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Bedding as an Enrichment Strategy in Group-housed Mauritian Cynomolgus Macaques (*Macaca fascicularis*)

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The research community is committed to improving the well-being of nonhuman primates by providing opportunities to express species-specific behaviors such as foraging. In the wild, macaques spend a large part of their day foraging; this behavior is greatly limited in captivity. Bedding (wood shavings substrate) has been shown to promote foraging in rhesus macaques. However, the amount of bedding needed to affect these changes is unknown. Further, few studies have examined other benefits of bedding, including its potential to reduce noise levels, which can negatively impact welfare. We examined the use of bedding substrate in male Mauritius cynomolgus macaques (2-3-y-old) living in one of 2 social groups with either a full bale of bedding (that is, approximately 6 in of substrate) or a half bale (approximately 3 in) added to the pens for 10 d, followed by 4 d without bedding. We performed focal observations on 8 monkeys biweekly for 8 wk and used a dosimeter to measure sound in the room for 42 d. As expected, monkeys spent significantly more time foraging and less time self-grooming when bedding was present than when it was not. The amount of bedding did not make a difference. The presence of bedding did not affect social grooming or aggression, although it did help to dampen sound. Both peak and mean sound levels were lower with a full bale of bedding than with no bedding. Taken together, these results suggest that bedding is an effective enrichment strategy that can improve welfare of group-housed macaques.

Abbreviations: NHP, nonhuman primates; ONPRC, Oregon National Primate Research Center

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Introduction

A major goal of behavioral management programs is to increase environmental complexity for captive animals in order to give them opportunities to exhibit species-typical behavior.[7,11,17] Encouraging these behaviors is important to the well-being of nonhuman primates (NHPs). One such behavior is foraging. Macaques in the wild typically spend a considerable amount of their waking hours foraging for food.[10,13] Foraging behavior includes searching for, finding, processing (for example, removing the nut from the shell), and consuming food, and is thus a complex task that involves problem solving.[16] In the wild, such behavior comprises a major part of the behavioral repertoire of macaques; in captivity, time spent engaged in this behavior is often limited. For this reason, encouraging foraging behavior is often a focus of behavioral management programs.

The vast majority of environmental enhancement programs at primate facilities use enrichment devices such as puzzle feeders or foraging boards to promote foraging behavior in caged NHPs.[4] These devices are filled with food items, such as pasta, grain, fruit, or seeds, and may be frozen to prolong the amount of time it takes to consume them. While enrichment devices are effective at promoting foraging behavior, once the food in a device is consumed, foraging behavior often decreases.[6]

While foraging devices have benefits for caged animals, they are often somewhat less effective for group-housed animals, as it can be challenging to offer access to foraging devices to all members of a social group due to monopolization by dominant individuals. Individual animals may compete for access to devices, leading to tension or even aggression between group mates. Alternatively, bedding (a substrate commonly consisting of wood shavings) can be added to animal enclosures. Food items, such as trail mix or popcorn, can be added to the bedding to promote foraging behavior.

Several studies have shown that the presence of bedding increases foraging and decreases undesired behaviors such as aggression and self-grooming in various NHP species.[8,13,15] In a study of run-housed sooty mangabeys (*Cercocebus atys*) that received a simultaneous increase in multiple forms of enrichment including food devices and destructible items, the mangabeys demonstrated a preference for foraging through timothy hay substrate, leading to a significant increase in feeding and foraging behavior.[12] These results suggest that bedding is an effective alternative to foraging devices in group-housed animals.

