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A Short Report on the Extent of Stone Handling Behavior Across Otter Species

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Abstract – Animal stone-handling behavior (SH) has been recorded in detail only in primates, mainly across macaque species. The purpose(s) of SH are still unknown, yet various hypotheses have been suggested, including that it is a misdirected behavior when hungry and/or a play behavior that aids individuals' motor and stone tool-use development. SH has also been observed across both wild and captive otter species, but no overview report of the extent of this behavior across otter species has been published yet. To fill this gap in the literature, we contacted wild and captive otter researchers and keepers to enquire directly on SH in the species they work with. We accepted anecdotal reports in this first review of the behavior. Using the reports and anecdotes thus obtained, we compiled the first list of otter species that show SH. We found that most (10 out of 13) of currently known otter species practice SH. Therefore, similarly to macaques, SH is also common in otters and occurs in the majority of species. Future studies should focus on replicating these findings and further investigating the potential functions and selection pressures of SH in otters and other animal species.

Keywords – Otters, Stone handling, Stone manipulation, Stone play, Otter stone tool-use

Object-orientated play behaviors, defined as *"*the spontaneous, repeated, seemingly relaxed, incompletely functional, and usually solitary manipulation of inanimate objects*"* (Pelletier et al., 2017, p. 3), are observed in various species of animals (e.g., Power, 1999). One type of object-orientated play behavior is stone handling behavior (henceforth: SH). SH involves the manipulation of stones in various, not obviously goal oriented ways. Leca and colleagues (2011) defined SH as "spontaneous stone-directed non-instrumental manipulative behavior" (p. 61). SH includes behaviors such as "rock juggling" (Allison et al., 2020) and/or "gathering stones into a pile, clacking stones together, or repeatedly pounding a stone on a substrate" (Gunst et al., 2007, p. 254). More generally, various stone-related activities may be included under the SH umbrella (eight categories were identified by Huffman & Quiatt, 1986).

The most detailed records of SH in animals come from macaques, especially from Japanese macaques (*Macaca fuscata*; e.g., Huffman & Nahallage, 2007; Huffman & Quiatt, 1986; Leca et al., 2008). SH is also observed in rhesus macaques (*Macaca mulatta*; Nahallage & Huffman, 2012), long-tailed macaques (*Macaca fascicularis*; Bandini & Tennie, 2018; Pelletier et al., 2017; Tan, 2017) and Taiwanese macaques (*Macaca cyclopis*; Pelletier et al., 2017). However, SH has also been observed in wild and captive otters. Indeed, a recent article by Allison and colleagues (2020) provides one of the first in-depth investigation into SH in other animal species, namely in two species of captive otters (*Lutrogale perspicillata* and *Aonyx cinereus;* Allison et al., 2020).

The field of animal cognition seems to be somewhat biased towards observations of primates, perhaps due to their closer phylogenetic ties to humans (van Horik & Madden, 2016). However, studying the cognition of other species is just as important, and can provide a more complete picture of animal, and potentially even human, cognition (Pelletier et al., 2017). Therefore, the aim of this short report is to describe, to the best of our knowledge for the first time, the extent of SH across all currently known species of otters (including both wild and captive otters). We provide a list of species in which SH has been observed so far as a general basis for future in-depth studies (similar to the ones carried out by Allison et al., 2020).

Otter Species

Currently, there are 13 different species of otters recognized in the wild, distributed across all continents except Oceania, Antarctica and the Arctic (see Table 1; in alphabetical order: *Aonyx capensis; Aonyx cinereus; Aonyx congicus; Enhydra lutris; Hydrictis maculicollis; Lontra canadensis; Lontra felina; Lontra longicaudis; Lontra provocax; Lutra lutra; Lutra sumatrana; Lutrogale perspicillata; Pteronura brasiliensis*; Duplaix & Bandini, 2016).

All otter species present distinct ethological and morphological traits (see Table 1). They are, however, similar in their dietary requirements and are considered opportunistic carnivores, eating a wide range of prey species that they forage and hunt for using their sensitive vibrissae and tactile paws (Kruuk, 2006).

