The exact significance of this colour modulation and the difference observed in the male and the female is not clear. The state of arousal of a courting male is reflected in coloured skin patches and change in body colouration is one of the reliable indications of the motivational status of an organism[11]. Laboratory studies have demonstrated that females of sticklebacks, guppies and cichlids, when presented with males differing in body colouration preferred brighter males with brighter colouration[6], indicating sexual selection. Female mate choice can also be a powerful source of selection on male secondary sexual characteristics[12], and a potential agent for rapid population differentiation and speciation[13].

Goodenough *et al.*[14] suggested that despite costs associated with mating, males of most species appear to follow a strategy of copulating with as many females as possible. The results indicate that the males have a low threshold for sexual arousal and attain nuptial colouration earlier than the females. Thus, as it is observed in the present study, the persistent colour of the lateral band of the males may act as an attractive stimulus for the unmated females.


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# Observations on tool use in captive lion-tailed macaque (*Macaca silenus*)

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**Lion-tailed macaques in Sri Chamarajendra Zoological Garden, Mysore, India were observed to use several tools (plastic piece, candy wrapper, leaf, vegetable leaf, egg-shell and coconut shell) to drink water from the pool. Here we report the simple multiple tool use in the species. The behaviour was first observed in an adult male. This male was confiscated and was probably hand-reared. It started using tools within a short period of introduction. After some time, the other captive monkeys also started to use multiple tools in a similar way to drink water. This may be an example of social learning.**

**Keywords:** Captive monkeys, lion-tailed macaque, social learning, tool use.

A TOOL has been defined as 'an external object free of any fixed attachment to the substrate, which can be held, carried or manipulated by the user'[1]. Similarly, tool use can be defined as 'the use of such a tool to attain a particular goal, the user must hold or carry the tool during or just prior to use and is responsible for the proper and effective orientation of the tool'[1]. Tool use is interesting,

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because it reflects the complex cognitive abilities of the species[2]. However, mere presence of tool use in a species is not compelling evidence of any particular cognitive characteristic[3]. Tool use has been reported for all families of nonhuman primates, except the Callitrichidae and the Prosimians[1].

The lion-tailed macaque, *Macaca silenus* is an arboreal and omnivorous species, endemic to the wet forests of the Western Ghats in southern India. These animals spend a large amount of time in exploration in the wild[4] and consume a large variety of foods, extracting them from a variety of substrates[5]. Hohmann[6] reported that wild lion-tailed macaques used litter or leaves to remove poisonous stings from chrysalis. In captivity, lion-tailed macaques are known to engage in a variety of goal-directed manipulative activities with simple objects[7], and also to manufacture and use tools. Westergaard[8] showed that lion-tailed macaques spontaneously manufactured and used tools to extract syrup from specially designed apparatus. Similarly, Fitch-Snyder and Carter[9] reported that the lion-tailed macaques used litter as a sponge to extract water from tree holes. However, observation on using a variety of tools for the same purpose has not been reported, and also reports on simple tool use are few. In this study, we report simple tool use and use of multiple tools to drink water in captive lion-tailed macaques.

We studied the behavioural biology of captive lion-tailed macaques in the Chamarajendra Zoological Garden, Mysore, India from February to June 2003. Although the zoo had six animals (three adult males and three adult females), only four were kept together, viz. one adult male (Krishna) and three adult females (Netra, Priya, Shanthi). Krishna was confiscated near Bandipur National Park during October 2002 and is suspected to have been hand-reared. All the females were captive-bred. The animals were kept indoors, and were often released to the big open enclosure as part of the exhibit for the public. The enclosure had a few trees at the centre, a few stumps for play and a small water pool in the dry moat area in one corner of the enclosure. The oval-shaped pool was made of stone, ~45 cm length, 25 cm width and 8 cm depth. During the study period, animals were under constant behavioural observations from 07.00 a.m. to 06.00 p.m., for a total of 386 h in 88 days. Agonistic interactions were also recorded for a different study which, however, provides the dominance ranking that is also used in this communication.

On 18 April 2003 at 12.45 p.m., the adult male (Krishna) went near the water pool in the enclosure, sat on the edge of it and put his mouth to the water to drink. He then saw a piece of red plastic in the pool, took it in its right hand (fore leg), immersed it in the water and lifted it to drink, while sitting bent at 60° toward the pool. This drinking method was repeated four times. During this episode, only Shanthi was in the enclosure and the other two females were indoors. The plastic piece was used as a small utensil which could hold a small quantity of water. It was a piece of a toy thrown by visitors into the pool. Since leaving such plastic piece in the pool is against the rules, it was taken out of the enclosure by the zoo staff.

On 26 April 2003 at 11.20 a.m., three feet away from the water pool, one half of an empty coconut shell was introduced into the enclosure by a researcher to explore several aspects of tool-use behaviour. All four animals were in the enclosure. Although Priya explored the shell, no animal was observed using the shell for drinking. The next day at 3.47 p.m., Shanthi sat on the edge of the pool, saw the coconut shell in the water, took it with her right hand, sitting in the same posture as above, and drank water two times using the coconut shell in a similar way as Krishna had used the plastic piece. Meanwhile she saw a boiled egg piece without yolk near the pool, left the coconut shell in the pool, took the egg piece and started drinking water using it in a similar way with her right hand. Boiled eggs were given to the animals as part of their diet. One of the animals had taken the egg piece to the enclosure and left it near the water pool.

