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# Environmental factors and patterns of behaviour in zoo-housed Sumatran tigers, *Panthera tigris sumatrae*

Kimberley Jayne

*Project Advisor: Phil Gee, School of Psychology, University of Plymouth, Drake Circus, Plymouth, PL4 8AA*

**Abstract**

This study investigated how increased environmental predictability in captivity can impact upon animal behaviour. 'Busyness' was piloted as a method of measuring activity in relation to environmental factors and observations were conducted on the behaviour of 2 zoo-housed Sumatran tigers, *Panthera tigris sumatrae*. Graphical analysis revealed the tigers to show increased Busyness leading up to the time they were taken off-show, possibly indicating anticipation of this event. Both animals displayed stereotyped pacing within specific enclosure sections. The female tiger showed increased pacing leading up to the time she was taken off-show, whereas the male showed the opposite. Suggestions were made to explain differences in behaviour in relation to environmental events and personal history and proposals for future research using Busyness.

*Statement of Ethical Considerations*

Ethical implications must be considered for any study involving animal subjects in order to protect them from physical or psychological distress. Before commencing the study, ethical approval was established by the University of Plymouth School of Psychology and the School of Biological Sciences. This study was carried out in accordance with the British Psychological Society's Ethical Code of Practice and Conduct Guidelines for Psychologists Working with Animals (2007) and the Animals (Scientific Procedures) Act 1986. Ethical approval was also granted by Paignton Zoo Environmental Park where the animals were housed.
This research was purely an observational study of the animal subjects, and none of the data collection involved interaction with the animals in any way by the researchers. The subjects were housed in a zoological park and are therefore accustomed to being observed by the general public on a daily basis. All observations were conducted from public viewing areas of the animal's enclosure and within the Zoos visitor opening hours. In this respect, the researcher's presence at the enclosure was no different from visiting members of the public.

*Statement of Data Collection*

I confirm that I, Kimberley Jayne, partook in collecting data for this project. For the purpose of collecting a sufficient amount of data for analysis, my data was then pooled with that collected by other students.

*Statement of Acknowledgement*

Special thanks to my project supervisor, Phil Gee, and fellow research students involved in this study. Recognition is given to the University of Plymouth Research Apprenticeship Scheme volunteers who also assisted in conducting observations. Finally, thanks to the animal keepers at Paignton Zoo Environmental Park and the research staff of the Whitley Wildlife Field Conservation and Research Department for their kind support with this study.

## Introduction

Within their natural habitats animals are exposed to many rhythms to which they must adapt their behaviour in order to remain in synchrony with their environment. These can range from simple daily feeding patterns, to seasonal adjustments in pelage quality. Such events often occur with a degree of temporal regularity and therefore are vital in coordinating behaviour in daily life. This can have significant adaptive value, for example, light/dark cycles that facilitate feeding patterns can assist carnivores in tracking the temporal regularities of their prey (Mistlberger, 1994). Furthermore, it is essential that the animal is able to predict the environmental change so that a preparatory response occurs at the appropriate time for the organism to maintain optimal coordination within its habitat; for example, behavioural changes must occur in migratory birds so that they can prepare to journey long before the winter weather arrives (Mistlberger & Rusak, 2005).

For animals that live in captivity, such as within a zoo or wildlife park, their environment is often small, uncontrollable and far less complex than their natural habitat, and thus associated with increased predictability (Bassett & Buchanan-Smith, 2007). For the convenience of the animal's carers and the visiting public, animal husbandry is often set to a fixed schedule and events such as feeding often become highly predictable, both temporally and in complexity. Keeping animals within such environments exposes them to unnatural events, and with the absence of appropriate behaviour-eliciting stimuli can affect species-typical behaviour patterns (Markowitz, 1982; Wilson, 1982). For instance, the need for pre-feeding behaviours such as foraging or hunting is eliminated; however the desire to perform these behaviours may persist. Animals that live within a restricted environment may come to anticipate the rhythms of their captive surroundings and this can often be expressed through abnormal behaviour patterns such as stereotypies (these are "...rigidly repeated behaviour patterns with no apparent function or goal", Lyons, Young & Deag, 1997, p. 72) or through behaviours such as food anticipatory activity (characterised by "...increased arousal and activity", Bassett & Buchanan-Smith, 2007, p. 233). Indeed, Poole (1998) suggests that a significant lack of environmental complexity and habituation to an enclosure is one of the main sources of behavioural problems in captive animals.

Current zoological institutions promote themselves as educational resources and are highly significant in species conservation. Abnormal behaviours in zoo animals are unfavourable both in terms of public education and sensitivity, and also in preserving species-typical behaviour. Abnormal behaviours can be considered a significant indicator of reduced welfare and researchers have investigated ways to reduce or eliminate them. This particular piece of research aims to investigate what elements of the captive environment may contribute to the development and maintenance of abnormal behaviours, such as stereotypies and food anticipation, and how they may impact upon psychological welfare. The role of predictability will be discussed and how manipulating its temporal properties can have varying effects upon behaviour. This will be examined in terms of husbandry scheduling and food anticipation, and the inconsistency found between research will be discussed as the motivation for this study. Further factors contributing to environmental predictability will be considered, including the roles of perceived control and enclosure design, and finally the specific aims of this research will be outlined.

Researchers have discussed links between the predictability of environmental events with anticipatory behaviours displayed by some captive animals, particularly with reference to feeding schedules. For example, Wasserman and Cruikshank (1983) found that captive hamadryas baboons, *Papio hamadryas*, would show increased aggressive behaviour during pre-feeding periods. Furthermore, predictable feeding schedules have been linked to stereotypies in some carnivores (Carlstead, 1998). Within a captive environment an animal will be fed according to its carers schedule, however the animals desire to hunt or forage is not reduced (Shepherdson, Carlstead, Mellen & Siedensticker, 1993) and therefore the resulting continually frustrated appetitive foraging or hunting may be expressed as an abnormal behaviour, such as stereotypic pacing (Mason, 1991). Researchers have investigated how varying the predictability of food availability either temporally (to fixed or variable schedules) or in complexity (providing it in a way to encourage foraging) has been shown to affect the presence of such behaviours.

Bloomsmith and Lambeth (1995) illustrated how the temporal predictability of husbandry schedules can impact upon an animal's psychological well being. They conducted a study to determine whether feeding chimpanzees, *Pan troglodytes*, on a predictable schedule was preferable to an unpredictable schedule. They collected observational data on the behaviour of 30 adult chimpanzees during pre-feeding and baseline periods. Results showed that when the animals were fed to a predictable schedule, elevated levels of inactivity and abnormal behaviour were apparent in times leading up to feeding. The researchers state that such behaviour is undesirable because long periods of inactivity can lead to poor health. Furthermore, those animals that were fed on a highly unpredictable schedule exhibited lower rates of inactivity and abnormal behaviour at times prior to feeding. From their results the researchers concluded that feeding schedules that are temporally variable, and therefore unpredictable, promote more species-appropriate behaviours and are therefore beneficial to welfare.

