ENVIRONMENTAL CONTROL OF PACING IN COUGARS

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Pacing, a common form of stereotypy in captive animals, poses challenges for animal welfare and conservation initiatives. The current study used a comprehensive measurement system to investigate the impact of introducing a food-related activity on the daily patterns of multiple behaviors, including stereotypic pacing, in two zoo-housed cougars. The results showed that, while the intervention did not mitigate pacing overall, it did cause a shift in the cougars' routines. This demonstrated the significant influence of keeper behavior on the animals. Furthermore, the differing effects on each cougar’s behaviors underscored the necessity for individualized interventions tailored to the specific needs of animals.

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INTRODUCTION

Zoos serve as educational and interactive spaces where visitors can observe and engage with animals from diverse native habitats worldwide. They offer entertainment and meaningful learning opportunities for individuals of all ages. Additionally, zoos actively contribute to the conservation of endangered species through fundraising efforts and reintroduction initiatives. As such, these zoological facilities are an invaluable resource to visitors and animals alike.

However, when animals live in captivity it is not uncommon for them to exhibit stereotypic behaviors. These have been defined as repetitive, invariant behaviors that lack obvious function and can occur over extended periods of time, often to the detriment of the animal's welfare (Mason et al., 2007). Among these behaviors, pacing is a commonly seen behavior within zoo settings, particularly in carnivores (Breton & Barrot, 2014; Burgener et al., 2008; Cless et al., 2015; Clubb & Mason, 2007; Fernandez, 2021; Kroshko et al., 2016; Nevill & Friend, 2006; Ross, 2006; Tallo-Parra et al., 2023). Pacing is a specific form of stereotypy that involves walking or running back and forth in a repetitive manner. Pacing is often considered an indicator of stress (Cless et al., 2015; Clubb & Mason, 2007; Mason et al., 2007; Sheperdson et al., 2013; Vaz et al., 2017), suggesting that animals may be experiencing suboptimal conditions or a lack of environmental stimulation. Furthermore, these behaviors are thought to ultimately serve as unsuccessful coping mechanisms (Burgener et al., 2008).

In addition to the welfare implications, stereotypic pacing can impact public perceptions of zoos and their conservation efforts. Miller (2012) found that zoo visitors who observed a tiger pacing perceived the level of care for that animal to be lower when compared to visitors who observed a sleeping tiger, and this affected visitors' support of zoos. In a review of stereotypy in zoos, Godinez & Fernandez (2019) described how visitors who acknowledged a jaguar's behavior as stereotypic rated their zoo experience, the exhibit quality, and the animal's well-being as lower than those who did not describe the behavior as stereotypic. Thus, finding effective strategies to reduce pacing and minimize environmental shortcomings is crucial for improving animal well-being, ensuring a positive visitor experience, and supporting zoo conservation initiatives.

Recent studies have challenged the notion that stereotypic behaviors are solely caused by innate biological compulsions or automatic reinforcement. Instead, research has shown that pacing and other stereotypies can be modified through changes in animal management procedures. Coleman & Mair (2010) used positive reinforcement training to decrease stereotypic behavior in rhesus macaques. Fernandez (2021) explored how different feeding schedules impacted stereotypic behavior in polar bears and found that some schedules reduced stereotypies and increased overall activity. Furthermore, Kalafut (2009) was able to alter the patterns of stereotypic behavior for black bears by changing their feeding times via remote controlled feeding boxes. These findings indicate a functional relationship between an animal's stereotypic behaviors and their environment.

Researchers have also investigated the impact of some other environmental factors on pacing to gain a better understanding of their role in the development and maintenance of stereotypic behaviors. These include visitor levels (Vidal et al., 2016), visitor proximity (Miller et al., 2019), noise intensity (Maia et al., 2012), and the relative natural range sizes of the animals (Breton & Barrot, 2014; Kroshko et al., 2016).

Identifying specific potential causes and associations of stereotypic behaviors has led to the design of various interventions. Ross (2006) saw a significant decrease in stereotypic behavior and an increase in species-typical behavior in a pair of captive polar bears after providing them with open access to indoor areas. Nevill and Friend (2006) implemented exercise routines for circus tigers and saw no significant effect on their pacing. Skibiel et al. (2007) explored the impact of different enrichment items on 14 felids from six species, resulting in a reduction of time spent pacing. Burgener et al. (2008) found the use of electronic feeding boxes did not reduce spacing or fecal glucocorticoid levels in two snow leopards. While these treatments have demonstrated varying degrees of effectiveness, none have fully eliminated stereotypic behaviors in their participants. Further investigation is still needed to better comprehend the underlying factors involved. These studies often focus primarily on the specific behavior of interest, which may limit the broader understanding of the complex interactions involved. Therefore, a more holistic approach is required.

Additionally, the data collection system used in this study was adapted from the Time-Sample Behavioral Checklist (Paul, 1987) and the captive animal activity tracking system (Kalafut, 2009). Paul's comprehensive assessment system employed an instantaneous time-sampling method standardized over 19 years of research and development. Paul's system offered an efficient tool for healthcare staff to assess the welfare of mental health patients. By utilizing multiple categories to monitor patients' behavior over time, this information was utilized to create personalized treatment packages for each individual. Kalafut’s (2009) captive animal activity tracking system was the first to adapt Paul’s methods to the zoological setting. She used her system to monitor the effects of a treatment plan on the behavior of zoo-housed black bears.

The present study used a similar comprehensive data system to measure the daily behavior patterns of two zoo-housed cougars (*Puma concolor*), Ed and Al, to examine potential environmental factors influencing stereotypic pacing. In collaboration with zoo staff, this information was used to develop an intervention procedure that altered the daily routines of the cougars and keepers during a daily zoo event. The objective of this study was to investigate the impact of introducing a food-related activity on the overall daily patterns of multiple behaviors, including stereotypic pacing.

METHODS

Participants

The participants of this study were two male 8-year-old cougars (*Puma concolor*), Ed and Al, housed together at a zoo in Texas. These cougars were found in California as orphaned cubs of the same litter. Soon thereafter in 2013, they were relocated to Texas and have been at the zoo since that time. Ed was a healthy male adult cougar weighing approximately 60 kilograms with distinctive white spots marking his fur along his spine. The zoo staff reported that these markings appeared on Ed after he underwent surgery years ago. Al is a healthy adult male cougar weighing approximately 55 kilograms.

Setting

The cougar exhibit measured 757 square feet and was enclosed by chain link fencing and netting at the top. The enclosure included a shallow pool of water, a wooden panel overhang, a log, an elevated grassy area, a ledge along the perimeter of the elevated parts of the enclosure, trees, and dirt. There was a walkway for visitors that wrapped around part of the exhibit. The walkway was about three feet from the cougar's fence line and was separated by a waist-high fence. The experimenter collected data from the public walkway where the entire enclosure could be seen.

Materials

Data was collected using data sheets, a pencil, a clipboard, a Gymboss Interval Timer and Stopwatch®, and an iPhone XR for occasional video recording. Data was collated and graphed using Microsoft Excel software on a MacBook Air.

Measurement

There were five behaviors for which data were collected: pacing, locomotion, vocalizing, sleeping, and panting. These behaviors were not all mutually exclusive; thus, multiple activities could be coded within one observation. For example, the animal being observed could be panting and pacing at the same time. Both of those behaviors would be reflected in the data collection for that observation interval.

Pacing was recorded when the animal walked back and forth successively along the lower fence line directly in front of the public walkway. Pacing did not occur along the upper fence line. This behavior must have occurred two or more times with no more than a 3-second pause in between instances.

Locomotion was recorded when the animal moved from one location to another. This included movements such as walking, running, lunging, pouncing, jumping, and climbing. This definition excluded repetitive, stereotypic movement, such as pacing, as defined above.

Vocalization was recorded when an audible noise was emitted by the animal being observed. These vocalizations included hissing, spitting, growling, yowling, and mewing.

Sleeping was recorded when the animal was lying down with its eyes closed and not engaging in concurrent behavior. For example, if the selected cougar had their eyes closed but was panting, panting but not sleeping would be recorded.

Panting was recorded when the animal was breathing with quick breaths through an open mouth. A cougar could be in any body posture while exhibiting this behavior but this behavior never cooccurred with sleeping. It could, however, happen with other behaviors such as locomotion, pacing, or vocalizing.

Data were collected during multiple observations throughout the day. Each observation lasted for 20 minutes and consisted of 60 intervals. Each interval was 20 seconds. The initial observation always occurred within the first hour of the zoo opening. Observations occurred approximately every hour after the initial observation and until the zoo closed. The zoo's hours shifted depending on the season. As a result, the number of observations that occurred per day varied from six to eight.

Just before each observation, observers collected information on variables such as the date, ambient temperature, weather conditions, enrichment items available to the cougars, and any other notable remarks about the cougars provided by the keepers (e.g., recent procedures or injuries).

I used a momentary time sample recording system to collect data during observations. To begin an observation, the observer recorded the time of day and then started an interval timer set for 60 intervals of 20 seconds each. At the onset of an interval, the observer located the animal of interest and watched the selected animal for two seconds. To ensure accuracy in differentiating between predefined behaviors, the observer closely monitored each animal's behavior between the intervals. Any of the predefined behaviors that occurred only within the two seconds were recorded. After 20 seconds had passed, the interval timer would make a sound to indicate the start of a new interval. During the next interval, the observer would record the behaviors of the other cougar in the enclosure in the same way. The observer alternated between the two cougars throughout the observation. This process was repeated until all sixty intervals were completed.

Data were collected intermittently from May 2022 to March 2023. Data for the initial baseline phase was collected for seven days, on May 29, May 31, June 2, June 7, June 9, July 7, and July 10. Additional baseline data were collected for seven days, July 17, July 19, July 21, July 26, August 2, August 4, and November 6. Data for the intervention phase was collected for seven days, on December 1, 4, 6, 8, 11, 14, and 15. Data for the second baseline phase was collected for 6 days, on January 15, February 12, February 26, March 17, March 19, and March 26.

