THE CAPTIVE ANIMAL ACTIVITY TRACKING SYSTEM: A SYSTEMATIC METHOD FOR THE CONTINUOUS EVALUATION OF CAPTIVE ANIMAL WELFARE

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Optimal animal welfare has been a long-term goal for captive animal institutions. To measure welfare a definition and identification of elements that make up welfare need to be established. Further, a method to measure welfare's elements that can be implemented into staff's daily routine is necessary to establish baseline levels and track changes in welfare. The goal of the proposed captive animal activity tracking system is to allow for the measurement of each element of welfare quickly, while providing information regarding the animal's current state of welfare and how changes to the animal's environment affect welfare. The data show that this system is effective in revealing behavioral patterns and changes in behavior that occurred in response to environmental changes.

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INTRODUCTION

Captive animals interact with their environment daily and over time develop patterns of behavior to meet the demands of their environment. Some of these patterns may mirror the animal's wild counterpart and are considered natural, such as foraging for food, caring for young appropriately, and resting appropriate amounts of time. Other, more detrimental patterns may develop, such as high levels of stereotypic behavior, general inactivity or lethargy or inappropriate interactions, which are not in line with an animal's wild counterpart. The differences between these two different types of patterns are usually discussed in terms of welfare. However, a working definition of welfare is difficult to find. For example, Broom and Johnson in their book *Stress and Animal Welfare* (1993) define welfare as "the state of an individual as regards its attempts to cope with its environment (p. 74)." While this definition may be a useful starting point in discussing welfare, it is not a useful definition for researchers who wish to begin to directly measuring welfare. Similarly, goals like "bettering animal welfare" or "measuring an animal's welfare" state a desired outcome but they do not provide information about what that outcome would look like once achieved or how to achieve the outcome. Two important questions need to be resolved before an animal's welfare can be gauged: *what* aspects of an animal's behavior and environment should be measured and *how* should it be measured.

With respect to what to measure, Broom and Johnson recognize that welfare is difficult to define, and strongly suggest that any definition must be measurable and reflect both short-term responses (behavioral and physiological measures) and long-term responses (reproductive success, life expectancy etc). Other researchers also

agree that multiple aspects of an animal's behavior needs to be measured in order to further our understanding of animal welfare (AZA, 2009; BIAZA, 2008; Broom, 1993; Watters, 2008) However, which aspects of behavior are important for welfare is still unclear.

In 2008 the British and Irish Association of Zoos and Aquariums (BIAZA), the professional body representing the best zoos and aquariums in Britain and Ireland, proposed the physical health, social life, enclosure space and complexity, environmental enrichment, and mental health should be considered when evaluating an animal's welfare. These elements seem to have been embraced by the zoo community and attempts have been made to develop methods and systems to measure these individual elements.

In efforts to maintain an animal's physical health preventative measures are usually taken such as: feeding the appropriate diet, keeping their environment and food free of contamination, fecal examinations for parasites, quarantining new animals to avoid cross contamination, giving appropriate immunizations, and physical examinations. Preventative medicine is emphasized because of the general difficulty in identifying health problems (Guidelines, 1998). One thing that has not been emphasized in the measurement of the physical health of an animal is the animal's behavior. Behavioral measurements may be productively used to give insight into an animal's health and may lead to identification of illness or injury; for example, if an animal is increasingly lethargic, stops eating or favors one leg over another (BIAZA, 2008; Watters, 2009).

With respect to social life, much time and effort on the behalf of the institutions staff goes into creating environments for their animals that mimic the wild. These efforts are made under the assumption that these environments have the desired and anticipated effects on the animal's behavior. For example, research has been aimed at studying the particulars of different species' social groupings in the natural environment, and how captive institutions can re-create an animal's natural social environment (Fábregas, Guillén-Salazar, 2007; Marolf, 2007). The working assumption is that by recreating these environments animals may be more likely to engage in appropriate breeding patterns, which are extremely important, both individually and as a species for any given animal (AZA, 2008).

With respect to enclosure space and complexity, much effort is put into creating an animal's physical enclosure that allows animals to escape from aversive stimuli in their environment (for example, the public or conspecifics), while allowing them to behave as naturally as possible. This includes giving arboreal animals areas to climb, foragers room to dig or search for food, and nocturnal creatures dark spaces for activities. BIAZA stresses that it is not only the amount of space that is important for an animal, but also the complexity of its environment. A complex environment, according to BIAZA (2008) includes "variety, challenges and options" for the animals. However, according to Hutchinson (2005) complexity can only be judged by the ability of the animal to express its full range of natural behaviors. One popular way to address the complexity of the environment and its desired behavioral effects is known as environmental enrichment. Enrichment is defined as "a dynamic process in which changes to structures and husbandry practices are made with the goal of increasing

behavioral choices available to animals and drawing out their species-appropriate behaviors and abilities" (BHAG, 1999).

The last agreed upon component of animal welfare is "mental" well-being. This is perhaps the most abstract element recommended by BIAZA. One way to address that component is suggested by the Canadian Council on Animal Care's (CCAC) *Guide to the Care and Use of Experimental Animals* (Olfert, 1993). The CCAC states that, "behavioral well-being is manifested by behavior considered to be normal for that species and strain, together with the absence of significantly abnormal behavior. Behavioral well-being is considered to reflect psychological well-being, and to that extent, the terms are considered synonymous..." (p. 52). Their assumption is that any "psychological" distress should reflect itself in the animal's behavior. Therefore by measuring both normal and abnormal behavior, an animal's "psychological well-being" can be monitored. For example, a bear that is behaving naturally (foraging for food and interacting with its environment in the same manner and for a comparable amount of time to its wild counterparts) would be considered more "psychologically sound" than a bear that is spending its time pacing in its exhibit, or is sleeping all day long.

In addition to what should be measured with respect to animal welfare another difficult issue is how it is going to be measured. As Watters (2009) states it is clear that by collecting data on an animal's behavior a better understanding of normal behavioral patterns and changes in these patterns can be seen. But how much data should be collected and for how long? Ideally, data collected in zoos should be continuous, complete and direct. However, that kind of data collection is unlikely to occur in any captive animal setting. Busy staff members may not have time to collect and analyze

large amounts of behavioral data for each animal within their care. Because of this many institutions have used alternative data collection methods that are more efficient in this setting, but may limit the information gained about their animal's welfare.

A good case and point is the study of enrichment. There have been many studies conducted on the effects of specific enrichment items on certain species of animals. These studies are usually conducted for a short period of time and report only whether or not the enrichment had a positive impact on the animal during that time frame (Carlstead, 1991; Mallapur, 2002; McPhee 2002). Although, these studies provide useful information regarding enrichments effects, for example, it has been found that certain enrichment item are enriching for one individual animal in one situation, but not for another individual of the same species in another situation (Swaisgood, 2005), these studies are mainly concerned with local effects of enrichment, that is, with effects behavior immediately before, during and immediately after enrichment is provided. What these studies do not report is how long enrichment items continue to enrich or the most appropriate schedule in which enrichment items remain most effective over time. To answer these questions a continual data collection system is needed.

Because of the difficulties in establishing a time effective, continuous method to measure the effects of enrichment, captive animal institutions have relied on non-continuous data collection methods. Rating scale systems are a commonly used tool. They usually involve staff members directly observing an animal and rating its interaction with the enrichment item on a scale from 1 and 5. The value of 1 indicates that no interaction with enrichment was witnessed by the data collector during their observation, and 5 indicates that 10 or more interactions with the enrichment occurred

during the time of observation. This rating is usually taken whenever the staff member has time to observe and the observation lasts for an unspecified amount of time (Disney, 2003). One drawback of these assessments is that they rely on a staff member's view of an animal's level of "interaction." They provide no information about what type of interaction the animal had with the enrichment or what other behaviors the animal was engaging in if no interaction was observed. In addition, without specified times to observe and rate interactions it is possible that the rating given for a particular enrichment item may not accurately reflect its effects on behavior. For example, an animal may interact with an item consistently before engaging in other behaviors that do not include interaction with the enrichment item. If a staff member rates the number of interactions during the period of time when the animal is engaging in other behaviors, the rating may not reflect the items actual effect on behavior.

Given the difficulty in gathering behavioral data another strategy has been to rely on a single physiological measure to gauge an animal's welfare. Many studies have emphasized the importance of measuring endorphins, plasma cortisol, or heart rate (Hewston, 2003; Mason, 2001). These physiological measures vary from species to species and between individuals and need to be validated before they can be used to draw conclusions about the animal's well-being (Barber, 2009). By only looking at an animal's physiological state no information can be gained regarding what particular aspects of an animal's environment are causing a physiological change. For example, the general time frame for elephants between the onset of a stimulus and a spike in cortisol levels is approximately 30 hours (Mason, 2009). While this window of time narrows down what the spike in cortisol may be in reaction to, but the particular

elements in that environment that created this spike cannot be known. As Dawkins (2003) has pointed out many of these physiological responses occur during activity and arousal, and therefore cannot be a sole indicator of poor welfare.

It seems that captive animal institutions would greatly benefit from a system that would allow for data to be collected on the animal's social and physical interactions, area usage, mental and physical health in a timely manner with minimal intrusion to a staff member's day. It is equally as important that the observations system yields data that is useful and sensitive. That is, data reflects the animal's behavioral patterns and its sensitive to environmental changes. Such system would help institutions to take an active role in providing and determining environments that will allow for optimal welfare for their captive animals.

The purpose of the following experiment was to test the usefulness the captive animal activity tracking system, or CAATS. CAATS is an observation system that covers the generally agreed upon aspects of animal welfare advised by BIAZA (2008). CAATS utilizes a time-sampling method in which small amounts of data are collected on the animal's area usage, environmental and social interactions, mental well-being and physical health over time to allow for an overall picture of the animal's welfare to develop as well as monitor how changes in the animal's environment affect its welfare. Collecting small amounts of data over time allows for minimal time to be spent collecting and analyzing data. This time-sampling method has shown to be successful previously in similar circumstances. In 1987 Gordon Paul needed to assess the functionality and nature of all the residents in a major mental health hospital in order to determine treatment packages specifically designed for each individual's needs. Previous to this

assessment, blanket treatment packages were implemented across patients. Similar to captive animal institutions, Gordon's staff needed a tool that could be easily and efficiently implemented into busy schedules that also yielded useable, informative results that could then be used to benefit that individual. Interestingly, the categories used by Gordon Paul were similar to those suggested by BIAZA (2008). This may be due to the fact that the welfare of humans in mental hospitals is similar to captive animal welfare. In that sense, this study can be seen as an extension of Paul's work in a captive animal setting. The systems usefulness was tested at the Fort Worth Zoo in Fort Worth, Texas. Data collection focused on the behavior of the American black bears behavior over many conditions in order to test the systems sensitivity to the various changes made to the bear's environment over time.

METHOD

Subjects

The participants were two American black bears (*Ursus americanus)*, one male and one female. The 8-year-old male was put into captivity after being caught multiple times in campsites and garbage cans. The 7-year-old female was born and raised in captivity. Because of the breeding season during this experiment, the bears were never on exhibit at the same time. The male and female alternated days on and off exhibit for a portion of the experiment, but then moved to a schedule when the female was continually on exhibit everyday.

Setting

The study was conducted at the Fort Worth Zoo, in Fort Worth, Texas. Data were collected while the bears were out in the public viewing exhibit. The exhibit was approximately 20 ft X 30 ft, surrounded by chain link fencing and glass partitions approximately 12-ft. tall. The enclosure included a wooden porch with shade, a log pile, a stream that gradually increased in depth to approximately 4 ft., trees, bushes, dirt and grass (see Appendix A). Experimenters collected data from the public viewing glass area where the entire exhibit could be seen.

Measurement

The ethogram used in the captive animal activity tracking system (CAATS) consists of seven measurement categories: visitor level, animal location, awake/asleep status, animal body position, interaction, attention and concurrent activities. These categories were similar to those used in Paul's' (1987) system and match the critical

welfare elements issued by the British and Irish Association of Zoos and Aquariums (BIAZA).

Visitor Level (Record 1)

This category identifies the number of visitors at the viewing glass in the front of the bears exhibit at the time of observation. To estimate the visitor level, the observer recorded a (+) if there were more than 4 individuals in front the of exhibit, and a (-) if there were less than four individuals. A (K) was additionally noted if there were children included in the individuals in front of the enclosure. For example, if there were a group of 6 individuals including both children and adults in front the exhibit, the observer would note (+K) in the visitor level box of the data sheet for that interval. If there were an elderly couple in front of the glass, the experimenter would record (-).

Location (Record 2)

This category identifies the geographical location of the animal of interest at the time of observation. If animal moved from one location to another during the observation the animal's starting location was recorded. For purposes of this study the enclosure was divided up into 6 different areas (see Appendix B). These areas were easily distinguishable because of permanent landmarks within the enclosure (e.g. large logs, trees, exhibit furniture, water, etc). Area 1 was the porch area, which included the doors to the off-exhibit area. Area 2 was in front of Area 1 (from the experimenters' perspective), and included a large log pile. Area 3 was the area in front of the large log pile in Area 2 and extended up to the viewing glass. Area 4 was in front of the stream in the enclosure and up to the alternate visitor viewing glass. Area 5 was behind the stream and to the right of the large log pile in Area 2. Area 6 was recorded when the

animal's four paws were in the water. Each area was similar in size and represented all dimensions of the enclosure. Since the bears were not given any climbing structures (with the exception of a few logs) there was no need to create areas at varying aerial locations.

Body Position (Record 3)

This category identifies the animal's physical orientation in the environment. The recording options were: sitting, lying down, rearing, climbing, standing, and out of sight. The codes for this category were mutually exclusive and exhaustive, so only one position could be coded during each observation. If a change in position occurred during observation, the first position was recorded.

Sitting was defined as the position in which the animal's buttock and hind legs were on the ground while maintaining an upright position. Some typical examples of sitting were when the animal's buttock was on the ground while resting its back on a log or fence post. Some rare examples of sitting included scooting their buttock across ground, or leaning on an object with its back more than 90 degrees from its hindquarters, but still at an angle less than 180 degrees.

Lying down was defined as the position in which the animal had at least part of its back on the ground and its torso mainly horizontal. Some typical examples of lying down included the animal lying on a log, or on the ground inside the enclosure. Some atypical examples of lying were when the animal would lie perpendicular to a log or other enclosure item where torso is not fully supported by the object its resting on.

Rearing was defined as the position in which the animal was standing upright with its hind legs fully extended. Typical examples may include standing up with paws against the fence or an object within the enclosure or free standing.

Climbing was defined as when the animal was in an upright position with at least three paws on an object other than the ground. The animal can either be stationary or moving. Typical examples of climbing included when the animal was standing with three paws on the logs and making forward movement.

Standing was defined as the position in which the animal had at least three paws on ground while maintaining an upright position. Typical examples of standing included the animal having three paws on the ground while the other is up during forward movement (locomotion), or all four paws on the ground while the animal was stationary.

Out of sight defined when the animal of interest could not be seen, therefore its position could not be observed. If out of sight is coded for the animal's position no other observations could be made until, possibly, the next observation period.

Awake/asleep Status (Record 4)

This category identified whether the animal of interest was sleeping or awake during the observation period. This was determined by both the body position and presence or absence of other concurrent activities or attention (see Concurrent Activities and Attention).

The animal was scored as asleep if two criteria were met: first, if the body position was either lying or sitting and second, if the animal was not engaging in any behavior listed under the concurrent activities or attention sections (e.g., when the animal was lying on the ground, with no movement, with its eyes closed).

The animal was considered awake when it was attending to anything outside its enclosure (see attention) or if it was emitting any of the concurrent activities. Awake status could occur in conjunction with any body position, including lying or sitting as long as the animal was also behaving as described in the attention or concurrent activities sections.

Interaction (Record 5)

This category identified any contact that resulted in the movement or displacement of all or part of an object within the animal's external environment. The appropriate interaction was scored if the animal had direct contact with any of the following options: door, logs, foliage inside the enclosure, foliage outside the enclosure, cub, or enrichment. This list is not mutually exclusive and it is possible that the animal could interact with multiple elements in its environment at once. If this was the case, all were noted. If the animal was not interacting with any element in its environment at the period of observation, NONE is recorded.

Door was recorded when any interaction with the door (that is between the public exhibit area and the indoor dens,) where the bears were put to sleep after hours. A typical example of interaction with the door was when the animal scratched with a paw or put its nose against the corners of the door.

Log was recorded when the animal manipulated the logs located within the exhibit area. The exhibit had many large logs and log piles. A typical example of interaction with log is when the animal scratched on or climbed on the logs. An atypical example of log interaction would be when the animals were digging beneath or between the logs, while directly contacting the log.

Foliage on the inside of enclosure was recorded when the animal manipulated the plants within the exhibit fences. An example of interaction with foliage on the inside included the bears eating the grass or pulling leaves off of a tree with their paws or mouths within the enclosure.

Foliage outside of the enclosure was recorded when any direct contact between the animal of interest and any plant life rooted outside of the exhibit area. An example of interaction with foliage on the outside of the enclosure included when the animal reached its paw or tongue through the mesh fence to pull leaves off of a bush along the outside of the fence line.

Conspecific was defined when any physical contact between the animal of interest and another animal within the enclosure caused displacement of any body part of either animal. An example of conspecific interaction was when the animals were pushing one another to the ground. A non-example of conspecific interaction was when the animals were sleeping against, or in contact with, one another without any body displacement. If the observer could identify the other animal in the interaction the name (or other identifier) were included with the code. If there were more than one other animal involved in the interaction, all names were included if possible.

Enrichment interaction defined any direct contact made by the animal with a removable item that had been placed within the enclosure for enrichment purposes. If there were multiple items considered enrichment within the enclosure it was important that particular enrichment item be identified. If dual items were being manipulated at once, all were listed. A typical example of enrichment manipulation was the animal pushing a boomer ball around the enclosure or licking a frozen ice block.

Attention (Record 6)

This category identified any open-eyed, head orientation of the animal to elements outside of its exhibit for a period of 2 s or longer. If the animal was not attending to any elements outside of its enclosure, NONE was recorded. The following could have been scored under attention: keeper, visitors or other.

