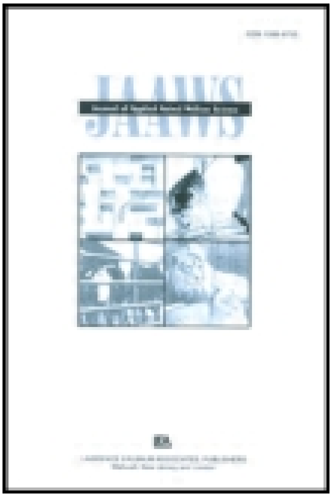

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Improving the Welfare of Captive Macaques (*Macaca sp.*) Through the Use of Water as Enrichment

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This review evaluates the use of water as a tool for enriching the environments of macaques (*Macaca sp.*) in captivity. Many macaque species are known to swim and forage in water in the wild, and in-situ reports suggest that access to water promotes activity and cultural behavior. Yet, there is a relative dearth of information on water enrichment, covering only a small number of macaque species in both laboratory and zoo settings. Previous studies in captivity report high levels of usage of water enrichment as well as further behavioral benefits, including increases in play, exploratory behavior, and tool use. Subsequently, there is a clear need for more research on the potential benefits of water enrichment for both macaques and other primate species, especially given that small water troughs and pools provide an inexpensive method for enriching nonhuman primate lives in captivity.

Finding environmental enrichment strategies that are effective and that remain so over time is challenging. Object enrichment is frequently used with nonhuman primates (Kong toys, mirrors, balls); however, these are often of little benefit. Animals may ignore the objects and may habituate to them quickly, which limits their usefulness (Pruetz & Bloomsmith, 1992; Shefferly, Fritz, & Howell, 1993). Objects that have more biological relevance to a species are likely to be more effective (Newberry, 1995), and many facilities seek to use naturalistic

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enrichment based on natural stimuli that primates in the wild interact with in their daily lives. Although swimming and diving are infrequently observed in most other nonhuman primates (Agoramoorthy, Smallegange, Spruit, & Hsu, 2000), many macaque species in the wild swim or forage in water as part of their daily routines. Exploiting this fact in terms of providing an inexpensive and easy-to-manage form of enrichment in captivity seems obvious until one considers the lack of research to support the efficacy of water in this regard (Parks & Novak, 1993).

IN SITU AQUATIC BEHAVIOR: A JUSTIFICATION FOR WATER ENRICHMENT

Many macaque species interact with water on a regular basis in their natural environments to the extent that some have developed behavioral adaptations as well as foraging and thermoregulatory strategies in relation to water (Hori, Nakayama, Tokura, Hara, & Suzuki, 1977; Stewart, Gordon, Wich, Schroor, & Meijaard, 2008; Van Schaik, Van Amerongen, & Van Noordwijk, 1996). Several macaque species swim well and appear to enjoy water. Those species reported to be habitual swimmers include pig-tailed macaques (*M. nemestrina*), lion-tailed macaques (*M. silenus*), toque macaques (*M. sinica*), bonnet macaques (*M. radiata*), Tibetan macaques (*M. thibetana*), long-tailed macaques (*M. fascicularis*), rhesus macaques (*M. mulatta*), and Japanese macaques (*M. fuscata;* Bertrand, 1969; Fooden, 1986; Roonwal & Mohnot, 1977). Wild macaques that swim across rivers to extend foraging or to increase ranging include long-tailed macaques (Fittinghoff & Lindburg, 1980) and bonnet macaques (Agoramoorthy et al., 2000). Swimming is often associated with social and solitary play in young macaques. For example, Berman (1977) describes acrobatic diving and play in juvenile rhesus macaques (Figure 1), and Kawai (1965) describes how juvenile Japanese macaques seem to enjoy swimming and diving underwater for extended periods.

Bodies of water are often important features of macaque habitats and can factor in feeding strategies and the promotion of cultural behavior. Long-tailed macaques have frequently been observed to forage aquatically for crabs and other water-dwelling prey (Son, 2003; Sussman & Tattersall, 1986). They also display cultural behavior through the use of tools to access riverine prey (Wheatley, 1988), including the use of stone tools to crack open oysters (Malaivijitnond et al., 2007).

Other research suggests the development of fishing behavior in separate groups of Indonesian long-tailed macaques (Stewart et al., 2008). Aquatic foraging has also been observed in Japanese macaques, who catch fish and octopi in rock pools (De Waal, 2001) and in rhesus macaques, who forage for fish and

FIGURE 1 Wild rhesus macaques (*Macaca mulatta*) playing in water (photo courtesy of Corri D. Waitt, coauthor).

aquatic plants (Fooden, 2000). Although stump-tailed macaques (*M. arctoides*) have not been reported to swim, they have been documented entering shallow water to forage for snails (Estrada & Estrada, 1977). Evidence of cultural behavior being promoted by access to water is provided by the well-documented reports of food washing (Kawai, 1965) and cleaning (Itani & Nishimura, 1973) by provisioned free-ranging Japanese macaques.