Interobserver Agreement

Before assisting in data collection, observers were familiarized with the behavioral definitions and the corresponding behavior codes. Observers were provided with written definitions and video examples of the cougars performing the defined behaviors. They were asked to review this information and later discussed the definitions with me. The observers were then brought to the cougar exhibit and practiced the data collection procedure using the data collection sheets.

Reliability was calculated by dividing the number of agreements by the number of agreements plus disagreements. Reliability data were collected for all observations conducted on February 26, March 19, and March 26. Interobserver agreement was 88% for 12% of total intervals.

Procedures

This study used an ABA single-subject reversal design to test the effect of the behavior intervention plan on the cougars' behavior.

During baseline, the cougars were observed under regular conditions. For five days each week and while still in their indoor holding area, both cougars received husbandry training sessions with their morning meal just before they were given access to their public exhibit. During the training sessions, the keepers trained behaviors such as stationing, holding, and rearing during husbandry training. On the remaining two days, the cougars did not receive a husbandry training session. They were fed their morning meal and given access to the public exhibit.

The cougars were shifted from their indoor holding area onto their public-facing habitat when the zoo opened. The zoo's opening and closing times varied depending on the season and day of the week. From March to June, the zoo was open from 10AM to 5PM on weekdays and from 10AM to 6PM on Saturdays and Sundays. In July and August, the zoo was open from 9AM to 4PM on weekdays and from 9AM to 5PM on Saturdays and Sundays. In September and October, the zoo was open from 10AM to 5PM on weekdays and from 10AM to 6PM on Saturdays and Sundays. From November until March, the zoo was open from 10AM to 4PM on all days of the week.

Each cougar was provided with an enrichment item each day. These items were placed in the public exhibit each morning before they were given access to the exhibit. Examples of these items include plastic tires, boomer balls, ice blocks, Saurus Eggs, Weeble toys, Tipsy Toms, and Rocky Lou mirror toys. The enrichment items were cycled so that they do not receive the same items in succession. Furthermore, while in holding the cougars had enrichment items separate from the enrichment items they received while on exhibit.

Each day at 2:30 PM, the keepers were available to the public for Keeper Chats. During this time, there was at least one keeper and one interpretive specialist standing nearby the cougars' habitat to offer information and answer questions that individuals may have about the animals in the Mountains and Desert, Texas Wild exhibit. Keeper Chats occurred at the same time each day, regardless of opening and closing times.

When the zoo closed, the cougars were given access to their private holding area. The cougars traveled through chutes from one location to another. The chute doors were manually opened and closed by the keepers from behind the public-facing exhibit. When the cougars were in the holding area, they were provided with their evening meal. The cougars' diets were approved by the zoo veterinary nutrition staff and consisted of ground raw meats, chunk meat, and a selection of fish.

Following the collection of preliminary baseline data, I collaborated with zoo staff to develop a suitable intervention. The data revealed a typical pattern of behavior for the cougars in which they would be active for part of the morning, inactive midday, and then an increase in activity in the afternoon after keeper chats, before being let in for the evening. Stereotypic pacing was observed particularly from Ed in the afternoon after keeper chats. This pattern of behavior was orderly across seasons, open/closing time shifts, and days of the week. Various intervention strategies were suggested during the meeting with zoo staff. Ultimately, an intervention was created that was practical for the zoo staff and potentially beneficial for the cougars.

The first step of the intervention involved training both cougars to recognize a recall-shift cue (bike horn). The observer did not begin data collection for the intervention phase until the cougars reliably responded to the cue. The recall cue would occur in conjunction with the keeper chats at 2:30 pm when keepers and interpreters would ordinarily already be present nearby. Upon hearing the horn, the cougars would travel through the chutes into their stalls for a feeding and/or training session. The training session involved practicing the same behaviors that the cougars were already familiar with from their morning training sessions (i.e., stationing, holding, and rearing). For the successful performance of these behaviors, the cougars were provided with a food item, a mixture of blood and other liquids left over from their daily meat diet. At the time of this training session, an interpreter staff member was present at the cougar exhibit to explain why the cougars were temporarily off-exhibit. After the 2:30 pm training session, the cougars were once again given access to the public exhibit. Then, around 3:15 a keeper would spray a scent (various perfumes) into the habitat to provide olfactory stimulation and enrichment for the cougars.

At the conclusion of the observations, the behavior codes were tallied for each cougar and converted into a percentage, derived from the number of occurrences over the number of intervals. For example, if one cougar was sleeping for 6 of the 30 intervals during an observation, his score for sleeping during this observation would be 0.2 or 20%. This is done for each type of predefined behavior.

When the day's observations were completed, the scores for each behavior for each animal were charted on a scatter plot to represent the behavior pattern for that day, with the *y*-axis representing the score (ranging from 0 to 100%) and the *x*-axis representing time. For comparisons of one behavior over multiple days, the corresponding score lines were extracted and stacked into their own graph.

RESULTS

Figure 1 displays the patterns of pacing over the time of day for Ed during all the phases of the experiment. In these graphs and all graphs to follow, the *x*-axis represents the time of day from 9:00 am until 6:00 pm, the outer limits of the zoo hours across seasons. The *y*-axis represents the percentage of intervals in which the behavior occurred during an observation period. The black arrow in the graph represents the time that the keeper chats began. In the intervention graph, this arrow also signifies when the intervention took place. Each line on the graph corresponds to a specific day shown in the legend and represents the occurrence of behaviors during the multiple observation periods each day.

During Baselines 1 and 2 (top two graphs), Ed began pacing just after he entered the exhibit on most days. On days he entered the exhibit before 10 AM, higher percentages of pacing were observed. From about 11:00 AM until about 2:30, Ed stopped pacing to rest. He then resumed pacing sometime after 2:30 PM and continued until he was brought into holding for the evening when the zoo closed (4:00 PM, 5:00 PM, or 6:00 PM). On May 31, both cougars entered the exhibit at 10:56 AM, after the first observation had concluded. Thus, there was no opportunity to observe at that time.

During intervention (third graph from the top), Ed began pacing just after entering the exhibit and then again before leaving the exhibit, much like in Baseline Phases 1 and 2. However, in this phase afternoon pacing began earlier than in the initial baseline phases, starting between 1:30 PM to 2:00 PM. Pacing would then continue until Ed was brought in for the evening at 4:00 PM. On December 1 and 15, Ed paced through the period of resting that was seen in Baseline Phases 1 and 2.

During Baseline 3 (bottom graph), Ed began pacing just after he entered the exhibit on January 15 and March 26. Then he rested and resumed pacing sometime between about 2:00 PM and 5:30 PM. Here, the onset time of afternoon pacing widens in comparison to the intervention phase. He continued to pace until he was brought in for the evening. On February 26, pacing occurred for 0% of intervals. On March 17, Ed was out of sight until 12:00 PM, so there was no pacing to record prior to that time.

Figure 2 displays the patterns of pacing over the time of day for Al during all the phases of the experiment. During Baselines 1 and 2 (top two graphs), Al began pacing in the morning on June 2, July 21, August 2, and August 4. On days he entered the exhibit before 10 AM, higher percentages of pacing were observed. From about 11:00 AM until about 2:30, Al stopped pacing. He then resumed pacing sometime after 2:30 PM and typically continued until he was brought into holding for the evening when the zoo closed (4:00 PM, 5:00 PM, or 6:00 PM). On May 31, both cougars entered the exhibit at 10:56 AM, after the first observation had concluded. Thus, there was no opportunity to observe at that time.

During intervention (third graph from the top), Al often paced in the morning but stopped by midday between 12:00 PM and 1:00 PM. Then pacing resumed just before he was brought in for the evening at 4:00 PM.

During Baseline 3 (bottom graph), Al often paced in the morning but then around 1:00 PM, pacing stopped. Al resumed pacing around 3:00 PM on March 26 only. He continued to pace until the zoo closed. On February 12 Al was out of sight until 11:00 AM and on March 17 he was out of sight until 12:00 PM, so there was no opportunity to observe prior to those times.

Figure 3 displays the patterns of locomotion over the time of day for Ed during all the phases of the experiment. During Baseline 1 and 2 (top two graphs), Ed began locomoting just after he entered the exhibit on most days. Then, Ed's locomotion typically began to decrease until it reached a low point around 11:30 AM. Locomotion then began to increase again around 2:00 PM to 3:00 PM, typically reaching a peak before he was brought in for the evening. On November 6, there was a spike in the occurrence of locomotion around 1:30 PM but it returned to typical levels after this.

During intervention (third graph from the top), Ed often began locomoting after entering the exhibit, much like in Baselines 1 and 2. However, the occurrence of locomotion remained at an elevated level throughout the day when compared to Baselines 1 and 2.

During Baseline 3 (bottom graph), the pattern of locomotion is much like Baseline 1. Ed typically began locomoting after entering the exhibit, then it decreases around 11:30 AM to 12:30 PM. Locomotion began to increase again around 2:00 PM and it continued until Ed returned to holding when the zoo closed.

Figure 4 displays the patterns of locomotion over the time of day for Al during all the phases of the experiment. During Baselines 1 and 2 (top two graphs), Al often began locomoting just after he entered the exhibit. Then, Al's locomotion typically began to decrease until it reached a low point around 10:30 AM to 11:30 AM. Locomotion then began to increase again just after 2:30 PM, typically reaching a peak before he was brought in for the evening. On July 21, there was a spike in the occurrence of locomotion around 11:30 AM but it returned to 0% for the rest of the day.