Further studies have investigated how delays to feeding conducted on a temporally predictable schedule can impact negatively upon behaviour in a similar way. Waitt and Buchanan-Smith (2001) investigated whether the anticipatory behaviours present in a group of stump-tailed macaques, *Macaca arctoides*, were favourable to welfare. The researchers compared the animal's behaviours when feeding was carried out on time with when feeding was carried out either earlier or later than scheduled. The results showed that having a predictable schedule had a negative impact upon behaviour in the times when animals were waiting to be fed. During these pre-feeding periods there was a significant increase in rates of self-directed behaviour, inactivity and abnormal behaviour. Moreover, these behaviours were prolonged when feeding was delayed, particularly inactive-alert behaviours. In the times preceding feeding researchers noted "It did appear as if the monkeys were sitting around waiting for their caretakers to arrive" (Waitt & Buchanan-Smith, 2001, p. 82). Waitt and Buchanan-Smith advise that these behaviours may indicate predictable feeding as a significant source of stress for captive primates. They suggest that preferably animal keepers should conduct feeding on an unpredictable schedule. Both the studies of Bloomsmith and Lambeth (1995) and Waitt and Buchanan-Smith (2001) indicate that increased predictability of feeding schedules in captive primates leads to abnormal behaviours and to increased inactivity. Further studies have also shown negative pre-feeding behaviours in pigs (Carlstead, 1986) and in carnivores (Carlstead, 1998) exposed to temporally predictable schedules.

In contrast, some researchers have found that different species appear to show a preference for temporally predictable feeding schedules, as demonstrated in the following study by Ulyan, Burrows, Buzzell, Raghanti, Marcinkiewiez, and Phillips (2006). Behavioural observations and physiological measures were taken of a group of captive brown capuchins, *Cebus apella*, in response to varying the predictability of their feeding schedules. Animals were first exposed to a six week predictable feeding schedule followed by a further six weeks of unpredictable feeding. The researchers found major differences in behaviour during the two phases. In particular when feeding was changed to the unpredictable schedule the animals showed behaviours characteristic of stress and anticipation. During this phase there was an increase in abnormal and self-directed behaviours and the animals were observed to spend less time in proximity to one another, less time engaged in social behaviour and more time inactive. In addition, cortisol concentrations were found to be significantly higher during the unpredictable feeding phase and this was maintained up to the sixth week of feeding. In contrast to the aforementioned studies, behaviours observed during the predictable feeding phase were more positive than when feeding was scheduled unpredictably or delayed. These positive behaviours included spending more time in proximity to one another and increased activity and social behaviour. Overall, both the behavioural and physiological data showed that anticipation of feeding was particularly pronounced when feeding schedules were unpredictable or delayed, and therefore the researchers concluded that predictable feeding schedules may be more favourable to the well-being of captive capuchins.

Furthermore, research has highlighted important factors that can often confound with predictability. For instance, Shepherdson (1989) asserts that a temporally predictable schedule is preferred because it offers the individual security and control and thus reduces stress. The Preparatory Response Hypothesis (Perkins, 1955, 1968; Lockard, 1963) states that given the choice an animal will prefer predictability because it allows them to prepare to interact with the forthcoming event. Therefore, in terms of captive animal management, predictable schedules may be preferable as they encourage food anticipatory behaviours that may promote salivation and aid digestion. In addition, understanding predictability in terms of feeding complexity has also demonstrated how reduced environmental control can affect behaviour. For example, a wide range of stereotypies have been found in animals fed predictable diets and restricted amounts of food (Lyons et al., 1997).

The studies presented thus far illustrate some of the confusing literature that zoo staff may be faced with when deciding the optimal conditions in which to keep their animals. Environmental predictability can be approached in terms of the temporal scheduling of husbandry routines such as feeding. However, this literature is inconsistent in whether fixed or variable feeding schedules are preferred for welfare, and even conflicts in whether the anticipatory behaviours demonstrate increased activity or inactivity. Some of the research indicates that food anticipation may be of beneficial importance to the species involved, alternatively, great variability may exist across the needs of different species. Other studies have also been presented that briefly outline how further factors can influence or confound predictability measures, such as control and feeding provisions.

There are other features of environmental predictability that can influence behaviour and thus potentially affect welfare, for instance, enclosure design and complexity. Compared to a natural habitat, typical zoo enclosures are far from optimal in terms of size and complexity; consequently the animal is faced with increased predictability and reduced control. This can restrict an animal's behavioural repertoire and species-specific behaviour, and encourage abnormal behaviour including stereotypies (Mallapur, Qureshi & Chellam, 2002). Lyons et al., (1997) observe that often enclosure edges are specifically used for pacing by captive felids and this may indicate that such areas form an enforced territorial boundary. Research has been conducted in how improvements to enclosure design and features can influence the presence of these behaviours.

Mallapur et al., (2002) investigated the effect that enclosure design had upon the behaviour and activity of Indian leopards, *Panthera pardus*, and if this contributed to aspects of welfare. They studied the following behaviours in 16 leopards: resting behaviour, activity-related behaviours, and stereotypies. They also recorded the proportion of time the leopards spent in four different enclosure areas (these included the back zone, enrich zone, edge zone, and the other zone) and gathered information on the structural enrichment of these areas. The researchers found that the leopards typically used certain areas within the enclosure to exhibit specific behaviours. All the leopards were found to pace along the edge zone, use the back zone for resting, and the other zone for activity. In addition they found that leopards in structurally enriched exhibits showed higher levels of activity compared to those housed within more barren enclosures. Mallapur et al., (2002) proposed that more a complex enclosure will stimulate the animal to use more space and produce more species-specific behaviours. They suggest that provisioning enclosures with more enriched features will reduce abnormal behaviour patterns and stereotypies and increase positive active and resting behaviours.

Further studies have investigated the relationship between enclosure complexity and behaviour. Lyons et al., (1997) discovered that positive species-typical behaviours were exhibited by captive felids housed in enclosures that contained raised areas and elevated platforms, and that these areas were used more frequently if they provided the animals with a good view. They reported that enclosure edges were typically used for pacing. However, they discovered that although enclosure size did not influence pacing behaviour, enclosure design and management regime were significant factors. This research highlights how it is not purely the physical complexity of enclosures that influences behaviour but that they must also be psychologically enriching. What is more, Kilchenmann (1997) demonstrated that varying the spatial regularities of feeding regime in Mongolian wolves, *Canis lupus chanco*, increased foraging behaviour and use of the whole enclosure. Studies such as these highlight the importance of considering environmental predictability in a more holistic way that can incorporate the enclosure design and complexity with aspects of husbandry scheduling (e.g. food delivery time or style) in order to understand the impacts upon behaviour and welfare.

The following study demonstrates how combining aspects of the enclosure with feeding regime can help to reduce food anticipation and pacing behaviour. Jenny and Schmid (2002) investigated the stereotyped pacing of two zoo-housed Amur tigers, *Panthera tigris altaica*. The researchers considered that if the behaviour was caused by frustrated appetitive foraging then varying aspects of feeding predictability could potentially reduce or eliminate this unwanted behaviour. They introduced several electronically controlled feeding boxes around the animal's enclosure that would provide food throughout the day at semi-random times. This method was intended to reduce food anticipatory behaviours by making feeding less predictable while at the same time providing the tigers with increased control by allowing them opportunities for successful foraging throughout the day. The results showed that both tigers displayed a significant reduction in stereotyped pacing during box-feeding compared to conventional feeding when housed together. This study illustrates the importance in understanding predictability both in terms of its temporal and spatial properties, as well as demonstrating how to incorporate factors such as control to into the animal's environment, thus reducing negative behaviour and improving welfare.

