Parenting Phase and Abnormal Repetitive Behavior Among Two Captive, North American River Otters (Lontra canadensis)

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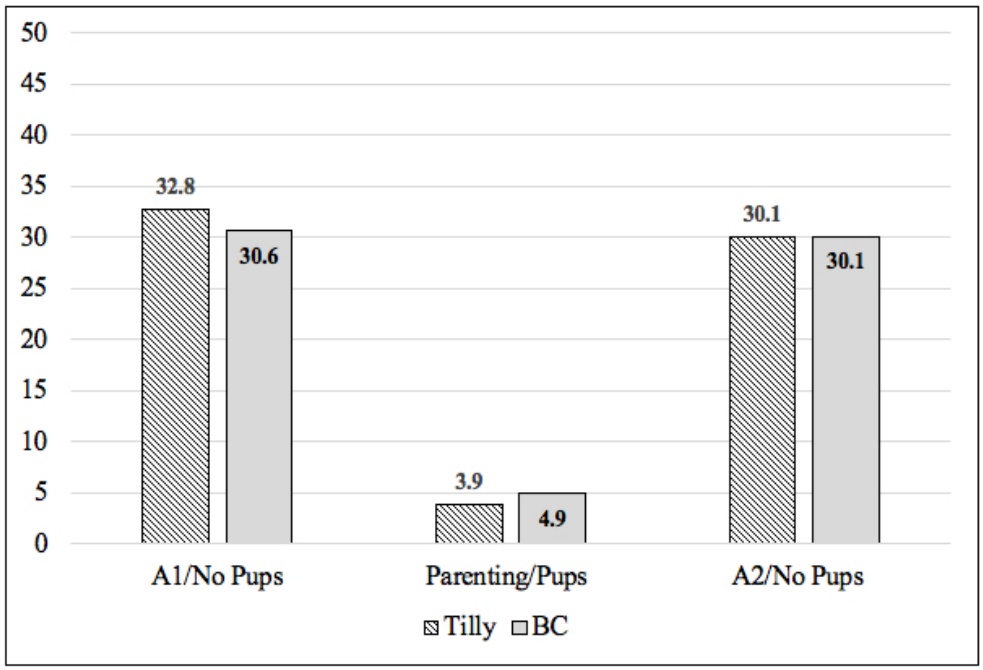

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Research Highlights

- This is the first published study of river otter abnormal repetitive behavior across parenting conditions.
- ARB frequency for both otters was lowest during parenting and highest following pup relocation, when the female adjusted a pre-existing ARB to include foot suckling and a foot-grab.

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Parenting Phase and Abnormal Repetitive Behavior Among Two Captive, North American River Otters (*Lontra canadensis*)

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Abstract

One adult female and one adult male North American river otter *(Lontra canadensis)* were observed for the presence of abnormal repetitive behaviors from March of 2016 through August of 2018 at the Oregon Zoo. This study represents a natural ABA design, where the A reflects two absent pup phases (i.e., post-alloparenting and post-parenting), while the B condition refers to the observational period when pups were on exhibit with one or both biological parents. The goal of this study was to explore the differential variability of abnormal repetitive behavior relative to parenting condition among two captive, adult North American river otters. Both adult otters engaged in locomotor abnormal repetitive behaviors prior to and following the parenting condition. Between the adult male and female, the sequence of their abnormal repetitive behaviors were qualitatively different. The frequency of abnormal repetitive behaviors was also highest for both adult otters prior to and following parenting, when one foster pup and two biological offspring were relocated to other zoos. The abnormal repetitive behaviors were also significantly correlated with visitor density, visitor effect score, and exhibit zone, though not in consistent directions. Therefore, the parenting condition was the only consistent moderator of the abnormal repetitive behaviors observed during the A phases of this longitudinal investigation.

Key words: stereotypy, pups, otters

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Parenting Phase and Abnormal Repetitive Behavior Among Two Captive,

North American River Otters (*Lontra canadenesis*)

North American river otters (*Lontra canadensis*), within the family of Mustelidae and part of the subfamily Lutrinae, are among the thirteen global otter species (DeLong, Wright, Fobe, Wilcox, & Morrison, 2018). Otter morphology, habitat, diet, foraging behavior, group size, and sociality vary across the species (Yoxon & Yoxon, 2014). The North American river otter, one of the more gregarious otters may be found alone in its natural habitat; though frequently, otters live in adult bachelor groups (Blundell, Ben-David, & Bower, 2002) or kinship groups, consisting of a matriarch and her offspring (Kruuk, 2006, pp. 55-73). Their fast metabolism, 20 percent higher than most other mammals, requires otters to spend much of their active waking hours foraging or hunting for food, predominantly fish and crustaceans in their home ranges (Kruuk, 2006, pp. 143-161). These territorial ranges vary considerably from 4 to 70 kilometers depending on available resources and are scent-marked through regularly used latrine sites, typically along water features surrounding river banks, lacustrine shores, estuaries, and marine harbors (Sussex Wildlife Trust, 2016). Despite broad and varied territories in their natural habitat, territorial analogous enclosures in captivity are not practical for several reasons, not the least of which includes the pragmatics of management and space availability; but also, mustelids are notorious for finding structural weaknesses in the enclosures (Kollias & Fernandez-Moran, 2015). The restricted range and constrained space of captive enclosures limit the availability and necessity for foraging, hunting, scent-marking, territorial patrol, and traveling – behaviors involved in the search, seizure, or preparation of resources. Without a clear need to engage in these biologically relevant activities, the idleness of captivity can encourage repetitive, invariant behavior, referred to as stereotypy (Clubb & Mason, 2003).