During intervention (third graph from the top), Al often began locomoting after entering the exhibit, much like in baseline 1 and 2. Locomotion then decreased around 11:30 AM. However, the occurrence of locomotion remained slightly elevated throughout the day when compared to Baselines 1 and 2. Furthermore, locomotion began to increase again around 2:00 PM, earlier than in Baselines 1 and 2. Locomotion then increased until it reached a peak just before the zoo closed.

During Baseline 3 (bottom graph), Al typically began locomoting after entering the exhibit, then it decreased around 11:30 AM to 12:30 PM. Locomotion began to increase again typically after 2:30 PM and it continued until Al returned to holding when the zoo closed. However, on March 17, levels of locomotion remained elevated throughout the day when compared to other days. On February 12 Al was out of sight until 11:00 AM and on March 17 he was out of sight until 12:00 PM, so there was no opportunity to observe prior to those times.

Figure 5 displays the patterns of vocalization over the time of day for Ed during all the phases of the experiment. During Baselines 1 and 2 (top two graphs), vocalizations in the morning were infrequent, only occurring on three days. From 11:30 AM to about 2:30 PM, there were no vocalizations recorded. Vocalizations were more frequent in the afternoon after 3:30 PM and remained elevated until Ed returned to holding when the zoo closed.

During intervention (third graph from the top), vocalizations in the morning were still infrequent, occurring in two of seven days. Like in Baselines 1 and 2, vocalizations decreased to 0% around 11:30 AM. However, the occurrence of vocalization began earlier (around 1:00 PM) and remained at an elevated level throughout the rest of the day when compared to Baselines 1 and 2.

During Baseline 3 (bottom graph), the pattern of vocalization is much like Baseline 1. There was no vocalization in the morning through midday. Vocalization began to increase again after 2:30 PM and continued until Ed returned to holding when the zoo closed.

Figure 6 displays the patterns of vocalization over the time of day for Al during all the phases of the experiment. During Baselines 1 and 2 (top two graphs), vocalizations in the morning were infrequent and only occurred on three days. From 11:30 AM to about 2:30 PM, there were no vocalizations recorded. Vocalizations were more frequent in the afternoon after 3:30 PM and remained elevated until Al returned to holding when the zoo closed.

During intervention (third graph from the top), vocalizations in the morning were still infrequent, occurring in three of seven days. Like in Baselines 1 and 2, vocalizations decreased to 0% around 11:30 AM. However, the occurrence of vocalization began earlier (around 2:00 PM) and remained at an elevated level throughout the rest of the day.

During Baseline 3 (bottom graph), there was minimal vocalization in the morning through midday. Vocalization began to increase again after 2:00 PM to 3:00 PM and continued until Al returned to holding when the zoo closed. On February 12 Al was out of sight until 11:00 AM and on March 17 he was out of sight until 12:00 PM, so there was no opportunity to observe prior to those times.

Figure 7 displays the patterns of sleep over the time of day for Ed during all the phases of the experiment. During Baseline 1 (top graph), Ed typically began sleeping around 11:30 AM. Then, sleeping reached its highest point around 12:30 PM to 1:30 PM. Sleeping typically returned to 0% by 3:30 PM. On July 10, there were two peaks in sleeping (12:30 PM and again at 3:30 PM), with a low occurrence of sleeping in between the two periods.

During Baseline 2 (second graph from the top), Ed typically began sleeping around 10:30 AM. Then, sleeping reached its highest point around 11:30 AM to 12:30 PM. Sleeping typically returned to 0% by 3:30 PM. On July 17, there were three peaks in sleeping, at 10:30 AM, 12:30 PM, and 2:30 PM.

During intervention (third graph from the top), Ed began sleeping around 11 AM. Then, sleeping reached its highest point around 12:00 PM to 12:30 PM. This time, sleeping typically returned to 0% by 2:30 PM, an hour earlier than in Baselines 1 and 2. On December 6, there were two peaks in sleeping (11:30 PM and again at 1:30 PM), with a 0% occurrence of sleeping in between the two periods.

During Baseline 3 (bottom graph), Ed typically began sleeping around 11:30 AM. Then, sleeping reached its highest point around 12:30 PM. Sleeping typically returned to 0% between 3:30 PM and 4:30 PM.

Figure 8 displays the patterns of sleep over the time of day for Al during all the phases of the experiment. During Baselines 1 and 2(top two graphs), Al typically began sleeping between 10:30 AM and 11:00 AM. Then, sleeping increased until peaked around 12:30 PM to 2:00 PM. Sleeping typically returned to 0% by 4:30 PM. However, On July 21, Al began sleeping in the morning, then sleeping fell to 0% at 11:30 AM, but he was sleeping again at 12:30 PM.

During intervention (third graph from the top), Al began sleeping around 11 AM on most days but on December 1 and December 8, he did not begin sleeping until after 12:30 PM. Then, sleeping reached its highest points around 11:30 AM and 1:30 PM. This time, sleeping typically returned to 0% by 2:30 PM, an hour earlier than in Baselines 1 and 2. On December 6, Al began sleeping in the morning, then sleeping fell to 0% around 12:30 PM, but he was sleeping again at 1:30 PM.

During Baseline 3 (bottom graph), Al typically began sleeping around 11:30 AM. Then, sleeping reached its highest point between 12:30 PM and 1:30 PM. Sleeping typically returned to 0% between 3:30 PM and 4:00 PM, which is much more like what was observed in Baselines 1 and 2. However, on March 19, sleeping did not fall to 0% until after 5:30 PM, just before the zoo closed. On February 12 Al was out of sight until 11:00 AM and on March 17 he was out of sight until 12:00 PM, so there was no opportunity to observe prior to those times.

Figure 9 displays the patterns of panting over the time of day for Ed during all the phases of the experiment. During Baselines 1 and 2 (top two graphs), Ed began panting just after he entered the exhibit on most days. Then, Ed’s panting typically began to decrease until it reached its lowest point around 11:30 AM to 12:30 PM. Panting then began to increase again around 12:00 PM to 1:00 PM, typically reaching a peak during the hour just before he was brought in for the evening. On May 31, both cougars entered the exhibit after the first observation had concluded so there was no opportunity to observe at that time.

During intervention (third graph from the top), like in Baselines 1 and 2 panting began just after he entered the exhibit on most days. Panting typically stopped completely around 11:30 AM. Panting then began to increase again between 1:00 PM to 2:00 PM and would continue until it peaked before Ed was brought in at 4:00 PM. However, on December 6 and December 15, there was a spike in panting around 12:30 PM that dipped by 1:30 PM and peaked again around 4:00 PM.

During Baseline 3 (bottom graph), Ed began panting just after he entered the exhibit on

January 15, February 26, and March 26. He stopped panting around noon to rest. Then, panting resumed in the mid-afternoon and continued until he was brought in for the evening. The onset time of afternoon pacing in Baseline 3 widens in comparison to the intervention phase. On March 17, Ed was not let onto the exhibit until 12:00 PM, so there was no panting to record prior to that time.

Figure 10 displays the patterns of panting over the time of day for Al during all the phases of the experiment. During Baselines 1 and 2 (top two graphs), Al began panting just after he entered the exhibit on most days. On days he entered the exhibit before 10 AM, higher percentages of panting were observed. Then, Al's panting typically began to decrease until it reached a low point around 11:30 AM. Panting then began to increase again between 1:300 PM and 3:00 PM, reaching a peak just before the zoo closed. On May 31, both cougars entered the exhibit after the first observation had concluded so there was no opportunity to observe at that time.

During intervention (third graph from the top), like in Baselines 1 and 2 panting occurred in the morning after Al entered the exhibit. Then panting reached a low point around 11:30 AM. Al's panting began to increase again after 2:00 PM and would continue until it peaked around 4:00 PM when the zoo closed. However, on December 6 and December 8, there was a spike in panting around 12:30 PM and 1:30 PM respectively. Panting then decreased and peaked again around 4:00 PM for those days.

During Baseline 3 (bottom graph), Al often began panting in the morning after he entered the exhibit. He stopped panting by 12:30 PM. Then, panting usually resumed after 2:30 PM and continued until the zoo closed. On February 12 Al was out of sight until 11:00 AM and on March 17 he was out of sight until 12:00 PM, so there was no opportunity to observe prior to those times. Furthermore, on March 17 panting continues throughout the day without decreasing to 0% like the other days in Baseline 3.

Figure 11 displays the time that Ed was out of sight during all the phases of the experiment. During Baselines 1 and 2(top two graphs), Ed was rarely out of sight. A cougar was out of sight when they were not on the exhibit. On May 29, he was out of sight for 3% of the last observation of the day. On July 26, he was out of sight for 17% of the first observation. During the intervention (third graph from the top), Ed was out of sight for part of the morning on December 1(7%) and December 11 (67%). Then he was out of sight during the training sessions, which took place in the holding area and only lasted 5 to 10 minutes. After they reentered the exhibit and remained there until the zoo closed. During Baseline 3 (bottom graph), Ed was out of sight for 100% of the first two observation periods on March 17, 40% of the first observation on January 15, and 7% of the last observation on March 19.

Figure 12 displays the time that Al was out of sight during all the phases of the experiment. During Baselines 1 and 2(top two graphs), Al was rarely out of sight. On May 29, he was out of sight for 3% of the last observation of the day. On July 21, he was out of sight for 3% of the first observation. During the intervention (third graph from the top), Al was out of sight for part of the morning on December 1(3%) and December 11 (53%). Then he was out of sight during the training sessions, which took place in the holding area and only lasted 5 to 10 minutes. After they reentered the exhibit and remained there, in sight until the zoo closed. During Baseline 3 (bottom graph), Ed was out of sight for 100% of the first two observation periods on March 17, 100% of the first observation on February 12, 10% of the first observation on January 15, 1% of the first observation on February 26, and 7% of the last observation on March 19.