In their species conservation efforts, it is vital that zoos attempt to preserve species-typical behaviour and eliminate abnormal damaging behaviour. Increased predictability in captivity has been linked with negative behaviours and the various environmental factors that may contribute to this have been discussed. However, these factors are often studied in isolation and current research appears to have neglected their collective impact. Therefore, the purpose of this study is to investigate environmental factors, such as the temporal regularity of husbandry events, in combination with enclosure design and usage, in order to determine how they may impact collectively upon behaviour and may be associated with abnormal behaviour.

The current literature is inconsistent in determining a preference for predictability and therefore does not provide zoo staff a solution to manage their animals. An individual's preference is likely to depend on many factors ranging from schedule reliability, the ecological needs of a species, or even interpersonal factors including personality type or how long they have lived in captivity. It is necessary to develop a method that can assist in assessing behaviour on a more individual basis and yet is transferable across many species. For this purpose, a construct has been operationalised as a tool of measuring animal activity in relation to environmental patterns and events. This has been given the term 'Busyness' and can be used either as a measure of an individual animals activity, or of the activity and density of an animals enclosure as a whole. As mentioned previously, stereotypic pacing is a frequent problem in captive carnivores (e.g. Carlstead, 1998). This behaviour can serve both as an outlet for frustrated appetitive foraging as well as an active waiting strategy to an artificially imposed feeding regime (Jenny & Schmid, 2002). Much of literature on anticipatory stereotypies has been laboratory studies of primate behaviour (e.g. Waitt & Buchanan-Smith, 2001). For this study to have increased applied value, the investigation will be conducted on zoo-housed animals and will focus on the behaviour of two Sumatran tigers, *Panthera tigris sumatrae*, to increase the literature on this species.

Observational data will be collected on the behaviour of these animals, alongside Busyness scores and information on environmental events the animals are exposed to, particularly those that may become anticipated. Throughout the study the animals will remain on a fixed husbandry schedule of feeding, cleaning and access. It is expected that such a regime will affect Busyness scores and demonstrate this as a good measure of anticipation, although it is not predicted in what direction this may be for this species. The regularity of such events may also impact upon specific behaviours such as stereotyping or inactive-alert, which may also provide good correlates of Busyness. Furthermore the study will monitor enclosure space activity in order to assess whether this may be related to any behaviour or environmental patterns. Overall, the ultimate intention of this investigation is to pilot Busyness as a tool that will be simple enough for animal caretakers to use with minimal training in order to provide information on indicators of welfare. From this, observations can be related to environmental factors in order to assess if any patterns exist in-line with past research. Consequently, minor changes could be applied that may have a potentially significant impact upon the behaviour and psychological welfare of those animals being observed.

# Method

### Subjects and their enclosure

Two captive bred Sumatran tigers, *Panthera tigris sumatrae*, served as the subjects for this study. Throughout the investigation, adult breeding male (b. 2000 Perth Zoo, Australia) and adult breeding female (b. 2002 Dudley Zoo) were housed together at Paignton Zoo Environmental Park, and had been living in their enclosure for at least 3 years (see Appendix A and Appendix B for profile of male and female respectively). The pair bred 2006 and prior to the study the female tiger was living with her female cub until October 2008 when it was re-housed at another zoo. During this time the male was kept in isolation, and the male and two female tigers were given access on alternate days to on-show areas. The breeding pair was reunited in October 2008.

The tiger enclosure consisted of an on-show paddock and an indoors off-show area. The animal keepers would allow them access to their outdoor paddock in the morning prior to the zoo opening at 10:00 hours. During the day the indoor enclosure was locked and the animals would remain on-show until the advertised time of 16:45 hours when they were locked inside for the night. This was intended to be conducted to a fairly rigid schedule as determined by zoo staff. The animals were housed in separate indoor enclosures and were fed off-show. For the duration of the study, both tigers had equal access to outside enclosure areas at the same times.

The animals were observed only in their outside exhibit. This consisted of paddock area that was on a slight slope (see Appendix C for images of paddock). The enclosure contained various plants and trees, a pond, two elevated platform areas with shelter underneath, and fallen branches with elevated areas for climbing (see Figure 1). One full length of the enclosure contained a pathway where visitors could view the animals through the fencing, a viewing window and a newly built viewing platform that was completed October 2008 (see Appendix D for images of the visitor viewing areas). Observations were conducted from these areas only. The enclosure also overlooked a large pond housing many wetland species, and backed onto an adjacent lion enclosure, as well as the tiger's off-show enclosure building.

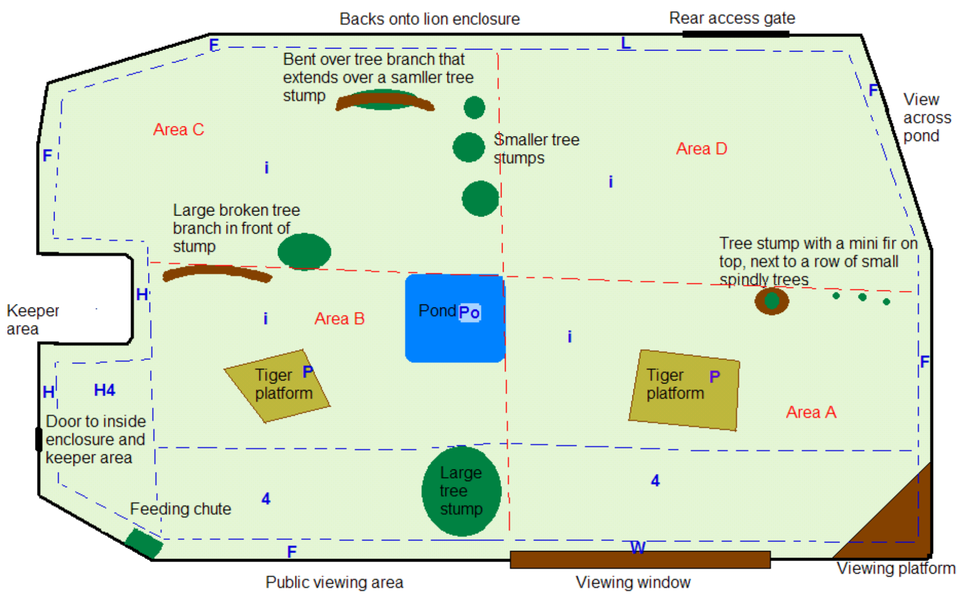


*Figure 1.* Enclosure paddock area with features, areas and sections (not to scale).

