of the leaves being on the inner part of the bundle or being oriented outwards from the mouth. It is easy to speculate that this is done to reduce the pain of the thistle spines in the mouth, because when the leaves are not folded before inserting into the mouth, the gorillas often show a 'wincing' expression while chewing [pers. observation]. Hereafter, we refer to this method as the 'standard method'. Only this method was observed to be used by all the members of the Kyagurilo group during the first several years of the study.

We refer to the novel technique as the 'palm roll' technique. It differs from the standard method only in the stage of 'tidying up the bundle'. Following the procurement of leaves by stripping a handful of leaves from one or more stems, the gorilla placed the handful between both palms, holding palms flat against one another. Then she proceeded to vigorously rub her palms back and forth against one another for several seconds, forming a tight ball of thistle leaves. Lastly, she ingested the processed ball of leaves. The palm roll technique was distinctly different from all 72 elements described in Byrne et al. [2001a]. It was also distinct from elements/actions used by Virunga mountain gorillas to process other foods [Byrne and Byrne, 1993] and those used by captive gorillas to consume nettles [Tennie et al., 2008].

Data Collection

Bizibu (BB), a female born in February 2000, was first observed processing thistle *(C. nyassanus)* using the novel palm roll technique in March 2006. After she had been observed using this technique on 2 days, we established a protocol for observing the technique used by all group members. In Bwindi, thistle predominantly grows in discrete patches in small swamps (typically less than 150 m by 30 m) that occur in the valleys. Therefore it was possible to define 'an event' of thistle eating by the group as when they first entered a swamp and began to consume thistle until the last group member stopped eating thistle (events lasted an average of 21 min, range 5–53 minutes, n = 21). When the group consumed thistle, great effort was made to observe, on an ad libitum basis, BB and as many group members as possible eating thistle, which took precedence over other data collection. Each individual was observed for several minutes to note if each gorilla was using the standard method or the palm roll method for thistle leaf processing.

BB emigrated out of the Kyagurilo group into a neighboring unhabituated group on September 15, 2006. However, we continued to record thistle processing by other group members systematically until March 8, 2007.

Results

The gorillas were observed eating thistle on 21 of the 162 days (13%) between April 8, 2006 and March 8, 2007. BB was seen eating thistle on 7 of these days before she transferred out of the group, and she used the palm roll technique on all 7 days. During one event, BB was observed to use the palm roll technique 35 times in 12 min. All other weaned individuals (n = 13) were observed processing thistle using only the standard method for a minimum of 8 and a maximum of 16 events.

Discussion

The palm roll technique described here represents an innovation for processing thistle leaves in wild mountain gorillas. The innovator, BB, was the only individual out of the 14 weaned individuals of the group observed to use this technique. The standard technique was used by her mother, full brother and all other group members. The palm roll technique differs from the 72 food processing elements described by Byrne et al. [2001a] and is also not known to be used in the processing of any other foods by mountain gorillas of the Virunga Volcanoes or Bwindi [Robbins, pers. observation].

Gorillas typically begin to consume thistle regularly as unweaned infants at approximately 2 years of age, and some researchers claim that they acquire the complex food processing techniques by social learning from their mothers [Byrne and Byrne, 1993; Byrne et al., 2001a, b]. While we cannot say for certain whether BB began to use this novel technique in March 2006, we know that her mother does not use this technique, and it is unlikely that such a novel technique would have gone unnoticed for the 4 years prior to this observation. Therefore it is most likely that she initially used the standard technique until she invented the palm roll technique. The observations that BB used this new technique, and only this technique, repeatedly over a 6-month period helps rule out the possibility that this was a short-lived trial-and-error event by an immature individual. Unfortunately her emigration out of the research group precludes the possibility of determining whether the behavior would be transmitted by social learning within the Kyagurilo group.

A recent study on captive gorillas has called into question to what degree social learning plays a role in the acquisition of processing techniques for nettles [Tennie et al., 2008]. At the program or structural level at which food processing occurs, both wild mountain gorillas and captive western gorillas exhibited large similarities in using the sequence of 'procure, gather, process and insert' when consuming nettles [Byrne and Byrne, 1993; Tennie et al., 2008], suggesting that it may develop through means other than social learning, such as genetic predispositions, stimulus enhancement by the plants, or individual learning [Tennie et al., 2008]. Bwindi gorillas also use the same sequence in processing thistles [pers. observation]. More variability was observed within and between the Virunga mountain gorillas and captive western gorillas at the level of specific actions used in each of the program level processes, particularly within the stage of processing, suggesting that individual learning may play an important role at this stage. The palm roll technique observed by BB was also a specific action within the processing stage of thistle eating. Therefore this innovative behavior lends further support to the proposition that many actions used for

food processing by gorillas are likely to be individually learned and not socially transmitted.

The novel thistle processing technique described here represents an important case of innovation in a highly endangered primate species in the wild. Though captive gorillas have shown both innovation [Pika and Tomasello, 2001] and imitative learning [Stoinski et al., 2001], few studies have documented either in wild populations [but see Boesch, 1995; van Schaik et al., 2006]. Only continued long-term studies of several populations of gorillas will enable us to document any rare instances of innovative behaviors, as well as examine the ecological and social conditions under which they may arise, investigate the influences on the spread/transmission of these behaviors, and the possibility of social traditions and/or culture.

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