Otter Tool-use

Enhydra lutris (sea otter) is the only species of otters currently known to use stones as tools to access prey. *Enhydra lutris* uses rocks and other hard objects as hammers to pound open invertebrate prey (Fujii et al., 2015). This behavior has been compared to long-tailed macaque (*Macaca fascicularis aurea*) stone tool use – pound-hammering behavior – a behavior in which wild long tailed macaques use stones to crack open shelled food sources (Fujii et al., 2017). *Enhydra lutris* will likewise use stones, acquired during foraging (Perry, 2012), as “hammers” to smash the hard exoskeleton or shells of their food items (mollusks, crustaceans and other invertebrates). This is done by raising the stone above their heads with their paws whilst floating on their backs and bringing it down, with considerable force, on the invertebrate lying on another stone on their chest (Haslam et al., 2019). However, *Enhydra lutris* also uses stones as anvils to pry open their prey or to hit mollusks, such as abalone, from underwater and surface rocks (Riedman & Estes, 1990). Stone tool-use has not yet been observed in any other wild or captive otter species.

Table 1

Distribution and Main Characteristics of Wild Otter Species

Otter species	Distribution	Social behavior	Foraging habitat	Prey preferences	Main morphological characteristics
Aonyx capensis	Sub-Saharan Africa	Small family groups (3-10 individuals)	Freshwater and coastal habitats	Crustaceans, mollusks, frogs, insects, invertebrates	12-19kg Absence of claws and reduced webbing on paws
Aonyx cinereus	Southeast Asia and India	Large family groups (up to 30 individuals)	Slow moving freshwater systems, rice paddies	Crustaceans, mollusks, insects	2-5kg Absence of claws and reduced webbing on paws
Aonyx congicus	Central Africa	Small family groups (3-10 individuals)	Slow moving freshwater systems	Mollusks, crustaceans, earthworms, frogs	12-17kg Absence of claws and reduced webbing on paws
Enhydra lutris	North Pacific Ocean	Large, same sex groups (up to 100 individuals)	Kelp forests and rocky coasts	Invertebrates, mollusks, crustaceans	23-36kg Absence of blubber, thick webbing on paws
Hydrictis maculicollis	Sub-Saharan Africa	Small family groups (3-10 individuals)	Freshwater systems	Fish, crustaceans	4-7kg Developed webbing on paws
Lontra canadensis	North America	Small family groups (3-10 individuals)	Freshwater and coastal habitats	Fish, mollusks, crustaceans	8-11kg Developed webbing on paws
Lontra felina	Pacific coast of South America	Solitary	Rocky coastal habitats	Mollusks, crustaceans	3-6kg Developed webbing on paws
Lontra longicaudis	Central and South America	Solitary	Freshwater systems	Fish, crustaceans, small mammals, birds, reptiles, amphibians, invertebrates	10-14kg Developed webbing on paws
Lontra provocax	Chile, South America	Solitary	Freshwater and coastal habitats	Fish, mollusks, crustaceans	5-10kg Developed webbing on paws
Lutra lutra	From Europe to Korea	Solitary	Freshwater and coastal habitats	Fish, crustaceans, small mammals, birds, reptiles, amphibians, invertebrates	4-11kg Developed webbing on paws
Lutra sumatrana	Southeast Asia	Solitary	Freshwater systems	Fish, crustaceans, small mammals, birds, reptiles, amphibians, invertebrates	5-8kg Developed webbing on paws
Lutrogale perspicillata	India and Southeast Asia	Large family groups (up to 30 individuals)	Freshwater and coastal habitats	Fish, crustaceans, small mammals, birds, reptiles, amphibians, invertebrates	7-10kg Developed webbing on paws
Pteronura brasiliensis	South America	Medium family groups (5-15 individuals)	Freshwater systems	Fish	24-34kg Developed webbing on paws

*Note. Species in **bold** have no recorded observations of stone handling behavior yet.*

