Prototyping Naturalistic Enrichment Features*: A Case Study*

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ABSTRACT

While working on the research and design phase of a naturalistic Asian rainforest exhibit for the California Science Center's World of Ecology exhibit, we had the unique opportunity to research and develop innovative habitat components intended to showcase naturalistic behaviors. In many cases, the cost of designing and constructing truly naturalistic enrichment devices may not be worthwhile, particularly when it is uncertain how target taxa may respond. We were tasked with the challenge of designing, constructing, testing, and assessing naturalistic enrichment prototypes for siamangs (Hylobates syndactylus), babirusa (Babyrousa babyrussa), crocodile monitors (Varanus salvadorii), and Komodo dragons (Varanus komodoensis). Design objectives included: 1) striking a balance between ensuring sound husbandry while maintaining the natural appearance of the exhibit; 2) providing animals the opportunity and motivation to express species-typical behaviors; and 3) exploring enrichment options within the context of the natural exhibit design. Data were collected by observing animals that were well habituated to their enclosures. Analysis of the data provided valuable design insight and suggested that modifications range from none to some changes necessary to fully achieve design objectives.

INTRODUCTION

As animal behavior specialist (Whittaker) and zoo exhibit specialist (Coe), we have endeavored to offer enriched environments that would motivate and stimulate animals to express a wide range of natural behaviors and to be challenged to fully use their physical and mental attributes. These same features create dynamic exhibits that provide visitors with an enhanced experience and opportunity to view active animals.

With the many advances and trends in animal exhibition in zoological facilities, providing animals with enrichment options that fit the exhibit themes can be challenging. Naturalistic exhibits and landscape immersion exhibits, now considered international best practice (Coe, in press) should a) ensure sound husbandry while maintaining natural appearance, b) provide animals the opportunity and motivation to express species-typical behaviors, c) be aesthetically pleasing to the public, d) meet institutional objectives regarding conservation education and animal exhibitory, e) while facilitating management requirements and f) maintaining psychologically and physically healthy inhabitants.

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As exhibit designers and behavioral consultants, we often find ourselves involved in heated discussions amongst those trying to provide inexpensive, commercially available environmental enrichment, even if it doesn't look naturalistic, and zoo directors who want to preserve the natural look of the exhibits. We attempted to avoid this polarized debate with the simple solution of providing enrichment features that were inexpensive, functional, and natural-looking.

THE PROJECT

California Science Center (CSC) in Los Angeles will be opening a World of Ecology complex. This includes an Asian rainforest exhibit designed to display animals in large, natural looking enclosures. CLRdesign, Inc. (CLR) were designers of the living exhibits as sub-consultants to the overall project architects, the EHDD/ZGF joint venture. Co-author Coe headed the CLR design effort. Active Environments provided design input, assisted in species selection, and animal and personnel management information for the research and design phase of this project. Exhibits are designed not only to facilitate behavioral management activities, but will rely heavily upon it to convey the complete message of the exhibits.

The Rainforest will feature a walk-through aviary, surrounded by three large rotation exhibits that will house primates, birds, otters, fishing cats, and ungulates in an Asian forest landscape. The intent is to randomly rotate and mix individuals and species in naturally occurring combinations, based upon different spatial preferences. For example, an arboreal species (siamang), a terrestrial species (babriusa) and an aquatic species (otter) may jointly use the same three-dimensional volume. While rotation of these combinations of animals has been used elsewhere (Coe 2004, in press), the enrichment features discussed here add an important new dimension to the rotation concept.

The animals' behavior will be highlighted through this dynamic exhibit concept which will be further enhanced by a progressive behavioral management program that relies heavily on facility design, positive reinforcement training, and environmental enrichment. These natural looking exhibits will require creative enrichment techniques to occupy the animals' time, promote species-typical behavior, offer expanded education opportunities for the visitors, while maintaining appropriate aesthetics and exhibit theme. In other words, the enrichment must completely blend into the natural appearance of the exhibit.

Coe's and CLR's design goals for CSC's exhibits were to develop relatively low cost, natural appearing enrichment features that could easily be changed or removed for later reinstallation to sustain the animals' interest. Three of these devices were particularly novel in their design and application, and had not been used elsewhere. Therefore, we recommended funding a project to design, construct, and test prototypes devices, which was graciously approved by the California Science Center. Objectives of the prototype project included the following:

- Determine the appropriateness and durability of materials. Since the final products for the Rainforest exhibit will be fabricated to simulate natural items, we tested internal structures only. External materials must be tested at a later time.