Since stereotypic behaviors appear to serve no immediate biological need or function it is widely assumed such behaviors are an artifact of frustration, anxiety, or boredom due to the behavioral restriction of captivity (e.g., Meagher & Mason, 2012), enrichment scarcity (e.g., Mason, Clubb, Latham, Vickery, 2007), social isolation (e.g., Carlson & Earls, 1997; Latham & Mason, 2008), or environmental stressors (e.g., Hosey, 2000). Stereotypies are often learned and developmental, as they evolve over time through

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neural potentiation, adjusting in frequency, duration, and form, though once established may be resistant to change (Garner, 2006). Stereotypy has traditionally served as a metric of poor captive animal welfare (Mason, 1991). However, captive animals that are provided with creative enrichment, species-appropriate social interactions, good veterinary care, adequate exhibit space and opportunities to escape environmental stressors may still engage in stereotypic behavior. As such, researchers, animal care-providers, comparative psychologists, and ethologists have moved toward simply reporting, "abnormal repetitive behavior" (ARB; Rushen & Mason, 2006). While not all captive animals engage in ARBs, their occurrence does appear to be a product of captivity (Mason & Latham, 2004). The breadth and contexts in which ARBs occur can be unique across all taxonomic classifications, vary within species, across individual animals, and may be acculturated through observation of other conspecifics (Mason, 2010).

Mustelids, the large family of carnivores that include mink, ferrets, weasels, martens, otters, badgers, polecats and wolverines, are especially susceptible to abnormal repetitive behavior in captivity (Kollias & Fernandez-Moran, 2015). These may include locomotor ARBs (e.g., pacing, repetitive swimming) as well as oral ARBs (e.g., grooming, chewing, ingesting) with enrichment, parts of their enclosure (Kollias & Fernandez-Moran, 2015), as well as overgrooming, licking or sucking their pelage, or the fur and anatomy of conspecifics (Island, Wengeler, & Claussenius-Kalman, 2017). Among farmed mink, pacing behavior is common, the frequency of which often increases prior to mealtimes (Mason & Mendl, 1997) and can be mitigated through variable feeding schedules (Mason, 1991). In a study of olfactory stimuli as a moderator of abnormal repetitive behavior among wolverines, Chaudhary, Godoy, Hofling and Olsson (2007), reported pacing in the form of pirouettes and circling. Similarly, Morabito and Bashaw (2012) in a large survey of AZA accredited zoos and aquariums reported that among 55 institutions and 129 individual river otters, 46 percent of the otters performed ARBs, with repetitive swimming and pacing as the most common. Reed-Smith (2012) reported that some otters, particularly those without access to aquatic setbacks and only provisioned swim space by viewing windows, developed repetitive swimming sequences (pp. 230-249). Though some of these behaviors can be resolved by identifying and providing species-salient enrichment (Swaisgood & Shepherdson, 2005).

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The breadth of animal enrichment has progressed from quality husbandry and veterinary care to include biologically relevant stimuli and behavioral opportunities to engage in species-typical activities, especially concerning appetitive behavior (e.g., foraging and territorial protection) (Grams, 2000). It could be argued that one of the most motivating and biologically germane adult behaviors for all animals is an opportunity to parent. Though parenting opportunity has been overlooked in the enrichment literature, which has focused largely on the offspring and the mental and physiological health consequences of maternal deprivation (Latham & Mason, 2008) and pre-weaning (e.g., sea otters, Hanson, Bledsoe, Kirkevold, Casson, & Nightingale, 1993; primates, Harlow, 1958; mink, Díez-León & Mason, 2016; elephants, Clubb & Mason, 2002; review, Latham & Mason, 2008) with little mention of the effects of parentage on emergent or existent abnormal repetitive behavior by captive parents. Certainly, the inclusion of parenting or alloparenting opportunities offer a biologically meaningful and natural context in captivity that may, depending on the social dynamics of resident animals and species-typical parenting behavior, facilitate intraspecific cohesion.

The goals of this observational study were to identify: 1.) the frequency of abnormal repetitive behavior among two adult North American river otters at the Oregon Zoo; 2.) individual differences in ARBs between the two otters; and 3.) if ARBs in either one or both of the adult otters differed across parenting phases. In their natural habitat, female river otters maintain kinship bonds for six months or more post-weaning; while male river otters have limited to no parental investment, generally departing a mate's territory following breeding (Kruuk, 2006). As such, rearing opportunity may be more biologically meaningful for female otters than males, thus we predicted the observed ARBs would be lowest for the female during the parenting condition of this study.

Method

Focal Subjects

The subjects of this research were two captive North American river otters in the Cascade Stream and Pond exhibit at the Oregon Zoo. Tilly, named after the Tillamook River, is a 23-pound North American river otter, found orphaned, malnourished, and wounded from an animal attack (scar is still apparent on

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her right thorax) near Johnson Creek in 2009. She arrived at approximately 4 months of age. Once her health improved, Tilly came to the Oregon Zoo in a transfer facilitated by the Oregon Department of Fish and Wildlife (Lewis, 2016).