Water is also used to manage thermoregulation. Wild Japanese macaques may spend several hours per day bathing in hot springs in the winter, sometimes even overnight (Zhang, Watanabe, & Eishi, 2007). In warm weather, swimming or submerging parts of the body in water may also provide heat avoidance (Kawai, 1965).

BENEFITS OF WATER ACCESS

Based on the degree to which macaques in the wild interact with water, the potential for using water as an enrichment technique for macaques is considerable. The few studies that have been carried out point to numerous behavioral, and potentially physiological, benefits for captive animals.

Foraging and Play Behaviors

As foraging increases, water features may lead to reduced levels of aggression within groups (Blount, 1998)—a fact that is of particular relevance when housing volatile primates such as Sulawesi macaques. That water features may promote foraging is supported by the finding that exploratory behavior was stimulated in lion-tailed macaques living in enclosures containing bodies of water, partly because “a water body is an ideal area to forage for insects, as they congregate and hover above the water surface” (Mallapur, Sinha, & Waran, 2007). Scientists who have provided submerged foods for primates agree that once food provisioning ceased, underwater swimming and diving continued—representing play behavior among groups of long-tailed, rhesus, and Japanese macaques (Anderson, Peignot, & Adelbrecht, 1992; Anderson, Rortais, & Guillemein, 1994; Gilbert & Wrenshall, 1989; Kawai, 1965).

Tool Use

When confronted with troughs of still water, rhesus macaques exhibit tool use—specifically, the use of cuplike containers as drinking utensils (Parks & Novak, 1993). Numerous macaques in the same study also washed their chow before eating, which has become part of the natural behavioral repertoire of many macaque species (Fragaszy & Visalberghi, 1996; Marriott, 1986). Additionally, all the macaques used the trough as a drinking source, with many animals displaying new forms of drinking (licking from a hand dipped in water) as observed in wild macaques (Malik & Southwick, 1988). These results suggest that exposure to water sources may elicit a broad spectrum of in situ species-typical activities.

Unfortunately the implications of these findings are yet to be realized within the published captive literature, and follow-up research is yet to be conducted. For example, it would be useful to know whether habituation to water enrichment occurs over time and how use of water enrichment varies with age, sex, and species.

Possible Physiological Benefits

According to Shevchuk (2008), brief exposure to cold water alone has numerous psychological and physiological benefits in humans, including activating the sympathetic nervous system; increasing the blood level; and increasing the production of beta-endorphins, which are known to produce a sense of well being. When coupled with clear evidence of the use of water by primates as a means to aid thermoregulation (Anderson et al., 1992; Kawai, 1965; Zhang et al., 2007), it is possible that access to water at certain temperatures may confer neurophysiological benefits among some macaques.

PRACTICAL ISSUES OF WATER FEATURES

Size and Temperature

Adding water features to captive enclosures need not be expensive or complicated (Yoshida, 2006). Simple changes to the captive environment, such as the inclusion of metal stock tanks (Rawlins, 2005), portable fiberglass, plastic, and metal pools or troughs (Parks & Novak, 1993; Rock, Azzarano, Adams, Murray, & Clark, 2004; Yoshida, 2006), can be added with minimal cost. Using a 120 × 50 × 60 cm glass aquarium and a group of juvenile rhesus macaques, Anderson et al. (1994) found that full immersion and diving did not occur until water levels reached 30 cm or greater. This study also noted that contact with water increased as the depth increased, as did use of water by lower ranking animals. Decisions on the exact dimensions of a pool or trough, however, should be taken on a case-by-case basis and should consider species, group size, and group composition. Unless specifically manipulated, water temperature is likely to be dictated by seasonality in outdoor enclosures, whereas room temperature will determine the water temperature in most indoor laboratory settings.

Drowning

With most macaque species being able swimmers, drowning should not be a realistic concern among all but infant animals. To prevent such occurrences in smaller pools, built-in lips located halfway up the inside of shallow tanks could facilitate infant escapes (Kirby, Rawlins, Schultz, Down, & Reinhardt, 2006). Research suggests that pools as shallow as 30 cm could be sufficient for stimulating underwater diving and swimming among macaques (Rawlins, 2005; Rock et al., 2004). Alternatively, in larger pools or tanks, carefully arranged polyvinyl chloride tubing (both inside and out) could act as a bridge between the water and the rim of the pool (Kirby et al., 2006). It should also be noted that when water resources do not constitute part of a permanent enclosure, a resource could be used periodically to facilitate safer use (such as not using it with infants) and supervision by captive animal caregivers. Periodic access to a water feature could be particularly relevant in laboratory settings. When applying water enrichment to other nonhuman primate species, such as great apes, greater care must be taken because of their inability to swim (Brown, Dunlap, & Maple, 1982).