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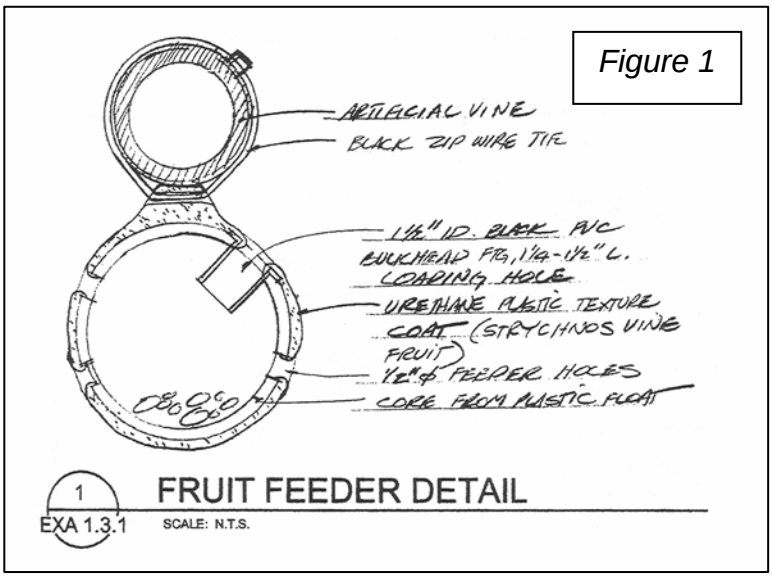
- Assess potential safety risks of devices and consider factors to avoid these risks (i.e. size of device, size of access holes, method of securing device, etc).
- Determine the amount of time each of the animals used each device.
- Catalogue species appropriate behaviors (feeding, locomotion, social – affiliative and agonistic) as exhibited in relation to enrichment device use.
- Determine what percentage of food in enrichment devices was accessed by each animal. Different food types and sizes were tested.
- Appraise novel use of devices that may suggest additional potential variations.
- Record negative consequences of the presence of the devices such as aggression between animals, potential injury, etc.
- Suggest modifications to improve devices.

The Houston Zoo had the appropriate animals and agreed to allow us to conduct our research, for which we were grateful. The species used to test the enrichment devices included: siamangs (Hylobates syndactylus), babirusa (Babyrousa babyrussa), crocodile monitors (Varanus salvadorii), and Komodo dragons (Varanus komodoensis).

Descriptions of Devices

The natural appearing enrichment devices for which prototypes were designed and developed included: a durian fruit feeder, tree root feeder, and "dead" fish feeder. The durian fruit feeder (figure 1) will look like a large durian fruit with holes in it. It can be hung from artificial vines that can be raised and lowered using electric winches. Thus, the fruit can be hung at different levels to allow for different feeding strategies and sizes of animals. The target animals for this device are primates, but it could be used for hornbills as well. To prototype this device, we developed a simple 6" PVC pipe with capped at each end. The end caps screw on and off, and have eye bolts set in them. These eye bolts can be attached to chain and used to hang the devices. It can be hung either vertically or horizontally. One-inch diameter holes were drilled in the devices to allow food treats to fall out and/or to allow the siamangs to put their fingers inside the device to search for food. The device was filled with various items including small pieces of cut fruit, peanuts, and seeds, which were stuck in place around the edges of the holes with applesauce and baby food.

Figure 1



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The root feeder (figure 2), used for the babirusa, will look like a tree root jutting off the base of a tree; the babirusa can root and dig around the base of the tree. The 'root' will be flexible and have holes of different sizes that necessitate shaking the root to make the food fall out. Food items can be loaded from the top of the root. The root can be buried at varying depths under substrate requiring that the animal uncover it prior to being able to shake it to obtain any food. The prototype feeder was constructed of sturdy 1.5" diameter, 5 foot long, braided PVC tubing, which is both strong and flexible. One-inch diameter holes were drilled throughout the length of the tube to allow food to drop from it. The tube was capped on each end with removable caps, and both ends anchored. Initially, this device was not be covered by any substrate, but as the animal became more proficient at using it, the device was buried in a loose substrate. Food items were placed in the hose such that the babirusa had to shake the device to make the food fall out of the holes.