Buttercup ("BC"), a 23-pound male, North American river otter was found in 2009 orphaned near Star City, Arkansas. He was initially taken in by the Little Rock Zoo, but transferred to the Oregon Zoo the following year as a companion for Tilly. He had surgery to remove his left maxillary canine, but was otherwise healthy. BC and Tilly had a long, shared parenting history. In January of 2013, Tilly gave birth to two pups, Molalla and Ziggy, both were weaned at the Oregon Zoo. Molalla was relocated a year later, in January of 2014 to the Seattle Aquarium and Ziggy was transferred to the Seattle, Washington's Woodland Park Zoo in March of 2015. That same year, Little Pudding, an orphaned pup rescued on the road near Corvallis, Oregon was brought to the Oregon Zoo, where Tilly alloparented the pup until it was transferred to the Maryland Zoo on March 29 of 2016. Again in 2016, Tilly birthed three more pups, though two were still births, and the last died a short time later. On February 26 of 2017, Tilly gave birth to three more pups, two survived, Tucker (male) and Nellie (female). Both remained with Tilly for one year. Tucker was transferred on February 27, 2018 to the Children's Zoo at Celebration Square in Saginaw, Michigan. Nellie was relocated at 1 year and 2 weeks to Prospect Park Zoo in Brooklyn, New York on March 18, 2018 (Lewis, 2019a).

Materials

Observations were digitally video recorded using a Sony FDRAX33 4K digital video camcorder mounted on a 12-foot telescoping Sunpak Ultra tripod. Behaviors were simultaneously documented using a behavioral ethogram printed on legal sized Rite in the Rain® all weather copy paper, clipped to a 11"x17" acrylic, side-fastener clipboard and entered into an SPSS datafile. Digital data were archived into an online cloud, using Box® software.

Design

This study reflects a natural ABA longitudinal design. Observations occurred over the course of two years and five months. The A conditions refer to phases of the study when pups were absent from both

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the enclosure and the exhibit. Specifically, the "A_1" condition (i.e., post-alloparenting) reflects the observational period following the relocation of Little Pudding, a pup Tilly alloparented for approximately one year. While the "A_2" condition (i.e., post-parenting) refers to the observational period following the relocation of the biological pups, Nellie and Tucker. Thus, the B condition (i.e., parenting phase) represents the observational period in between the two absent-pup phases, wherein Nellie and Tucker were on exhibit with one or both biological otter parents.

Procedure

A total of eight observers participated in collecting data for this project with no more than two concurrent observers during any one of the three conditions (A_1, B, A_2) of this longitudinal project. Data collection began in March of 2016 and continued through August of 2018. Activity budgets consisted of 10-minute blocks divided into 30-second intervals. Periodically, researchers stopped between the 10-minute observation intervals to focus the camera or zoom in on a specific behavior. The two observers concurrently recorded data for the same otter to track inter-observer agreement. For times in which multiple animals were on exhibit and engaged in autonomous activity, observers recorded behavior for a single focal animal and then referred to the video footage to record behavior for the other otters. The observation times varied across Zoo Exhibit hours, between 9:30 am and 5:00 pm, with an average observation period of 85-minutes. The total number of minutes in observation over the 38-month period was 9,386 minutes (app. 156 hours) across four, paired observers (eight total) with an interobserver agreement value (Cohen's kappa) of K=.848 or 85%, indicating substantial agreement.

Ethogram. Individual animals as well as animal communities establish their own behavioral repertoire in captivity, contingent upon training, experience, age, sex, and social cohesion (Schork, de Azevedo, & Young, 2018). The development of a valid ethogram requires a pilot observation period to gauge individual idiosyncrasies and the social dynamics within a particular community. Some animals only engage in certain behavior in the presence of another animal, in the absence of people, with fewer people, when the noise level is high, around feedings, etc. These kinds of complex behavioral nuances cannot be ascertained without simply observing. The initial observation period lasted one week, prior to formal data

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collection. The 36-item ethogram, originally adapted from the activity budget of sea otters (Packard & Ribic, 1982; Island, Wengeler, & Claussenius-Kalman, 2017), was modified to reflect species typical behavior among captive North American river otters (Smith, Win, & Island, 2018). For each day of the pilot observation period, unobserved behaviors were excluded from the working ethogram with the inclusion of specific behaviors repeatedly evidenced among the two adult, captive North American river otters at the Oregon Zoo. The ethogram that emerged from this initial pilot period included four species-typical behavioral categories: Vigilance; Resting and Eating; Socializing and Play, Locomotion and Investigation (see Table 1) as well as one additional category labeled Visitor Impact. The ethogram's Visitor Impact category included two visitor variables, Visitor Number and Visitor Effect Score to identify contextual cues in which visitors may contribute to dramatic changes in otter behavior, including relocation to more secluded areas of the enclosure. According to Hosey (2000), the mere presence of visitors may not affect animal behavior if their behavior and presence is passive and transient. The degree of disruption is not necessarily correlated with visitor density either, different visitors engender different levels of introspection regarding their effect on the animals. For example, eight visitors watching an exhibit may observe respectful, mindful distances and speak in a hushed register, offering little in the way of threat or disruption. In contrast, one loud, invasive visitor may clap on the glass of the exhibit, walk in restricted areas too close to the enclosure and actively seek out the attention of the exhibit animals. Thus, a Visitor Effect Score (VES) was established so the investigators had a metric to assign visitors in each observation session. The VES reflected a continuous, modestly subjective, linear, scoring system along a 10-point scale, where 1 represented calm, unobtrusive visitor behavior and 10 represented loud, disruptive, and invasive behavior (i.e., harassment), which resulted in the displacement of one or more of the otters to an exhibit zone away from visitor view.