Figure 13 displays the average occurrence of the five target behaviors and the average occurrence of an animal was out-of-sight during all the phases of the experiment for Ed (top) and Al(bottom). In the graphs displayed, the *x*-axis lists the behaviors of interest, and the *y*-axis represents the percentage of intervals when the behavior occurred. For each behavior, there are four bars that represent the four phases of the experiment: Baseline 1, Baseline 2, intervention, and Baseline 3.

For Ed, pacing ranged from 10% of intervals to 16% during initial Baseline Phases 1 and 2. In the intervention phase, it increased to 22% and then reduced to 16% for Baseline 3. During initial Baseline Phases 1 and 2, panting ranged from 59% of intervals to 64%. In the intervention phase, it decreased to 26% and then decreased further to 24% in Baseline 3. During initial Baselines 1 and 2, locomotion ranged from 4% of intervals to 8%. In the intervention phase, it increased to 13% and then decreased to 10% in Baseline 3. During initial Baseline Phases 1 and 2, sleep ranged from 14% of intervals to 18%. In the intervention phase, it remained at 14% and then occurred at 18% in Baseline 3. During initial Baseline Phases 1 and 2, vocalization ranged from 1% of intervals to 2%. In the intervention phase, it increased to 6% and then returned to 2% in Baseline 3. During initial Baseline Phases 1 and 2, out-of-sight occurred in 0% of intervals. In the intervention phase, it increased to 6% and remained at 6% during Baseline 3.

For Al, pacing ranged from 2% of intervals to 3% during initial Baseline Phases 1 and 2. In the intervention phase, it remained at 3% and then occurred at 4% in Baseline 3. During initial Baseline Phases 1 and 2, panting ranged from 31% of intervals to 32%. In the intervention phase, it decreased to 16% and then increased to 27% in Baseline 3. During initial Baselines 1 and 2, locomotion ranged from 6% of intervals to 11%. In the intervention phase, it increased to 18% and then increased again to 20% in Baseline 3. During initial Baseline Phases 1 and 2, sleep ranged from 35% of intervals to 37%. In the intervention phase, it decreased to 20% and then increased to 30% in Baseline 3. During initial Baseline Phases 1 and 2, vocalization ranged from 0% of intervals to 4%. In the intervention phase, it occurred at 2% and then remained at 2% in Baseline 3. During initial Baseline Phases 1 and 2, out-of-sight occurred in 0% of intervals. In the intervention phase, it increased to 4% and then occurred at 8% in Baseline 3.

DISCUSSION

Despite the variance in the zoo's seasonal schedule, the cougars' behavior adjusted with the changes and revealed an orderly pattern during baseline. It was common to observe the cougars being active in the morning, followed by a period of inactivity, and then active again from the end of keeper chats until the zoo's closing time. During the intervention, the cougars' routines shifted. They continued to be active in the morning, but their period of midday inactivity was shortened, and their afternoon activity began earlier. When the intervention was withdrawn, this pattern ultimately reverted to what was seen in baseline conditions.

Although the cougars followed the same routines, the intervention affected their behaviors in different ways. With the treatment, Ed's pacing increased and shifted in time, beginning earlier in the day. For Al, pacing was generally unaffected by the intervention. However, Al's locomotion was affected similarly to Ed's pacing, increasing overall during treatment and comparably shifting in time. It is likely that Al's locomotion often served the same function as pacing for Ed, but it was not recorded as the same behavior due to the topographical definition and measurement methods used in this study. The definition of pacing stipulated that a cougar must traverse back and forth at least twice along the public fence line, but Al tended to walk along larger areas of the exhibit and avoid the fence line where Ed was pacing. It is possible that Al was pacing over a greater distance in the exhibit, but due to the alternating intervals used during data collection, the observer was unable to verify by continually tracking his movements. This could account for some of the individual differences seen in the data for these behaviors.

From baseline to intervention, the data reflected an overall increase in vocalizations from Ed and a shift in the patterns of vocalizations for both cougars. This behavior was typically observed concurrently with pacing and locomotion. Like pacing and locomotion, the onset of vocalizations shifted from after keeper chats in baseline to before the chats during treatment. The increase in vocalizations during the intervention and its covariation with pacing and locomotion suggests that vocalizations were part of the same response class.

The sleep schedules of both cougars were also affected by the intervention. During baseline, the cougars typically slept from about 11 AM until after the keeper chats, especially on days when the cougars entered the exhibit later in the morning. During the intervention, both cougars experienced truncated sleeping periods compared to the baseline. They still began sleeping around 11 AM but finished sleeping before the keeper chats, when alternative activities became available. The intervention did not significantly impact Ed's sleep overall, but Al experienced a significant decrease in sleep. This outcome implies the keepers' actions are important for the cougars since they adjust their behavior according to the keepers' behavior.

Unlike pacing, locomotion, and vocalization, the daily patterns of panting did not show a shift in time from baseline to treatment conditions. This suggests that panting may not have been part of the response class that was affected by the keepers' behavior. However, overall levels of panting appeared to decrease for both cougars during the intervention phase. While the decrease in panting during the intervention phase may imply a positive outcome for both cougars, it is important to consider the underlying factors. Felines typically pant due to overexertion, stress, illness, or heat. It is improbable that panting resulted from illness or overexertion in this study. The cougars were monitored by on-site veterinary staff and rarely exhibited behaviors that might require considerable amounts of energy. Outdoor temperatures likely played the most significant role in the variation of panting levels between baseline and intervention. Baseline measures were taken during the summer months when temperatures sometimes reached over 105 degrees Fahrenheit, while the intervention occurred in the winter with cooler temperatures. The decrease in panting during the intervention can be attributed to these temperature differences.

The cougars' behavior showed a clear correlation with keeper behavior, specifically with the keeper chats. The results showed that the chats were predictors of the subsequent major activity in the cougars' schedules (moving indoors and being fed) and function as cues for a class of behaviors including pacing, locomotion, and vocalizations. During baseline, the cougars regularly exhibited these behaviors after the keeper chats and until the zoo closed, whereas during treatment, they started demonstrating the behaviors before the keeper chats. This reverted back to baseline levels when the intervention was withdrawn. The intervention had a significant impact on the cougars' routine, shifting their normal behavior patterns in time. When the keepers introduced a new activity involving a food item, the cougars' behaviors adjusted accordingly. This demonstrated that the cougars' behaviors, including stereotypic pacing, were influenced by socially mediated contingencies and underscored the significant influence of the keepers' behavior on the cougars' behaviors (see also Dorey et al., 2009; Morris & Slocum, 2019).

The keepers also played an important role in the collaborative creation of the treatment plan. Through our initial analysis of behavior patterns, we were able to develop an intervention together that sought to address the needs of the cougars, keepers, observers, researcher, and administration. Despite our efforts, the treatment did not prove successful in mitigating stereotypic pacing. However, this process yielded valuable insights and emphasized the importance of exploring alternative solutions to address the situation more effectively. One possibility could be to modify the times of the keeper chats and compare animal behaviors before and after changes in keeper behaviors. This could provide additional information about the impact of keeper schedules on the cougars' behaviors. Another avenue of exploration could involve investigating the effects of implementing a feeding system contingent on naturalistic behaviors. Furthermore, offering the cougars choice and control over their environment, such as through open access to indoor enclosures or other areas, may prove beneficial in reducing stereotypies. By pursuing these alternative solutions, we can gain deeper insights into the relationship between food delivery and stereotypic behaviors, ultimately improving the welfare of animals in human care. In addition to these solutions, an alternative perspective involves shifting the focus toward desired animal behaviors, implementing training programs, and creating environments conducive to fostering those behaviors (Goldiamond, 1974).

The multiple effects on behavior illustrate how changes to the environment of zoo animals can have effects that extend beyond our behavior of focus. To get a full picture of the intended and unintended effects of an intervention, researchers must measure broadly to monitor for behavioral byproducts that might be problematic for the organism’s welfare when implementing plans that target certain behaviors. By adapting the Time-Sample Behavioral Checklist (Paul, 1987; see also Kalafut, 2009), we were able to identify these patterns of behavior and analyze the effects of the treatment across the behavior chain, rather than focusing on one behavior in isolation. This information aided in identifying environmental cues and informing interventions by predicting when the cougars would exhibit stereotypic behaviors. Additionally, the distinct effects observed in Ed and Al's behaviors during the intervention phase highlight the importance of considering individual differences when implementing interventions for stereotypic behaviors in captive animals. It is crucial to tailor interventions to the specific needs and characteristics of each animal, as what may be effective for one individual might not produce the same results for another. Through this comprehensive and individualized approach, we can promote the well-being of captive animals and enhance our understanding of behavior management in zoological settings.