Keeper was recorded when the animal directly oriented its head in the direction of a keeper for 2 s or longer. It was not necessary for the keeper to make any effort to gain the animal's attention or to respond to it.

Visitor was recorded when that the animal oriented its head directly in the direction of the public for two seconds or longer. It is not necessary for the visitors to make any effort to gain the animals attention or if they responded to the animal's attention.

Other was recorded when the animal oriented its head to the outside of the enclosure and maintained this posture for 2 or more seconds and this did not meet any other attention definitions. If the observer knew the stimulus to which the animal was orienting to the source was noted. An example of other attention was a loud construction truck moving behind the enclosure and the animal orienting its head toward the truck and maintained this posture for 2 or more seconds.

Concurrent Activities (Record 7)

This category identified particular behaviors that could occur in conjunction with the animal's body position, attention, and interactions with its environment. These behaviors included: locomotion, licking air, sniffing, biting, vocalization, marking, eating/drinking, urinating/defecating, grooming, pacing, manipulating an object, pause,

digging, other or none. These behaviors were not mutually exclusive so it was possible for multiple options to be scored. If the animal of interest was not engaged in any of these activities (as when asleep), the category was left blank.

Locomotion was recorded when the animal was engaging in directional, non-repetitive movement of its entire body in rearing, climbing or standing positions.

Lick air was recorded when the animal had its tongue sticking out of its mouth without contacting any object.

Sniffing was recorded when the animal had its nose directed toward the ground and was not eating. Sniffing was also coded when the animal's nose rose above the horizontal plane.

Biting was recorded when the animal was moving its jaw up and down, while contacting an object, without any ingestion. An example of biting was when the animal's mouth contacted a conspecific while its jaw was moving.

Vocalization was recorded when the animal emitted an audible noise during the observation period.

Marking was recorded when the animal rubbed its neck or head on an object located within the enclosure two or more times, with each rub occurring within a period of 2 s of each other.

Eating/drinking was recorded when the animal made contact with its mouth on an edible object or water that was followed by ingestion of the object.

Urinating/defecating was recorded when the animal voided.

Grooming was recorded when the animal contacted its own body with its mouth or paws.

Pacing was recorded when the animal moved in a repetitive pattern on land or in water that occurred two or more times with no more than a 2-s pause between repetitions. It was important that the observer watch the animal of interest until the observer was able to accurately identify whether or not the animal was moving directionally (see locomotion), or if the animal was completing a repetitive pattern (pacing).

Manipulating object(s) was recorded when the animal made any body contact with a non-edible object. This was always accompanied with the appropriate code of what the animal was interacting with in the interaction category (See Interaction).

Pause was recorded when the animal maintained the same body position without movement for at least 2-s, and then returned to activity. If activity did not continue within 2-s, NONE was recorded.

Digging was recorded when the animal made contact with its paw two or more times with the ground or log.

Other was recorded when the animal emitted any behavior that did not fit any of the definitions above.

None was recorded when the animal did not emit any visible concurrent behavior. A typical example of this was when the animal was sleeping.

Observer Training and Reliability

Observer training included a familiarity with the categories, behavioral definitions and codes used in the CAATS system listed above before going to the bear's exhibit and practicing the data collection procedure. Reliability was calculated by dividing the number of agreements (full agreement on all the categories of observation) by the

number of agreements plus disagreements. This was done for approximately 20% of the data collected,. Ninety percent agreement was considered satisfactory.

CAATS Recording Procedures

At the beginning of a data collection session, information such as the data collector's name, animal being monitored (species, sex and name), weather conditions, date, time and any enrichment were noted on the data collection sheet (see Appendix A). Any other events that could affect the behavior of the animal (recent medical procedures, environmental changes, changes in schedule etc.) were also noted.

The recording method used was an instantaneous time sampling. Every 15-s a visual "snap shot" of the animal in its enclosure was taken by the observer and the appropriate codes were scored in each column. This continued for a total of 15-min. Four 15-min data collection sessions were completed each observation day. One during each of the first 4 hours the animals were on exhibit (10:00 a.m., 11:00 a.m., 12:00 p.m., and 1:00 p.m.). Each data collection period occurred at a predetermined random time, never closer than 40 min from the previous session and never further apart than 90 min. The following is an example of when the different 15-min data collection periods began on a given day: 10:30 a.m., 11:15 a.m., 12:45 p.m., and 1:20 p.m. The randomized data collection times were conducted to mimic a busy zoo staff member's day, when set data collection times may not have been possible.

Data Analysis

For data analysis purposes the recorded behaviors were grouped into "active," "interactions," "stereotypic" and "area usage". By dividing the behaviors into these categories, the observers were able to measure the appropriate, species-specific

behaviors desired by the institution (active behaviors); the inappropriate behaviors (stereotypic); as well as how often the animals were interacting with elements within their environment. Active behaviors included all concurrent activities (except “none” or “pacing”); interactions, and attention behaviors recorded. Levels and types of interactions were measured by counting the number of intervals during which an interaction was observed, as well as noting the particular item that was being manipulated. Stereotypic behaviors were measured by counting the instances when the concurrent activity recorded was “pacing”.

Procedure

Experiment 1: Enrichment Present and Enrichment Absent Conditions

During the enrichment present condition the bears received their normal enrichment and feeding schedules. Data were gathered during the summer months of June, July and August of 2007. Data were collected during all days of the week regardless of weather conditions. The enrichment schedule was predetermined and included various items such as, grapevine wreaths, boomer balls, scents, hidden food, PVC tubing, etc. The enrichment items were placed on exhibit before the bears and were delivered once daily. The bears received an additional snack late in the afternoon that was fed through the enclosure by a keeper. This was done at approximately 3 p.m. The data collection was terminated during the 2 o’clock hour to avoid conflict with this feeding. The bears received the rest of their food in the dens when they were brought in for the night.

Later that fall the female bear gave birth to two cubs that were put on exhibit in April, 2007. Data was collected on the female bear when on exhibit with her cubs to

monitor any behavior changes she exhibited during this time. Once her behavior returned to baseline levels the next phase began.

To evaluate the enrichment program of the bears, it was necessary to analyze any effects the absence of enrichment might have had on the bear's behavior. During the enrichment absent portion of Experiment 1, the only change made to the bears schedule was that all forms of enrichment were withheld. The bears maintained their normal feeding schedule and time spent on and off exhibit. Experiment 1 took place during the month of August and due to the concern of possible adverse effects of the no-enrichment schedule, only 3 non-enrichment days were implemented for each bear.

Experiment 2: Automatic Feeder

The second experiment was a multiple baseline and alternating treatment design to test the effects of an automatic feeder on the bear's behavior. The bear's normal enrichment schedule was reinstated as in the previous condition, and an automatic feeder was installed. The feeder was placed above area 5 outside of the enclosure and, when deployed, scattered approximately five cups of dog kibble over the enclosure. The kibble landed mostly in area 5, landing on the log pile, as well as the water source within the enclosure. Because of the small size of the kibble it was impossible to differentiate foraging on the grass and foraging for the kibble. For this reason the observer recorded an "interaction" with "inside foliage" when the bears were foraging following the feeder deployment.

In August the male and female bears alternated days spent on exhibit, and the feeder was deployed every day at 11:30 a.m. Because of the desire to have the cubs on exhibit more frequently, changes were made to the rotation schedule between the male

and female bears time on exhibit. For the rest of the experiment the female bear and cubs were put on exhibit each day, and the feeder was then deployed only every other day. In September the feeder was deployed at 12:00 p.m., in October the feeder was deployed at 12:30 p.m., and was then switched back to the original 11:30 a.m. deployment time in November. When the feeder was presented every other day, data were collected during both “feeder present” and “feeder absent” days to note any durational effects the presence of the feeder may have had. Because of the schedule shift, the male bear could be observed only during two of the four feeder deployment times, the 11:30 a.m. and 12:00 p.m. Feeder absent data was only able to be collected for the female bear during the 12:00 p.m., 12:30 p.m., and the return to11:30 a.m. deployment times.

RESULTS

Experiment 1: Enrichment Present and Enrichment Absent Conditions

Figure 1 shows the number of active intervals recorded for the male and female bear's when enrichment was present and when enrichment was absent over the observations periods of 10:00 a.m., 11:00 a.m., 12:00 p.m. and 1:00 p.m. Figure 1.1 illustrates the male bears activity level when enrichment was present for 3 days in June and for 4 days in July, 2007. During the 10:00 a.m. period the male showed the highest levels of activity (between 50 and 60 intervals) with the exception of June 23, when zero intervals of activity were recorded. During the 11:00 a.m. period the male bears activity was more variable but lower than the 10:00 a.m. time period with the exception of July 22, during which activity increased to 60 intervals. Activity levels decreased even further during the 12:00 p.m. where all days had 10 or fewer intervals of activity with the exception of July 20 and July 24, which had activity levels similar to 11:00 a.m. (between 40 and 50 intervals of interaction). The male bears active behaviors continued to decrease through the 1:00 p.m. period where no activity was recorded for all days of the enrichment phase except on June 23, which had 4 intervals of activity recorded.

Figure 1.2 shows the number of intervals recorded as active for the male bear during 2 days in August and 1 day in September when enrichment was absent. This graph shows a similar decreasing trend as was seen when enrichment was available. The activity level was highest during the 10:00 a.m. period with activity levels between 54 and 60 intervals of activity for all day except September 17 during which zero intervals of activity were recorded. During the 11:00 a.m. period activity levels were lower than the 10:00 a.m. period. Activity levels ranged between 47 and 50 intervals for

all days observed. Activity decreased further during the 12:00 p.m. period to near zero levels for all days except September 17 when 34 intervals of activity were recorded. During the 1:00 p.m. period, activity decreased to zero intervals of activity for August 21 and August 23, and decreased to 16 intervals of activity on September 17.

Figure 1.3 shows the number of active intervals recorded for the female bear during 4 days in June and 5 days in July when enrichment was present. This graph shows a similar decreasing trend as seen in the male bear's previous activity graphs. During the 10:00 a.m. period the majority of days included between 50 and 60 intervals of activity. June 22, July 10, and July 21 were the exceptions, having 44, 27 and zero intervals of activity, respectively. During the 11:00 a.m. period activity levels decreased, between 48 and 56 intervals for 5 days, and between 15 and 33 for the other 4 days. Again activity decreased during the 12:00 p.m. period to zero levels of activity for all days except June 28 and July 25, (which had 41 and 15 intervals of activity respectively). During the 11:00 a.m. period all days decreased to zero intervals of activity except June 22, which showed 38 intervals of activity.

Figure 1.4 shows the number of intervals recorded as active during 3 days in August when no enrichment was offered to the female bear. All 3 days fit the same general decreasing trend with the exception of August 22. During the 10:00 a.m. period activity was between 47 and 55 intervals of activity for August 20 and August 24, but only 24 intervals of activity on August 22. During the 11:00 a.m. period behavior was variable between days, ranging from 23 and 51 intervals of activity. The 12:00 p.m. and 1:00 p.m. periods showed overall decreases in activity with zero intervals of activity recorded.

Figure 2 shows the number of intervals recorded as interaction for the male when enrichment was present. The top row of pie charts corresponds to the 10:00 a.m. time period, followed by the 11:00 a.m., 12:00 p.m. and 1:00 p.m. time periods. Each pie chart represents the total 60 intervals available for recording. Above each pie chart is the total number of intervals an interaction was recorded during that day and period. Each vertical row of pie charts corresponds to a given day of data collection. During the 10:00 a.m. time period interactions took place on all days of data collection with interactions ranging from 6 to 18 intervals. The only exception was June 23 on which no interactions were recorded. During the 11:00 a.m. time period interactions decreased, with only 4 days in which interactions occurred (ranging between zero and 20 intervals). The 12:00 p.m. period had even fewer interactions with three days having 5 or fewer interactions (June 23, July 20, and July 22) and one day, July 24, having 15 intervals of interaction. By the 1:00 p.m. period all days had zero intervals of interactions. Overall, the male interacted most consistently with the logs and foliage. The male bear interacted with enrichment on only two occasions, July 20 during the 10:00 a.m. and 12:00 p.m. periods for a total of 8 intervals.

Figure 3 shows the number of intervals recorded as an interaction for the male bear when enrichment was absent. Interactions look similar to the interactions recorded for the male bear when enrichment was present. During the 10:00 a.m. period interactions took place on only one day, August 23, with 23 intervals of interaction. During the 11:00 a.m. period all 3 days included interactions with 16, 18, and 16 intervals of activity respectively. During the 12:00 p.m. time period, September 21 was the only day during which interactions were recorded, with 17 intervals of interaction.

During the 1:00 p.m. period the male interacted for a total of 10 intervals on September 21. Overall the male bear interacted with the foliage, logs and the door most frequently.

Figure 4 shows the number of intervals recorded as an interaction for the female bear when enrichment was present. During the 10:00 a.m. period interactions occurred on each day with the exception of July 21, where no interactions were recorded. Intervals of interactions ranged from 2 to 35. During the 11:00 a.m. period interactions occurred each day of data collection and ranged from 2 intervals on June 22, to 20 intervals on July 10. Interactions decreased during the 12:00 p.m. period, when June 24 was the only day in which interactions took place. Interactions increased slightly during the 1:00 p.m. period with interactions ranging from 4 intervals of interaction on June 22 and 31 intervals of interaction on June 28. Overall, the female bear interacted most frequently with the logs, door and the inside foliage. Enrichment was available on each day of data collection, but the female bear interacted only with the enrichment items during 7 periods on different days.

Figure 5 shows the number of intervals recorded as an interaction for the female bear when enrichment was absent. The interactions seen in this graph are similar to the female bear's interactions when enrichment was present. During the 10:00 a.m. period only 2 days included interactions: August 20 with 23 intervals of interaction, and August 22 with 8 intervals of interaction. Interactions were recorded each day during the 11:00 a.m. period ranging from 12 to 24 intervals. During the 12:00 p.m. time period no interactions were recorded for any days. During the 1:00 p.m. period the only interactions recorded were on August 20 where the female interacted with the inside

foliage for 49 of the total 60 intervals. Overall, the female bear interacted with the inside foliage and the logs most frequently.

Figure 6 shows the male bears area usage when enrichment was present. Each pie chart shows the number of intervals the bear spent in a given area of the enclosure. There is a pie chart for each period of each day of data collection. During the 10:00 a.m. period the male bear utilized 5 of the 6 areas on 3 days and 4 of the 6 areas on 2 days. June 23 was the only day during which the male bear utilized only area 5 over all 60 intervals. During the 11:00 a.m. period the number of areas utilized by the male bear decreased from the 10:00 a.m. time period. The male bear utilized three areas on June 23 and June 29, and only 2 areas on July 20, 22 and 24. On June 27 and July 11 the male bear remained in area one for all 60 intervals. During the 12:00 p.m. period the male bear remained in a single area for all 60 intervals on 4 of the 7 days. The male bear utilized 5 of the 6 areas on July 20 and 24, and utilized two areas on July 22. During the 1:00 p.m. period the male bear remained in area one for all 60 intervals on all days.

Figure 7 shows the area usage for the male bear when enrichment was absent. The male bears area usage when enrichment was absent looks similar to the previous graph when enrichment was present. During the 10:00 a.m. period the male bear remained in one area for all 60 intervals on August 21 and September 17. On August 23 the male bear spent 25 intervals in area 2, 14 intervals in area 4, and 20 intervals in the water. During the 11:00 a.m. time period the number of areas visited increased. On August 21 areas 2, 4, 5 and the water were all visited. On August 23 each area of the enclosure was visited for fairly even amounts of time, ranging from 12 intervals spent in

areas 1 and the water to 6 intervals spent in areas 2 and 5. On September 17 only areas 1 and 2 were visited with 49 and 11 intervals spent in the respective areas. Area usage was identical for the 12:00 p.m. and 1:00 p.m. time periods with the male bear remaining in area 1 for the entire period on August 21 and 23, and remaining in area 3 for the entire period on September 17.

Figure 8 shows the female bears area usage when enrichment was present. During the 10:00 a.m. period the female utilized all 6 areas on June 24. The female utilized 2 or fewer areas on only two occasions, July 10 when she visited areas 1 and 2, and on July 21 when she remained in area one for all 60 intervals. During the 11:00 a.m. period the female utilized all 6 areas on June 24. On all other days she utilized 3 or 2 different areas, with the exception of June 28 when she remained in area 1 for the full 60 intervals. During the 12:00 p.m. period the female remained in area 1 for the full 60 intervals everyday, with the exception of June 24 where she utilized 4 of the 6 areas. During the 1:00 p.m. period, June 22 was the only day in which multiple areas were utilized. The rest of the days were spent in either area 1 or area 5 for all intervals.

Figure 9 shows the area usage for the female bear when enrichment was absent. Area usage when the enrichment was absent is similar to area usage when the enrichment was present for the female bear. During the 10:00 a.m. period the female utilized multiple areas on all days of data collection. On August 20 the female spent the majority of her time in area 5 with 30 intervals recorded, but also visited areas 1, 2 and 4. On August 22 and August 24 the female spent the majority of time in the water with 48 and 30 intervals recorded, respectively. During the 11:00 a.m. time period the female utilized the majority of areas during August 20 and 22 of data collection. On August 20

the female visited areas one, 2 3 and 4, spending the majority of time in area 1 (42 intervals). On August 22 the female utilized areas 1, 2, 4 and 5, spending 31 intervals in area 5. On August 24 she remained in area 1 for all 60 intervals. During both the 12:00 p.m. and 1:00 p.m. periods the female remained in area 1 for all 60 intervals.

Experiment 2: Automatic Feeder

Figures 10 shows the level of activity for the female bear throughout the four periods of data collection during different deployment times of an automatic feeder. Figure 10.1 shows the activity levels for the female bear during 2 day in July and 3 days in August when the automatic feeder was deployed at 11:30 a.m. During the 10:00 a.m. period the female bear's activity was variable, ranging between 4 intervals of activity on August 11 to 52 intervals of activity on August 1. During the 11:00 a.m. time period activity peaked with all days having between 55 and 60 intervals of activity, with the exception of August 8 which had 31 intervals of activity. Activity decreased during the 12:00 p.m. time period, ranging from 43 intervals of activity on July 28 and zero intervals of activity on August 11. Activity continued to decrease during the 1:00 p.m. period with all days having zero intervals of activity with the exception of July 28 during which 5 intervals of activity were recorded.