**Materials**

Observational data on the animals behaviour was collected for both subjects using a check sheet (see Appendix E). During each observation session, observers would possess a range of reference materials to assist in collecting accurate observations, including: detailed advice on how to record Busyness scores (for tiger examples see Table 1), detailed behaviour categories and definitions (see Appendix F) with separate information on *directed gaze* behaviour, and enclosure maps (as per Figure 1) with perimeter definitions for enclosure areas and sections (see Appendix G). For the purpose of collecting a sufficient quantity of data, several observers were involved in this research. To ensure that all observations were conducted under the same conditions, a set of standardised procedures were designed for all observers to follow (see Appendix H for protocol). Finally, a stopwatch was used to inform of sample intervals, or alternatively a 30 minute long MP3 file was designed that contained a tone at the end of each 1 minute interval to signify the sample point.

**Design and procedure**

This was an observational research study monitoring the behaviour of two zoo-housed tigers. All observations took place at Paignton Zoo Environmental Park on weekdays during visitor opening hours of 10:00-17:00 hours. Observations would commence at the earliest of 10:00 hours and would be conducted for 30 minute sessions, continuing until the tigers were taken off-show at about 16:45 hours.

In order to obtain a sufficient quantity of data, this study involved the assistance of multiple observers, all of which had some previous undergraduate / graduate experience in research procedures. The observers consisted of four primary researchers, involved in designing the study and collecting the majority of data, and four student volunteers participating as part of an extracurricular university activity (the Research Apprenticeship Scheme). All observers were subject to a training period and during this time some observations were also conducted simultaneously to obtain data for inter-observer reliability tests. Inter-observer reliability was also checked midway through the study to avoid observer drift. Following successful training, observers would collect data according to time-slots that were pre-determined by a rota divided into 30 minute observation periods.

During the study the animals were only observed in their outside exhibits from visitor viewing areas. Observers were encouraged to follow the focal tiger they were observing even if it meant moving between viewing locations to provide a better view of behaviour (please note, moving locations did not affect the perception of enclosure boundaries). During the first 5 weeks of observation, the viewing platform was not open to the general public and therefore in order to allow the tigers to adjust to a person on the platform, observations would only be conducted from this area if both tigers were in an area of the enclosure that could not be viewed from the ground and for longer than 5 minutes. Once the platform was open to the public (from December 15, 2008 inclusive), all remaining observations allowed the observer to move freely between visitor viewing areas. If multiple observers were recording for inter-observer reliability measures, they would ensure that they were observing from the same location.

Each observation session was conducted for a 30 minute period using a check sheet that recorded items at 1 minute sample intervals. The focal tiger for the observation minute would alternate at each sample interval but always commencing with the male tiger for minute 1, followed by the female tiger for minute 2, and so on for the duration of the observation period. Before commencing observations, the observer would record information about the observation session on the check sheet, including the *date* and *time* of observation, the weather as *wet/dry* and *warm/cold*, and space was provided to include any *other information* the observer thought might be relevant. During each sample interval, the check sheet would also monitor *crowd size* (as *small*, *medium*, *large*), *crowd noise* (as *quiet*, *medium*, *loud*) and *staff presence* at the enclosure. These items were recorded using a scan-sampling technique (Martin & Bateson, 1993) whereby the observer would record the intensity of the item since the last record at 1 minute intervals.

In order to assess the activity levels of the subjects, the term 'Busyness' was operationalised, intending to measure a combination of animal activity and density. In this study, Busyness was not specific to a focal animal but would record the total activity that could be observed in the tigers outside enclosure area during each sample interval. Busyness was also recorded using a scan-sampling method whereby the observer would record the degree of behaviour observed in the enclosure at the end of each sample interval of 1 minute. This was assessed using a Busyness score rating on a scale of 0 – 5, where zero signifies that no animals are visible for observation, 1 relates to a low Busyness score, and so on up to a maximum Busyness score of 5. However, if for example, only one tiger could be observed for the sample interval, the Busyness score would not include the tiger that could not be seen, thus providing a score for 100% of the visible population of the enclosure. Furthermore, observers were advised that if they were in doubt over which level of Busyness to chose, to record the higher level of activity. Examples of Busyness for the tigers in this study are presented in Table 1.

Table 1. *Busyness definitions and examples for tiger subjects.*

| Busyness | Definition | Tiger activity example | Tiger density example |
|---|---|---|---|
| 0 | Not visible | Not applicable | None visible |
| 1 | Very quiet | Sleeping or inactive alert small | Almost all visible animals |
| 2 | Quiet | Inactive but alert, slow movement, self maintenance | Equal numbers of slow inactive with those active |
| 3 | Moderate | Locomotion, positive social interaction, moderate pacing | Almost all moderately active |
| 4 | Busy | Increased locomotion or pacing | Majority of animals aroused |
| 5 | Very busy | Highly aroused, maximum level of activity | All animals visible highly aroused |

During alternate sample intervals the check sheet would record the individual behaviours of the male and female tigers respectively. The behaviour of the focal animal was recorded using a one-zero time-sampling method (Martin & Bateson, 1993) whereby if the behaviour occurs at all within the sample interval of 1 minute it was noted by ticking the appropriate category once. These behaviours included *sleeping*, *self-maintenance*, *locomotion*, *stereotyped pacing*, *investigating*, *marking*, *feeding*, *enrichment-directed behaviour*, *staff-directed behaviour*, *visitor-directed behaviour*, *agonistic behaviour* and *social activity*. For the categories of *inactive-alert* and *vocalisation* these would be recorded on a one-zero basis by noting the maximum level of the behaviour displayed as either *small*, *medium* or *large* and *quiet, medium* or *loud*, respectively. An *others* category was provided to include any other relevant information that may have affected behaviour for the sample interval or to include any species specific behaviours. If the focal animal could not be viewed for entire sample interval, a *not visible* category was also provided, and the Busyness score for this minute would only include the visible animal. After the first 5 weeks of observation, it was deemed that a further category should be included that incorporated *stop and gaze* behaviour as well as the *direction of gaze*. This item was also recorded on a one-zero basis if the tiger under observation stopped a behaviour in order to look in a particular direction for more than 2 seconds. If the tiger was already *inactive-alert*, *stop and gaze* would only be recorded if the tiger showed a change in behaviour to a higher level of *inactive-alert* and with gaze directed for more than 2 seconds. The *direction of gaze* category would only be noted on the condition that *stop and gaze* had occurred and the *direction of gaze* could be determined towards the following objects or areas: *T* = towards other tiger, *V* = towards visitors, *I* = inside the enclosure towards the centre, *S* = towards staff, *H* = towards the house, *L* = in direction of lake, *Li* = in direction of lion enclosure, *P* = in direction of path.

In addition to the behaviour of the focal animal, data was also recorded regarding their location within the enclosure in order to determine where an animal may spend more time. The animals outside enclosure was divided into four roughly equal areas labelled *A*, *B*, *C*, *D*, see Figure 1. After the first 5 weeks of observation, the enclosure areas were further sub-divided into sections that were thought to be related to behaviours, see Figure 1. These sections included: within 1 meter of the house (*H*), window (*W*), lion enclosure (*L*), fence (*F*), or fence/window areas; within 4 meters of the fence (*4*) or house (*H4*); or underneath the platform (*P*), in the pond (*Po*) or in the centre of the enclosure (*i*). For a detailed explanation of area and section perimeters see Appendix G. Using a scan-sampling technique, at the end of each sample interval the observer would note the area and the section of the enclosure in which the majority of the focal animal was residing on the sample point.