Stone Handling in Otters

SH has been observed in wild and captive otters (see supplementary video by CT of captive *Aonyx cinereus* practicing a form of SH), although the form and distribution of this behavior across otter species is still unknown, providing the impetus for this report. A recent study conducted by Allison and colleagues (2020) presents the first in-depth investigation of one specific type of SH behavior ('rock juggling') in otters. These authors examined rock juggling in two species of captive otters (*Lutrogale perspicillata* and *Aonyx cinereus*) across three zoological institutions in the UK. The authors did not find any sex differences in rock juggling in either of the otter species but did find that rock juggling frequency decreased with age in mature individuals and increased with age in elderly otters. Similar to some of the theoretical approaches to macaques (Nahallage & Huffman, 2007), Allison and colleagues (2020) hypothesized that rock juggling may aid motor development in young otters and/or prevent cognitive decline in older otters. Furthermore, the authors report that otters juggled significantly more before feeding than after feeding. They interpret this finding as suggesting that rock juggling behavior in otters may be a misdirected feeding behavior, as has also been suggested for some species of macaques (Huffman & Nahallage, 2007; Leca et al., 2008; Pellis, 1991). Whilst Allison et al. (2020) provided the first in-depth investigation into rock juggling in two species of otters, an overview of the general distribution of this and other SH behaviors across otter species is still missing; this would, however, be useful to target further in-depth investigations into SH in otters.

Figure 1

Artistic Rendition by M.B. of an Otter Practicing Stone Handling Behavior

Scope of the report

The aim of this short report was to examine the distribution of SH across otter species both in the wild and in captivity, and therefore to provide the first database of accounts of SH across otter species as a starting point for guided in-depth exploration of the SH phenomenon in otters.

Our first step was to conduct a literature review on reports of SH in otters. The search engines: *Google scholar* and *Web of Science,* alongside a private database of relevant literature available to otter specialists were searched by EB and MB between June 2019 and April 2020. The search terms: '*otter stone handling behavior,'* '*otter stone play*,' '*otter stone tool-use,'* and *'otter stone manipulation'* were used. The only literature we were able to find using this method described the stone tool-use of *Enhydra lutris* (see above) and the study on 'rock juggling' in otters described above (Allison et al., 2020). No other reports of SH in otters were found. To continue examining the distribution of SH in otters, MB (a specialist in the field of otter behavior) personally contacted other otter specialists through email, messages, in person at conferences and on online forums for any reports of observations of SH in their studied populations and species of otters (all otter species were targeted this way).

Method

To conduct our first overview of the extent of otter SH, MB contacted otter specialists to enquire if they had ever seen any of their studied species practicing SH. Specifically, the specialists were asked whether they had seen any of their subjects: "manipulating stones in non-instrumental ways," roughly following the definition of the behavior provided by Leca et al., 2011: "spontaneous stone-directed non-instrumental manipulative behavior" (p. 61). If the researchers answered 'yes,' we then asked them whether the otters they observed had been in captivity or in the wild and to provide a very brief description of the behavior they observed. We asked for all accounts to be written and provided by email or message. All the researchers agreed to their observations being included in this report and are mentioned in the acknowledgments section. Following this method, we collected several anecdotal observations of SH across species. A summary of the observations is provided in Table 2.

Although we asked the researchers to be as descriptive as possible, it is important to note here that these are all anecdotal accounts of SH in the populations - intended to be a first overview of the extent of SH in otters - and no explicit studies or observations were carried out prior or during the data collection for this report. Therefore, although we are confident in the observations compiled in Table 2, follow up studies are required for further details. In coding for rock juggling, we followed the definition provided by Allison et al. (2020) in which rock juggling is defined as: "fast, erratic movements that pass an object between the forepaws and sometimes the mouth" (p. 2).

We asked researchers only about handling behaviors with stones, as this seems to be a crucial aspect of stone handling behavior (see also definition by Leca et al., 2011). As the aim of this short report was to provide a first overview of the extent of SH behavior across otter species, and to encourage the specialists to answer within a certain timeframe, only a binary (yes/no) response was required from the contacted researchers. We did not ask any further details other than a brief description of the behavior (as this was beyond the scope of this particular report).