Figure 10.2 shows the female bear's activity recorded during 5 days in September when the automatic feeder was deployed at 12:00 p.m. During the 10:00 a.m. time period activity levels were variable, ranging from 50 to 16 intervals of activity. During the 11:00 a.m. time period activity ranged from 19 to 42 intervals of activity. During the 12:00 p.m. period activity levels increased for all days (with the exception of September 1, which decreased from 21 intervals of activity during the 11:00 a.m. period

to 2 intervals of activity during the 12:00 p.m. period). Activity during the 12:00 p.m. time ranged from 2 to 56 intervals of activity. During the 1:00 p.m. time period activity decreased further for all days except September 1 and September 22, which increased from the previous interval to 21 and 46 intervals of activity, respectively. Overall, this was the first time the decreasing trend of activity throughout the day was not observed in the female bear activity.

Figure 10.3 shows the number of intervals recorded as active for the female bear during 5 days in October when the automatic feeder was deployed at 12:30 p.m. During the 10:00 a.m. time period activity levels were variable, ranging from 12 intervals to 53 intervals of activity. During the 11:00 a.m. period all days ranged from 3 to 12 intervals of activity, with the exception of October 8, which increased slightly from 30 intervals of activity during the 10:00 a.m. period to 36 intervals of activity during the 11:00 a.m. period. During the 12:00 p.m. period all days increased in activity, ranging from 19 to 60 intervals of activity. During the 1:00 p.m. period the female bears activity decreased in on all days with the exception of October 13, during which activity increased from 27 intervals during the 12:00 p.m. period to 55 intervals of activity in the 1:00 p.m. period.

Figure 10.4 represents the number of intervals during which activity was recorded for the female bear during 5 days in November when the automatic feeder's deployment time was returned to 11:30 a.m. This graph shows a similar pattern to the previous 11:30 a.m. feeder deployment time but with higher levels of activity during the 12:00 p.m. and 1:00 p.m. time periods. During the 10:00 a.m. period the majority of the days recorded ranged from 44 to 59 intervals of activity. The exceptions to this were November 17 and 19, which had 7 and 3 intervals of activity respectively. During the

11:00 a.m. period all days ranged between 46 and 54 intervals of activity with the exception of November 10, which had 25 intervals of activity. During the 12:00 p.m. and 1:00 p.m. time period's activity levels ranged between 22 and 3 intervals. This graph is similar in the overall decreasing trend throughout the day, as was seen in the previous and 11:30 a.m. feeder, but differs in that activity levels never reached the zero level for any day during the 12:00 p.m. and 1:00 p.m. time periods.

Figure 11 illustrates the number of intervals recorded as an interaction when the automatic feeder was deployed at 11:30 a.m. During the 10:00 a.m. period the female's interactions decreased over the 4 days of data collection ranging from 2 to 30 intervals of interaction. During the 11:00 a.m. period interactions decreased from the 10:00 a.m. period, ranging from 30 intervals to zero intervals of interaction. During 12:00 p.m. interactions again decreased to 36 intervals on July 28, 6 intervals of interactions on August 1, and zero intervals of activity on August 18 and September 11. During the 1:00 p.m. period interactions were only recorded on July 28 where the female interacted with the cub for 5 intervals. The female interacted with the inside foliage, logs and cubs most frequently.

Figure 12 depicts interactions recorded during September when the automatic feeder was deployed at 12:00 p.m. Interactions during the 12:00 p.m. deployment time increased throughout the day compared to the interactions during the 11:30 a.m. feeder deployment time. During the 10:00 a.m. period interactions occurred on each day and ranged between 3 and 30 intervals. During the 11:00 a.m. period interactions occurred on all days and ranged from 9 to 36 intervals. During the 12:00a.m. period interactions ranged between 2 and 51 intervals of interaction. During the 1:00 p.m. period

interactions ranged from zero intervals of interaction on September 8 and 24, to 31 intervals of interaction on September 22. Overall, the female interacted most frequently with the inside foliage not only throughout the month, but also throughout the day.

Figure 13 shows the interactions recorded during October when the automatic feeder was deployed at 12:30 p.m. Overall this graph looks similar to the interactions that took place during the 12:00 p.m. feeder deployment time. During the 10:00 a.m. period interactions ranged between 1 interaction on October 29 and 37 intervals on October 13. Interactions decreased from the 10:00 a.m. period to the 11:00 a.m. period with interactions ranging from 2 to 20 intervals. During the 12:00 p.m. period interactions ranged between 7 and 48 interactions. During the 1:00 p.m. period interactions decreased from the 12:00 p.m. period and range from 1 to 27 interactions. Overall, the female bear interacted most frequently with the inside foliage.

Figure 14 shows the interactions for the female bear during 5 days in November when the automatic feeder deployment time was returned to 11:30 a.m. This 11:30 a.m. deployment time showed an increase in overall interactions compared to the previous 11:30 a.m. deployment time (seen in Figure 11). During the 10:00 a.m. period interactions ranged from 1 to 31 intervals. Interactions during the 11:00 a.m. period increased from the 10:00 a.m. period, ranging from 23 to 34 intervals. During the 12:00 p.m. period interactions decreased from the 11:00a.m. period, ranging from zero to 12 intervals of activity. Interactions decreased further during the 1:00 p.m. period with interactions ranging from zero to 7 intervals of interaction. Overall, the female bear interacted with the inside foliage the most frequently.

Figure 15 shows the area usage for the female bear during the 11:30 a.m. feeder delivery. During the 10:00 a.m. time period the female utilized three areas each day with the exception of August 1 when she utilized 2 areas: area 1 for 39 intervals and area 2 for 21 intervals. During the 11:00 a.m. period area usage decreased from the 10:00 a.m. period. On August 8 the female spent the majority of time in area 5 with 50 intervals recorded and also visited areas 1 and 2 with 5 intervals recorded in each area. On August 11 the female spent the majority of her time in area 5 with 55 intervals recorded, but also utilized area 2 for 5 intervals. On July 28 and August 1 the female remained in area 2 and 5, respectively for the entire 60 intervals. During the 12:00 p.m. period the female remained in area 5 for all 60 intervals on July 28 and August 11. On August 1 the female bear utilized area 5 for 36 intervals and area 2 for 24 intervals, and on August 8 she spent time in area 1 for 32 intervals and area 2 for 28 intervals. During the 1:00 p.m. time period the female remained in area 1 for all 60 intervals for all days of data collection. Overall, areas 1, 2 and 5 were utilized most frequently.

Figure 16 shows the area usage for the female bear when the feeder was deployed at 12:00 p.m. During the 10:00 a.m. time period, the female utilized multiple areas on September 1, 8, and 29. On September 22 and 24 the female remained in area 5 for all 60 intervals. During the 11:00 a.m. the female utilized areas 1, 2 and 5 on September 1, 22 and 24, while on September 8 and 29 the female remained in area 5 for all 60 intervals. During the 12:00 p.m. time period the female remained in area 5 for the majority of intervals on September 1, 24, and 29. On September 8 the female spent 40 intervals in area 1, 2 intervals in area 2 and 18 intervals in area 5. On September 22 the female visited areas 1, 2, 3, 5 and the water. During the 1:00 p.m. period the female

remained in area 5 for the majority of intervals on September 1, 8 and 24. On September 22 the female spent 41 intervals in area 3, 2 intervals in area 2 and 17 intervals in area 1. On September 29 the female again spent the majority of intervals in area 3 with 34 intervals, but also visited area 1 for 20 intervals, area 5 for 4 intervals and area 2 for 2 intervals. Overall, the female spent the majority of intervals in area 5.

Figure 17 shows the area usage for the female bear when the feeder was deployed at 12:30 p.m. The female's area usage was more variable during the 12:30 p.m. feeder deployment than the previous feeder times or when enrichment was present or absent. During the 10:00 a.m. time period the female utilized multiple areas of the enclosure on each day of data collection. On October 8 and 13 the female spent the majority of intervals in area 5, also utilizing areas 1 and 2. On October 18 and October 29 the female spent the majority of intervals in area 1. On October 6 the female utilized multiple areas, remaining in area 3 for 26 intervals, area 2 for 10 intervals, area 1 for 15 intervals and area 5 for 9 intervals. During the 11:00 a.m. time period the female remained in area 1 for majority of the intervals on October 6, 13 and 18. On October 8 and 29 the female spent the majority of the intervals in area 5. During the 12:00 p.m. time period, which is when the feeder was deployed, the female's area usage was more variable. The only day when she did not enter three different areas was October 29 where she remained in area 5 for the entire period. During the 1:00 p.m. time period the female again utilized multiple areas. The only day with less than 3 areas utilized was October 6 with 59 intervals spent in area one and one interval spent in area 2. Overall, the female bear utilized areas one, 2, 3 and 5 most consistently.

Figure 18 shows the female bear's area usage when the feeder was returned to the 11:30 a.m. deployment time. The female bear utilized more areas more consistently during this 11:30 a.m. deployment time than she had during the previous 11:30 a.m. deployment time (shown in Figure 15). During the 10:00 a.m. time period the female utilized multiple areas on November 5, 10 and 12 with the majority of intervals spent in area 3. On November 17 and 19 the female spent the majority of intervals in area one. During the 11:00 a.m. time period the female visited areas one, 3 and 5 on November 5. On November 10 and 12 she remained in area 5 for all 60 intervals. On November 17 and 19 the female bear utilized areas one, 2 and 5 with the majority of intervals spent in area 5. During the 12:00 p.m. time period the female utilized multiple areas on each day of data collection, with the exception of November 10 when she remained in area one for all 60 intervals. During the 1:00 p.m. time period the female spent the majority of the intervals in area 5 on November 5, 10, and 17. On November 12 the female bear utilized areas one, 2 and 3 with 15, 17 and 28 intervals spent in the respective areas. On November 19 the female spent the majority of the intervals in area one. Overall, the female bear utilized areas one, 3 and 5 for the majority of intervals.

Figure 19 illustrates the levels of stereotypic behavior during the different automatic feeder deployment times. Stereotypic behavior was divided into the area in which this type of behavior was taking place, which was always either area 1 or area 5. The X-axis indicates the four time periods for a given day, for each day of data collection. There are four hash marks within each day of data collection. The number of intervals recorded as stereotypic for the 10:00 a.m. time period can be seen behind the first hash mark, the number of intervals of stereotypic behavior during the 11:00 a.m.

time period behavior behind the second hash mark, etc. The Y-axis indicates the number of intervals in which stereotypic behavior occurred.

Figure 19.1 shows the intervals of stereotypic behavior during one day in July and three days in August when the feeder was deployed at 11:30 a.m. There were only two time periods in which stereotypic behavior occurred, the 10:00 a.m. time period on August 1 with 7 intervals of stereotypic behavior recorded in area 1, and on August 11 with 55 intervals of stereotypic behavior occurring in both areas 1 and 5.

Figure 19.2 shows the intervals of stereotypic behavior for the female bear during 5 days in September when the automatic feeder was deployed at 12:00 p.m. Overall, there was an increase in stereotypic behavior compared to the 11:30 a.m. feeder deployment time. Each day during the 12:00 p.m. feeder showed some level of stereotypic behavior with the exception of September 8, where no stereotypic behavior was recorded. September 1 began with high levels of stereotypic behavior in area 1 during the first and second periods, with 43 and 40 intervals respectively, and then decreased during the 12:00 p.m. and 1:00 p.m. time periods to 4 and 12 intervals respectively. No stereotypic behavior was recorded on September 8. On September 22 stereotypic behavior occurred during the 11:00 a.m., 12:00 p.m. and 1:00 p.m. time periods, ranging between 5 and 26 intervals, occurring mostly in area 1. Stereotypic behavior occurred on September 24 during the 10:00 a.m. and 11:00 a.m. time periods, 15 and 20 intervals respectively, occurring predominately in area 5. On September 29 stereotypic behavior occurred during the last three time periods, during the 11:00 a.m. and 12:00 p.m. time periods stereotypy occurred in area 5 while stereotypic behavior was only recorded in area 1 during the 1:00 p.m. time period.

Figure 19.3 shows the number of intervals recorded as stereotypic when the automatic feeder was deployed at 12:30 p.m. This condition produced the highest and most consistent stereotypic behavior witnessed throughout the entire experiment. Each day had more than one time period in which stereotypic behavior was recorded for the majority of the 60 intervals observed. On October 6 high levels of stereotypic behavior were recorded during all time periods, with the highest amounts occurring during the 11:00 a.m. and 1:00 p.m. time periods with 48 and 50 intervals recorded in area 5. On October 8 stereotypic behavior occurred for 28 of the 60 intervals during the 10:00 a.m. time period and for 33 intervals during the 1:00 p.m. time period. On October 13 and 18 stereotypic behavior was observed in area 1 during all periods, with the exception of the 10:00 a.m. time period on October 13 in which no stereotypic behavior was recorded. On October 29 stereotypic behavior was recorded during the majority of intervals during the 10:00 a.m., 11:00 a.m., and 1:00 p.m. time periods, with 46, 39 and 49 intervals of stereotypic behavior respectively, occurring in both areas 1 and 5.

Figure 19.4 shows the intervals of stereotypic behavior when the automatic feeder was returned to the 11:30 a.m. deployment time. Stereotypic behavior was much higher during this 11:30 a.m. deployment time than was seen in the previous 11:30 a.m. deployment time (Figure 19.1). While November 5 and November 12 show little to no stereotypic behavior, the other three days show stereotypic behavior as the majority of behavior for three of the four time periods. On November 10 stereotypic behavior occurred during the majority of the 11:00 a.m., 12:00 p.m. and 1:00 p.m. time periods. On November 17 and 19 the majority of the 10:00 a.m., 12:00 p.m. and 1:00 p.m. time periods were spent engaging in stereotypic behavior. The 11:00 a.m. time period only

had 3 and 4 intervals of stereotypic behavior on November 17 and 19, this was the time period in which the feeder was deployed.

Figure 20 shows the activity levels for the female bear during the alternate days of the feeder conditions when the feeder was not deployed. No data could be collected for the 11:30 a.m. deployment time because the male and female alternated days on exhibit. Figure 20.1 shows the activity levels for the female bear when the 12:00 p.m. feeder was absent. During the 10:00 a.m. period activity was variable, ranging from 42 to 15 intervals of activity. During the 11:00 a.m. time period activity levels for September 9 and 20 were 46 and 36 intervals respectively. September 23 was much lower during the 11:00 a.m. time period with 3 intervals of activity. During the 12:00 p.m. time period activity ranged from 22 to 2 intervals of activity. During the 1:00 p.m. time period activity for September 9 and 23 was 4 and 7 intervals respectively, while September 20 included 46 intervals of activity.

Figure 20.2 shows the activity levels for the female bear during the days in which the 12:30 p.m. feeder was absent. While her activity is variable during the 10:00 a.m. time period (ranging from 8 to 60 intervals of activity), 11:00 a.m. time period (ranging from zero to 42 intervals of activity), and 1:00 p.m. time period (ranging from zero to 43), her activity decreased during the 12:00 p.m. time period for 3 of the 5 days monitored, and was less variable. During the 12:00 p.m. time period the female's activity ranged from 2 to 26 intervals of activity. The 12:00 p.m. time period is when the feeder would have been deployed on the alternate days.

Figure 20.3 shows the activity levels for the female when the feeder was returned to an 11:30 a.m. deployment time and was absent. During the 10:00 a.m. time

period the female's activity ranged from 23 to 60 intervals of activity. During the 11:00 a.m. time period the females behavior ranged from 10 to 12 intervals of activity for all days with the exception of November 8, which had 29 intervals of activity. During the 12:00 p.m. time period the female's behavior decreased further from the 11:00 a.m. period for each day and activity ranged between 3 and 22 intervals of activity. During the 1:00 p.m. time period activity ranged between zero and 5 intervals of activity for all days with the exception of November 11which had 27 intervals of activity.

Figure 21 shows the female bears interactions during the days in which the 12:00 p.m. feeder was absent. During the 10:00 a.m. period the female interactions ranged between 7 intervals on September 9 and 12 intervals on September 23. During the 11:00 a.m. period the female's interactions ranged between 4 and 23 intervals. During the 12:00 p.m. period the female interactions ranged between 1 and 12 interactions. Interactions decreased from the 12:00 p.m. period to the 1:00 p.m. period with interactions ranging from zero intervals on September 9 to 9 intervals on September 20. Overall, interactions with the inside and outside foliage were most frequent.

Figure 22 shows the female bears interactions when the 12:30 p.m. feeder was absent. Interactions during the 10:00 a.m. time period ranged between 6 and 25 intervals. During the 11:00 a.m. period the females interactions decreased from the 10:00 a.m. period, ranging between zero and 11 intervals. Intervals of interaction remained sparse during the 12:00 p.m. period ranging from 2 to 15 intervals. During the 1:00 p.m. period interactions increased slightly from the 12:00 p.m. time period and ranged from zero to 26 intervals of activity. The inside foliage was, again, the most consistent interaction.

Figure 23 shows the female bears interactions when the return to 11:30 a.m. feeder was absent. During the 10:00 a.m. period all days recorded included interactions, ranging between 13 and 33 intervals of interaction. During the 11:00 a.m. period the females interactions decreased from the 10:00 a.m. period, ranging between zero and 17 intervals of interaction. Interactions continue to decrease during the 12:00 p.m. and 1:00 p.m. time periods with interactions ranging between 1 and 4 during the 12:00 p.m. time period and zero and 5 during the 1:00 p.m. time period. Overall, interactions with the inside foliage and the cub were most frequent.