Figure 1

Patterns of Pacing for Ed

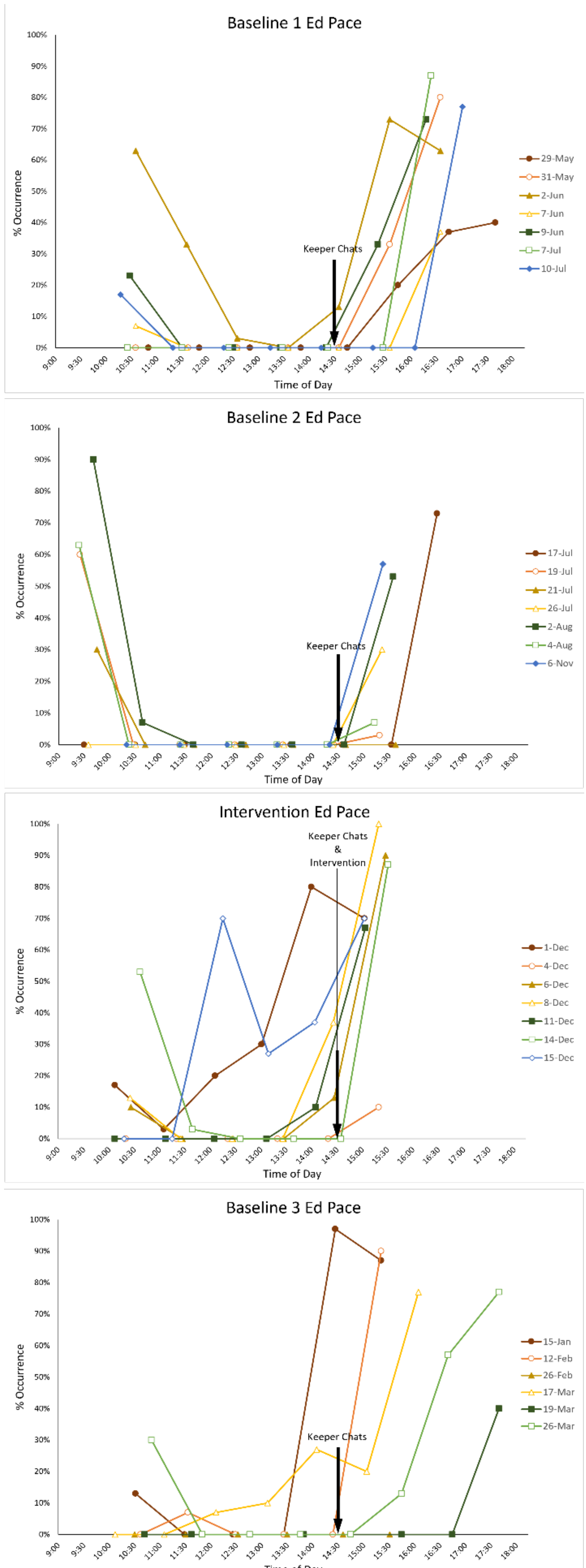


Figure 2

Patterns of Pacing for AI

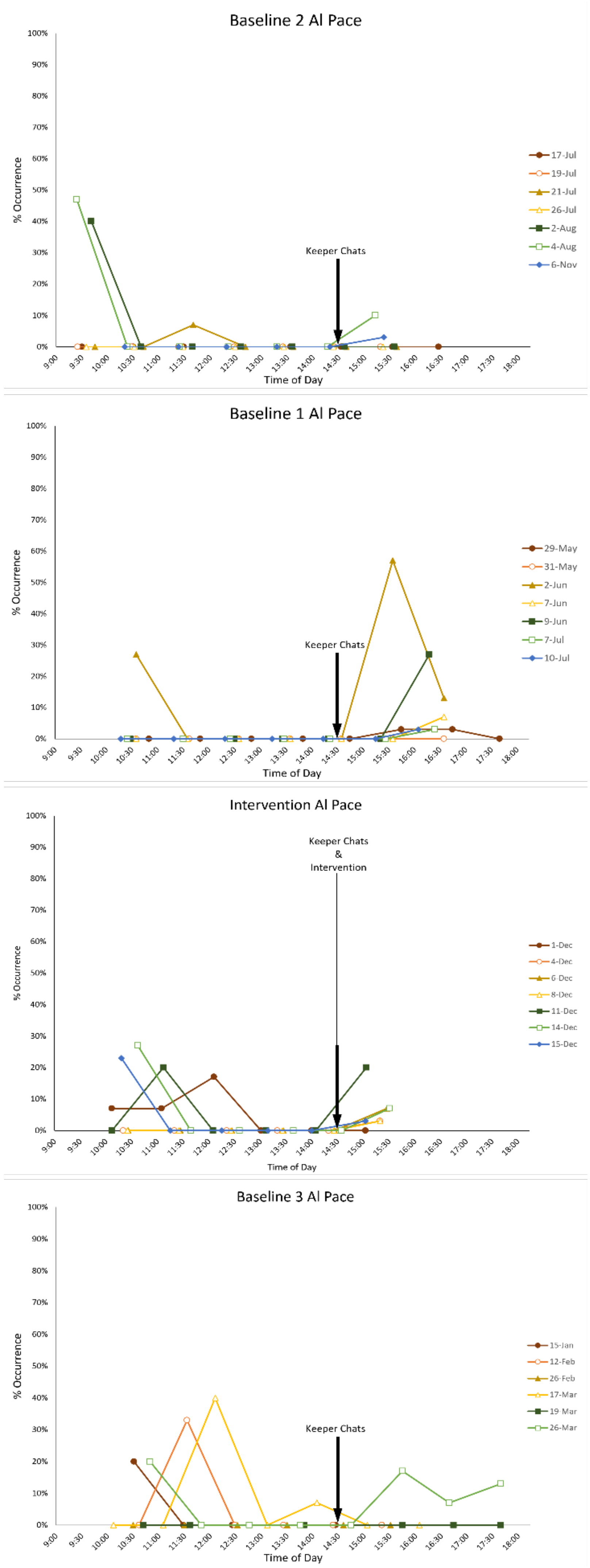


Figure 3

Patterns of Locomotion for Ed

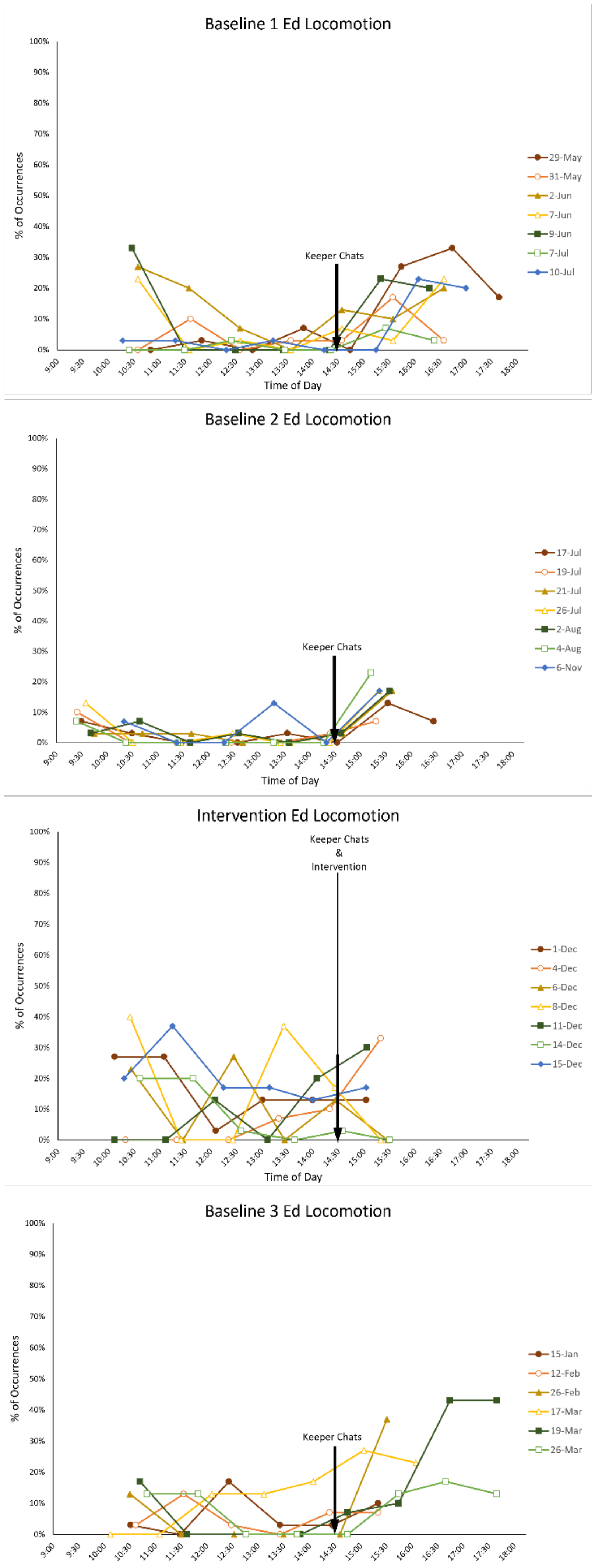


Figure 4

Patterns of Locomotion for Al