In addition to the ethogram, contextual data including time of day, temperature, weather, the number and name of the otters on exhibit (i.e., all otters within the exhibit), and the location of the animal/s within the enclosure (i.e., zone) was collected.

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Exhibit Zones. The length of the Oregon Zoo Cascade Stream and Pond exhibit is 1,330 square feet with the pond occupying 40% of the exhibit. The pond is fed by a small waterfall and supports a floating, circular enrichment platform (Lewis, 2016, 2019b). Exhibit habitat includes boulders, logs, trees, and other vegetation, as well as a terrestrial path behind the pond to the covered den. In order to document where behaviors occurred in the habitat and the location of visitors when referencing visitor variables, the investigators divided the exhibit into six zones (See Figures 1-3). All areas of the exhibit are visible from the visitor viewing theater, a covered area with five windows extending along the water line of the pond (Zone 3) from the west side (Zones 1 & 2) of the exhibit to the east side (Zones 3 & 5) as well as a separate observation window into the enclosed den (Zone 6).

Results

Activity budget and ethogram behaviors were tagged as ARBs if they occurred in a repetitive, invariant sequence with no apparent function. We observed both adult North American river otters at the Oregon Zoo engage in locomotor ARBs. Phi correlations for the female's (Tilly) abnormal repetitive behaviors included a sequence of several behaviors: Push off (exhibit) Surface, $\phi = .37$, $p < .001$, Surface Swim, $\phi = .23$, $p < .001$ to the central area of the enclosure (Zone 4), repetitive Somersault, $\phi = .23$, $p < .001$, and Surface Swimming again to the opposite side of the exhibit. This sequence was labelled an ARB (1=present; 0=absent) in the ethogram if it occurred repeatedly over a period of several minutes. The male's (BC) abnormal repetitive behaviors included a series of aquatic locomotor behaviors in which he entered the water and initiated a Surface Swim, $\phi = .28$, $p < .001$ to the end of the exhibit in Zone 4, pushed off the wall or the platform (i.e., "Push-off Surface") into a Backward Dive, $\phi = .24$, $p < .001$ and Underwater Swim, $\phi = .22$, $p < .001$, back to the original entry point in the water. The sum of this sequence looked like an infinity symbol, thus we referred to BC's ARBs as an "infinity sequence."

Tilly and/or BC were on exhibit in over 80 percent of all behavioral observations regardless of parenting condition (Table 2). The frequency of ARBs varied between the otters and across the three parenting conditions of the study (Figure 4). During the A_1 phase, Tilly engaged in abnormal repetitive

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behaviors in 32.8% (*n*=981) of all observations in which she was on exhibit (*N*=2,987). Similarly, BC engaged in ARBs 30.6% (*n*=970) of all observations in the A_1 phase (*N*=3,166). Throughout the B condition (i.e., parenting) of observations, both Tilly (*N*=4,180) and BC's (*N*=3,460) ARBs decreased to 3.9% (*n*=165) and 4.9% (*n*=169) respectively. The ARB type and frequency returned to pre-pup levels for Tilly and BC once Nellie and Tucker were relocated to another Zoo. In the A_2 phase, following the relocation of the pups, Tilly adjusted her repetitive behavioral sequence. Tilly held her rear foot (i.e., "Foot-Grab" $\phi = .23$, $p < .001$; Figure 5) as part of the repetitive Somersault and suckled one or both rear feet (i.e., "Suckle") $\phi = .23$, $p < .001$ when she slept (Figure 6). Further, among Tilly's observed repetitive hind Foot-Grab and Foot-Suckle behavior, she demonstrated a side bias, as 75% were with the right hind foot (see Table 3). According to Tilly's keepers at the Oregon Zoo, there were no current foot-related problems or injuries in her veterinary files that would explain the inclusion of the Foot-Grab behavior in the ARB sequence, or in favoring the right rear foot during resting activity (Lewis, 2018).

A Brown-Forsythe one-way analysis of variance was conducted to accommodate varied observation numbers across the three conditions and yielded significant differences in mean abnormal repetitive behaviors across the parenting or B condition of observations, $F(2, 9265) = 585.81$, $p < .001$. Pairwise comparisons of frequencies of abnormal repetitive behaviors across the three conditions (A_1, B, A_2) were conducted using a Bonferroni adjusted alpha level of .017 per test (.05/3). Results indicated that the average number of abnormal repetitive behaviors were significantly lower at the .001-level in the B condition (i.e., parenting; $M = .04$, $SD = .20$) than those in both the A_1 (i.e., post-alloparenting; $M = .30$, $SD = .46$) and the A_2 conditions (i.e., post-parenting; $M = .30$, $SD = .46$). However, there were no significant differences in the frequencies of abnormal repetitive behaviors between Tilly and BC in the Post-alloparenting (A_1) and Post-parenting (A_2) phases, thereby suggesting the "A" in our natural ABA design reflected truly analogous A phases. Given the nature of the aquatic, locomotor ARBs, a one-way ANOVA of Zone by ARB frequency, $F(5, 9251) = 495.17$, $p < .001$, with an adjusted alpha level of .008 (.05/6) for pairwise comparisons revealed the bulk of ARBs emerged in Zone 4, the open water directly in

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front of the observation window. This is consistent with other published reports of river otter locomotor ARBs in captivity (Reed-Smith, 2012).