Despite this supportive evidence, bedding does not appear to be as widely used as other enrichment options. Factors that may contribute to lack of use include cost, infrastructure limitations, and the perception that substrate increases the amount of time it takes to clean.[13] Thus, further studies to address some of these issues are warranted. For example, no studies to date have examined the amount of bedding necessary to provide welfare benefits. Because the amount of bedding directly influences cost and labor, knowing the minimal amount necessary might

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promote its use. Furthermore, although bedding has been shown to be beneficial for animals,[8,13,15] few, if any, studies examine other properties of bedding as enrichment for NHPs. Because excessive sound can negatively impact welfare of animals in captivity,[18] finding ways to reduce excess noise can be beneficial. For example, toys dropped into bedding make less sound than toys dropped onto floors. The potential sound dampening qualities of bedding have not been examined.

Figure 1. Flexible pen housing (Carter2Systems, Hillsboro, OR) without bedding (A) and with a full bale of bedding (B). The pens contained verandas, climbing structures, perches, and other platforms. Each side of the room housed 1 group of either 12 or 14 macaques. When bedding was not present, other enrichment items such as Ferris wheels or pools were placed on the floor.

The main goal of this study was to compare the effectiveness of 6 in and with 3 in of bedding as an enrichment strategy for group-housed cynomolgus macaques *(Macaca fascicularis)*, a species for which the use of bedding has not been studied. In addition, we used a portable sound meter to measure ambient sound levels with and without bedding to determine whether the bedding might reduce noise in the rooms.

Materials and Methods

Subjects and setting. Subjects for this study were members of 2 groups ($n = 12$, $n = 14$) of male Mauritius cynomolgus macaques (*Macaca fascicularis*) purpose bred by Bioculture US (Florida). Macaques were between 2 and 3 y of age (average age 3.3 ± 0.1 y at start of study). Both groups had *ad libitum* access to water through automatic watering systems and high-fat chow, Typical American Diet (TAD) Primate Diet (36.59% of calories are from fat, Purina TestDiet, St. Louis, MO). Each group was housed in a single indoor run (36.25′ x 20′ x 46.25′) consisting of 5 modular pens[2] (Figure 1; Carter2Systems, Hillsboro, OR) that could be separated by dividers. Both groups lived in the same room, across from one another. The pens featured multiple perches and catwalks for macaques to access various heights in the enclosure. The room featured LED circadian lighting with a dimming timer to simulate sunrise and sunset over the course of half an hour. Lights were on a 12:12 cycle; lighting started at approximately 0700 and started to dim at 1900. The temperature was set for 72F (22.2C) and daily humidity levels ranged from 30-70%.

Bedding. Wood shavings (pine or aspen; Cozy Den Premium, Idaho) were used as a bedding substrate. Each bale contained 3.6 cubic ft of bedding when compressed and provided 10 cubic ft of bedding when distributed. Either half or a full bale was added to each pen (that is, 5 per run). A full bale per pen provided roughly 6 in of substrate per pen and half bale roughly 3 in of substrate per pen.

Bedding (full or half bale per pen) was added and remained in the pens for 10 d, followed by 4 d of washing and sanitation. To ensure that the monkeys had access to bedding over the weekends, it was always added on a Friday afternoon and removed 10 d later (on a Monday morning). During the first 10-d period, we added a full bale per pen of bedding to both groups. For the next cycle, we added a half bale per pen. We repeated this pattern for another iteration, resulting in 20 d in which macaques received a full bale per pen, 20 d with a half bale per pen and 16 d of no bedding (Figure 2). Bedding was 'spot cleaned' daily. When bedding was not present, each group received other enrichment including large metal Ferris wheels to play on and plastic pools to swim in. Macaques received daily produce enrichment and had

Days of study	Amount of substrate
1-10	Full
11-14	None
15-24	Half
25-28	None
29-38	Full
39-42	None
43-52	Half
53-56	None

Figure 2. Timeline of study. Bedding (half or full bale per pen) was placed in the pens for 10 d and then removed for 4 d.