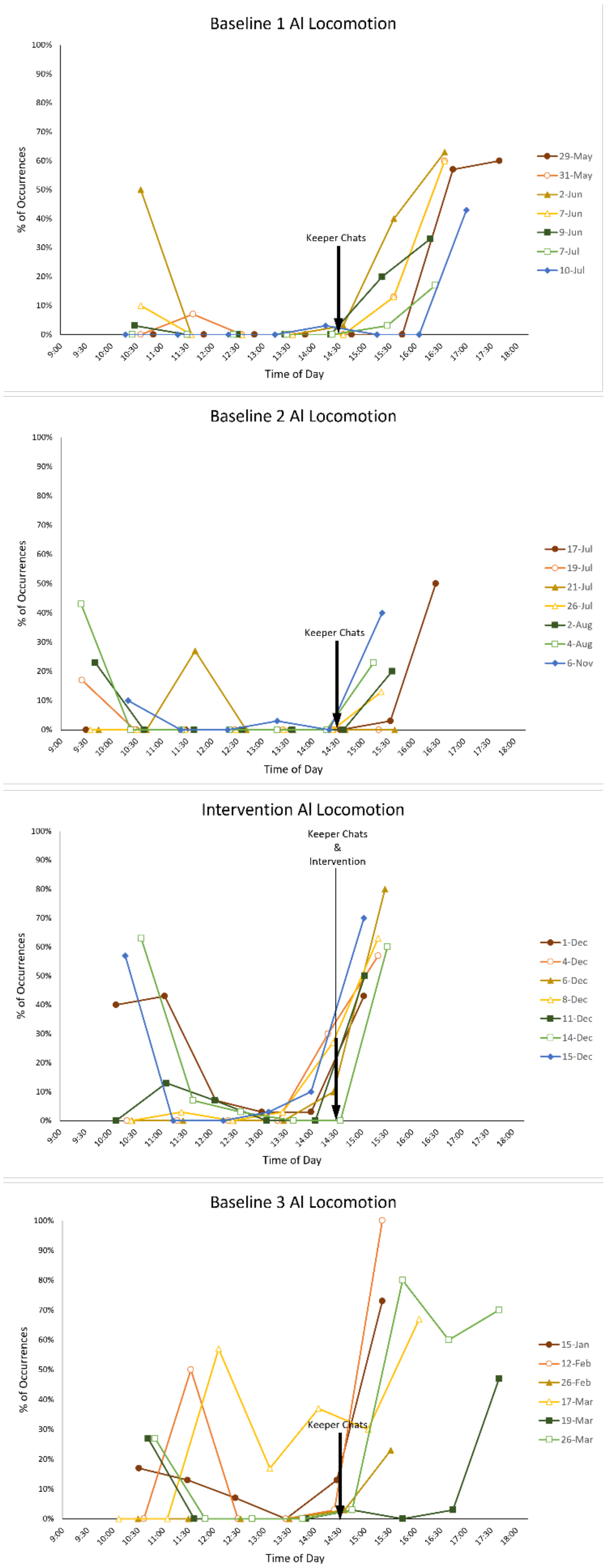


Figure 5

Patterns of Vocalization for Ed

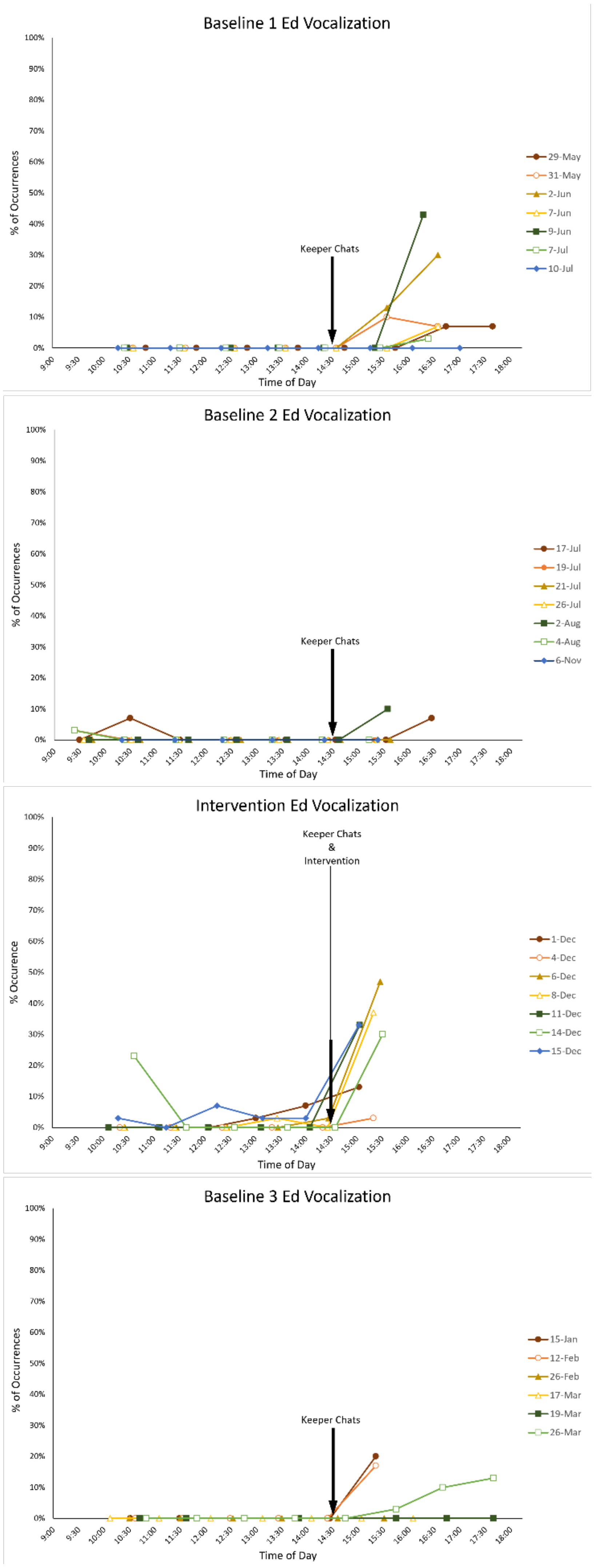


Figure 6

Patterns of Vocalization for Al

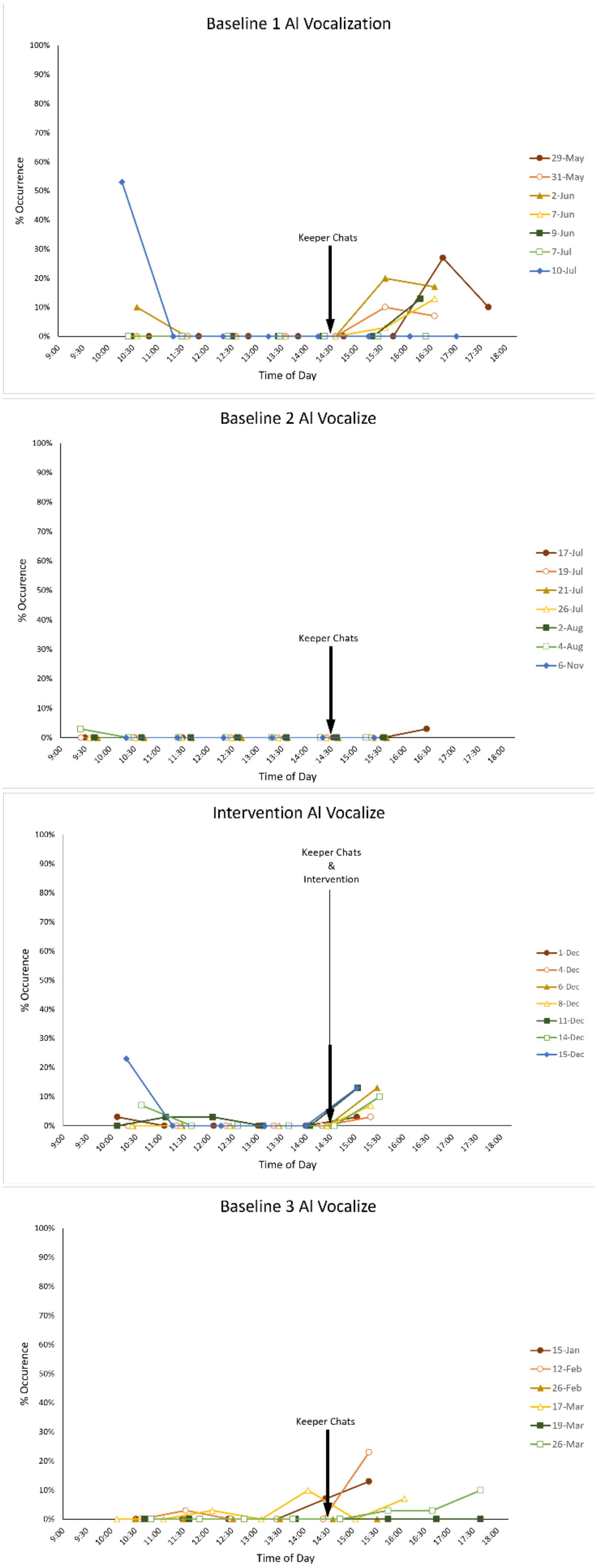


Figure 7

Patterns of Sleep for Ed