An additional Brown-Forsythe one-way analysis of variance between parenting condition and the frequency of Displacement was also conducted yielding significant mean frequencies between behavioral displacement, $F(2, 9265) = 311.71$, $p < .001$. Again, pairwise comparisons of Displacement frequencies across the three conditions were conducted using a Bonferroni adjusted alpha level of .017 per test (.05/3). Based on the results, the otters appeared to become sensitized to disruption following the relocation of the pups, as the average number of times the otters were displaced from one area of the exhibit to another was significantly higher ($p < .001$) in the A_2 (M=.18; SD=.38) phase than in the A_1 phase (M=.00; SD=.00) or the B condition (i.e., Parenting; M = .14; SD =.35). Though both Displacement and ARB were variables sensitive to parenting condition, Displacement and ARBs were negatively correlated, ϕ = -.08, $p < .001$. Rather, behavioral displacement was related to environmental context and Vigilance Variables: Alert, ϕ = .27, $p < .001$ and Periscope, ϕ = .03, p = .002.

Unlike other studies of otter abnormal repetitive behavior and feeding schedules (e.g., Morabito & Bashaw, 2012; Hawke, Lauer, Bartholomeusz, & Steen, 2000; Ross, 2002), only two instances of Begging (Tilly) were observed during feedings. Further, ARBs were negatively correlated with feeding times, defined as 10-minutes prior to and following feeding, ϕ = -.14, $p < .001$. Similarly, Enrichment (i.e., the presence of enrichment toys or changes to the exhibit) was negatively correlated with ARBs as well, ϕ = -.06, $p < .001$(see Table 4). This is not surprising given the Oregon Zoo incorporates enrichment regularly as part of both their otter feeding and husbandry protocols.

Ethics Guidelines Acknowledgement. The authors abide by Wiley's ethical guidelines and by the guidelines produced by the Committee on Publication Ethics. Although this study was submitted to Pacific University's Institutional Animal Care and Use Committee (IACUC) for consideration, it was deemed "Exempt" from review given the study posed no additional risks or harm to the observational

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animals beyond daily zoo visitor interaction. In other words, this project was entirely behavioral observation with no direct interaction with or manipulation of the river otters observed at the Oregon Zoo.

Discussion

This behavioral account provides to our knowledge, the first published longitudinal study of abnormal repetitive behavior across captive river otter parenting phases. The purpose of this study was to determine if the two adult river otters at the Oregon Zoo engaged in abnormal repetitive behavior and if so, to identify the individual differences between the two otters in type and frequency of ARBs across parenting cycles. It was predicted that Tilly's abnormal repetitive behavioral sequences would decline during the parenting condition. This prediction was confirmed; however, BC's ARBs were also significantly lower during the parenting condition than in the no-pup conditions (A_1 & A_2). Although no causal conclusions can be drawn from these data, it does appear that rearing-opportunity or presence of pups, mediated invariant, repetitive behavior for the two observed otters.

Both adult river otters at the Oregon Zoo were observed performing ARBs and similar to the Morabito and Bashaw (2012) large-scale survey of North American river otter behavior, locomotor ARBs were the most frequently observed stereotypy. The two otters' ARBs were qualitatively different, with the emergence of an oral ARB among the female's (Tilly) ethogram involving foot sucking and foot grabbing following the relocation of the subadult pups. If we consider the typical stressors in a captive environment which may contribute to abnormal repetitive behavior, they include: 1.) boredom from limited enrichment and/or an inability to perform species-typical feeding and foraging behavior; 2.) high visitor density or disruptive noise; 3.) non-natural habitat, a restricted range within the habitat, and/or absence of retreat space; and 4.) disrupted intraspecific cohesion (Morgan & Tromborg, 2007). Since the Oregon Zoo incorporates more than 200 enrichment items and activities in the otters' training and in all physical therapies, husbandry, and veterinary care on and off exhibit (Lewis, 2017), it is unlikely the performance of ARBs is the result of limited enrichment. This is especially implausible since enrichment and feeding times were negatively correlated with ARBs.

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Concerning the influence of visitors or a visitor effect on ARB performance, significant correlations for the performance of ARBs and visitor number (positively) and visitor effect scores (negatively) were correlated in opposite directions. Limited exhibit retreat space cannot be excluded as a moderator of ARBs, as two of the six zones offer otters obscured visitor visibility and retreat space on exhibit, though the location of ARBs did not differ by parenting condition. Further no ARBs were observed in these areas of the exhibit. Morgan and Tromborg's (2007) fourth explanation for the establishment of ARBs, "disrupted intraspecific cohesion" appears to be the most appropriate explanation relative to ARB frequency for both the adult male and female captive otters at the Oregon Zoo. The absent-pup (A_1 & A_2) conditions revealed the most frequent and consistent ARBs, with the emergence of an oral ARB for Tilly immediately following the relocation of her biological pups (A_2).