Behavior	Definition
Anxiety	Scratch, yawn, shake
Groom	Manipulation of the hair of another individual with hands and/or mouth
Forage	Subject is searching through bedding substrate, presumably for food
Self-groom	Picking through own hair with hands and/or mouth
Aggression	Bite, hit, slap, threat, chase
Abnormal	Individual engages in atypical behavior, such as self-bite, floating limb, eye-poke, feces-smearing, or urine drink
Stereotypical behavior	Repetitive (at least 3 iterations) pacing in the same path, hopping or bouncing in place, twirling, or flipping

Figure 3. Ethogram of behaviors coded during observations of cynomolgus macaques.

access to chew toys and other enrichment items (for example, large hard plastic balls) at all times. These enrichment items were rotated when they became soiled or every 14 d. Daily food enrichment was provided by the animal husbandry staff, generally in the afternoons. The type of enrichment changed each day, depending on availability, and included items such as apples, carrots, and berries. Larger pieces of produce were placed on the perches of the pen, while smaller pieces were scattered on the floor, regardless of whether the bedding was present.

Behavioral observations. Behavioral observations were performed on days with either a half bale of bedding per pen, a full bale of bedding per pen, or no bedding present. At the start of the study, we randomly chose 4 macaques from each group as focal subjects for all the behavioral observations. To take observations, a trained observer with whom the macaques were familiar entered the room 5 min before the start of the observation period to acclimate the animals to her presence. The observer had worked with these animals for several weeks and could distinguish among individuals. The observer then used instantaneous focal sampling techniques[1] in which the behavior of the subject was recorded at 20 s intervals for 10 min. Because aggression and anxiety had relatively short durations, all occurrence sampling was used to record these behaviors (that is, the observer recorded the number of times the focal individual engaged in the behavior throughout the 10-min period). We focused on behaviors found to be influenced by bedding in our previous study (Figure 3). Each focal macaque was observed twice a week for 8 wk (Figure 2). Observations were conducted between the hours of 1130 and 1430 to avoid coinciding with husbandry procedures such as feeding or spot cleaning the pens, and were not made on days in which the bedding was removed. The order in which the macaques were observed was randomized. Data were collected directly on an iPad using HanDbase (DDH Software, Milton, GA).

Sound recording. Several weeks after the behavioral observations concluded, sound was recorded semi-continuously for 42 d with a dosimeter (TSI Edge eg5 Noise Dosimeter with Wire-free Microphone, GS Galson, Syracuse, NY). The dosimeter was placed at the end of the animal room opposite the door (approximately 38 ft from the door). Average and peak sound was calculated for various 1 h time blocks throughout the day. The monitor was removed from the room when the pens were cleaned to avoid getting it wet.

To assess noise across the 3 conditions (no bedding, half bale, full bale), we examined peak and average sound from 1830 to 1930, right before and during the time in which the room lights went off. The time was chosen because at this time people were not in the room with the monkeys, but the lights were not completely off. The data set included sound recorded 17 d with full bale, 14 d with half bale, and 11 d with no bedding.

Data analysis. To determine whether bedding presence or amount type was related to behavioral differences, we calculated the average time each of the 8 focal individuals spent in each of the behaviors with a full bale, half bale, or no bedding. The assumptions of normality were tested for all variables using the Shapiro-Wilk test. Data were analyzed with 1-way repeated measures ANOVA, or the Friedman test when data did not meet the assumption of normality. Where appropriate, we used Tukey's (ANOVA) or Dunn's (Friedman Test) post hoc analyses to determine differences between a full bale, half bale, and no bedding. No behavioral differences were detected between animals in the 2 pens in the study. To determine the effect of bedding on sound, we compared both the peak and mean dosimeter readings for the designated time period using a 1-way ANOVA. Data are presented as mean ± SEM. Alpha values were set at 0.05. GraphPad 8 (Prism, San Diego, CA) was used for all analyses.

Humane care guidelines. This study was conducted in compliance with all federal regulations, including the United States Animal Welfare Act[19] and the *Guide for the Care and Use of Laboratory Animals*,[14] and was approved by the ONPRC Institutional Animal Care and Use Committee. The ONPRC is accredited by AAALAC, International.