Figure 24 shows the female bear's area usage when the 12:00 p.m. feeder was absent. During the 10:00 a.m. time period the female bear spent the majority of time in area 5 on September 9 and 23. On September 20 the female visited area 1 for 28 intervals, area 2 for 2 intervals, area 3 for 26 intervals and the water for 4 intervals. During the 11:00 a.m. period the female remained in area 3 for all 60 intervals on September 20 and 23. On September 9 the female spent the majority of intervals in area 1 with 45 intervals, but also visiting areas 2, 3 and 4. During the 12:00 p.m. time period the female remained in area 3 for all 60 intervals on September 20, and spent the majority of September 23 in area 1 with 58 intervals. On September 9 the female visited areas 1, 2 and 5 with 13, 18 and 29 intervals spent in the respective areas. During the 1:00 p.m. time period the female bear spent the majority of intervals on September 9 in area 2, and on September 20 she spent the majority of intervals in area 1, but also visited areas 2, 3 and 5. On September 23 the female spent 51 intervals in area 1 and 9 intervals in area 2.

Figure 25 shows the female bear's area usage when the 12:30 feeder was absent. Area usage decreased throughout the days compared to when the 12:30 p.m. feeder was present. During the 10:00 a.m. time period the female visited areas 1, 2, 3, 4 and 5 on October 11 and areas 1, 2 and 5 on October 14 and 21. On October 7 she remained in area 5 for all 60 intervals. During the 11:00 a.m. period the female utilized 3 or more different areas on all days with the exception of October 7 and October 21 where she remained in area 5 for all 60 intervals. During the 12:00 p.m. time period the female remained in area 5 for all 60 intervals on October 7, 11 and 14 and the majority of intervals in area 5 on October 25. On October 21 the female spent the majority of intervals in area 1, but also visited area 2 for 3 intervals and area 4 for 15 intervals. During the 1:00 p.m. time period the female remained in area 5 for the majority of all intervals with the exception of October 14 when the female spent 31 intervals in area 1, 14 intervals in area 3, 9 intervals in area 2, and 1 interval in area 4. Overall, areas 1 and 5 were utilized most frequently.

Figure 26 shows the female bear's area usage when the feeder was returned to 11:30 a.m. and was absent. Overall, there was a decrease in the areas utilized during the 12:00 p.m. and 1:00 p.m. time periods from the 11:30 a.m. feeder present condition to the 11:30 a.m. feeder absent condition. During the 10:00 a.m. period the female utilized 3 and 4 different areas respectively on November 8 and 11. On November 15 and 20 the female spent the majority of intervals in area 5, but also visited areas 1, 2 and 3. During the 11:00 a.m. period the female spent the majority of intervals in area 5 on November 11 and 20. On November 15 the female bear spent 58 intervals in area 1 and 2 intervals in area 2. On November 8 the female spent 25 intervals in area 3, 22

intervals in area 5 and 13 intervals in area 2. During the 12:00 p.m. time period the female bear spent all 60 intervals in area 5 on all days, with the exception of November 8 when the female bear spent 2 intervals in the water, 5 intervals in area 2, 11 intervals in area 3 and 42 intervals in area 5. During the 1:00 p.m. period the female remained in area 5 for all 60 intervals on November 8 and 20. On November 11 she spent 58 intervals in area 3 and 2 intervals in area 4. On November 15 the female spent 43 intervals in area 1, 5 intervals in area 2 and 12 intervals in area 5.

Figure 27 shows the female bear's stereotypic behavior during the different deployment times when the feeder was absent. Figure 27.1 shows the stereotypic activity during the 12:00 p.m. feeder absent days. On September 9 high levels of stereotypic behavior were recorded during the 10:00 a.m. and 12:00 p.m. time periods, with 56 and 53 intervals of stereotypic behavior respectively, which all occurred in area 5. No stereotypic behavior was recorded on September 20. On September 23, stereotypic behavior was recorded for 18 intervals during the 10:00 a.m. period, all in area 5. The 12:00 p.m. and 1:00 p.m. time periods had 22 and 45 intervals of stereotypic behavior recorded respectively, all in area 1.

Figure 27.2 shows the stereotypic behavior that occurred when the 12:30 p.m. feeder was absent. All days included some stereotypic behavior. On October 7 all periods had high levels of stereotypic behavior, ranging from 37 to 51 intervals, which occurred mostly in area 5. October 11 had minimal stereotypic behavior, only 9 intervals recorded during the 1:00 p.m. period in area 5. October 14 had stereotypic behavior during the 10:00 a.m., 11:00 a.m. and 1:00 p.m. periods, ranging from 10 to 20 intervals, with the majority of stereotypic behavior occurring in area 1. On October 21

stereotypic behavior was only seen during the 10:00 a.m. time period with 19 intervals occurring in both areas 1 and 5. On October 26 all periods had high levels of stereotypic behavior, ranging from 32 to 45 intervals, occurring in both areas 1 and 5.

Figure 27.3 shows the stereotypic behavior when the return to the 11:30 a.m. feeder was absent. On November 8 a total of 4 intervals were scored as stereotypic during the 11:00 a.m. and 12:00 p.m. periods. No stereotypic activity was recorded on November 11. On November 15 high levels of stereotypic activity occurred in each period, ranging from 36 to 54 intervals, occurring in both areas 1 and 5. On November 20, again, high levels of stereotypic behavior occurred in each period, ranging from 27 to 53 intervals, with the majority of the stereotypic behavior occurring in area 5.

Figure 28 shows the number of intervals recorded as active for the male bear during the 11:30 a.m. and 12:00 p.m. feeder deployment times. Figure 28.1 shows the number of intervals recorded as active when the automatic feeder was deployed at 11:30 a.m. During the 10:00 a.m. time period activity was variable, ranging between 5 and 59 intervals of activity. During the 11:00 a.m. time period activity ranged from 20 to 45 intervals of activity, with the exception of August 10 in which only 1 interval of activity was recorded. During the 12:00 p.m. time period, activity decreased from the 11:00 a.m. time period, ranging from 3 to 16 intervals of activity with the exception of July 30, which had 58 intervals of activity. By the 1:00 p.m. time period each day had zero intervals of activity with the exception of July 30, which had 59 intervals of activity recorded.

Figure 28.2 shows the number of intervals recorded as active for the male bear when the feeder was deployed at 12:00 p.m. During the 10:00 a.m. time period the male bears activity ranged between 23 and 52 intervals of activity. During the 11:00 a.m. time

period the male bears activity was 54 and 52 intervals of activity for September 10 and 17, while September 3 had fewer interactions with 15 intervals. During the 12:00 p.m. time period the male's activity ranged between 16 and 36 intervals of activity. During the 1:00 p.m. time period activity was much more variable, ranging between 45 intervals on September 10 and 6 intervals of activity on September 3.

Figure 29 shows the number of intervals recorded as an interaction for the male bear when the feeder was deployed at 11:30 a.m. On July 30 the male bear's interactions ranged between 5 intervals during the 11:00 a.m. period, and 27 intervals of interaction during the 1:00 p.m. period. August 30 had the second highest level of interactions with interactions occurring during the 10:00 a.m., 11:00 a.m., and 12:00 p.m. time periods. Interactions ranged between 3 and 14 intervals. On July 27 the only interactions scored were during the 11:00 a.m. period with a total of 6 intervals. On August 10 no interactions were scored during any time period. Overall, interactions with the inside and outside foliage, and logs were most frequent.

Figure 30 shows the number of intervals recorded as an interaction for the male bear when the feeder was deployed at 12:00 p.m. Interactions were more consistent during the 12:00 p.m. feeder delivery then the 11:30 feeder delivery. Each period of each day at least one interaction with the environment was recorded. During the 10:00 a.m. period interactions ranged between 7 intervals on September 10, and 18 intervals on September 3 and 17. Interactions increased from the 10:00 a.m. period during the 11:00 a.m. period ranging between 7 and 34 intervals. Interactions began to decrease from the 11:00 a.m. period during the 12:00 p.m. period with interactions ranging between 11 and 16 intervals and decrease further during the 1:00 p.m. time period,

ranging between 1 and 11 intervals of interaction. Interactions with the enrichment provided were recorded during the 10:00 a.m., 11:00 a.m., 12:00 p.m. and 1:00 p.m. time periods and ranged from zero to 11 intervals of interaction. Interactions with the enrichment, inside and outside foliage and the logs were most frequent.

Figure 31 shows the male bear's area usage when the feeder was deployed at 11:30 a.m. On July 27 the male bear remained in area 1 for all 60 intervals of each day, with the exception of the 11:00 a.m. time period, where he utilized areas 2, 3 and 5. On July 30 the male bear utilized multiple areas during each period of the day. On August 10 the male bear remained in area 2 for all 60 intervals of each time period recorded. On August 30 the male bear utilized each area of the enclosure during the 10:00 a.m. time period. During the 11:00 a.m. time period on August 30, the male bear spent the majority of intervals in area 4 with 34 intervals. During the 12:00 p.m. and 1:00 p.m. time periods on August 30, the male bear spent the all 60 intervals in area 1.

Figure 32 shows the area usage for the male bear when the feeder was deployed at 12:00 p.m. On September 3 the male bear utilized area 3 for the majority of intervals during each time period of data collection. During the 10:00 a.m. time period on September 3 the male bear also utilized areas 2, 5 and the water with 7, 8 and 2 intervals spent in the respective areas. On September 12 the male bear utilized only area 4 during the 10:00 a.m. period, but utilized areas 5, 2 and the water during the 11:00 a.m. period, with 45, 7, and 8 intervals in each area respectively. The male bear remained in area 3 for all 60 intervals during the 12:00 p.m. and 1:00 p.m. time periods on September 12. On September 17 the male bear utilized multiple areas during each period. During the 10:00 a.m. time period the male spent the majority of intervals in area

5, but also utilized areas 1, 2 and 3. In the 11:00 a.m. time period the male bear utilized areas 1, 2, 3 and 5. During the 12:00 p.m. time period the male bear spent the majority of intervals in area 3, but also utilized areas 5 for 20 intervals, and areas 1 and 2 for 1 interval. During the 1:00 p.m. time period the male bear spent the majority of intervals in area 1, but also utilized areas 2 and 5.

DISCUSSION

The results of this study show that the captive animal activity tracking system (CAATS) was effective in revealing patterns of captive animal behavior as well as delineating how these patterns were altered by changes made in the animal's environment. All together the measures of the animal's activity, environmental interactions, stereotypic behavior, and area usage provided useful information about the behavior patterns of black bears in captivity.

One important aspect of captive animal welfare is the amount of active behaviors displayed by the individual animal. Ideally, captive animal behavior should approximate the animal's wild counterpart. In the wild American black bears spend the majority of their time foraging for food, up to 18 hours a day (Garshelis, 1980). Although it is suspected that captive black bears do not spend the majority of their time foraging for food in their enclosure, the actual amount of activity they engage in is unknown. The existing data in captive environments is concerned with the animal's behavior in relation to a particular aspect of the animal's environment (i.e. the effects of a new enrichment item) over relatively short periods of time (Carlstead, 1991). Because the observation systems are usually tailored to particular experimental questions and are intensive and time consuming, they do not seem practical to monitor the animal's behavior throughout the day. Ideally, data collected on an animal's behavior would be continuous, complete and direct. Unfortunately, this is not an option for captive animal institutions caring for multiple animals and enclosures with few staff available for data collection. It seems that the best alternative could be to use an observational system with a sampling method that would allow collection of *representative* data.

The CAAT system adapted the instantaneous time-sampling method used by Gordon Paul (1987) to create and alter personalized treatment packages for mental health patients based on the patient's behavior over time. The sampling method used in the CAAT system involved collecting data on 7 different categories (crowd level, animal location, sleeping status, animal body position, interaction, attention, and concurrent activity) every 15-s for fifteen min of every hour. The CAAT system was designed so that its implementation could provide information on behavior without lengthy data collection sessions or a rigid schedule of data collection. Data collection times for the black bears occurred within the range of 40 to 90 min between sessions. While this range of time between sessions highlighted the behavioral patterns of the black bears, an institution may be able to determine their own rules on the appropriate variations in time between their data collection sessions. Another way to make the implementation of the CAAT system easier in a captive animal institution the data collection sessions may be to shorten. Although data collected on the black bears behavior showed that 15 min sessions provided a clear picture of each animal's behavior, re-graphing 5 min subsets of the 15 min data collections gave a similar picture of behavior. However, the importance of the frequency of data collection should not be overlooked. A single data collection session may be meaningless in determining an animal's overall welfare.

The amount of time the bears were "active" was derived from the recordings when the bears were awake and engaging in concurrent activity, such as: sniffing, locomotion, manipulating object, eating, drinking etc. Pacing and stereotypic behavior fall under concurrent activities but were not counted as "active," they were recorded as stereotypic. The activities included in the "active" category were considered appropriate

and natural for the bears. This means that inactivity was recorded when the bears were either awake without any concurrent activity observed (i.e., sitting with eyes open with no movement) or sleeping. The data collected with the CAAT system indicated that the bears at the Fort Worth Zoo were inactive for more than half of their time on exhibit. The bears engaged in a pattern of high levels of activity during the 10:00 a.m. period, which decreased throughout the day until the bears were almost always completely inactive during the 1:00 p.m. period. This pattern was seen throughout months, days of the week, enrichment items, keepers working the area, and different weather conditions. Since this pattern of activity is far from their wild counterparts, these behaviors may be targeted for change.

In addition to the general "activity" of the bears, it is also important to know the aspects of their enclosure with which the bears were interacting. It has been suggested that the *quality* of an animal's space, (i.e. the amount of opportunities an animal has for environmental interaction), may be even more important than the *amount* of space made available (Maple, 2007). By measuring the frequency and manner in which animals are interacting with their environment, information regarding the animal's enclosure may be gained. This information can then be used to guide creation of future enclosures as well as additions to an existing enclosure.

During data collection an "interaction" was scored if the animal made contact with an object in its external environment that resulted in the movement or displacement of all or part of that object. Interactions for the black bears could have taken place with one or more objects within their environment (such as the inside and outside foliage, conspecific's, logs, enrichment items, etc.) Typical examples of interactions were the

bears digging at the bark on the logs, reaching through the fence with their claws to pull at leaves on the outside of their enclosure, or wrestling with another bear.

Similar to the result of activity, the black bear's interactions decreased throughout the day. During the 10:00 a.m. period interactions were the highest and fairly consistent throughout the data collection days. Interactions decreased during the 11:00 a.m. and 12:00 p.m. periods until, in general, no interactions were scored during the 1:00 p.m. period. Overall, however, compared to the bear's general activity, interactions were minimal. Interactions made up approximately 15% of the bears activity throughout the day. This pattern of interaction was seen regardless of weather condition, keepers on duty, days of the week and the presence or absence of enrichment items. Interactions with the inside foliage were the most frequent and consistent type of interaction for the black bears. Interactions with the inside foliage made up between 5 and 80% of the bear's interactions throughout the day. Other items the bears interacted with were the logs, door and outside foliage. The various enrichment items provided for the bears had little effect on the their level of interaction. The enrichment provided for the bears during this time came in various forms such as grapevine wreaths, puzzle feeders, boomer balls, scattered food, scents, etc. Enrichment interactions made up less than 5% of the bear's interactions. As suggested by Young (2003) enrichment items were meant to increase the bears "behavioral diversity", but unfortunately these items were ignored. The enrichment items perhaps had a positive effect on the bear's behavior when they were first introduced because of their novelty. Sometime between the time of the enrichments introduction and the time of data collection, these effects diminished. Seeing only a "short-lived" effect from enrichment items is not uncommon (Carlstead,

1991). These results clearly show why collecting data over time is necessary, in order to see the ever changing effects of an animal's environment on their behavior. Discovering the lack of effect these items had on the animal's behavior could save time, money and effort spent by the zoo staff providing these items. Resources could then be put towards building new, more appropriate enrichment.

Area usage was another important aspect of behavior that was collected using the CAAT system. While many captive animal institutions have made great efforts to increase the overall size of their animal's enclosures (Hutchins, 2006), there are only a small number of published data on the use of an animal's available space (Leighty, 2009). Knowing how an animal is utilizing the space available to it may shed more light on the importance of space as well as determining the appropriate amount of space for individuals and species. In the present study area usage was determined by counting the number of intervals the bears were in each area.

Data showed that the bears utilized the majority of the 6 areas in their enclosure during the 10:00 a.m. and 11:00 a.m. periods when activity was high. During these two periods the bears moved in front of the viewing glass, into the water, on the porch and into the grassy areas in the back of the enclosure. During the 12:00 p.m. and 1:00 p.m. periods the number of areas utilized by the bears decreased, and the animals remained almost exclusively in area 1 for the duration of these periods. Area 1 in the bears' enclosure is located the furthest from the public viewing area (See Appendix A). It is unfortunate that the bears slept in this area during the 12:00 p.m. and 1:00 p.m. periods because visitor level was highest at the bear's enclosure during that time. The areas the

bears are utilizing throughout the day may be targeted for change for not only the welfare of the bears, but also the enjoyment and education of the visitors.

With respect to stereotypic behavior, there was no occurrence of stereotypic behavior during Phase 1. Interestingly many publications have stated that stereotypic behavior may be detrimental to an animal's health (Sambraus, 1985), and an indicator of poor welfare (Mason, 1991). With an emphasis on the severity of stereotypic behavior and its detrimental effects, it may be easy to assume that the absence of stereotypic behavior is an indicator of high welfare. In the present experiment even with the absence of stereotypic behavior during Phase 1, based on the bear's level of activity, interaction and area usage, it was concluded that the current environment was inadequate for natural bear behavior and changes should be made in order for more natural behaviors to occur. These data suggest that the presence or absence of stereotypic behavior should not be used as a sole indicator of a captive animal's welfare status.

In efforts to create an environment in which more natural behaviors could occur, an automatic feeder was set up over area 5 above the bears' enclosure and was deployed at various times. In addition to trying to increase naturalistic behaviors, the introduction of the automatic feeder also served as a good test to see if the CAAT system would be sensitive to the bears' changing behavior. During this second phase of the experiment, data were collected as usual.