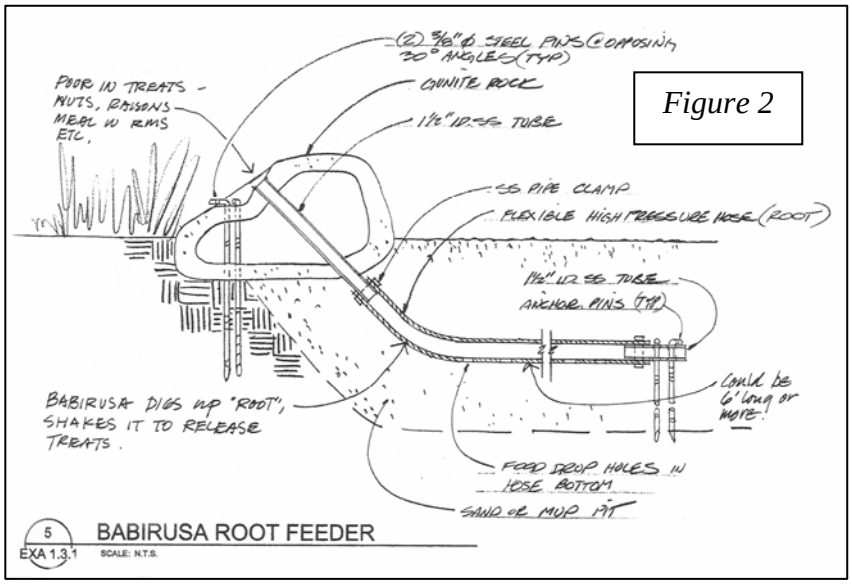

Figure 2

The feeders used for the monitors will look like large, dead fish (figure 3) on the bank of a stream. The feeders will "fight back" when the monitor pulls on the food items due to a hidden "bungee"-like cord attached to the tail that appear to make it flop around. Three prototype feeders were constructed which are essentially the same design but of different diameters for different sizes and species of animals. The male Komodo device, the largest, was constructed from 6" PVC and narrowed to a 4" segment that was capped on the narrow end and open on the 6" end. The female's device, which was also used for the crocodile monitors, was constructed from 4" and narrowed to 3" and also capped on the narrow end. The narrowing of the opening allowed the animals to get their heads partially inside the device, but was intended to add some difficulty to obtaining

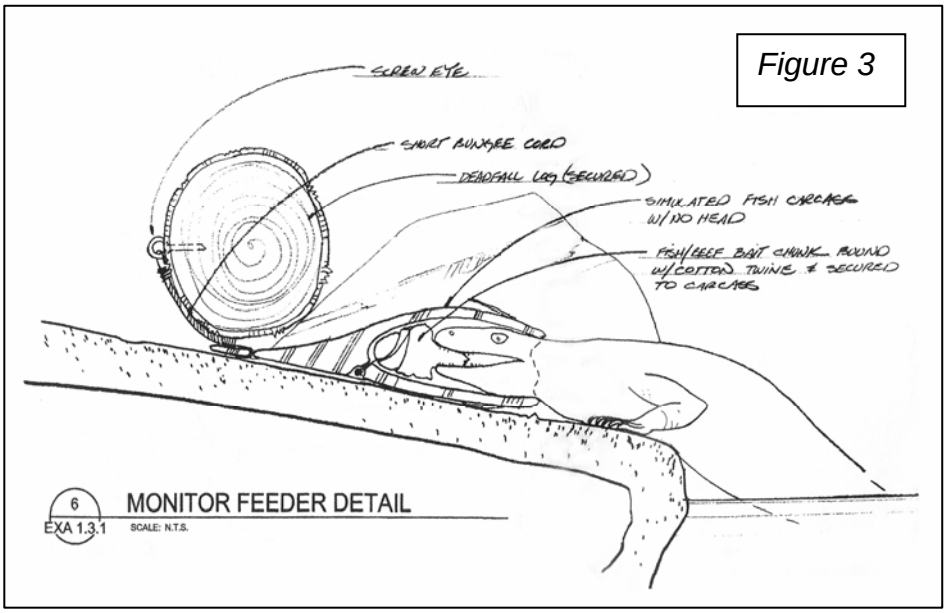

Figure 3

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the food by restricting total access to the end with the food items. These devices were presented to the animals in two different ways, one attached at ground level, and one attached hanging from a prop for the arboreal species. Both presentations were tested with arboreal and terrestrial species. Food items were attached with cat gut suture material to strong, but flexible rubber tubing. Chicks and rats were used in the devices, and usually 3 of either were in a single device. The rubber tubing was attached to the end cap.