Results

Behavioral observations. Monkeys spent significantly more time foraging when bedding was present as compared with when it was not ($F(2,14) = 10.19$, $P = 0.003$, Figure 4). The amount of bedding had no effect on time spent foraging (Table 1). With either amount of bedding, monkeys spent about 12% to 15% of the time foraging during the 8 observations in which bedding was present. Individual monkeys also engaged in less self-grooming when bedding was present (Friedman test = 7.548, $P = 0.019$, Figure 5). Monkeys spent more than twice as much time self-grooming in the absence of bedding as compared with when either a bale or half bale was used (full bale, 1.35 ± 0.41 %time; half bale, 0.97 ± 0.53 % time; no bedding, 3.83 ± 1.24 % time). As with foraging, the amount of bedding did not change the amount of self-grooming (Dunn's Z=0.63, P= 1.0).

Unlike self-grooming, the presence of bedding did not affect social grooming (Friedman Test = 0.483, $P = 0.84$). Very

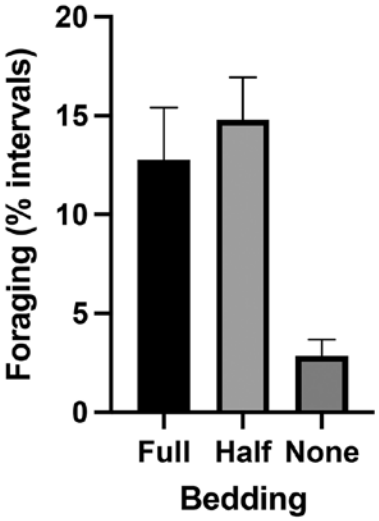

Figure 4. Percent of intervals in which the focal macaques were foraging with a full bale per pen, half bale per pen, or no bedding present.

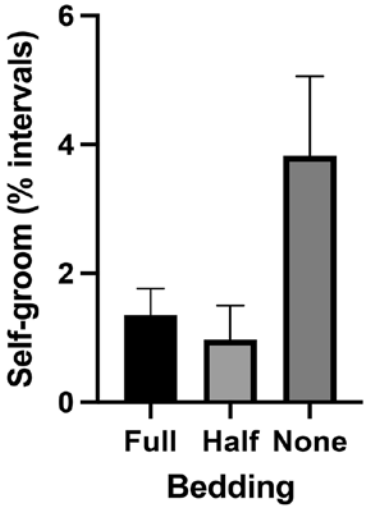

Figure 5. Percent of intervals in which focal animals were self-grooming with a full bale per pen, half bale per pen, or no bedding present.

Table 1. Tukey's post hoc analyses for foraging

Behavior	Comparison	Mean difference	Adjusted *P*
Foraging	Full compared with half	−2.02	0.74
	Full compared with none	9.92	0.04*
	Half compared with none	11.93	0.006*

little aggression occurred in this study (full bale, 0.11 ± 0.04; half bale, 0.10 ± 0.06; no bedding, 0.08 ± 0.03 bouts/min), and the presence of bedding had no effect (Friedman Test = 2.387, $P = 0.35$). Almost no stereotypical or abnormal behaviors were observed during the study (1 monkey was observed urine drinking on 2 different days). However, there was a difference in anxiety behaviors across the three treatments (Friedman Test = 6.20, $P = 0.04$). The monkeys engaged in slightly more anxiety behaviors when there was no bedding (0.38 ± 0.12 bouts/min) compared with when a full bale (0.14 ± 0.04 bouts/min) was used (Dunn's Z = 2.25, $P = 0.07$).