Observations would continue recording at 1 minute intervals for the duration of the 30 minute period. In order to obtain as much coverage of the day, observers would then either have a break or continue observations according to a pre-determined time schedule. An approximate total of 100 hours of observations were collected over an 11 week period between November 17, 2008 to January 30, 2009 (excluding practice sessions) for at least 1 day every week, for a total of 32 days.

## Results

### Inter-observer reliability

To achieve consistency of measurement between observers, inter-rater reliability tests were conducted on *Busyness*, *crowd size* and *crowd noise* as these measures required a subjective judgment of the level at which the they occurred. Other categories that required a judgement of their level, *vocalisation* and *inactive-alert*, did not occur frequently enough to justify a comparison. Data of the principal researchers were compared for observation periods conducted earlier and later in the study, and the student volunteers were compared with one of the principal researchers. In order to perform statistical tests it was necessary to make adjustments to the data where scores did not contain the same values by both observers. This was resolved by adding an additional score to both observers' data if they did not contain the same set of values (see Appendix I for amendments made to raw data).

For early comparisons of Busyness, all observers achieved scores ranging between a minimum of Cohen's kappa = .23 to a maximum of Cohen's kappa = .93. For the later comparisons agreement was between Cohen's kappa = .46 to Cohen's kappa = .88. For crowd size, early comparisons revealed scores above Cohen's kappa = .59, and for later observations were above Cohen's kappa = .84. For crowd noise early comparisons, observers achieved a minimum score of Cohen's kappa = .48 and for later comparisons a minimum score of Cohen's kappa = .67.

To determine which data were used in final analysis for times when more than one observer was recording, preference was given to the observer who consistently achieved higher inter-observer scores or had more hours of research experience.

**Environmental categories and global measures**

*Busyness*

Busyness scores were analysed for the global enclosure. Average Busyness scores for the total observation period of 32 days are presented in Figure 2.

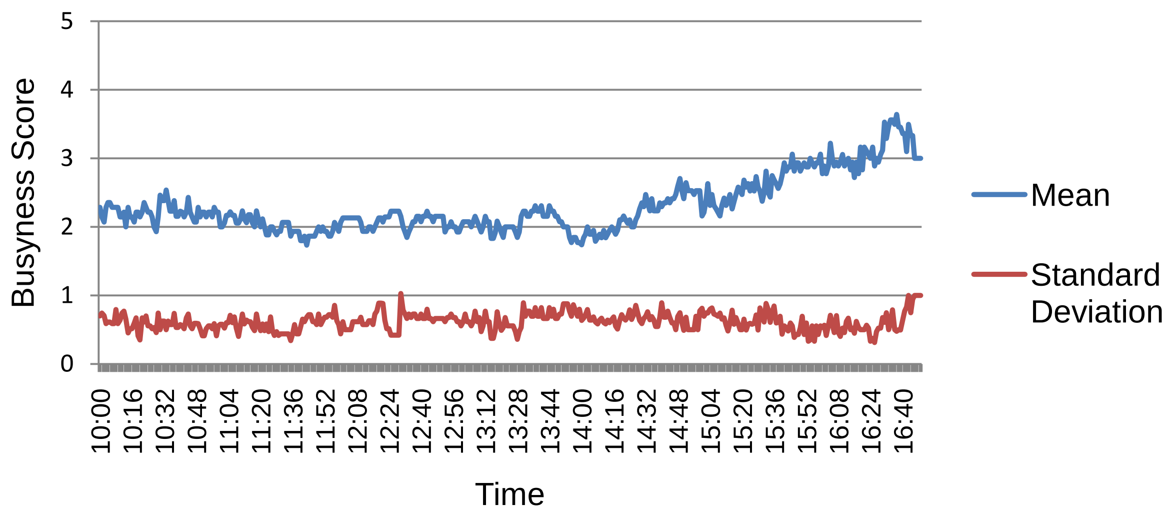


*Figure 2*. Scatterplot of average Busyness scores throughout a day.

The data in Figure 2 show how Busyness levels vary throughout a day for the tigers. Busyness scores remain between levels 1.5 to 2.5 for most of the day up to around 14:30 hours. After this time Busyness scores steadily increase up to their maximum score of around 3.5 at 16:30 hours. The standard deviation for Busyness scores remains fairly consistent throughout the day, although variation is at its highest points around 12:20 hours and after 16:30 hours. These total average Busyness scores have been further broken-down for time periods throughout the day and descriptive statistics for these data are presented in Table 2.

Table 2. *Mean and standard deviation of Busyness scores for time periods throughout a day.*

| Time | *M* | *SD* |
|---|---|---|
| 10:00-12:14 | 2.10 | .10 |
| 12:15-14:29 | 2.04 | .12 |
| 14:30-15:39 | 2.45 | .11 |
| 15:40-16:49 | 3.05 | .17 |

Table 2 further illustrates the total average busyness scores when divided into four time periods throughout the day. This shows that scores are highest in the hour prior to being taken off-show, which is almost 1 score higher than when observations commence in the morning. Busyness is at its lowest during 12:15-14:29 hours. Modal Busyness scores for the entire observation period are presented in Figure 3.

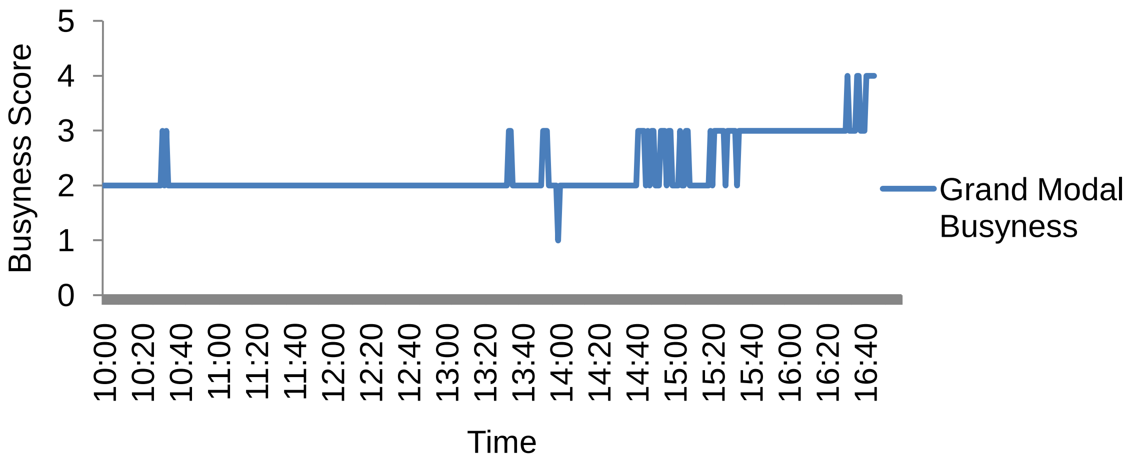


*Figure 3*. Scatterplot of modal Busyness scores throughout a day.