Each deployment time of the automatic feeder had unique effects on each bear's activity. In contrast to Phase 1 where the bears' general activity level continuously decreased from the 10:00 a.m. period to almost entirely no activity during the 12:00 p.m.

and 1:00 p.m. periods, during Phase 2, when the automatic feeder was deployed at 11:30 a.m., the female bear's activity increased from the 10:00 a.m. hour period to the 11:00 a.m. hour period. The female bears' activity was highest during the 11:00 a.m. hour period before activity decreased during the 12:00 p.m. and 1:00 p.m. periods. For the male bear, the 11:30 a.m. deployment time had little effect on the activity pattern that was seen during Phase 1, with the exception of one day in which high levels of activity occurred during the 12:00 p.m. and 1:00 p.m. time periods. During the 12:00 p.m. deployment time, the male bear's activity was maintained during the 10:00 a.m. and 11:00 a.m. periods, and increased the amount of activity during the 12:00 p.m. and 1:00 p.m. periods for both bears. Activity occurred throughout the day and there was no dramatic decrease in activity levels during the 1:00 p.m. hour period, as was seen when the feeder was deployed at 11:30 a.m. The male bear was not exposed to any other deployment times due to changes made in the bears exhibit schedule. In contrast to the 12:00 p.m. deployment time, when the feeder was deployed at 12:30 p.m. the female bears activity decreased from the 10:00 a.m. period to the 11:00 a.m. period before increasing during the 12:00 p.m. period. Activity was highest during the 12:00 p.m. hour period before activity once again decreased, for the majority of days, during the 1:00 p.m. period. When the feeder was returned to 11:30 a.m., the female's activity looked similar to the previous 11:30 a.m. deployment time in that the activity generally decreased throughout the periods of data collection. Unlike the previous 11:30 a.m. deployment time, the female bear was never completely inactive during either the 12:00 p.m. hour period or the 1:00 p.m. hour period. In terms of activity alone, this data would suggest that the 12:00 p.m. deployment time of the automatic feeder is optimal in

producing sustained naturalistic patterns of activity for the black bears. The data also show the sensitivity of the CAAT system in monitoring the changing levels of the animal's activity through alterations to the animal's environment.

The number of interactions for each bear increased throughout the day during the presence of the automatic feeder during all deployment times. During the different deployment times interactions made up between 16 and 28 percent of the bears overall behavior, compared to 15% during Phase 1. The male bear interacted more frequently with enrichment items during the 12:00 p.m. deployment time, approximately 16% of all interactions, than when the enrichment had been presented alone during Phase 1. Again, the inside foliage was the most frequent interaction for both bears. The bears level of interaction with the inside foliage consistently ranged from 40 to 80% of their total interactions. The data show that the presence of the feeder, deployed at any of the previously measured times, had beneficial effects on the levels of interactions each bear had with its environment. The data supports that the CAAT system was sensitive to the level of interactions as well as what items were interacted with during each deployment time.

In contrast to Phase 1, the presence of the automatic feeder produced stereotypic behavior in the female bear, but not the male bear. This is interesting because the timing of food has often been correlated with the presence of stereotypic behavior (Mason, 1993). Vickery (2004) suggests that to better understand the particulars of stereotypic behavior it is important to look at the frequency of the behavior, *where* it occurs, as well as *when* it occurs. As suggested by Vickery (2004),

the CAAT system allowed for information to be gathered regarding the frequency, location and timing of stereotypic behavior.

The female bear paced at varying levels during each of the automatic feeders deployment times. When the feeder was deployed at 11:30 a.m. the stereotypic behavior was minimal. The pace was observed only on two occasions, for 5 intervals during the 11:00 a.m. period on the second day, and for the majority of the 11:00 a.m. period on the fourth day of the 11:30 a.m. deployment time. The number of intervals the pace was observed increased further when the feeder was deployed at 12:00 p.m., in which 16% of intervals recorded were stereotypic. The 12:30 p.m. deployment time produced higher levels of stereotypic behavior than any other condition in Phase one or two. Stereotypic behavior made up approximately 45% of the female's behavior during this deployment time. When the feeder was returned to 11:30 a.m. stereotypic behavior did not return to the low levels previously seen in the 11:30 a.m. deployment time, but did decrease from the 12:30 p.m. deployment time. Still, 40% of the female bear's behavior was stereotypic during the second 11:30 a.m. period. Given the observable changes to the female bear behavior from the first 11:30 deployment time to the second, the data emphasize the importance of frequent observations completed over time.

In summary, during the 11:30 a.m. deployment time stereotypic behavior occurred only during the period during which the feeder was deployed for the female bear. During the 12:00 p.m. deployment time stereotypic behavior was observed during the 11:00 a.m. and 12:00 p.m. hour periods most frequently, but also occurred during the 10:00 a.m. and 1:00 p.m. hour periods. The 12:30 p.m. deployment time produced

the highest levels of stereotypic behavior, which occurred during each period of data collection fairly consistently. The return to the 11:30 a.m. deployment time showed consistent stereotypic behavior throughout the periods on 3 of the 5days of data collection. The feeder absent days in these conditions showed similar levels of stereotypic behavior, respectively.

The female bear's stereotypic behavior occurred in either one of two areas: area 1 or area 5. The female paced in front of the doors that led to the off-exhibit areas in area 1, or she would trace the fence line of the back of the enclosure in area 5. Since the automatic feeder was placed over area 5, it might be hypothesized that the presence of the feeder may have been the cause of the pacing in area 5. Moving the feeder over a different area of the enclosure and continuing data collection could test for this.

While the presence or absence, location and timing of stereotypic behavior are important to at when determining a plan of action to decrease these behaviors, the changing levels of appropriate behavior should also be considered. For the female bear, the presence of the automatic feeder increased the level of appropriate activity, as well as the amount of environmental interactions, but coincided with an increase in stereotypic behavior. While every effort should be made to decrease rates of these inappropriate types of behavior, as well as to create an environment in which they do not originate, a difficult decision needs to be made regarding what levels of inappropriate behavior are acceptable for the female bear. If it is decided that no stereotypic behavior will be tolerated, the feeder may be removed in efforts to restore the previous environment in which no stereotypic behaviors were observed, and other

changes may be implemented to increase appropriate behaviors. If small amounts of stereotypic behavior will be tolerated *if and only if they coincide with high levels of appropriate behavior*, the behavior witnessed during the 12:00 p.m. deployment may be determined to be acceptable. These decisions can be made only when data are collected that will reveal these patterns of behavior.

Changes in the patterns of the animals' area usage during the feeder conditions were also seen through the data collected with CAATS. During Phase 2, the presence of the automatic feeder did not have large effects on the male bear's area usage. For the female bear the 11:30 a.m. deployment time maintained area usage during the 10:00 a.m. and 11:00 a.m. periods and increased the number of areas utilized during the 12:00 p.m. period. The 12:00 p.m., 12:30 p.m. and return to 11:30 a.m. deployment times had a positive effect on the female bear's area usage. These deployment times maintained the level of area usage during the 10:00 a.m., 11:00 a.m. and 12:00 p.m. periods, but also, increased area usage during the 1:00 p.m. period. In addition to an increase in overall area usage, areas 3 and 5 were notably visited more frequently during Phase 2. Again, these changes may have been due to the fact that the food deployed from the automatic feeder landed primarily in area 5. In this scenario, moving the feeder so food would be dispersed into other areas of the enclosure may create an environment where the bear's area usage patterns change and allow the public to view them more clearly throughout the day.

These overall results demonstrate that the CAAT system was sensitive to changes in the animals' behavior regarding the multiple measures relevant to the measurement of captive animal welfare. CAAT seems practical because by using short,

frequent data collection sessions throughout the day a staff member can collect data without conflicting with other obligations. Collecting data on an animal's behavior is the necessary first step in setting and reaching goals set for the individual animal (Wolfle, 2005). Some institutions may feel as though data collection is time consuming and may not be a worthwhile venture for their staff. In considering the materials, resources, time and effort put into creating elaborate enclosures, enrichment and overall care for the animals, direct feedback regarding how the animals are responding to this intense effort is necessary and may be, in the long run, lucrative. It is quite likely that institutions could save time, money and resources by evaluating their efforts and making data supported decisions on what efforts are made in vain and what changes are necessary for optimal animal welfare.

In an applied setting, implementing and maintaining the best design for a particular experiment is often difficult. As was shown, the CAAT system was sensitive to unexpected changes, and could still yield usage data when optimal conditions were not available. Necessary changes in the bears exhibit rotation schedule, and public demand for more viewing time of the cubs were just a few of the unexpected events experienced during data collection. Even with these changes and unexpected events, the data collected using the CAAT system gave a clear look at the behavioral patterns for each bear.

By collecting data on multiple aspects of an animals behavior and their interactions, environments can be created that will allow for an animal to behave in ways that meet the behavioral goals set by their wild counterparts. While many publications have stressed the importance of data collection, most of these publications

give general rules for data collection or report data collected in reference to a single aspect of the animals behaviors (Canino, 2009; Watters, 2008). The data collected using the CAAT system clearly painted a picture of each animal's unique behavioral patterns and responses to environmental changes. Only by gathering a baseline of behavior for individual animals can the effects of future manipulations be measured and appropriately considered by an institution. By collecting data for short, frequent periods over time immediate action can be taken in response to an animals health, enclosure usage, social and environmental interactions. These actions will be guided by the behavioral data collected on the animal of interest's current behavior, as well as its baseline behavior. By understanding a captive animals behavior in response to its environment, its overall welfare can be controlled. This full understanding can only be developed through careful observation and frequent data collection of multiple measures that can directly gauge an animal's welfare. These measures can be successfully monitored through the use of the CAAT system.

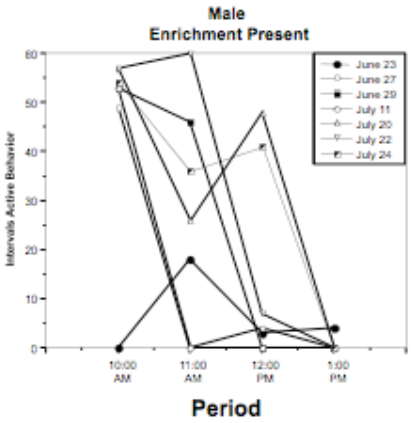


Figure 1.1

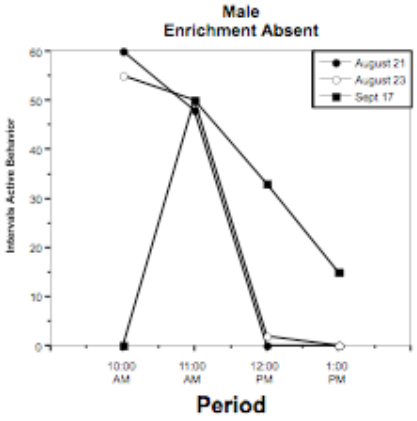


Figure 1.2

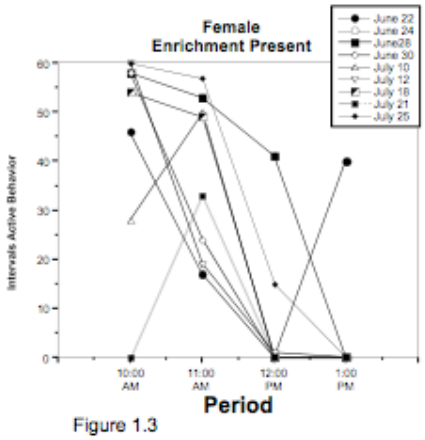


Figure 1.3

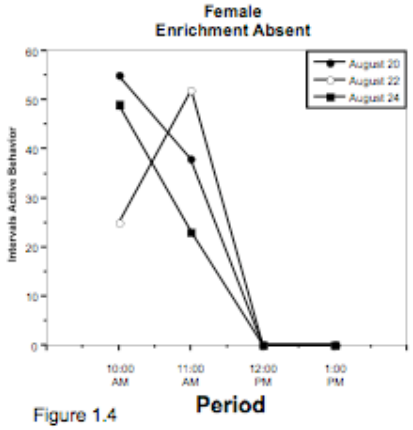


Figure 1.4

Figure 1. Activity levels for the male and female bears during periods when enrichment was either present or absent.

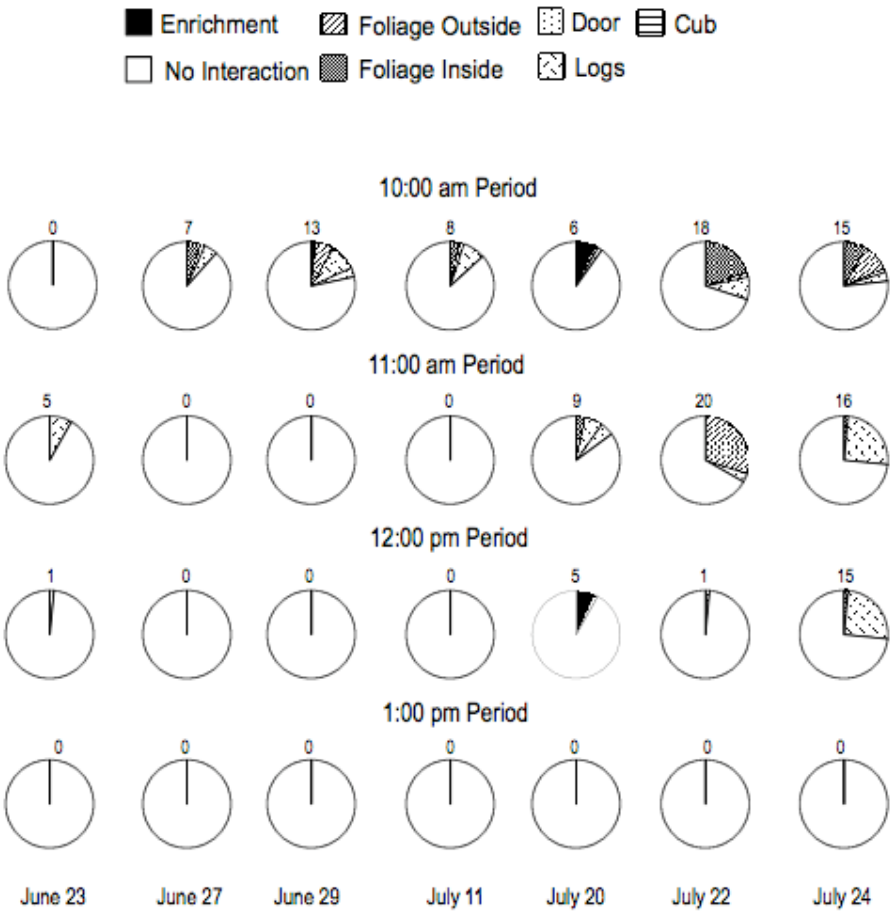


Figure 2. Male bears interactions while enrichment was present.

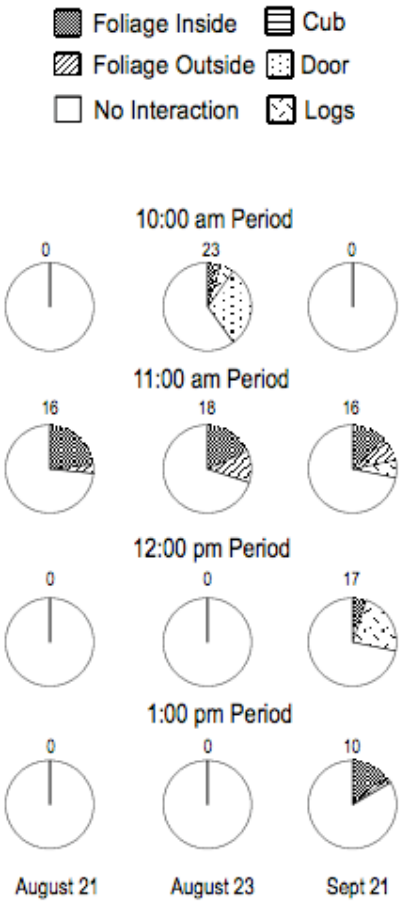


Figure 3. Male bear interactions while enrichment was absent.

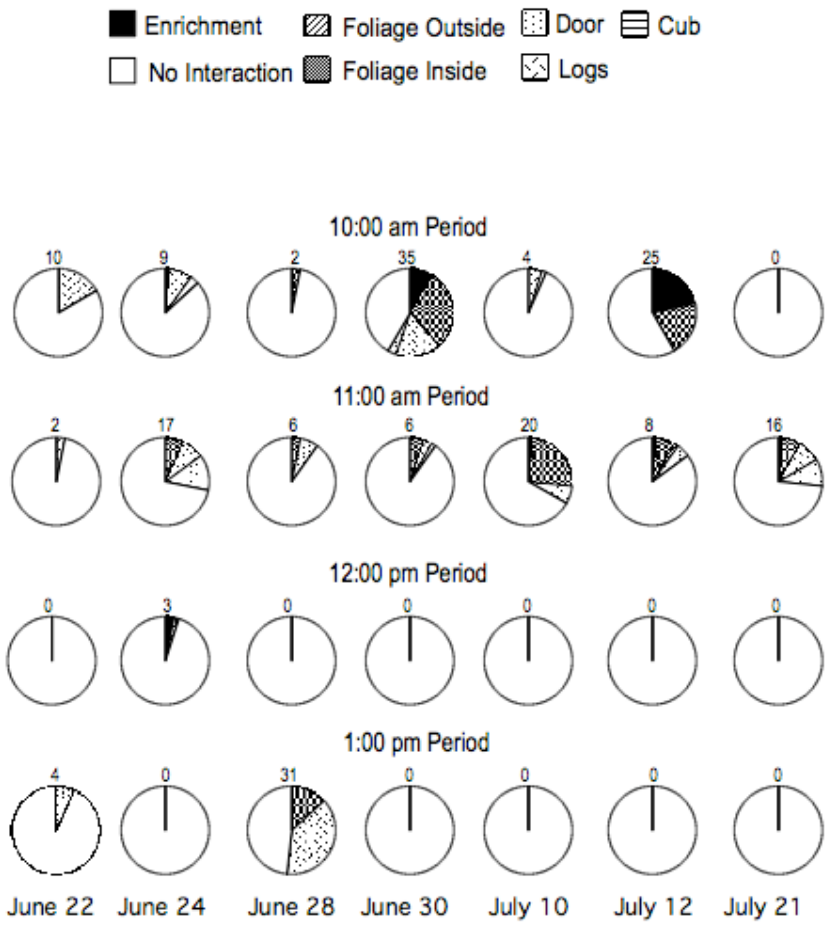


Figure 4. Female bear interactions while enrichment was present.