Sound levels. Sound levels varied considerably across days, ranging from a peak of 45.0 to 83.2 dB. The presence of bedding influenced the peak ($F_{(2,38)} = 4.377$, $P = 0.02$) and mean ($F_{(2,38)} = 8.110$, $P = 0.001$) sound as measured by the sound meter (Figure 6). Tukey's posthoc analyses revealed that both peak and mean sound levels were significantly lower when a full bale of bedding was used as compared with when no bedding was present (Table 2). A half bale of bedding did not significantly reduce the peak or the mean sound levels.

Discussion

Several studies have found that bedding promotes welfare for research- and zoo-housed animals including macaques.[8,13,15] Most of these studies examined behavioral effects and workload. However, little published work has examined the amount of bedding required to produce behavioral benefits. Here, we examined 2 volumes of bedding as a first step in determining the appropriate amount of bedding necessary to produce behavioral changes in cynomolgus macaques. We also examined whether bedding reduced noise.

We found that the provision of bedding increased foraging, a species-typical behavior, and decreased self-grooming in group-housed juvenile cynomolgus macaques living indoors. These results are similar to those found in rhesus macaques.[13] A study of outdoor-housed rhesus macaques found that monkeys housed in bedded pens spent more time foraging and less time self-grooming than those living in non-bedded pens.[13] The amount of bedding did not influence these behaviors in our study; even a half a bale of bedding per pen (approximately 3 in deep) was sufficient to produce these changes. This information can help colony managers balance the cost of providing bedding with the benefits it produces.

Further, in our study, monkeys tended to show fewer anxiety behaviors (scratch, body shake) when bedding was present than when it was absent. This result must be interpreted with caution, however, as the pens were sanitized on days in which bedding was not present. The sanitization generally required monkeys to be shifted to 1 section of their pen for a period of time, and could thus be somewhat anxiogenic for some individuals. While no observations were taken during the cleaning process itself, some observations may have been taken within a few hours of this husbandry event, and thus some animals may have experienced residual anxiety.

The presence of bedding did not correlate with aggression in our study. A previous study[13] showed that rhesus macaques fought less when bedding was present than when it was absent. Levels of aggression in the current study were relatively low even when bedding was absent. Similarly, the monkeys in our study did not show excessive abnormal or stereotypical behavior. Future studies should look for the effects of bedding on these behaviors for groups with higher levels of aggression and/or abnormal behaviors.

Another key finding of this study was that bedding dampened ambient sound levels in the room in which the monkeys lived, at least at some times of the day. Both the peak and mean sound levels were lower when bedding was present than when it was not. The sound dampening feature is especially pertinent to indoor-housed macaques that may live in large cacophonous rooms in which sound is easily amplified. Reducing sound is desirable in such conditions because noise can be detrimental to animal wellbeing.[18] Routine husbandry tasks such as cage change often produce substantial noise that may be distressing to animals. In addition, persistent sounds inherent to the indoor

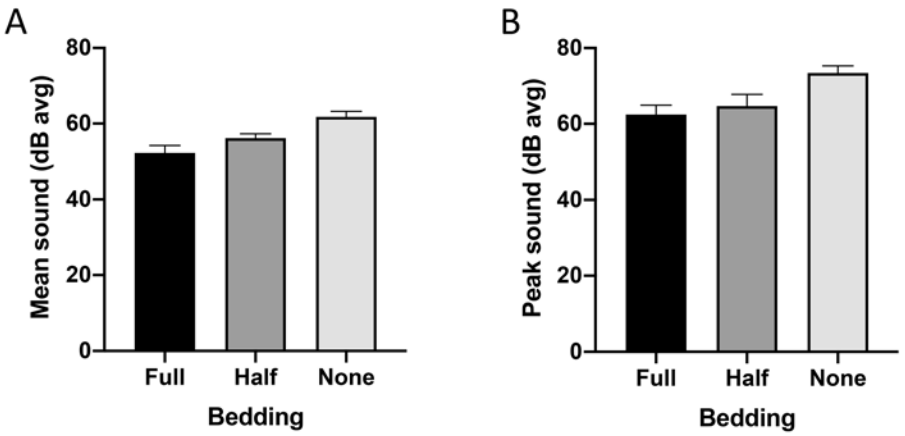

Figure 6. The mean (A) and peak (B) sound recorded in the room with a full bale per pen, half bale per pen, or no bedding present. Normal human conversations are generally around 60dB.[17]