RESEARCH DESIGN

Data were collected using continuous method sampling of focal animals (Martin and Bateson, 1993). Animals were observed for ten minute intervals with all occurrences of behaviors related to the enrichment devices recorded. In enclosures that contained multiple animals, the individual's behavior was recorded and analyzed separately. The categories of behaviors include: orient towards the device; investigate/touch the device; search for food from device; obtain food from device; not visible and other were also recorded and ad libitum notes accompany all observations. Definitions for the behavioral categories are the same for each of the species (although behaviors differ) and are defined as:

Orient Towards (the device) - conspicuously looking face on or laterally at device, or when there appeared to be a clear recognition of it.

Investigate/ Touch (the device) - any interaction with the device in a non-foraging, non-hunting manner, and included any behavior that involved directly touching, playing with, or interacting with the device in a non-food manner.

Search for Food - actively looking for food, but not obtaining it. Behaviors such as digging with fingers and manipulating the device to shake food out (siamangs), tongue flicking, digging at the device, and putting head in the device prior to obtaining the food (komodo), and looking at food inside, sniffing, and rooting (babirusa).

Obtain Food - included any time food was taken into either the hands or mouth.

Not Visible - any time the animal was out of sight.

Other - behaviors not associated with enrichment devices; Ad Libitum notes taken for all 'other'.

Study subjects included a pair of siamangs housed in a 45' x 25' x 30'natural looking exhibit, a female babirusa housed in a 30' x 20' naturalistic exhibit, and a pair of komodo dragons, and four crocodile monitors that each have a 20' x 15' x 12' semi-naturalistic exhibit.

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RESULTS AND OBSERVATIONS

Siamangs

These devices were successful in providing the siamangs with a novel foraging experience. During the first trial, only one device was used; the female used it exclusively. In all following trials, two devices were used. The results of the first trial are eliminated from the analysis. The female was pregnant throughout the study, and therefore ravenous. Her behavior changed and she demonstrated increasing dominance over desirable resources such as the enrichment devices, resulting in the male's reluctance to approach the devices when she was in close proximity. Since this type of foraging device was new to these animals, the first times the devices were presented, greens were put in the devices with the leafy portions hanging out of the holes so the animals could readily see food was available. The following reflects the study results:

Orient Towards - The male spent an average of 15% of his time oriented towards the device. He seemed to take much longer to become comfortable or brave enough to actually touch the devices. This may be a product of his tentative personality or of the female's increasing assertiveness. The female spent an average of 7% of her time oriented towards the device. She wasted no time getting to the food.

Investigate - When the siamangs investigated the device, they often appeared to be playing with it, sitting above it and kicking at the chain, and manipulating the hardware associated with it. The male spent an average of 5% of his time investigating the device. The female spent 11% of her time investigating the device; she was very active during this time.

Search - The male spent an average of 2% of his time searching for food.
The female spent an average of 8% of her time searching for food. It is our opinion that while the siamangs were orienting towards and looking at the devices, they most likely assessed the foraging opportunities. We base this assumption on their almost immediate response of obtaining food upon first touching the devices.
Obtain Food - The male spent an average of 34% of his time actually obtaining food. The female spent an average of 39% of her time obtaining food. Both animals used their feet and hands to manipulate the device. Most of the food was obtained by licking at the device during the initial trials, but both seemed to become more adept at using their hands to pick food out of the holes.

Other - The male averaged 35% of his time involved in behaviors not associated with the device. These often included vocalization, brachiation, avoidance of female, and eating other food provided throughout the exhibit. The female spent an average of 39% her time involved in other behaviors. The average was skewed by an isolated incident when there was a large amount of food scattered in the exhibit in easily obtainable sources. She

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chose to eat the readily available food first and then moved to the enrichment devices. During this trial, the male spent the greatest percentage of time associated with and obtaining food from the devices.