Again the coconut shell was introduced ~1.5 m away from the water pool on 29 April 2003. At 11.00 a.m., Krishna went towards the water pool, saw the coconut shell, and pushed the shell towards the pool using his left hand. After reaching the pool, he took the shell in his left hand and held it under the water. He sat at the edge of the pool and drank the water using the coconut shell six times using his right hand (Figure 1). On the same day, at 2.39 p.m., Priya was observed using the coconut shell for the first time. She found the shell in the pool and drank water once using her right hand. Later she drank from the pool by putting her mouth to the water, although the shell was still in the pool. On the same day, Shanthi went near the water pool and sat there as explained above. There was a candy wrapper floating in the pool; she took it with her right hand and drank water from it six times.

During the study period, we introduced a coconut shell into the enclosure. As part of the experiment, the shell

**Figure 1.** Lion-tailed macaque using coconut shell to drink water.

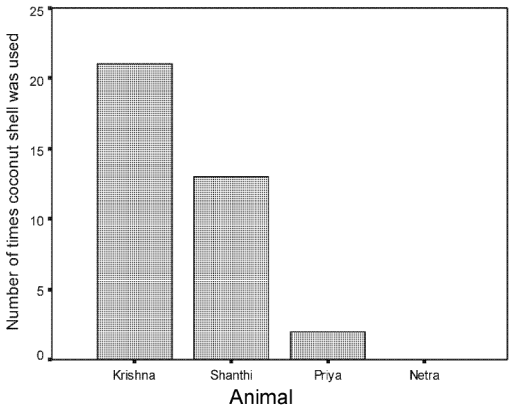


**Figure 2.** Plot showing the number of times different animals used the coconut shell to drink water.

was repeatedly taken out from the enclosure and reintroduced; hence the coconut shell was introduced 30 times for a total of 40 days of observation. During that period, the animals were observed to use the coconut shell to drink the water 36 times (Figure 2) and the frequency of use differed among animals significantly ($\chi^2 = 51.75$; $P < 0.01$). Netra was never observed to use the coconut shell to drink water. When the shell was within 1.5 m from the pool, Krishna was often seen bringing it to the water's edge before drinking. Shanthi was seen carrying the shell to the pool for drinking only once. Otherwise, she only drank from the shell if it was already in the pool. The other females were not observed carrying the coconut shell to the pool.

After the experimental period, the coconut shell was taken out of the enclosure. The next day Krishna was observed using leaf litter floating on the pool to drink water. Later during casual visits, we observed both Krishna and Shanthi using a cabbage leaf, tomato and pomegranate shell to drink water. During another visit to the zoo, Krishna was observed to carry the coconut shell from a distance of 5 m and use it to drink water from the pool. During the sampled observation period, a total of 40 instances of tool use were observed, including coconut shell (36 times), plastic piece (once), boiled egg piece (once), candy wrapper (once) and leaf litter (once). During the casual visits, a total of six instances that included leaf litter (once), coconut shell (once), cabbage leaf (2 times), tomato (once) and pomegranate shell (once) were observed.

Tool use to drink the water from the pool was first observed in the adult male (Krishna). Later two females (Shanthi and Priya) were seen performing the same activity. We suspect that Krishna was hand-reared, and may have learnt from humans how to use a tool to drink. However, the females were captive-bred and previously had not been observed using a tool to drink water. Hence we considered that tool use by Shanthi and Priya was due to watching another animal. Van Schaik *et al.*[10] have discussed this as socially biased learning. Many researchers[11–13] have considered the tool-use behaviour especially in great apes, to be traditions or culture, which will be a socially biased learning. After Krishna was introduced into the enclosure, tool use was occasionally seen by the zoo staff. However, after we noticed the tool use by Krishna, we increased the availability of coconut shell in the enclosure, which enhanced the use of tools by Krishna. Other than the coconut shell, the tools used by animals were either accidentally thrown in the enclosure by visitors or given as food items. This increased frequency of tool use by Krishna probably influenced the other individuals to notice and learn to use the tool. In captive macaques, the use of sticks to obtain food through wire mesh was presumed to be socially enhanced[8,14–16]. Hence it appears that the tool use for drinking in lion-tailed macaques is also a similar type of learning.

Netra was not observed using any tools to drink. She was the lowest ranking female and often kept her distance from the others (unpublished data). Netra's lack of proximity to a competent demonstrator, and her reluctance to approach the coconut shell probably contributed to her not acquiring the drinking skill.

A significant observation was the carrying of the tool (coconut shell) from a distance of 5 m to the pool and using it to drink water. This indicates intention and proper orientation of the tool[1]. The use of multiple tools is another important observation in lion-tailed macaques. It shows that the monkeys have an understanding of the tool's shape and properties necessary for its function. However, not much is documented on multiple tool use for the same function by macaques and this raises several questions on shape perception in monkeys, which needs proper investigation.

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