In natural environments, social groups for otters vary and rarely do males stay with a kinship group long-term (Blundell, Ben-David, & Bower, 2002). Among river otter kinship groups, it is most typical for offspring to establish new territories after one year of age (Kruuk, 2006, pp. 62). Among captive river otters, the dynamics of social groups also vary relative to differential temperaments, ages, history, and sex of individual otters. Thus, long-term housing of offspring with parents may not be feasible or practical in all captive contexts (Reed-Smith, 2012, pp. 126-128). This study does not seek to advocate for the retention of otter offspring, nor can we know how sustained residency of otters with their parents may affect the emergence of ARBs in the subadult offspring.

Since all female mammals exhibit some degree of parental care (Baker, 1994), the inclusion of parenting opportunity as an enrichment variable for zoo-housed animals is not unreasonable, particularly as part of a conservation, translocation or rehabilitation program. There is much discussion in the comparative literature of Asian elephants that multigenerational herds in captivity (e.g., Harvey, Daly, Clark, et al., 2018), as in the wild (Vidya & Sukumar, 2005) facilitate more affiliative interactions, de-escalate aggressive encounters, few stereotypies, and provide for optimal welfare among individual animals. There is also evidence that birth origin (i.e., captive-born or wild-born), specifically captive-born, may contribute to the development of stereotypy among mice (Jones, Mason, & Pillay, 2011),

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mustelids (Latham & Mason, 2008), and giraffes (Bashaw, Tarou, Maki, & Maple, 2001). Though, socialization period, weaning, and age at captivity among wild-born animals moderates the development of abnormal repetitive behavior, both Tilly and BC were wild-born river otters rehabilitated as pups and therefore may not have received enough parental socialization to preempt the development of ARBs. Yet the inclusion of parenting-opportunity for Tilly and BC provided a highly motivated natural behavioral context, wherein established repetitive, invariant behavioral sequences contracted during the parenting phase with the re-emergence of ARBs in the non-parenting baseline conditions. Given Nellie and Tucker were not exposed to significant ARB acculturation from their parents, and were socialized within the typical rearing period for North American river otters, it would be meaningful to compare Nellie (Children's Zoo at Celebration Square, Saginaw, Michigan) and Tucker's (Prospect Park Zoo, Brooklyn, NY) behavioral development with the behavioral data of their parents. We did not have sufficient behavioral data for Tilly and BC while Little Pudding, the foster pup, was on exhibit to compare to the B condition (biological pups). But based on the results of two years in observation, opportunities to parent or alloparent particularly among zoos and aquariums with rehabilitation resources, may be an appropriate consideration as part of an enrichment protocol for adult mustelids.

Conclusions

1. This study reflects the first published, empirical study of river otter abnormal repetitive behavior across parenting phases.
2. The locomotor ARB frequency for both adult otters, was lowest during the parenting condition and highest following the relocation of pups to other zoo facilities.
3. Following the relocation of the biological pups, the adult female adjusted a pre-existing ARB to include a foot-grab (predominantly, right hind foot), as well as foot suckling behavior.
4. This study does offer encouraging data to suggest parenting or alloparenting opportunity may moderate ARBs and provide another enrichment option in the pursuit of psychological and physiological well-being among zoo-housed animals.

Acknowledgements

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Conflict of Interest Statement

The authors have no conflict of interest to report. We are not employees of the Oregon Zoo, nor do we have any other potential sources of conflict of interest relevant to the publication of this paper, including no patents or stock ownership relevant to the study, membership or service as board of directors to the Oregon Zoo, membership of an advisory board or committee for the Oregon Zoo, and no consultancy for or receipt of speaker's fees from the Oregon Zoo or any other company relevant to zoo research.

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Table 1. Zoo-Housed River Otters Ethogram

Welfare Variables (6)	
Feeding	Otters are provided food during the behavioral scan, they may or may not eat.
Enrichment	Enrichment number is the number of enrichment items present in exhibit (e.g., puzzles, Kong toys, water bottles, fish popsicles, etc.)
*Enrichment Type**	*Qualitative description of each type of enrichment in the exhibit*
Visitor No.	Visitor number at the exhibit at any given time (including research observers)
VES	Visitor Effect Score, subjective scale of 1-10 that describes how loud, invasive visitors are.
Displaced	Following a disturbance or an event, the otter immediately departs one location for another.
*Displaced To**	*Describes the starting and the ending zones following the disturbance that displaced the animal (e.g., 1-2; 5-3, etc.)*
ARB	Abnormal repetitive behavior, any repetitive, unvarying, and apparently functionless behavior that is atypical in a natural environment
*ARB Sequence**	*Qualitative description of each ARB in sequence*
Vigilance (3)	
Directed Gaze	Directed gaze or eye contact with one or more of the visitors
Vigilance	Otter floats with head above surface, a directed gaze at the water or a target on land – often occurs following an environmental disturbance
Periscope	Otter floats vertically in the water column, head and shoulders above water level – often occurs concurrent with "Vigilance"
Rest/Eat (5)	
Sleep Number	Number of otters sleeping concurrently (typically in Zone 6)
Foot Suckle	Established ARB, while sleeping (typically Tilly), otter mouths or sucks one (L/R) or both hind feet
Eat	Ingestion of food (not simply appetitive behavior, but consumption)
Beg	Involves clear solicitation or door-monitoring prior to feeding.
Nurse/Suckle	Pups = suckling, Dam = nursing
Affiliative/Agonistic (11)	
Chase/Follow	Tailing, chasing or following another otter (or keeper)
Somersault	Somersault may start as a roll, but is head over feet and can occur as an ARB.
Foot-Grab	An established ARB wherein the otter holds one or both feet while somersaulting, this describes which foot (L or R or Both)
Grapple	Grappling, wrestling, tumbling, or rolling with another otter