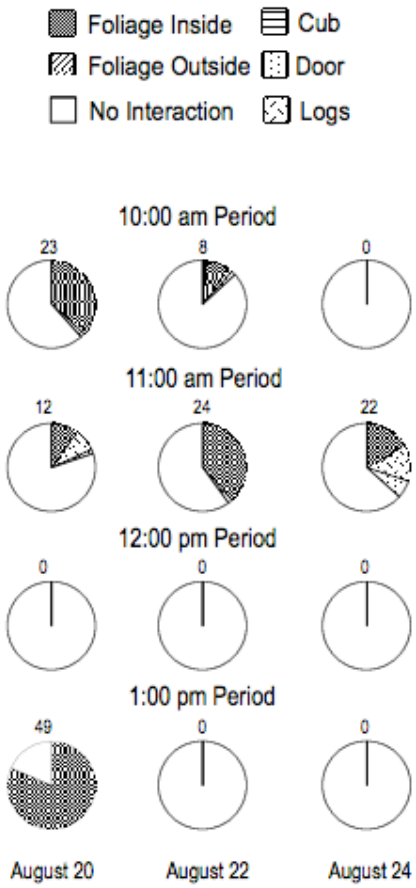


Figure 5. Female bears interactions while enrichment was absent.

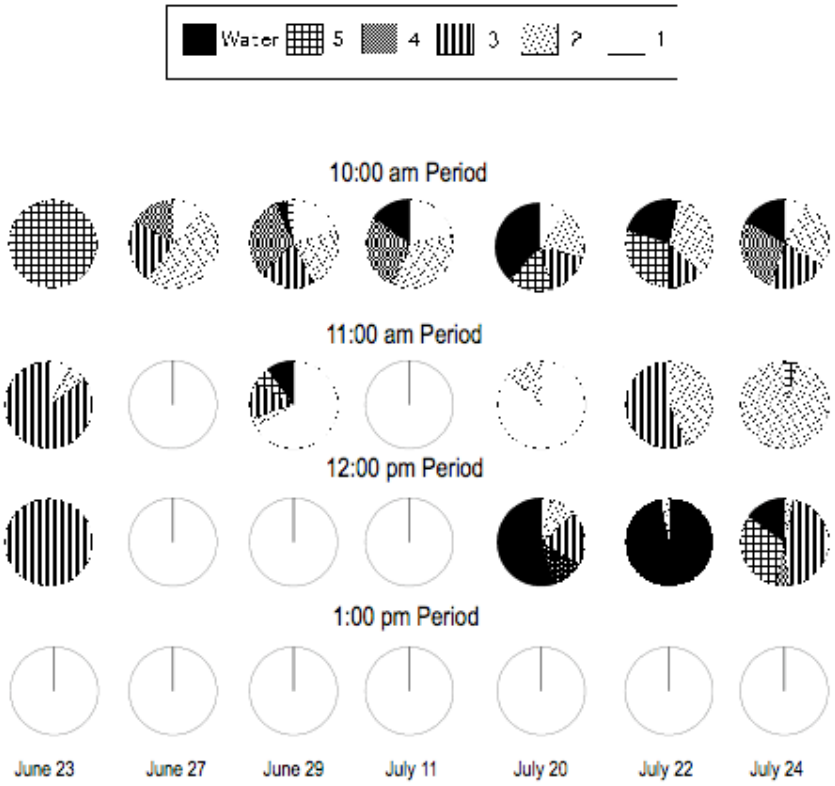


Figure 6. Male bears area usage while enrichment was present.

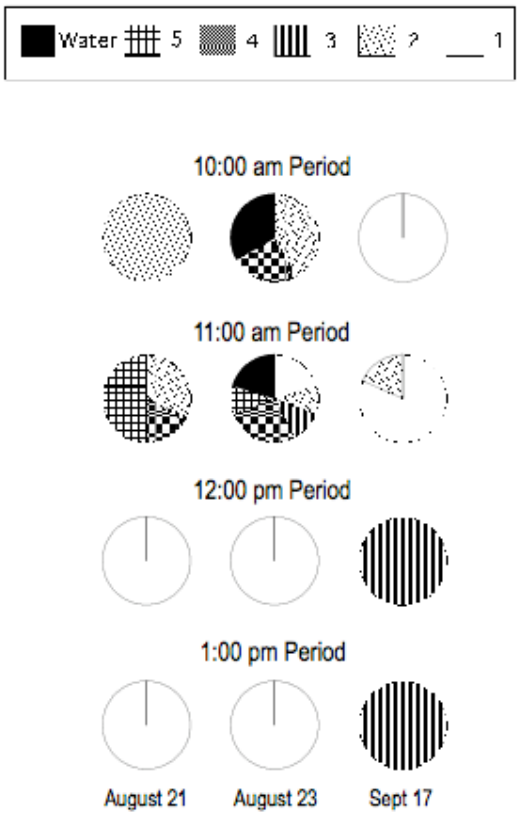


Figure 7. Male bears area usage while enrichment was absent.

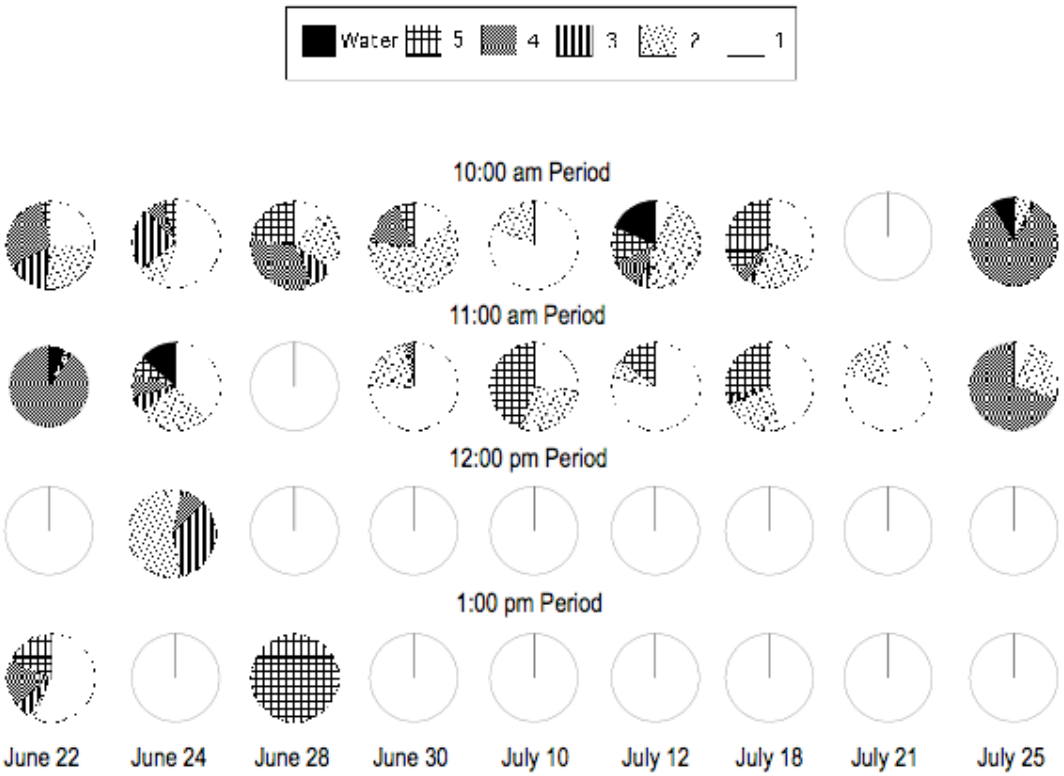


Figure 8. Female bears area usage while enrichment was present.

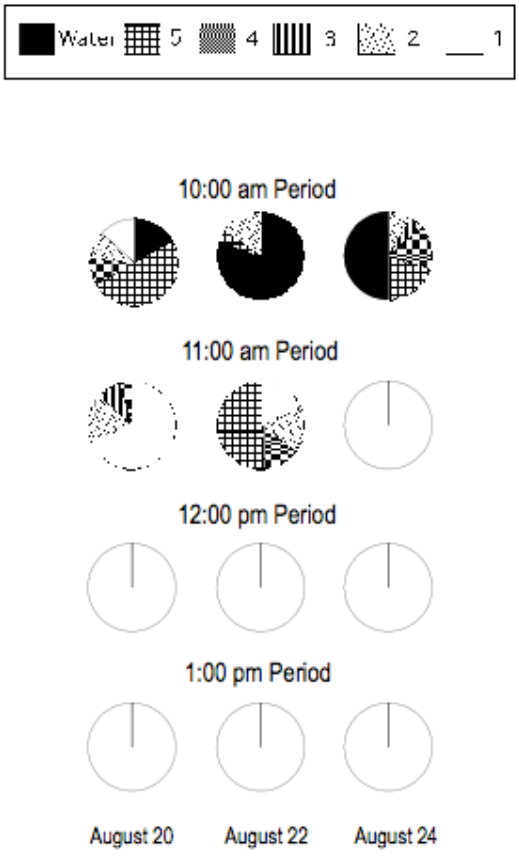


Figure 9. Female bears area usage while enrichment absent.

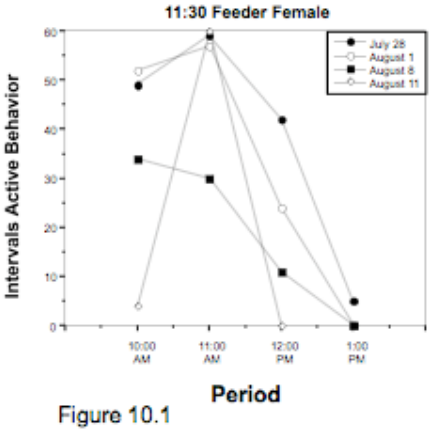


Figure 10.1

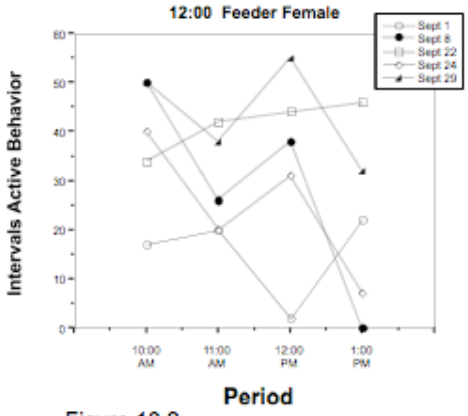


Figure 10.2

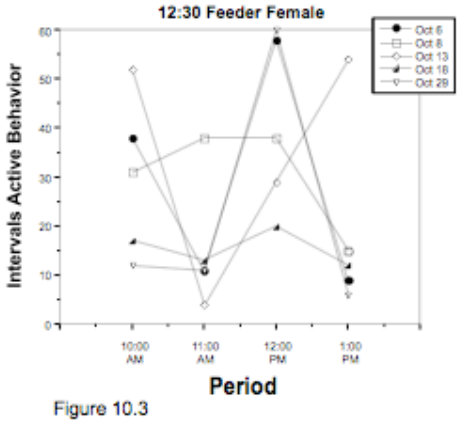


Figure 10.3

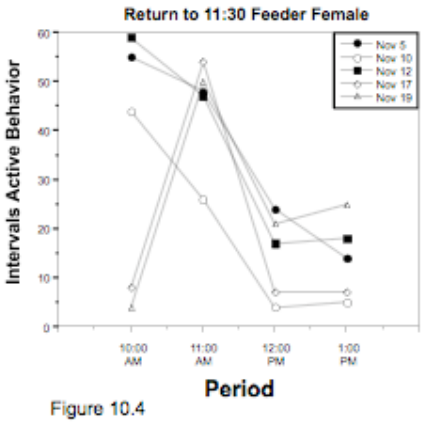


Figure 10.4

Figure 10. Activity levels for the female bear during the four feeder deployment times.

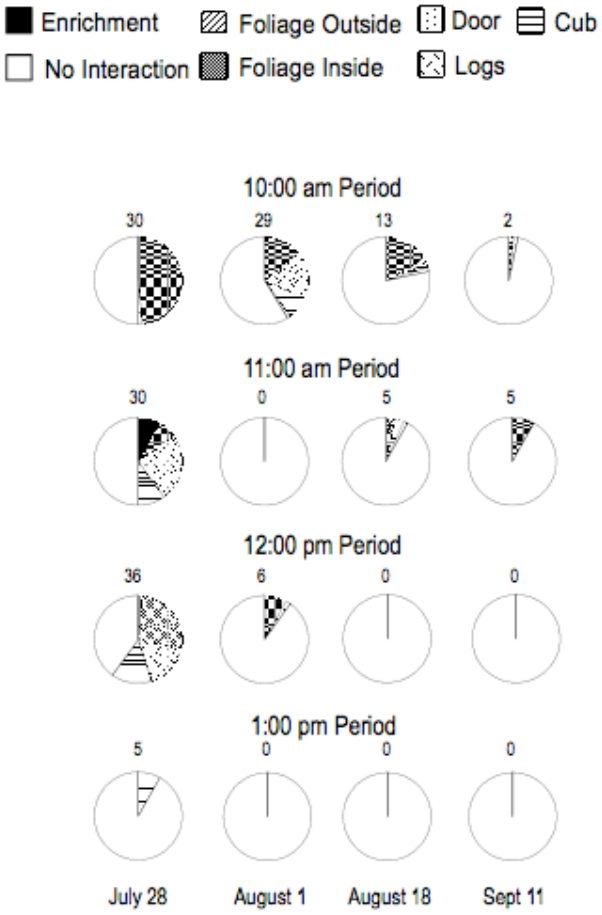


Figure 11. Female bears interactions during the 11:30 am feeder deployment time.

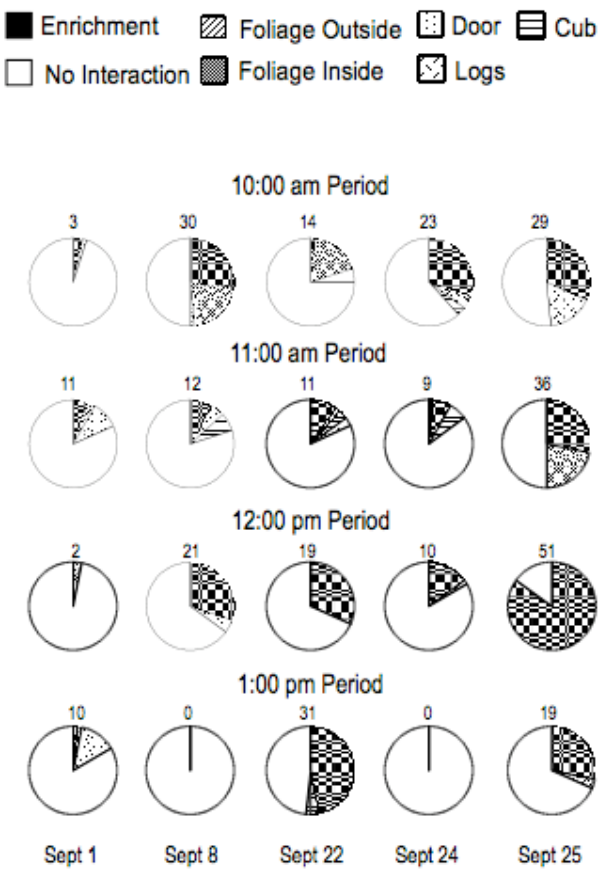


Figure 12. Female bears interactions during the 12:00 pm feeder deployment time.

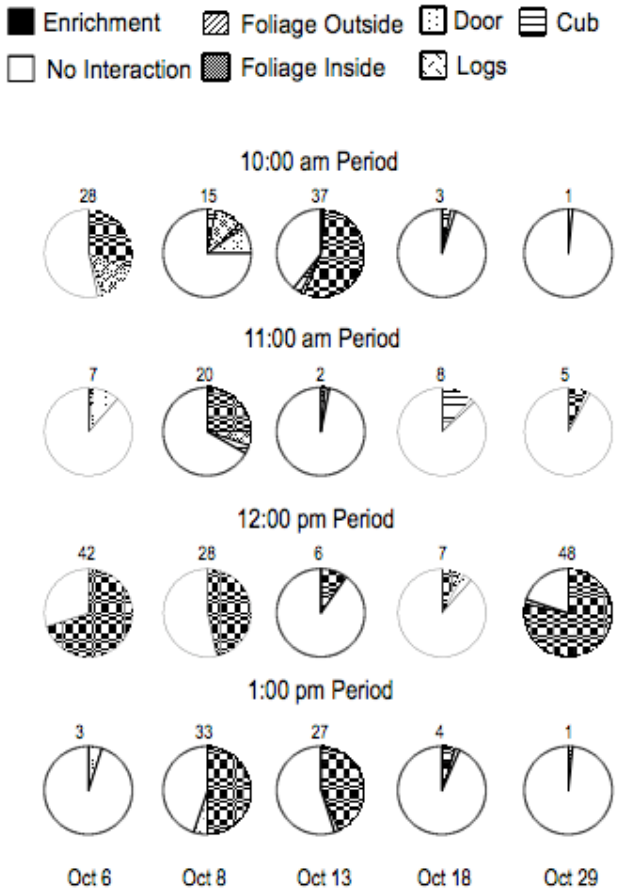


Figure 13. Female bears interactions during the 12:30 pm feeder deployment time.

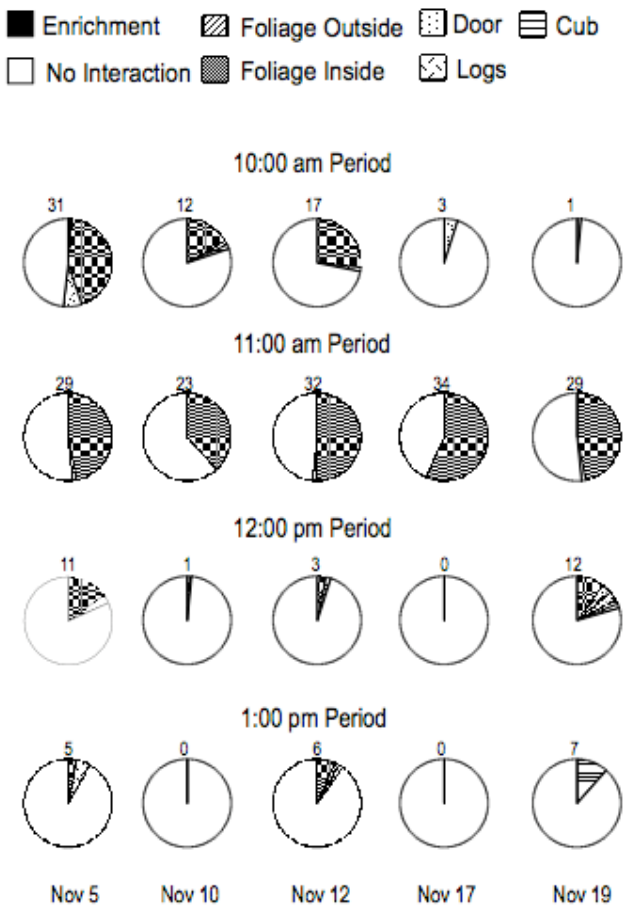


Figure 14. Female bears interactions during the time when the feeder was returned to 11:30 am.