Figure 3 shows that the modal Busyness scores replicate the general pattern of the average Busyness scores graph. Scores generally remain around a Busyness level of 2 up to around 14:30 hours, after which there is an increase up to a Busyness level of 3 up to approximately 16:30. Immediately prior to being taken off show (after 16:30 hours) the scores reach their peak of Busyness level 4.

Average Busyness scores for individual time periods over the 11 weeks of observations have been analysed into the following five time periods: weeks 1 and 2; weeks 3 and 4; weeks 5, 6 and 7 (consisting the Christmas holiday period and when the new platform was open); weeks 8 and 9; and weeks 10 and 11. Graphical analyses of these averages are presented in Figures 4-8.

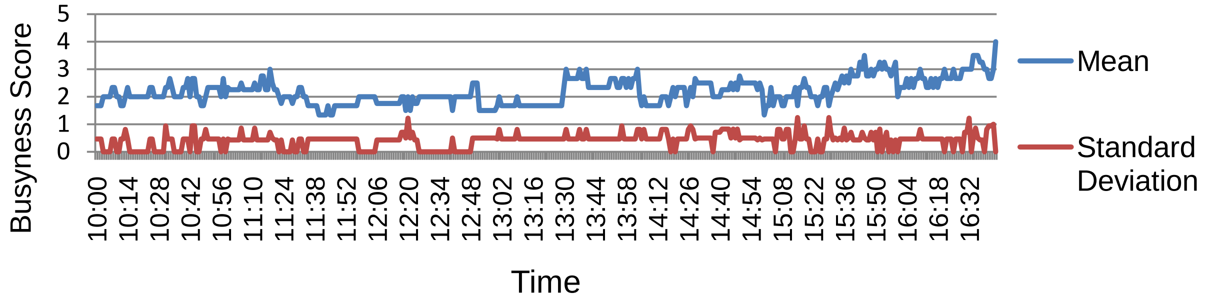


*Figure 4*. Scatterplot of mean and standard deviation Busyness scores throughout a day for weeks 1 and 2 (for a total of 5 days observation).

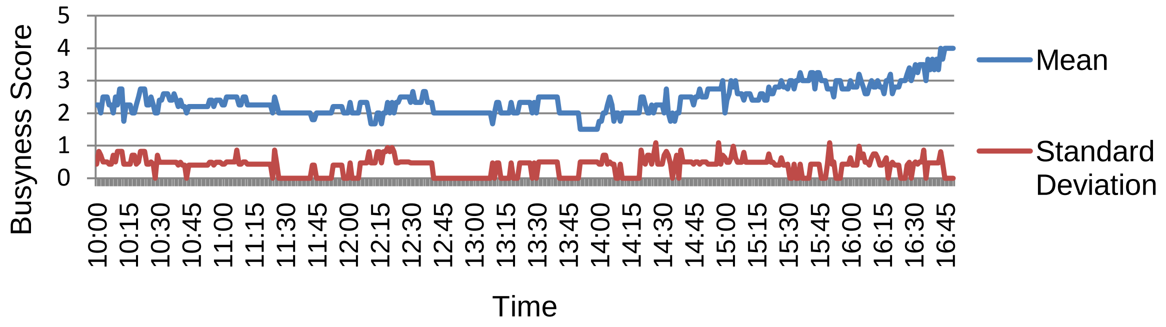


*Figure 5*. Scatterplot of mean and standard deviation Busyness scores throughout a day for weeks 3 and 4 (for a total of 9 days observation).

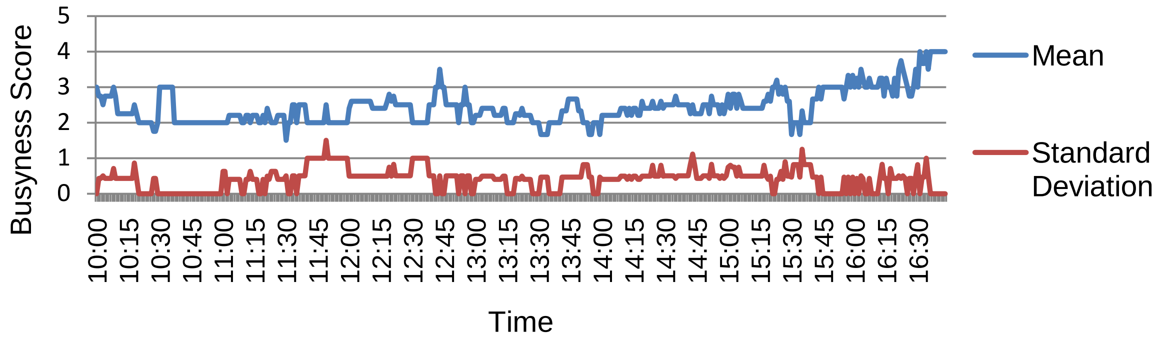


*Figure 6*. Scatterplot of mean and standard deviation Busyness scores throughout a day for weeks 5, 6 and 7 (for a total of 7 days observation).

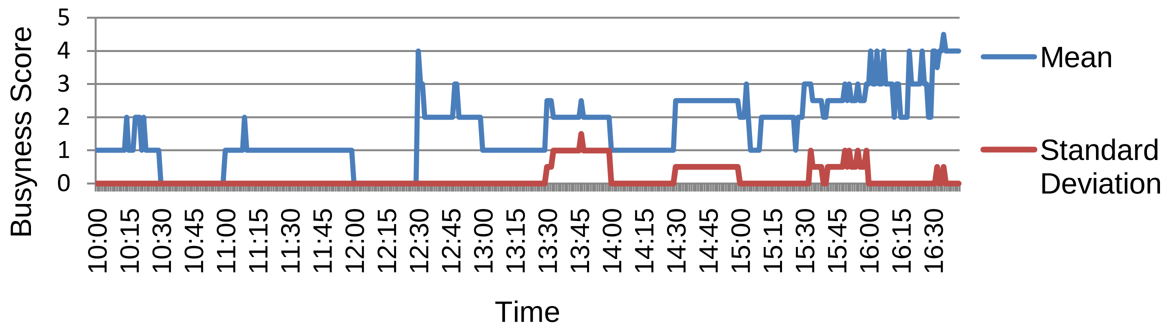


*Figure 7*. Scatterplot of mean and standard deviation Busyness scores throughout a day for weeks 8 and 9 (for a total of 3 days observation).

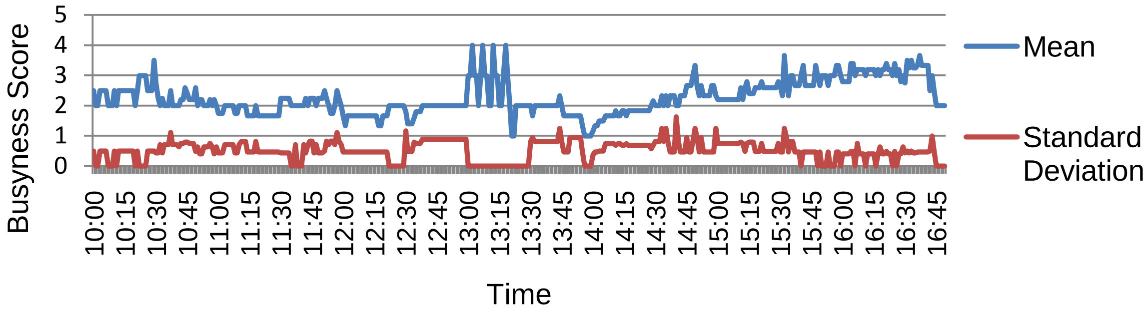


*Figure 8*. Scatterplot of mean and standard deviation Busyness scores throughout a day for weeks 10 and 11 (for a total of 8 days observation).