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(Side)Saddle	Describes a play behavior, wherein one otter "saddles" atop another, different from "mounting," often occurs as "side saddle"
Enrichment Play	Otter "plays" with enrichment, may be to mouth, toss, carry – may also use platform or food as play target
Muzzle	Nudges, grooms or licks at the body or pelage of a conspecific
Groom	Tug, scratch, lick, or strokes their own pelage ("muzzle" in a conspecific)
Nip	Non-aggressive, grabbing or nipping at another
Mount	Sexual or behavioral dominance, often with a neck bite
Aggression	Aggressive directed behavior (e.g., biting, hissing, open-mouth lunge at another otter, keeper, or at the exhibit glass)
Locomotion/Investigation (11)	
Forage	Appetitive, goal-directed behavior, toward food or enrichment, in water or land
UwSwim	Swimming activity underwater, breath held
SurfSwim	Swimming activity at the surface
ForDive	Otter tucks their head underwater and pinches their head to tail, thrusting the tail above their head to propel themselves to depth
BckDive	Tail thrust forward, back arched into backward dive, generally occurs less often than forward dive
Push-Off	Otter pushes off an exhibit surface (typically hind legs) to initiate a swim
Roll/Rub	May shake off water, roll in the dirt, or rub in the dirt, all usually to dry off.
Amble	Akin to "walk," but shorter front limbs make "walking" a poor description
Gallop	Akin to "run," though again "gallop" is more representative of otter running
Spraint	Otter engages in the "latrine dance" to urinate, defecate, or both
Scent	Otter smells the latrine site, or the genital/anal area of a conspecific

**Italicized rows are not a behavioral or contextual category, but a description of the preceding variable.*

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Table 2.

Percent Tilly and BC were on Exhibit during Focal Observations, By Phase

Otter	No Pups (A_1) *N*=3,306	Pups (B) *N*=4,240	No Pups (A_2) *N*=1,720
Tilly	90.4% (*n*=2,987)	98.6% (*n*=4,180)	100% (*n*=1,720)
BC	95.8% (*n*=3,166)	81.6% (*n*=3,460)	100% (*n*=1,720)

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Table 3.

Tilly's Foot-Grab and Hind Foot Suckle Side Bias Frequencies

Behavior	Left	Right	Both
Foot-Grab (*N*=84)	25% (*n*=21)	75% (*n*=63)	0
Foot Suckle (*N*=151)	19% (*n*=28)	76% (*n*=115)	5% (*n*=8)

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Table 4.

Pearson's Correlation Matrix for Welfare Variables

	ARB	Visitor Effect Score	Visitor Number	Displacement	Enrichment	Feeding
ARB	---					
Visitor Effect Score	-.08***	---				
Visitor Number	.10***	.26***	---			
Displacement	-.08***	.25***	-.02*	---		
Enrichment	-.14***	.40***	-.17***	.18***	---	
Feeding	-.06***	.11***	.19***	.13***	.14***	---

Note: *p<.05; **p<.01; ***p<.001

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Figure 1.

West Observation Window

In this photograph, Zone 1 and 2 are visible. Zone 1 designates the terrestrial area behind the logs; Zone 2 includes the logs and the platforms along the waterfall.

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Figure 2.

West to East Observation Window

The photograph reflects Zone 3 - 5. Zone 3 is visible from all three windows and reflects the land path that connects Zone 1 (land in the far-left window) and Zone 5 (land in the far-right window), which also leads into the covered otter den (Zone 6, not pictured). Zone 5 was the most frequently utilized latrine site. The open water area along all three observation windows reflects Zone 4.

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Figure 3.

Covered Otter Den

The photograph is of the covered, exhibit otter den is Zone 6. Here, visitors can see into the den through the one-way window, allowing the otters to find refuge while still providing visitors an opportunity to observe.

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Figure 4.

Observed ARB Percentages by Otter Across Three Parenting Phases

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Figure 5.

Tilly Foot Grab into Somersault

The photograph of Tilly above shows her engaged in a post-parenting (A_2 condition) ARB, Foot-Grab Somersault (right hind foot).

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Figure 6.

Tilly Foot Suckling

This photograph is also of Tilly, sleeping with both rear feet in or near her mouth. This is an extension of the Foot-Grab Somersault ARB, which also emerged following the relocation of the two pups, Nellie and Tucker (A_2 condition).