Monitors and Komodo

The crocodile monitors interacted very little with the devices. On exhibit, they never obtained food, but did investigate the device during a couple of trials. When the device was placed in a heated indoor area, one individual was quite interested in the device, investigated it, and eventually obtained the food in 32 minutes. Due to staff schedules for the crocodile monitors', the inside area couldn't be used as a testing site again.

Although successful in slightly increasing the male Komodo's feeding time, he learned very quickly how to decrease hunting time and proficiently obtain the food. The first time he was presented with the device, it took him 6 minutes to get the first food item. By the second time and all subsequent trials when the weather was warm, he obtained food in 3 to 4 minutes. The female never took the food items during the observations periods. On one occasion, she actually took the food at some point during the day. The following percentages reflect the male's behavior only; the female was inactive and was not observed to interact with the device at all.

Orient Towards - He spent an average of 4% of time oriented towards the device. The days with the highest percentage of this category were days when the weather was cool and cloudy. His interest in feeding, and general activity were greatly reduced due to weather conditions.

Investigate - To distinguish 'investigate' from other categories, a lack of tongue flicking was required. He spent an average of 12% of time investigating the device. There was no correlation of high/low percentages of this behavior with weather or trial sequence. During one trial, he was particularly interested in investigating the device and even pushed it around.

Search - He averaged 23% of his time searching for food. The highest percentage of time spent searching was on the first trial; subsequent trials resulted in reduced search time.

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Obtain Food - He 13% of the time obtaining food. The food items were attached in the device in such a manner that he often could get them all at once, but on about 40% of the trials, he had to return to the device a second and third time to get all the food.

Other - He averaged 48% of the time involved in other behaviors, most often sitting on his hot rock or attempting to get to the inside holding area. These behaviors were most frequent on cool, cloudy days.

Babirusa

Of the devices tested, the babirusa root feeder was perhaps the most successful in terms of novel behaviors observed, sustained foraging challenges, and level of interaction with the device; recommended changes for the final product are minimal. The babirusa spent the following average percentages of time engaged in these activities:

Orient Towards - She spent an average of 1% of her time in this behavior. The one trial she showed this behavior at higher rates was the one time she was fed her daily diet just prior to the observation period.

Investigate - She investigated the device an average of 8% of the time. The first trial with the device, she spent the greatest percentage of time investigating it. Throughout the study, she would spend some time each trial interacting with the device in a non-food searching manner. She would roll on it, lie down with it, and play with the chains and clips that attached it to the tree and ground. This level of interaction was a surprise to everyone and an added bonus towards increasing activity levels and sensory stimulation.

Search - She searched for food an average of 36% of the time. For this animal, searching frequently included picking up the device and dropping it, making the food fall out of the holes. Search was also scored when she would look through the substrate, either to dig up the buried device or after she had picked the tube up and dropped it making food fall to the ground. The first time she was given the device, she spent the greatest amount of time searching. As she became more skilled at retrieving the food, the search time dropped off. She did not have to go through this learning process when the device was buried; her search time was minimal during these trials as well.

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Obtain Food -She obtained food for an average of 52% of the time. She showed strong food preferences that seemed to change on a daily basis. Food items used included those from her daily diet such as sweet potato, carrot, apple, and treat items such as Chex cereal, peanuts, and seeds. At least three to four different items were placed in the device each time it was offered. Favored food items included: apple, peanut, carrot, and sweet potato, but as mentioned previously, one food item didn't persist as the favorite. During one trial, after shaking the food out of the device, she left all food items except peanuts, and another day she passed up peanuts for carrot. The keepers were surprised by her strong and changing preferences. This reinforces the need to a wide variety of food and treat items available for enrichment purposes. This will reduce the chance of boredom and acclimation, while maintaining a high interest in the enrichment.

Other - She averaged 3% of her time engaged in other behaviors; typically, these included drinking, entering the barn, or walking about the exhibit. The highest percentage of 'other' occurred when she had been fed her meal just prior to the enrichment device trial.