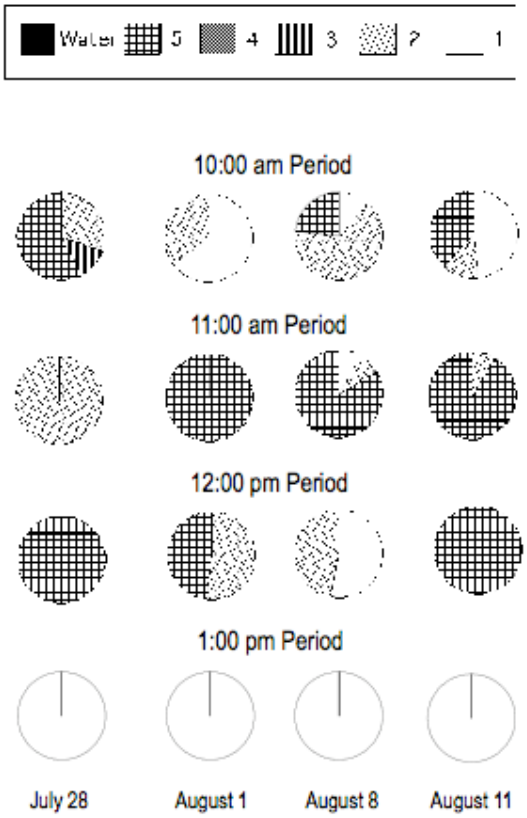


Figure 15. Female bears area usage during the 11:30 am feeder deployment time.

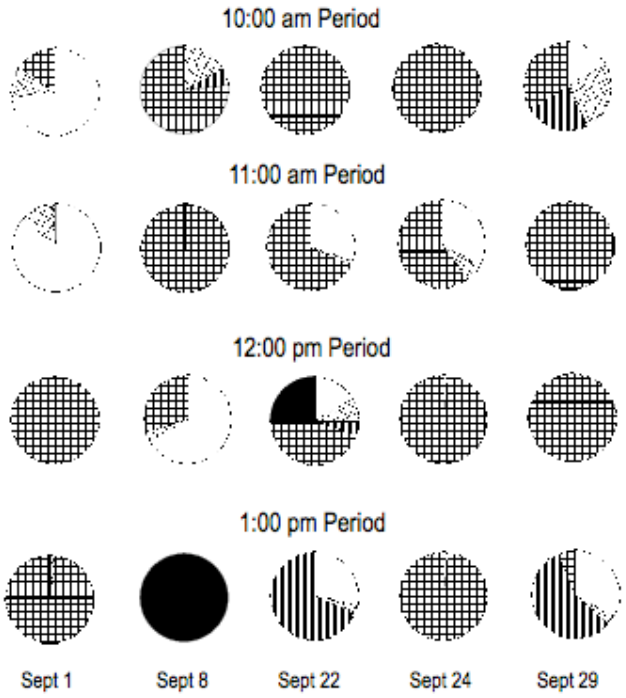


Figure 16. Female bears area usage during the 12:00 pm feeder deployment time.

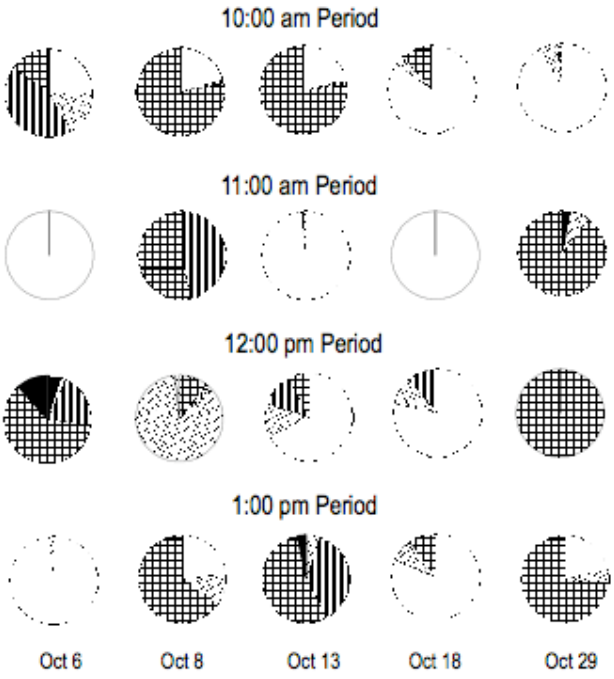


Figure 17. Female bears area usage during the 12:30 pm feeder deployment time.

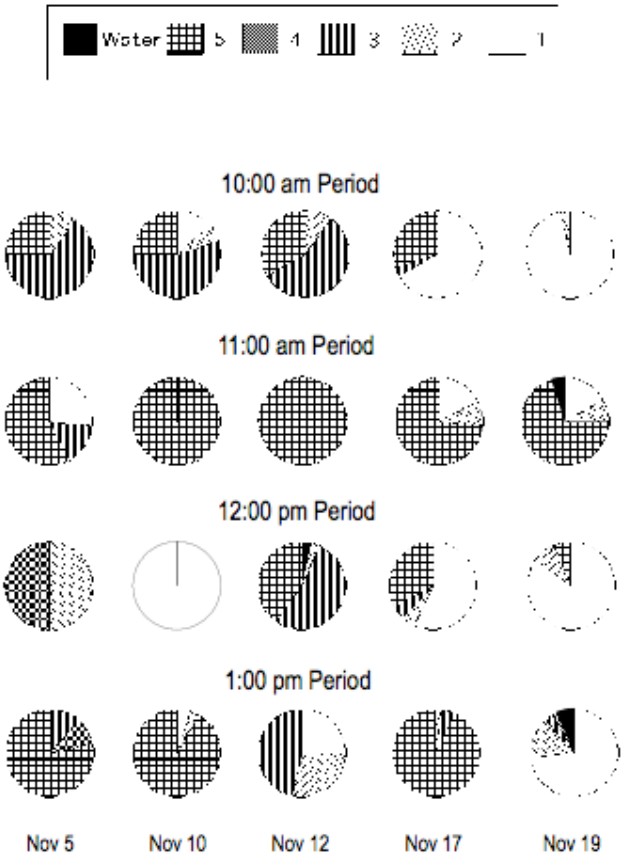
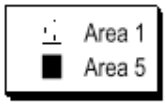


Figure 18. Female bears area usage during the time when the automatic feeder was returned to 11:30 am.



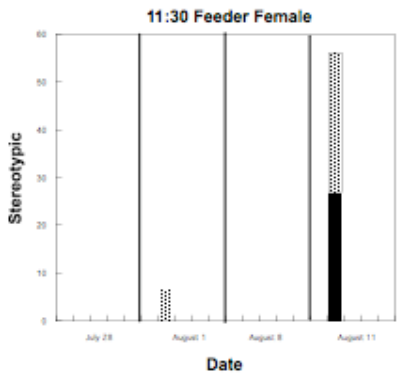


Figure 19.1

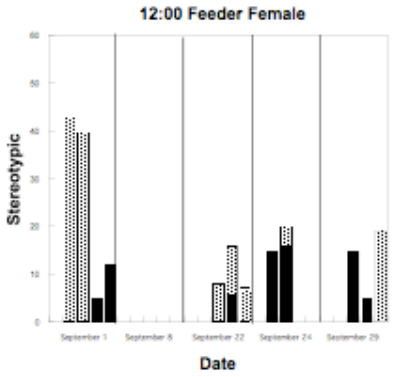


Figure 19.2

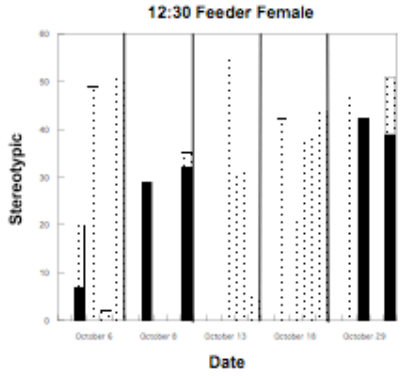


Figure 19.3

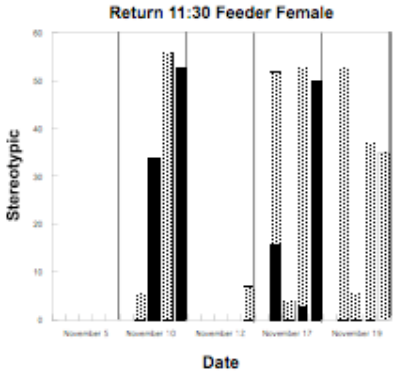


Figure 19.4

*Figure 19. Stereotypic behavior l*evels for the female bear during the four feeder deployment times.

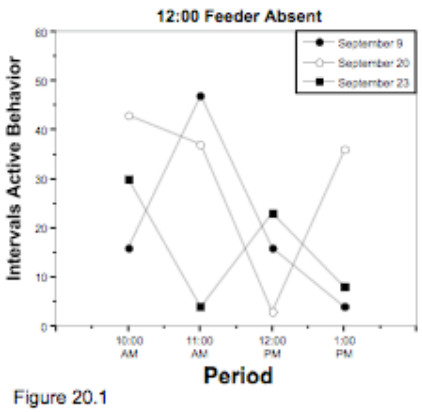


Figure 20.1

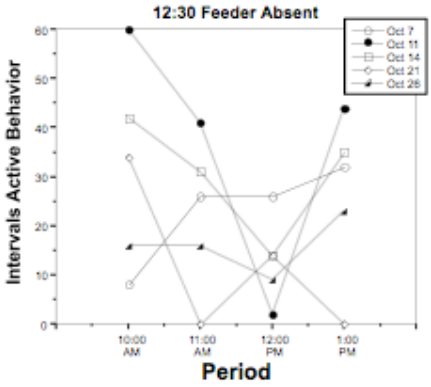


Figure 20.2

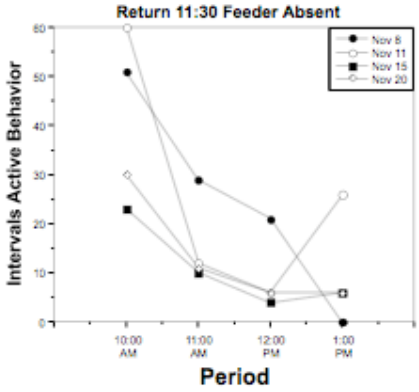


Figure 20.3

Figure 20. Activity levels for the female bear during the periods when the automatic feeder was absent.

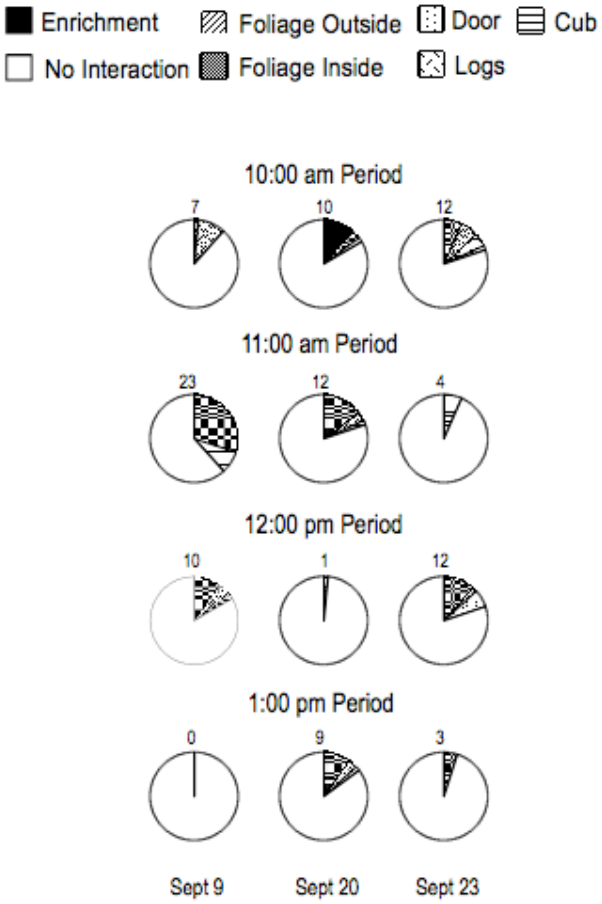


Figure 21. Female bears interactions when the 12:00 pm feeder was not deployed.

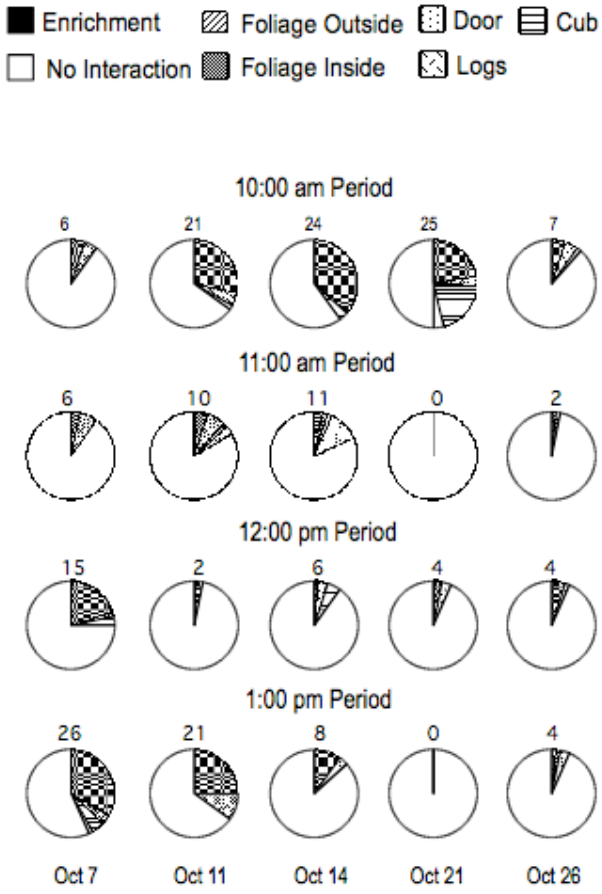


Figure 22. Female bears interactions when the 12:30 pm feeder was not deployed.

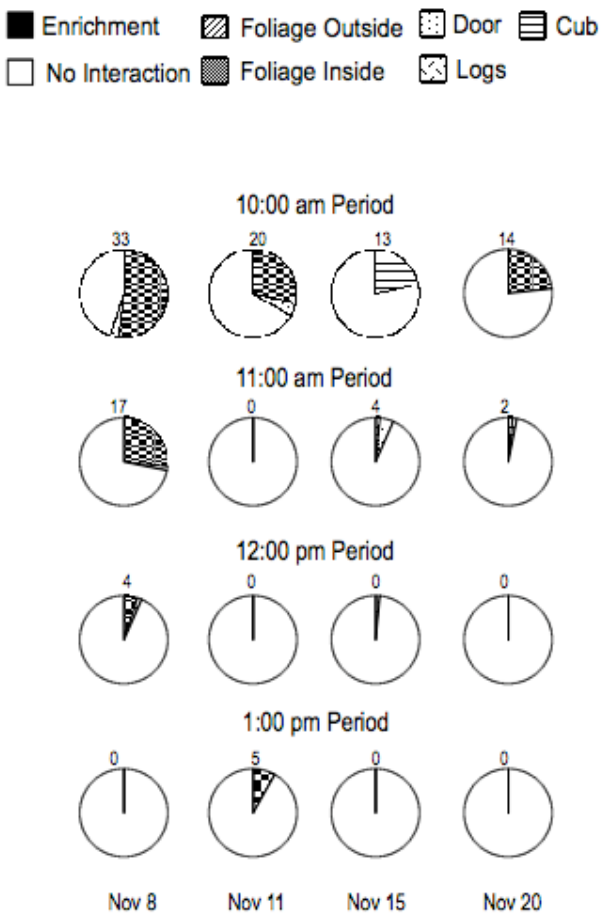


Figure 23. Female bears interactions when the feeder was returned to 11:30 am and not deployed.

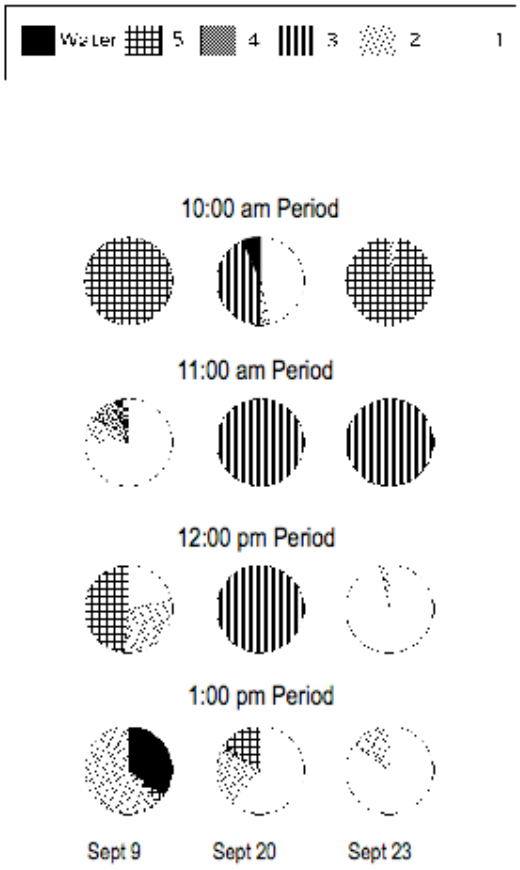


Figure 24. Female bears area usage when the 12:00 pm feeder was not deployed.