Table 2. Tukey's posthoc analyses for the peak and mean sound levels

Sound level	Comparison	Mean difference	Adjusted *P*
Peak	Full compared with half	−2.25	0.80
	Full compared with none	−10.98	0.02*
	Half compared with none	−8.73	0.08
Mean	Full compared with half	−3.797	0.21
	Full compared with none	−9.48	0.0007*
	Half compared with none	−5.68	0.06

environment may be present, such as ambient sound and cage washing equipment.

In an effort to reduce the confound of human-caused sounds (for example, moving equipment into and out of the rooms or in the hallway and training of monkeys, which occurred at various times throughout the day), and because the monitor had been removed for power washing, which only occurred when bedding was not present, we only examined sound levels at one time of day. We chose the hour right before the lights went completely off for the night because at that time human activity is limited. While anthropogenic sounds were minimized during this time, other sounds were still present, such as ambient sound pressure and noise from adjacent animal rooms. The peak sound levels measured by the dosimeter ranged from 45.0 to 83.2 dB, which is less than what one would expect during times in which equipment was moving, etc. Normal conversations are generally around 60dB, washing machines are around 70dB, and a lawn mower is about 80-85dB.[9] While the lack of sound data from "noisier" times is a limitation of this study, the fact that bedding reduced noise during a relatively quiet time suggests that this finding is worthy of future investigation.

The sound reduction could have occurred through at least 2 mechanisms. First, the bedding may have absorbed some sound waves, thus dampening the sound. Alternatively, the presence of bedding could have reduced vocalizations from the monkeys, thus resulting in less sound in the room. NHPs in rooms with conventional lighting often vocalize a great deal when the lights abruptly turn off. Although the circadian lighting in our study room slowly dimmed over 30 min, the macaques still vocalized toward the end of the cycle as the lights turned completely off for the night. In either case, the bedding seems to have dampened sound and potentially improved welfare. Alternatively, the animals may have made more noise when the bedding was not present. During these times, the monkeys had access to Ferris wheels and other enrichment items that were not present with the bedding. If the monkeys had been using these devices, this may have caused an increase in sound. However, the animals had other potentially loud enrichment objects such as hard plastic toys with the bedding. In addition, they tended to settle down and use enrichment less as the lighting began to turn off. Future studies should more carefully examine the sound dampening effects of bedding during routine husbandry events such as cage change and control for the presence of enrichment items. Another study could examine whether bedding promotes sleep for the macaques.

Together, these results demonstrate that bedding can be used as an enrichment tool that may help reduce sound levels, thus improving the environment of captive NHPs. Bedding is probably not used as often as it could be, given its ability to promote welfare. Facilities may not routinely use bedding for various reasons.[13] For example, a perception still exists among care staff and management at some facilities that bedding takes more time to maintain despite publications that have demonstrated the opposite.[5,13] Facilities can challenge these perceptions by examining their own time investment. Because runs do not require daily washing when bedding is used, bedding can reduce workload on weekends or days when staffing levels may be low.[3] Another reason given for not using bedding is that it is not compatible with other sorts of enrichment, particularly those that require water such as pools. In this scenario, bedding could be used on an alternating schedule (as in this study). Finally, cost of bedding and removal is another reason given for not using it as enrichment. To this point, we found that using half a bale of bedding per pen provided similar behavioral benefits as a full bale. More work is needed to determine whether even less bedding would also be effective in producing behavioral changes. The cost of bedding is, in many cases, balanced with the cost savings from decreased water use.[13] While the use of bedding may be associated with challenges, in many cases they are far outweighed by the welfare benefits of this form of enrichment.

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