DISCUSSION OF PROBLEMS

Siamangs

The original concept of this feeding device was to provide a cylinder with holes drilled in it encouraging the siamangs to use their fingers to work the food between the holes and eventually be able to extract it, like a finger puzzle feeder would be used. The holes were of adequate size to easily allow the animals see into the device and to put their fingers all the way in it. Holes were drilled close enough to each other so that if the animals put two fingers in adjacent holes, they would be able to reach the food easily. Both animals seemed challenged to the point of frustration, and would leave the devices if they were loaded with pieces of food requiring them to use their fingers to work the food out of the holes. The device that hung horizontally was easier for the siamangs to use, but still they were not adept at removing pieces of food. The siamangs' primary mode of removing any food was to lick the device obtaining applesauce and baby food from the edges of the holes; they may have picked up raisins incidentally. They seemed to become more adept at using their fingers to retrieve the sauce or baby food during the latter trials of the study. Heavier food pieces such as peanuts and apples were not removed. The most successful foods were those of a paste consistency, including baby food and applesauce.

Monitor and Komodos

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Although the device did increase the foraging time slightly when compared to presenting the food directly, the amount of keeper time to sew the chicks or rats in place is prohibitive. Typically it took 20 to 30 minutes to thaw chicks or rats, prepare the device, attach it, and give the animal access to it. The male Komodo was typically finished with it in less than 5 minutes. Komodo dragons have very powerful jaws and sharp teeth, making it difficult to attach the food items so they are not easily removed. Komodos are very visual; once he saw the food, obtaining it was quite simple. He also learned to recognize the device and associate it with food. Unfortunately, it was not a part of this study to look at presenting the devices without food, but this may have helped maintain an interest level and kept him investigating it for longer periods of time.

The weather was the biggest limiting factor in studying the Komodos. They become fairly disinterested in food when it was cool and cloudy, and during rain they retreated to the pools. The female was extremely shy and rarely ventured down to the ground. The device was presented hanging above her normal resting area, but still she showed no interest until much later that day. It was also presented to her in an inside holding area, but she showed no interest.

Crocodile Monitor Problems

Unfortunately, nearly all trials with these animals failed. They showed no interest in the food unless moved in front of them, nor did they show any interest in investigating the devices. The devices were the same dimensions as the female komodo dragon's. In addition to the komodo-like device, we also tried, unsuccessfully, a device that was the same concept but shaped differently. This device was more of a wide 'U'-shape with openings at both ends. It could be hung from the mid section, allowing the animals to enter either end to gain access to the food.

These devices were presented both on and off-exhibit, and both hanging and on a level surface. The animals are highly arboreal and spend the majority of time clinging to caging material or rocks. They are fed in holding areas where the food is clearly visible and easily obtained. We believe the management style had a significant effect on our ability to effectively provide enrichment. The animals are fed large amounts at infrequent intervals. The result of this style of management is that the animals are not frequently food motivated and therefore are not interested in searching, investigative, or hunting behaviors. We tried to coordinate provisioning of enrichment with the feed schedule, but staff schedules made this impossible within the study time frame.

The crocodile monitors are highly visual, and seem to focus on food items that were moving. During routine feeding, food items are moved across the caging to stimulate the hunting response. Moving the device, with the food hanging out of it, was the only way we could encourage the crocodile monitors to take food from the device. We discussed this situation with the keepers, who thought the devices would be effective if the animals were properly motivated by a different feeding schedule.

Babirusa

During the testing time, the only problem encountered was that squirrels chewed at some of the openings, making them larger and therefore too easy for the food to fall out. This shouldn't be a problem for CSC as the area will be enclosed and not accessible to

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squirrels. However, the babirusa has been known to kill squirrels, so this adds another dimension to the enrichment aspect of the device- a squirrel lure. However, she was never observed to use it as a lure for catching squirrels.

RECOMMENDATIONS AND CONCLUSIONS

Siamangs

This prototype confirmed our suspicions that siamangs are not particularly dexterous and may not be able to remove food pieces without considerable practice and maybe training. We recommend that this device be modified to allow the siamangs to obtain food by licking and minimal hand manipulation. One way this could be accomplished is to have shallow cups that can be placed in wells or holes in the device. These cups should be easily removable for cleaning, and clip safely into the device so the animals cannot remove them. We do feel that siamangs can learn to use their hands to obtain food from a device similar to these prototypes, but with slight modifications. Rather than the device having a large cavity for the food, a smaller one or larger one that is sub-divided into several smaller compartments, would allow the animals to manipulate it in such a way as to remove the food without becoming frustrated.