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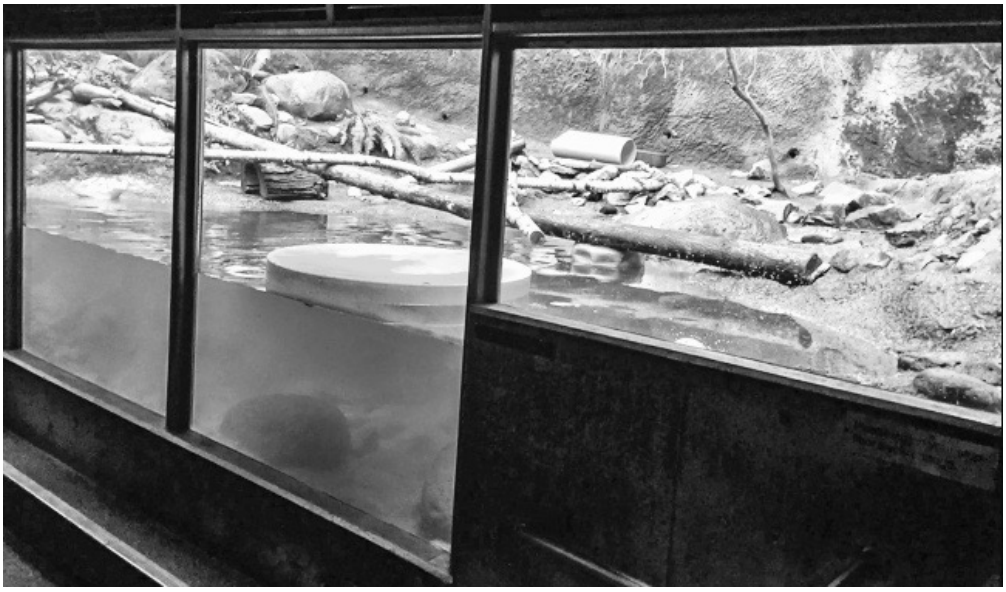
Figure 1. West Observation Window
In this photograph, Zone 1 and 2 are visible. Zone 1 designates the terrestrial area behind the logs; Zone 2 includes the logs and the platforms along the waterfall.

177x157mm (72 x 72 DPI)



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The photograph reflects Zone 3 - 5. Zone 3 is visible from all three windows and reflects the land path that connects Zone 1 (land in the far-left window) and Zone 5 (land in the far-right window), which also leads into the covered otter den (Zone 6, not pictured). Zone 5 was the most frequently utilized latrine site. The open water area along all three observation windows reflects Zone 4.

228x132mm (72 x 72 DPI)

Figure 3. Covered Otter Den
The photograph is of the covered, exhibit otter den is Zone 6. Here, visitors can see into the den through the one-way window, allowing the otters to find refuge while still providing visitors an opportunity to observe.

135x120mm (72 x 72 DPI)

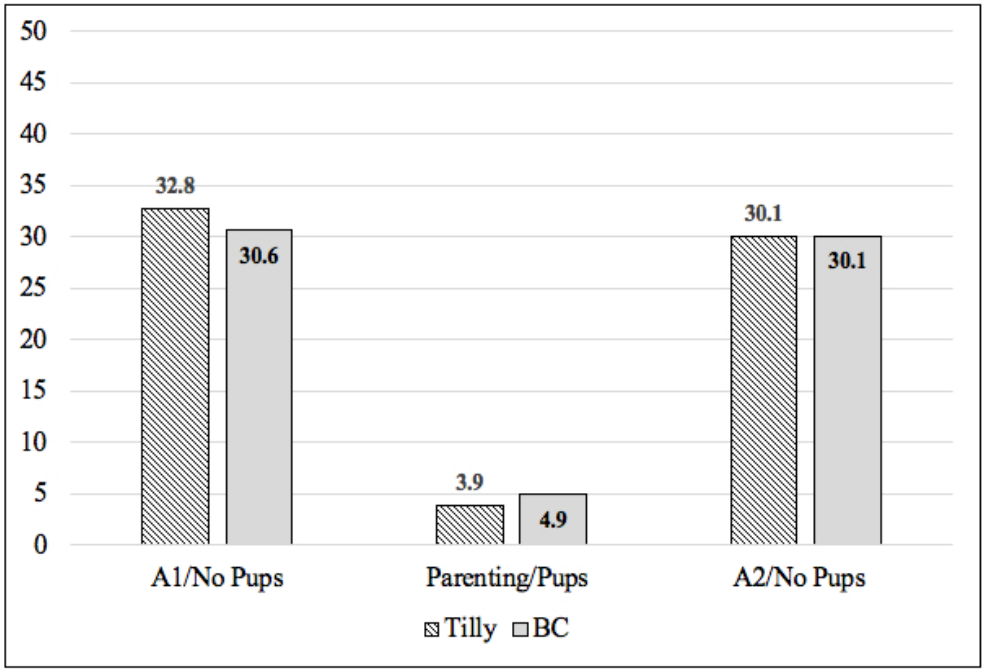

Figure 4. Observed ARB Percentages by Otter Across Three Parenting Phases

216x148mm (72 x 72 DPI)

Figure 5. Tilly Foot Grab into Somersault
The photograph of Tilly above shows her engaged in a post-parenting (A2 condition) ARB, Foot-Grab Somersault (right hind foot).

130x127mm (72 x 72 DPI)

Figure 6. Tilly Foot Suckling
This photograph is also of Tilly, sleeping with both rear feet in or near her mouth. This is an extension of the Foot-Grab Somersault ARB, which also emerged following the relocation of the two pups, Nellie and Tucker (A2 condition).

127x131mm (72 x 72 DPI)