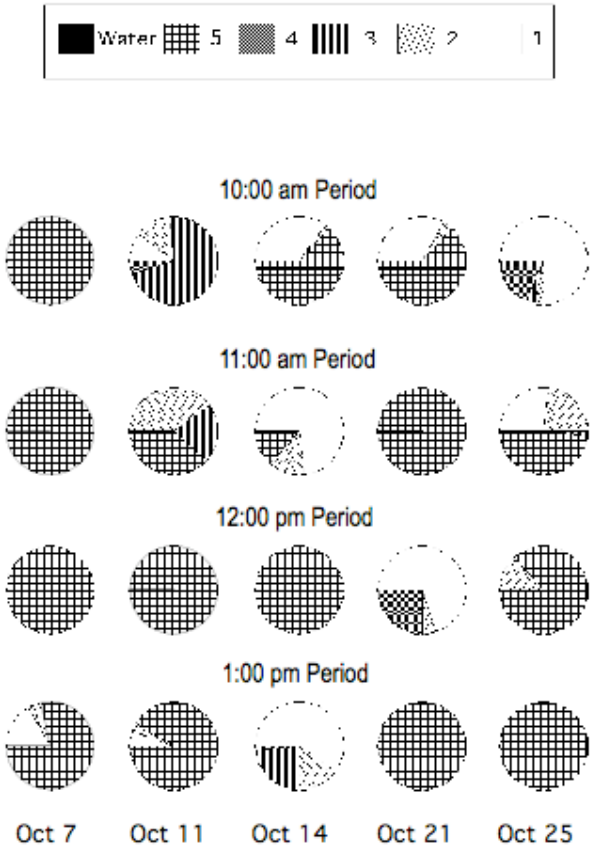


Figure 25. Female bears area usage when the 12:30 pm feeder was not deployed.

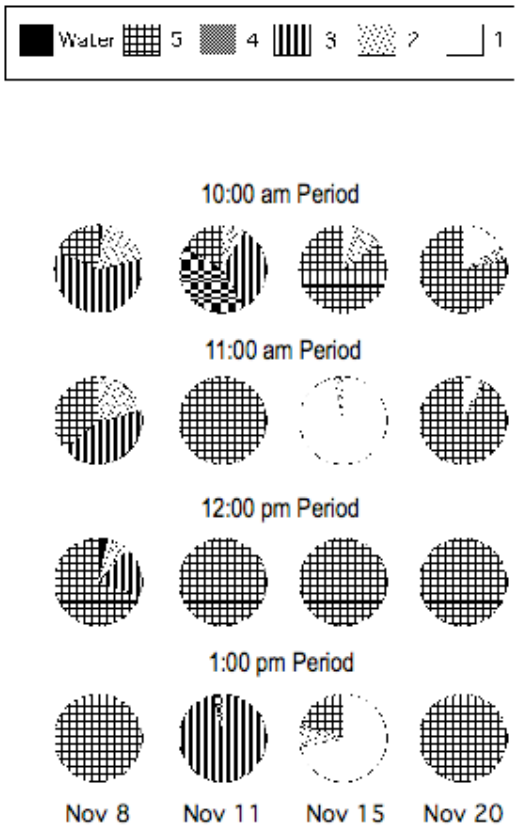


Figure 26. Female bears area usage when the feeder was returned to 11:30 am and was not deployed.

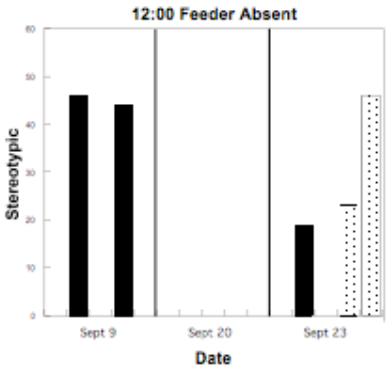


Figure 27.1

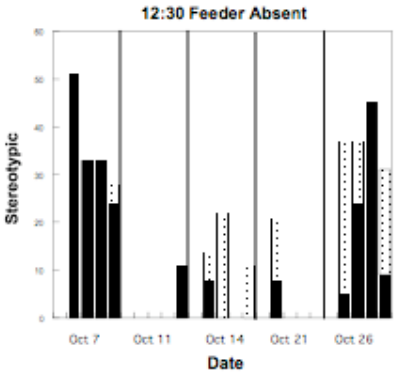


Figure 27.2

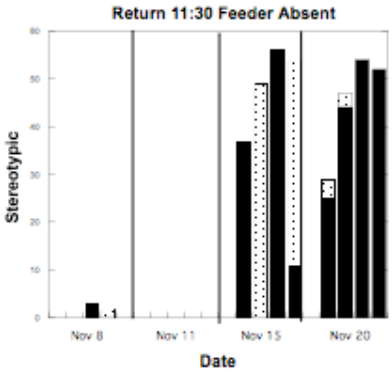


Figure 27.3

Figure 27. Stereotypic behavior levels for the female bear during the periods when the automatic feeder was not deployed.

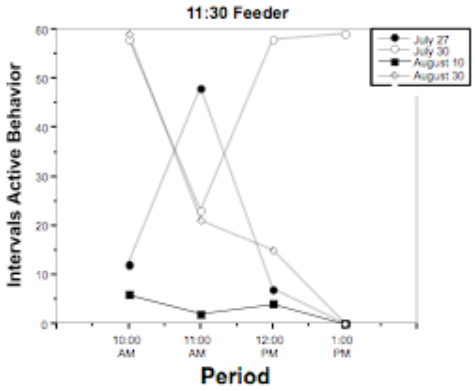


Figure 28.1

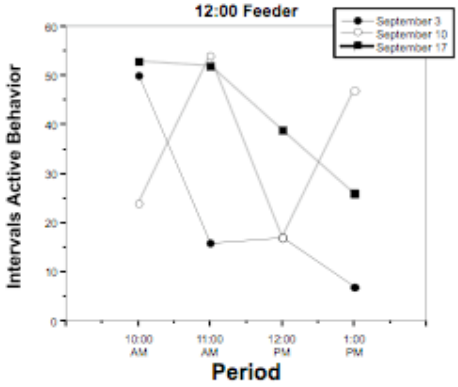


Figure 28.2

Figure 28. The male bears activity during the periods when the automatic feeder was absent.

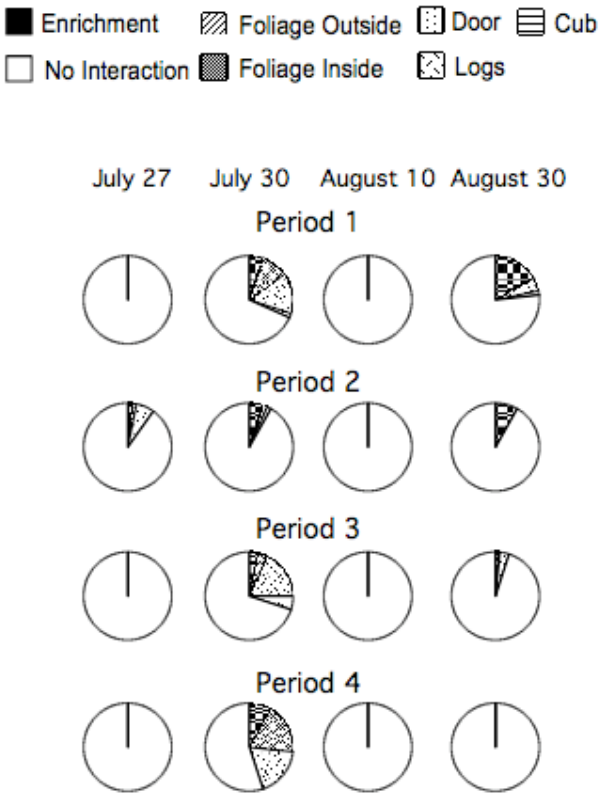


*Figure 29. M*ale bears interactions when the 11:30 am feeder was deployed.

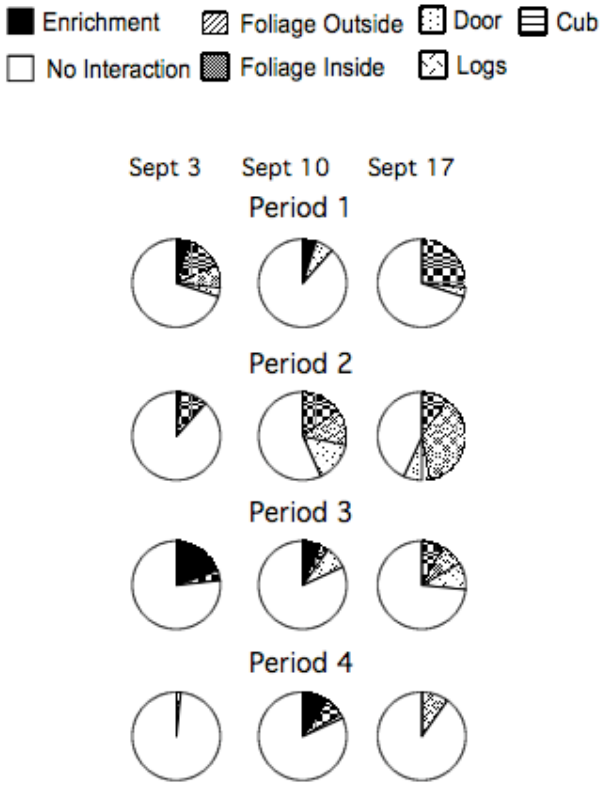


Figure 30. Male bears interactions during the 12:00 pm feeder was deployed.

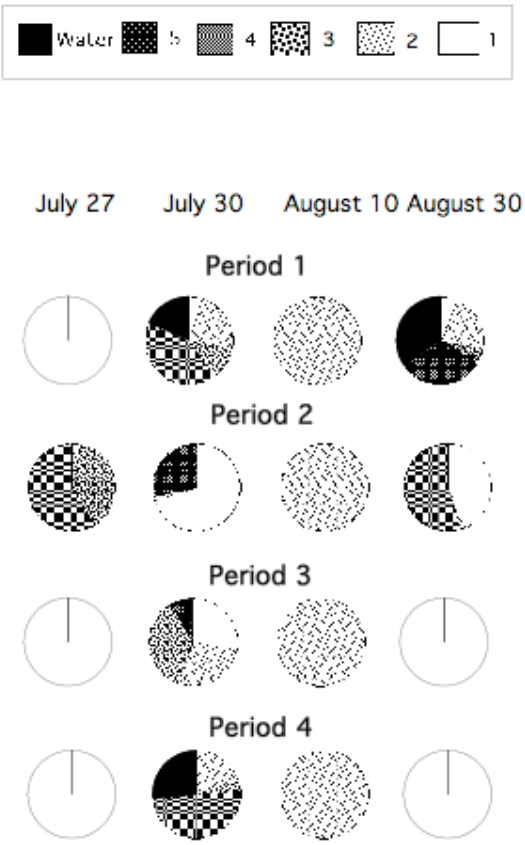


Figure 31. Male bears area usage during the 11:30 am feeder deployment time.

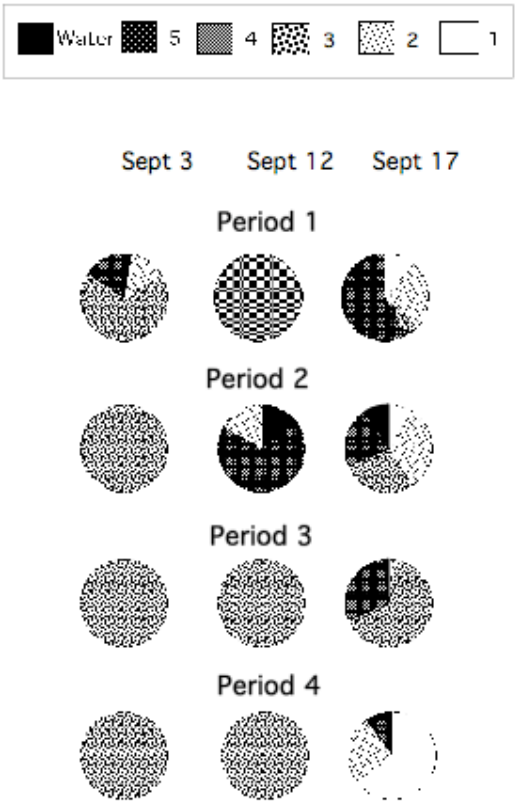
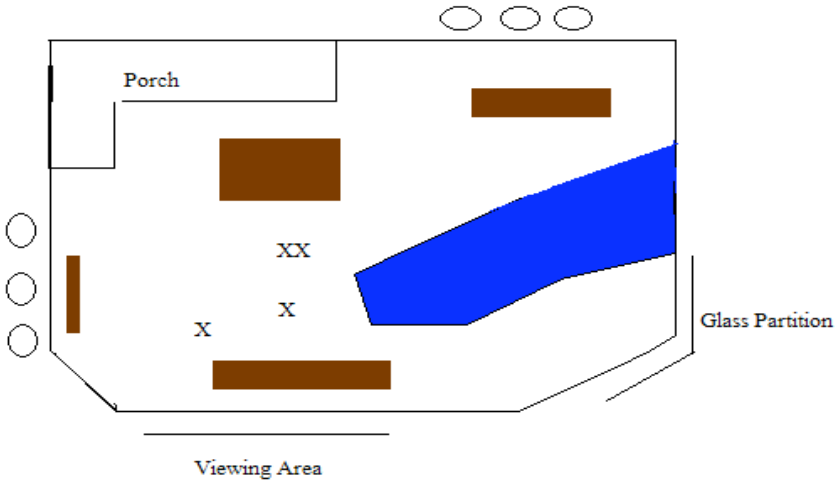


Figure 32. Male bears area usage during the 12:00 pm feeder deployment time.

APPENDIX A

ENCLOSURE DIAGRAM



XX= Tree with Hotwire

X= Tree without hotewire

= Water

= Logs

= Bushes

APPENDIX B

BLACK BEAR ETHOGRAM

I CROWD
1. 0- No visitors at enclosure
2. (-) 1-4 adult visitors at enclosure
3. (-k) 1-4 adult/children at enclosure
4. (+) 4+ adults at enclosure
5. (+k) 4+ adults/children at enclosure

II. LOCATION (may have more or less areas, according to enclosure specifics)
I
II
III
IV
V
Water

III. SLEEPING (Sl)

IV. POSITION
1. Sitting (Si)
2. Lying Down (LD)
3. Rearing (Re)
4. Climbing (Cb)
5. Standing (Sd)
6. Out of Sight (OS)

V. INTERACTION
1. Door
2. Logs
3. Foliage Inside
4. Foliage Outside
5. Enrichment

VI. ATTENTION
1. Keepers (Ke)
2. Visitors (Vi)
3. Outside of Enclosure (Ot)
4. Other bear (OB)
5. None (NN)

VII. CONCURRENT ACTIVITIES
1. Locomotion (Locom)
2. Licking Air (Lk)
3. Sniffing (Snf)
4. Biting (Bit)
5. Vocalization (Vo) (may be animal specific)
6. Marking (Mk)
7. Eating/Drinking (Eat)
8. Defecating/ Urinating (Df)
9. Grooming (Gr)
10. Pacing (Pc)
11. Stereotypy (St) (if other than pacing)
12. Manipulating Object (MO)
13. Mating (MA)
14. Pause (Pa)
15. Dig (Dig)
16. Other (O)
17. None (NN)

APPENDIX C

BEHAVIORAL DEFINITIONS

Crowd- Amount of visitors at the given enclosure during each recording.

Location- area where the bear is located

Position- orientation of bear in the environment

1. Sitting (Si)- butt and hind legs on floor while in an upright position

4. Lying Down (LD)- at least part of back on ground (that does not meet sitting)

5. Rearing (Re)- Standing upright on hind legs

4. Climbing (Cb)- locomotion or standing with at least three paws on an object other than the ground.
5. Standing (Sd)- at least three paws on ground in upright position

6. Out of Sight (OS)- Bear cannot be seen (no other codes necessary)

Sleeping- sitting or lying, no movement, no attention (if sleeping, no further codes necessary)

Interaction- any contact or manipulation with objects listed

Attention- focusing or interaction with any of those listed

Concurrent Activities-

1. Locomotion (Locom)- directional, non-repetitive movement

2. Licking Air (Lk)- sticking tongue out without contact to an object

3. Sniffing (Snf)- nose to the ground with no eating, or nose breaking the horizontal plane

4. Biting (Bit)- moving jaw up and down without any ingestion

5. Vocalization (Vo)- an audible noise emitted from the animal being observed.

6. Marking (Ma)- rubbing of neck or head on object located within the enclosure two or more times continuously.

7. Eating/Drinking (Eat)- mouth contact with an edible object

8. Defecating/ Urinating (Df)- voiding

9. Grooming (Gr)- licking or scratching-contacting body with paw or mouth

10. Pacing (Pc)- Repetitive moving pattern on land. Must occur 2 or more times with no more than 2s pause in between.

11. Stereotypy (St)- Repetitive moving pattern that does meet pacing criteria, must occur 2 or more times with no more than 2s pause in between.

12. Manipulating Object (MO)- any body contact with a non-edible object

13. Pause (Pa)- maintaining a position without movement for at least 2s

14. Dig (Dig)- repetitive paw contact with ground or manipulative object

15. Other (O)- any behavior that does not fit an above definition.

16. Out of Sight- bears activity cannot be seen.

17. None (NN)- animal is not emitting any visible behavior that has been defined.

APPENDIX D

DATA COLLECTION SHEET

Observer_____
Bear: **BOTH/FEMALE/MALE**
Temp_____

Date/Time_____
Enrichment_____
Current Conditions_____

Crowd	Time	Location	Sleeping	Position	Interaction	Attention	Activities
	0						
	15						
	30						
	45						
	0						
	15						
	30						
	45						
	0						
	15						
	30						
	45						
	0						
	15						
	30						
	45						
	0						
	15						
	30						
	45						

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