Although the animals did not use device exactly as we envisioned, it did add complexity to the exhibit, provided a unique feeding and foraging opportunity, and was completely novel for the animals when it was first presented. They did not appear to acclimate to it; their level of interest remained stable throughout the study. From the keeper's perspective, this device was great. It was easily opened and cleaned, and it was easy to disinfect. It was also fairly easy to place into and remove from the exhibit.

Monitors and Komodo

This device has the potential to challenge a monitor in searching for food and provide visual and olfactory stimulation, but it must be modified so it is more practical to use. The cat gut is a good material to use to attach the food items to the device because it is nearly harmless to the animals. The only foreseeable problem would be if it were presented in a long string that were to be swallowed this way; chances of this happening were very slim. One package of cat gut suture lasted for one to two uses of the device, depending on how many chicks or rats were used and how well they were sewn to the device.

The tubing or "bungee" that anchored the food to the device seemed appropriate as it offered some give and flexibility to allow the device to 'fight back' or pull as the animals tried to get the food. One problem with the prototype device, was that the capped end (where the tubing was secured) was too short for a longer piece of tubing that would have had even more play. The komodo never bit through the tubing because he couldn't get his face far enough in the device to reach it. If a longer "bungee" was used, a metal ring attached to the end of it could be used to anchor the food items. This should prevent the "bungee" being bitten through, and offer more flexibility and play as the animals used the device.

Since Komodos and monitors are such visual creatures, making the device more challenging by covering the opening would increase hunting time and difficultly in obtaining the food items. Covering the opening with a rubber sheet or other material so the animal

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would have to push his head through it in order to see and retrieve the food may accomplish the goal of increasing the difficultly of this device. The material would have to be flexible, replaceable, and unappetizing to the monitors. From our experiences with this project and in talking to the Houston Zoo staff, monitors are unlikely to mistakenly eat a non-food object. They are fairly adept at honing in on the food items, but caution should always be taken when providing a non-food item associated with food.

To further elicit the arboreal crocodile monitors' natural hunting behavior, we recommended that a bird nest feeder be constructed. This device could look like an oriole or weaver nest, and be hung from artificial vines (like the durian fruit feeder) in such a manner to facilitate movement of the nest to further attract this very visual predator.

In spite of the problems described, this device was successful, and we feel has tremendous potential to offer monitors a more complex environment, sensory stimulation, and the opportunity to 'hunt' for food. Watching the male Komodo learn to use it was a fascinating process, and adding variants to the device would allow an intelligent animal such as this to continue to be challenged. This device also has the potential to set a new standard for monitor enrichment. Neither I, nor the Houston Zoo's curator of herpetology and reptile staff had seen this type of enrichment. It also caught many visitors' attention and encouraged them to spend up to 5 minutes in front of the exhibit, when typically they would spend 30 seconds to 1 minute if the animal was inactive in an empty exhibit.

Babirusa

This device was very successful and accomplished the goals of increasing activity, providing foraging opportunities, encouraged natural behaviors such as rooting, investigation, and searching for food. From the perspective of the keeper, this device was very easy to load with food and clean because the end caps were easily removed. The concept and function of this prototype doesn't warrant any changes. The natural appearance of the tree root will require that it follow the trunk of the tree to the ground, and then can be buried or placed on the surface of the substrate. In order to look like the tree root, coating it with an appropriate substance will be necessary. This substance must be pliable, able to be drilled, and withstand the rough treatment it will most likely receive from the animals as they search for food. Other than cosmetic enhancements to make this device look natural, changes do not seem necessary.

CONCLUSION

This worthwhile project provided valuable information about how the animals to be housed at the California Science Center's World of Ecology exhibit may interact with various enrichment devices. The study provided hard data documenting time spent in various enrichment based activities, and most importantly, modifications that can be made to the enrichment devices so they are effective tools to elicit natural behaviors, increase appetitive behaviors such as searching, hunting, and foraging, and combat boredom.

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- Houston Zoo Herpatology Staff- Judith Bryja, Bennett Dones, and Charlie Mann

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