Cleaning and Disease Transmission

Water vessels should be emptied and cleaned daily (Parks & Novak, 1993) to prevent disease transmission and the spread of potentially harmful pathogens

FIGURE 2 A small pool for long-tailed macaques (*Macaca fascicularis*) (photo courtesy of James G. Robins, author).

and bacteria. This can be achieved relatively easily in an indoor setting when using smaller portable tanks. However, this becomes more difficult with larger permanent outdoor water features that are often found in zoos (Figure 2). Permanent outdoor water features are often found in zoos. To prevent the spread of disease, facilities may choose to invest in pump systems to circulate the water to reduce the spread of disease, although it is recommended that the water be fairly fast moving to most effectively achieve this (Eckert et al., 1999). In addition to this measure, institutions may also choose to add goldfish, guppies, or other larva-eating species to control mosquito populations while also providing added enrichment for the captive primates (Eckert et al., 1999).

Still Versus Running Water

Research by Parks and Novak (1993) investigated the effects of water troughs on rhesus macaques. Animals were provided with troughs of both standing and running water, and it was found that contact with standing water was greater than with running water. There was no associated increase in social tension or aggression. Water was also found to promote object manipulation, including immersion and removal within and from the troughs.

With such little data on the efficacy of water as enrichment, it is likely that practical preferences may change within and between species; therefore, further research should be a priority on all of the aforementioned considerations.

EXAMPLES OF WATER ENRICHMENT IN ZOOS

Zoo exhibits that better reflect in situ habitats have a greater educational value among zoo visitors (Blount, 1998) and are thus more relevant for conservation. Although many captive facilities employ water solely as a means to contain a species within its exhibit, the addition of certain enclosure furnishings and structures, including ponds or swimming pools, can be used to stimulate animals to exhibit species-typical behaviors (Honess & Marin, 2006; Mallapur, Waran, & Sinha, 2007). Monkey Jungle in Florida incorporated a swimming pool into its long-tailed macaque exhibit (Du Mond, Fiby, & Evans, 2000); the monkeys swim and dive in it. The pool contains various species of fish (Japanese koi, goldfish, African and zebra chiclids, and *plecostomus*) whom the monkeys may attempt to catch, and fruit is thrown into the pool to encourage its use. Similarly, Newquay Zoo made novel use of a water pump incorporated into a waterfall to sporadically dispense food into a pool. This was found to increase foraging activity by Sulawesi macaques (*M. nigra*): monkeys either waded in the pond or reached from the edge to retrieve food items (Blount, 1998).

The Central Park Zoo has incorporated both a hot tub and a pond into its outdoor exhibit for the Japanese macaques; this enables them to use water to stay warm in the winter and cool in the summer. The hot tubs are intended to simulate the natural hot springs this species uses in the wild and the temperature is set to 95–105°F in the winter (Scheier, 2002).

The Detroit Zoo has similarly incorporated hot tubs for its Japanese macaques (Goodwin, 1999).

CONCLUSIONS

The potential scope for further research on the effect of water on nonhuman primates goes far beyond its application as environmental enrichment. However, it is likely that the proliferation of water enrichment throughout laboratories and zoos worldwide will only occur when more research is published on the benefits of access to water. Applicable for use in smaller captive environments such as laboratories, small troughs or pools can be obtained at a minimum of cost to organizations and individuals. For water-loving species in larger public enclosures, permanent water features are better able to mirror species' natural environments. Water enrichment has been shown to reduce aggression, increase exploratory behavior and tool use, and promote natural behavior. Its effect on the social processes of macaques has shown little in the way of negative response so far, although there is an obvious need for further research to fully investigate this possibility. Methods employed to assess the value of water for other species (Cooper, McAfee, & Skinn, 2002; Vinke, Houx, Van Den Bos, & Spruijt, 2006) could perhaps be mirrored in an attempt to establish the importance of water as enrichment for macaques. Examples of the successful application of water enrichment in zoos and laboratories already exist; with careful consideration, these can be mirrored and adapted for other institutions that house macaques. Water enrichment for species that are used to frequent contact with water in the wild is recommended as a cost-effective and easily manageable way to enrich nonhuman primates.

For videos of long-tailed macaques swimming in a laboratory setting, please follow the link http://www.nc3rs.org.uk/category.asp?catID=26

For videos of macaques enjoying some of the benefits of a basic water feature in a zoo, visit http://www.youtube.com/user/macaca26#p/u/3/CphPwjCfTdw and follow the user links.

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