Results

Stone Handling in Otters

SH was anecdotally reported in 10 out of the 13 known species of otters (see Table 2). The three species for which anecdotal evidence of SH behavior was not reported were *Lutra sumatrana* (hairy-nosed otter), *Aonyx congicus* (Congo clawless otter) *and Lontra provocax* (southern river otter). We received no reports on these species, perhaps due to the fact that there are very few sightings of *Lutra sumatrana, Aonyx congicus and Lontra provocax* in nature and even fewer are found in captivity. This

should not, however, be taken as evidence for an absence of SH in these species in general (these might be false negatives). Indeed, we received one report of a young, captive *Aonyx congicus* showing SH-type behaviors with a plastic bottle cap, which we did not include in Table 2 as it was not directed towards stones. However, this report potentially suggests that one of the remaining species may also practice stone handling (although this remains to be confirmed).

Table 2

Observations of SH Behavior Across Wild and Captive Otters

Species	Behavior Description	Country	Captive or Wild
Aonyx capensis	Rock juggling and stone rolling on other stones	Gabon, Cameroon, South Africa & DRC	Captive
Aonyx cinereus	Rock juggling	UK	Captive
Enhydra lutris	Repeatedly drops stone in water and retrieves it; rock juggling	USA	Captive
Hydrictis maculicollis	Passes stone back and forth from mouth to paws and between paws and on other stones	USA	Captive
Lontra canadensis	Repeatedly drops stone in water and retrieves it, then juggles stone in hands and on belly	USA	Captive
Lontra felina	Rock juggling and juggling other stones	Brazil	Captive
Lontra longicaudis	Rolling stones on the belly	Mexico	Captive
Lutra lutra	Repeatedly drops stone in water and retrieves it; rock juggling; and rolls stones on other standing stones	UK	Wild & Captive
Lutrogale perspicillata	Rock juggling	India	Wild
Pteronura brasiliensis	Rock juggling	Brazil, USA	Wild & Captive

Overall, our findings suggest that the majority of known otter species practice some form of SH. Many of the SH reports described the otters 'playing' with the stones by rolling them across their body or between their paws (similarly to what some researchers described as 'juggling,' see also recent report by Allison et al., 2020), rolling the stones on other standing stones, and dropping stones in the water and then retrieving them (see supplementary video and Figure 1).

Discussion

Our survey resulted in several anecdotal observational accounts of SH in otters. Currently, the majority (10 out of 13) of known species of otters demonstrated positive, albeit anecdotal, evidence for SH. It is possible that the lack of reports of the behavior for the remaining three species may be false negatives, due to the rarity of general observations of these species both in the wild and captivity. These three species (*Lutra sumatrana, Aonyx congicus, Lontra provocax*) have been observed rarely due to the fact that they are elusive in the wild and inhabite countries that are difficult and/or dangerous to access for researchers. Furthermore, *Lontra provocax* is not currently found in captivity and only very few *Lutra sumatrana* and *Aonyx congicus* are found in captivity (unfortunately we were unable to communicate with the institutions that house these otters, and were able to find only one report of an *Aonyx congicus* showing SH-type behaviors with a plastic bottle cap). Overall, however, our findings suggest that SH is

present in most otter species, similar to SH in macaques. This finding also suggests that otters might have a genetic predisposition for SH (although this remains to be further investigated).

Only one formal study of SH has been carried out in otters (Allison et al., 2020). Allison et al. (2020) provide an ethogram of the rock juggling behaviors they observed in two species of otters (*Lutrogale perspicillata* and *Aonyx cinereus*). Using the observational and anecdotal reports provided by the researchers in this report, and the ethogram provided by Allison and colleagues (2020), some overlap between macaque and otter SH can be identified. For example, both otters and macaques have been described to roll stones on other stones, as part of SH and rock juggling. However, follow-up studies should examine in more detail the ethograms of the otter species identified in this study for further similarities and differences to be identified.

Future research on SH in otters should focus on replicating the observations compiled for this study, and conducting systematic and more detailed studies into the context, frequency, and types of SH observed in wild and captive otters to create an ethogram and extended distribution table of SH across otter species (e.g., Allison et al., 2020). Furthermore, experimental studies such as the one by Allison et al. (2020) should be conducted with captive otters to determine this ability in different captive species. The aim of our short report was to describe the extent of otter SH behavior across species and provide a foundation for interested researchers to continue studying this behavior in otters and other animals. Investigating SH in otters can provide insight into this behavior in other species, and into the development of foraging competence, the motivation underlying tool-use, and potentially even the evolution of some aspects of human material culture (Pelletier et al., 2017).

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