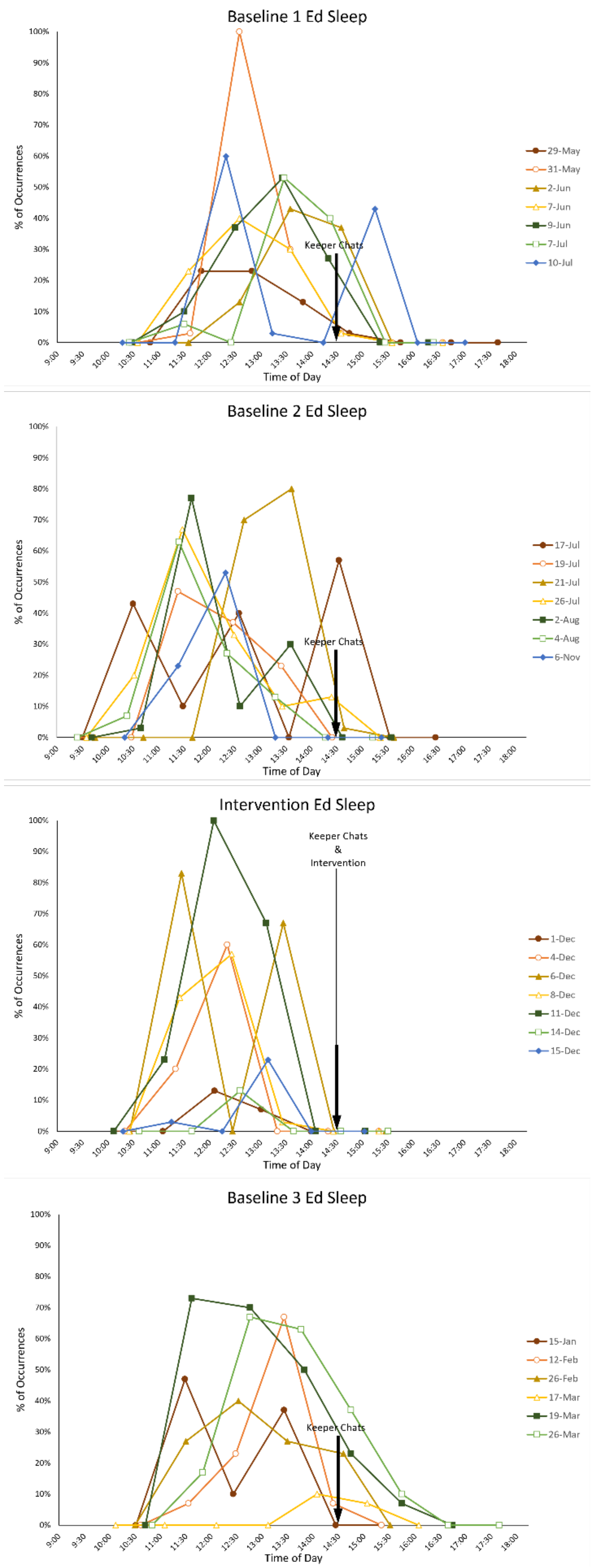


Figure 8

Patterns of Sleep for Al

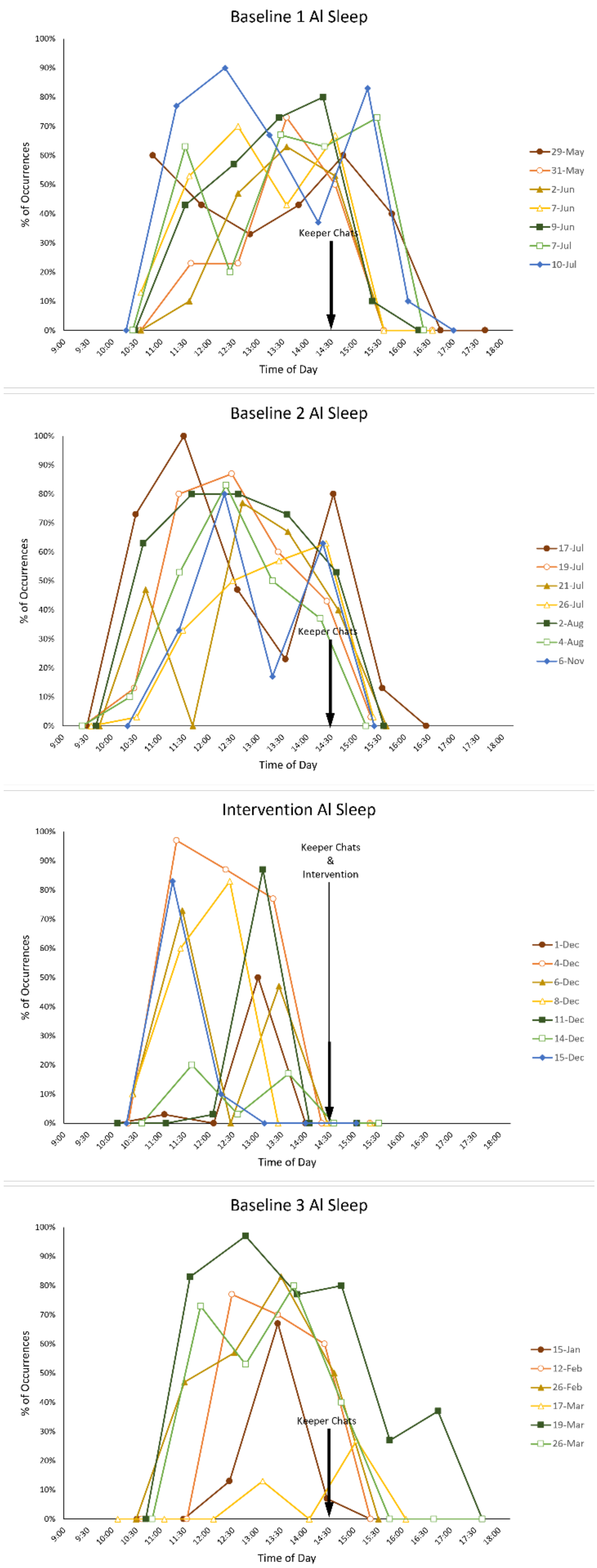


Figure 9

Patterns of Panting for Ed

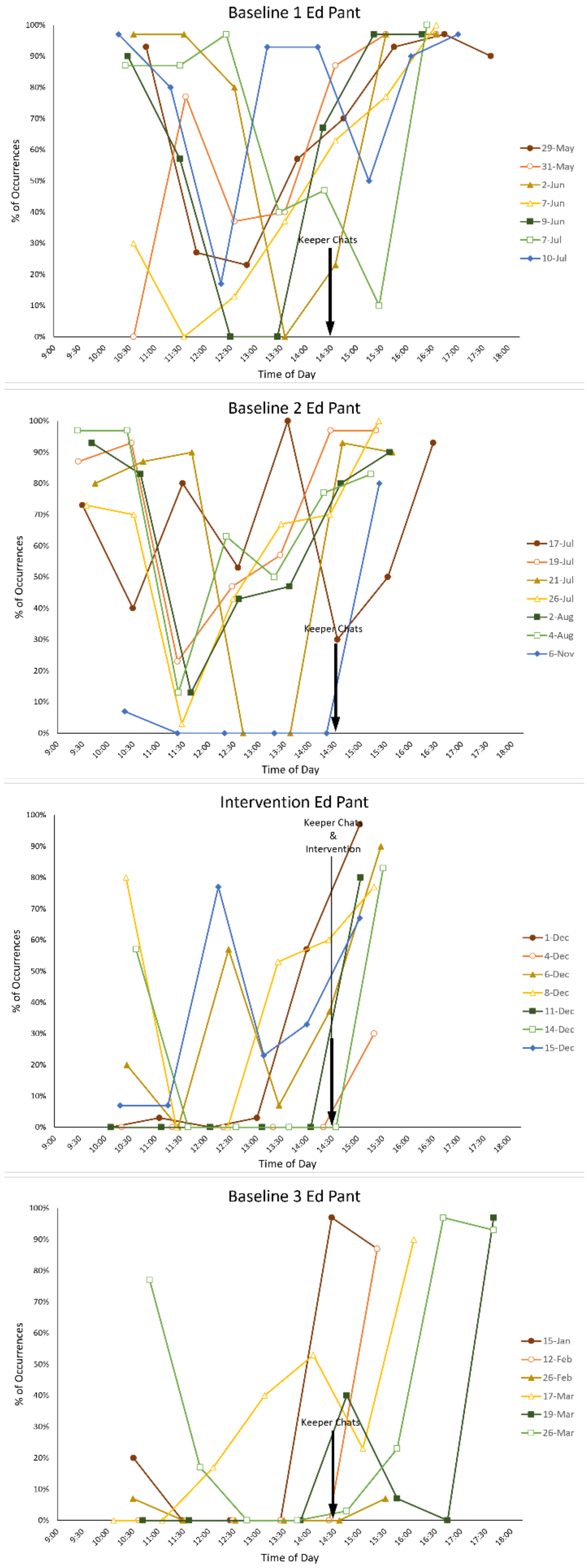


Figure 10

Patterns of Panting for Al

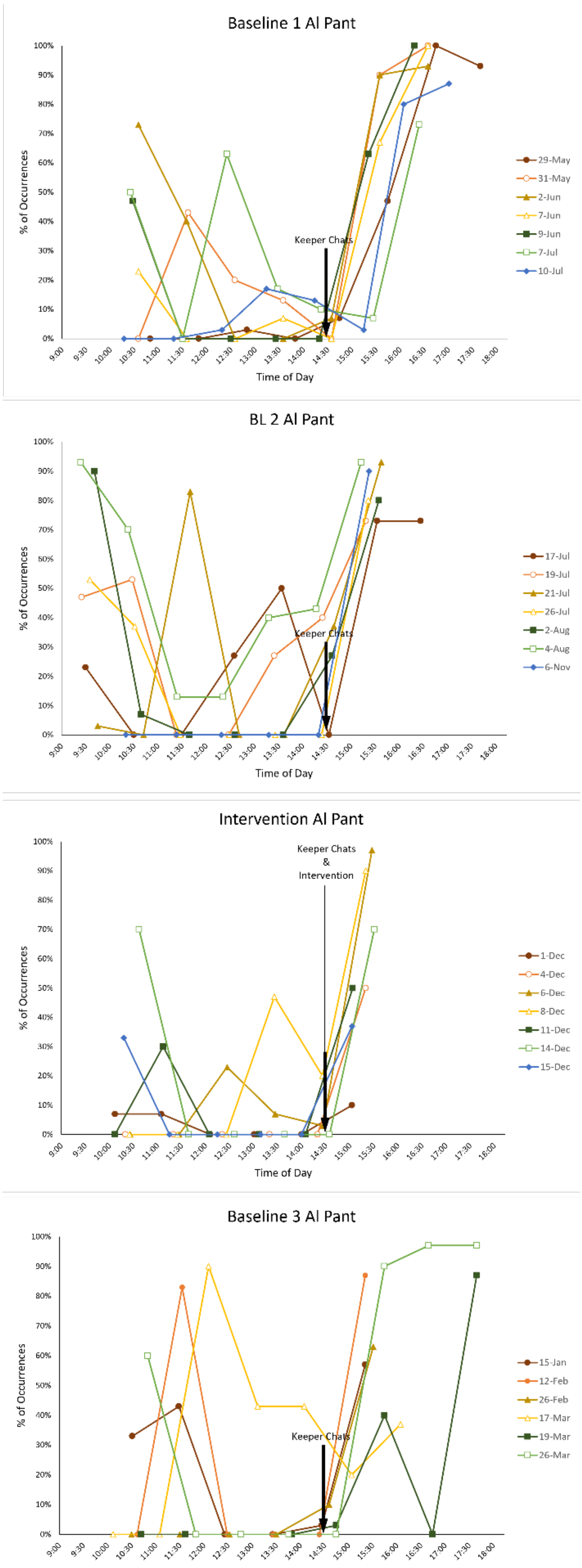


Figure 11