The data in Figures 4-8 data show the average pattern of Busyness scores over the 11 weeks of observations and all figures appear to display a similar trend throughout the study. During 10:00-15:00 hours across weeks 1-11 scores are around Busyness level of 2-3. After which there appears to be a steady increase to around a Busyness level of 3-4 at approximately 15:00 hours and leading up to when the animals are taken off show. For weeks 5-11 there also appears to be a distinctive peak in Busyness scores at around 12:30 hours. Standard deviation scores for the 11 week period do not vary greatly and remain low through most of the observations.

*Weather*

Weather conditions were coded however data revealed only *cold and wet* (coded as 4) or *cold and dry* (coded as 1) were recorded. Therefore, *wet* versus *dry* periods were analysed and revealed a total of 11 days of observation containing periods of wet weather and 30 days of dry weather. Weather and Busyness were correlated and found Busyness scores to be significantly lower in wet weather than when it was dry ($r_s$ = -.03, $N$ = 5981, $p$ = .01, two tailed). Please note, a Spearman's correlation has been used in several cases as data do not break assumptions of this test, however these results should be treated cautiously as they do not reveal a strong correlation, and the $N$ value is very large since it represents the number of observation minutes.

*Crowd Size and Crowd Noise*

Throughout observations data were recorded on crowd size and crowd noise and the total averages for these variables over all observations were analysed, see Figure 9. This shows that the crowd size and crowd noise averages remained similar throughout the day with both not greatly exceeding a level of 1. The raw data from these variables were compared and a highly significant positive correlation was found between crowd size and noise ($r_s$ = .98, $N$ = 5980, $p$ < .01, two-tailed).

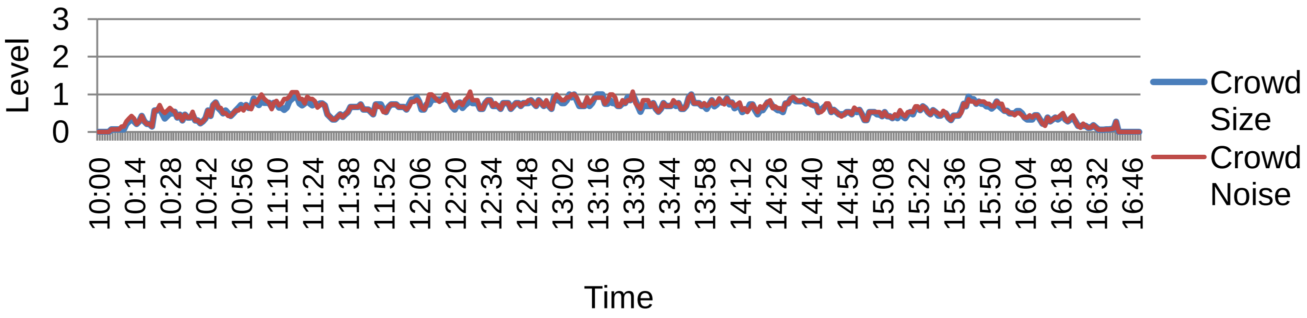


*Figure 9*. Total mean crowd size and crowd noise levels for 32 days of observation (please note, levels are coded as '0, 1, 2, 3' to represent 'none, small, medium, large' and 'none, quiet, medium, loud' for crowd size and noise respectively).

*Keeper Routines and Staff Presence at Enclosure*

Husbandry schedules were not manipulated in this study. Researchers would arrive to conduct observations at 10:00 hours, and for all occasions both tigers had been given paddock access by this time. Keepers were observed to have little interaction with the animals during the day. There was an advertised 'meet the keeper' talk at approximately 12:15 hours each day although this did not always occur due to low visitor numbers. Keepers would return to the enclosure around 16:45 hours to lock the animals in their off-show area for the evening. At this point observations ceased and it was unknown what occurred off-show. During times when observations were conducted as the animals were taken off-show, the time that this occurred was noted. Analysis revealed the mean time that both tigers were taken off-show was 16:42 hours, with the earliest occurring at 16:34 hours and the latest at 16:50 hours.

Observations recorded the presence of animal keepers at the enclosure and the proportion for this is in Figure 10. Data shows that during the day staff presence peaked around 10:00 hours, again between 12:10-12:40 hours, and is at a maximum after 16:30 hours. Staff presence was compared with Busyness and revealed a significant positive correlation ($r_s$ = .15, $N$ = 5976, $p$ < .01, two-tailed). However, results should be treated cautiously as they do not reveal a strong relationship and the $N$ value is very large since it represents the number of observation minutes.

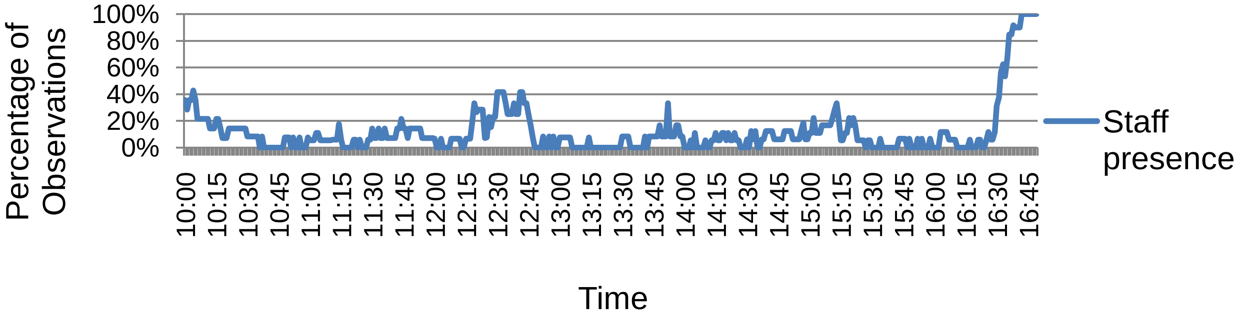


*Figure 10.* The proportion of observations staff present at enclosure (for period of 30 days excluding final 2 days of observation due to high staff presence).

*Further Information*

Other factors occurring during the sample interval that could affect the behaviour of the focal animal were categorised and included the following items: vomiting, abnormal or anxious behaviour, building noise or workers, staff nearby, behaviour directed at researcher, lions roar, object directed behaviour (e.g. toward a twig), flehming (a species specific behaviour used for communicating), zoo train past enclosure, other noisy zoo animals nearby, observation conducted in very dark conditions, and mating. However, as the frequency of these items was so low and the potential for errors or missed data quite high, no analyses were conducted. Details that could affect that entire observation period were also recorded and included: observation conducted from platform, enrichment items in enclosure, and weather conditions very cold. Although again the frequency of these events was very low, the modal average for these revealed that enrichment items were the most frequently occurring item over all observations. Occasionally the nature of the enrichment was noted if the item could be seen, and some of these included large barrels, straw sacks hung in trees and reused Christmas trees on the ground and hung from trees.