Out-of-Sight for Ed

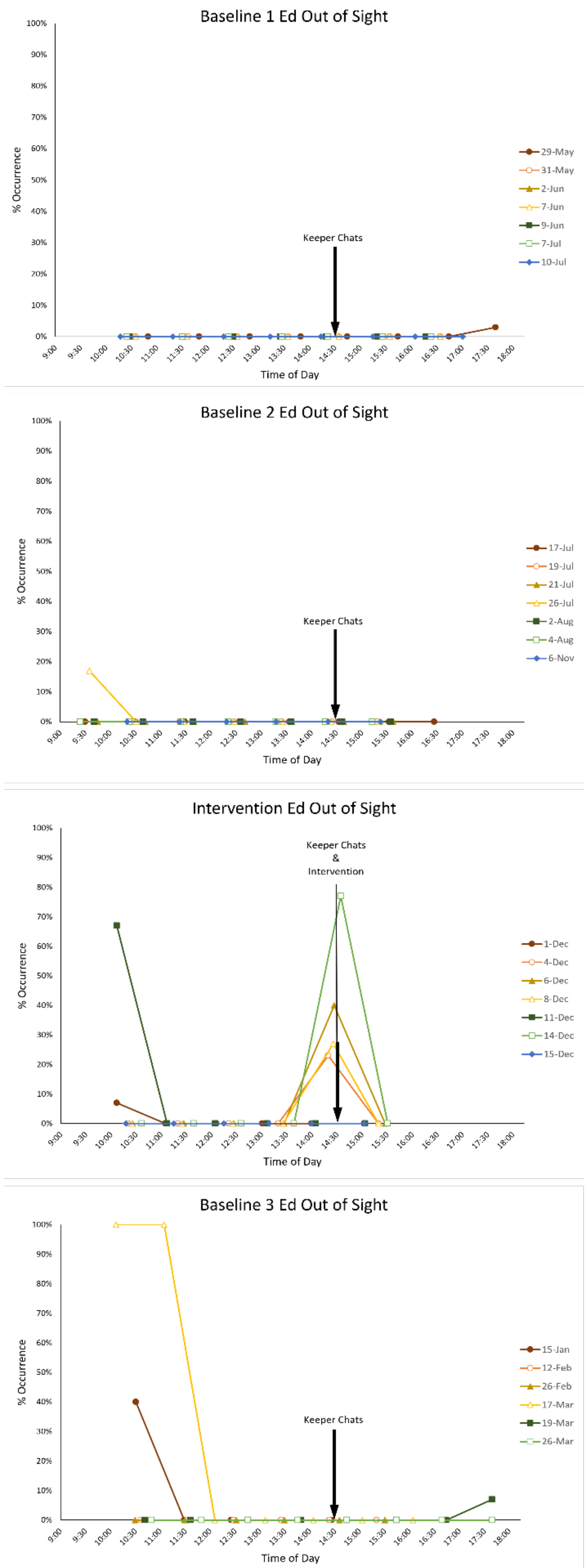


Figure 12

Out-of-Sight for Al

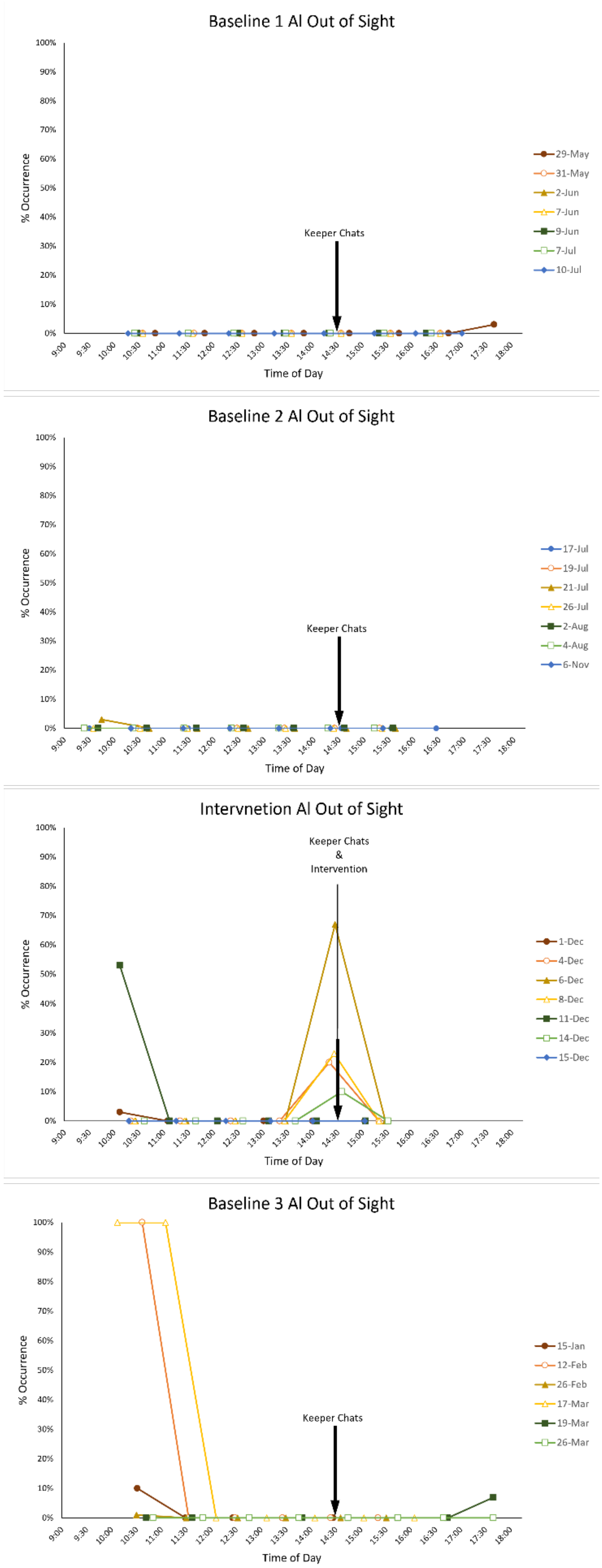
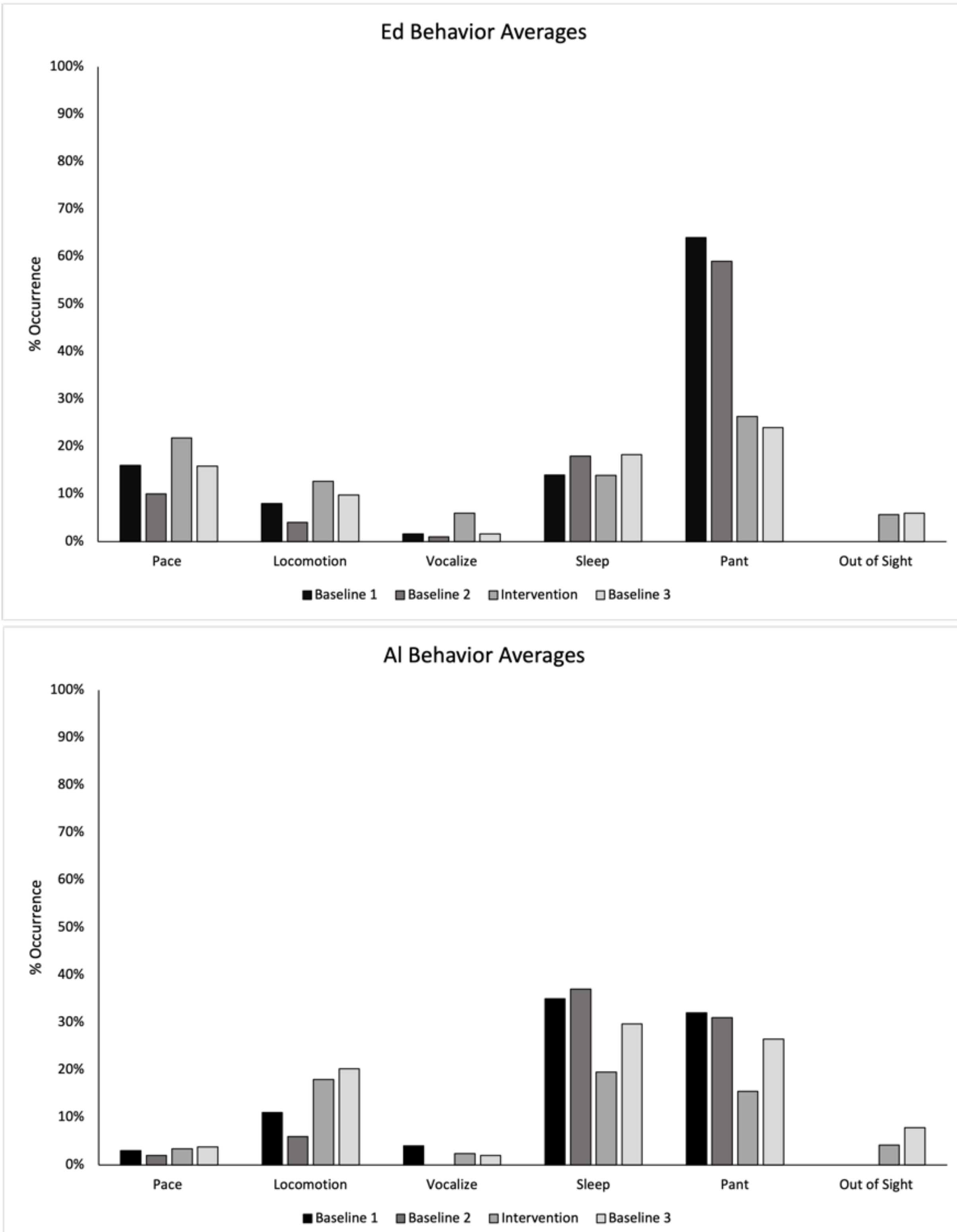


Figure 13

Average Occurrence of Behaviors



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