As a side note, on December 17, 2008 the keepers received permission to take the male tiger off-show due to an excessive amount of pacing behaviour displayed. However, a considerable decline in this pacing was noticed over the Christmas holiday period (December 18, 2008 to January 02, 2009) and therefore this decision was abandoned. Furthermore, the keepers took the female off-show at the end of the day on January 31, 2009 due to suspected pregnancy and therefore on the last 2 days of observations there was an abnormally high presence of staff at the enclosure preparing the off-show area for potential cubs. The female tiger gave birth on February 04, 2009 to four cubs.

**Behaviour categories**

Graphical analysis was conducted on the behaviour categories for the male and female tigers and the data for these were analysed to include the proportion of time the item was recorded over the 32 weeks of observations. Behaviours of the male and female tiger that were recorded throughout the day for approximately less than 20% of observations and appeared to occur with no particular pattern include: self-maintenance behaviour, investigative behaviour, marking, feeding, enrichment-directed behaviour, staff-directed behaviour, visitor-directed behaviour, agonistic behaviour, social activity and vocalisations (the data for these categories are presented graphically in Appendix J). In addition, records for the amount of time that the animals spent *not visible* for the duration of the sample interval is also infrequent and therefore the potential for missing data is minimal.

Several behaviour categories occurred over a greater number of observations. The proportion of observations that recorded sleeping behaviour was analysed for the male and female tigers and this data is presented in Figure 11.

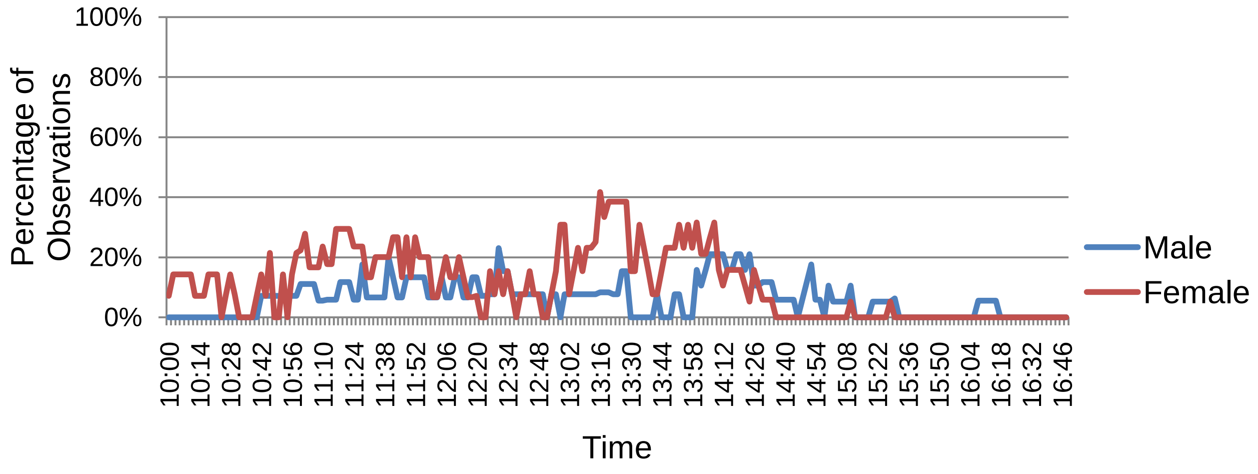


*Figure 11*. Scatterplot showing the proportion of observations that recorded sleeping behaviour in the male and female tigers throughout a day.

Figure 11 shows that more observations recorded sleeping behaviour in the female than the male tiger for most of the duration of day. For both tigers there was a steady increase in the number of times sleeping was recorded from 10:00 hours throughout the day, with the female tiger sleeping for about 40% of observations around 13:00-14:00 hours, declining to 14:30 hours and no sleeping behaviour occurring after 15:30 hours. For the male tiger, peaks in the proportion of observations recording sleeping are fewer and there is not such as rapid decline after 15:30 hours as in the female tigers data.

The proportion of observations recording the occurrence of inactive-alert was analysed for the male and female tigers (excluding levels of inactive-alert) and this data is presented in Figure 12.

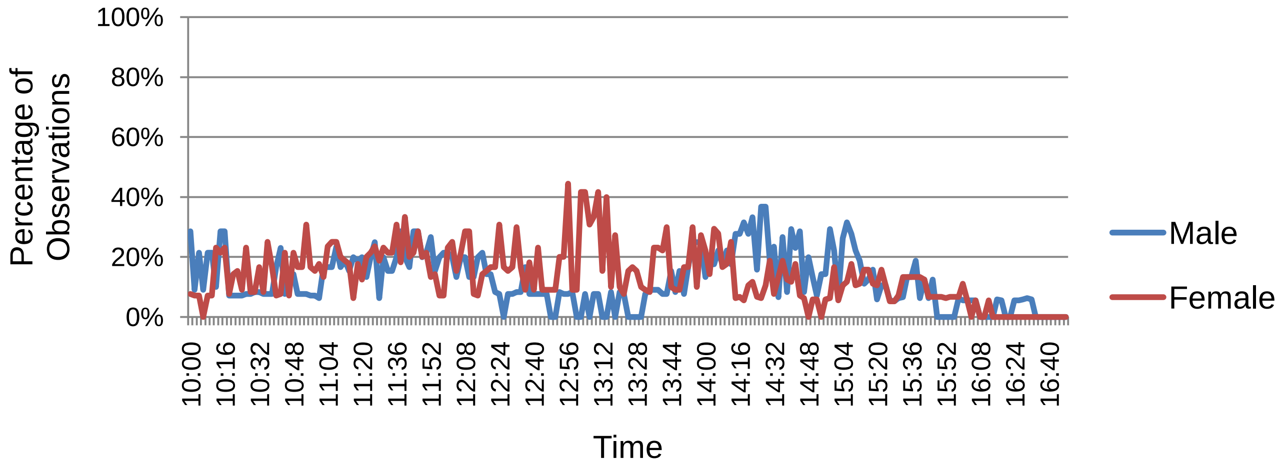


*Figure 12*. Scatterplot showing the proportion of observations that recorded inactive-alert behaviour in the male and female tigers throughout a day.

Figure 12 shows the proportion of observations that recorded inactive-alert behaviour and reveals a similar pattern to sleeping behaviour from Figure 11. There are a slightly greater number of observations recording the female than male tiger performing this behaviour, peaking for the female after approximately 13:00 hours and declining after 15:00 hours. The male inactive-alert behaviour shows more records being made around 14:00 hours which is similar to the proportions observed in the male tigers sleeping behaviour. As the data displayed in Figure 11 and Figure 12 is very similar this may indicate that observers may have made errors recording these behaviours, perhaps misinterpreting inactive alert behaviour for sleeping and vice versa. Therefore no further analyses have been conducted on these behaviours.

Each time a tiger was engaged in locomotion this behaviour was recorded and subsequently the proportion of observations this occurred throughout a day has been analysed and the data presented in Figure 13.

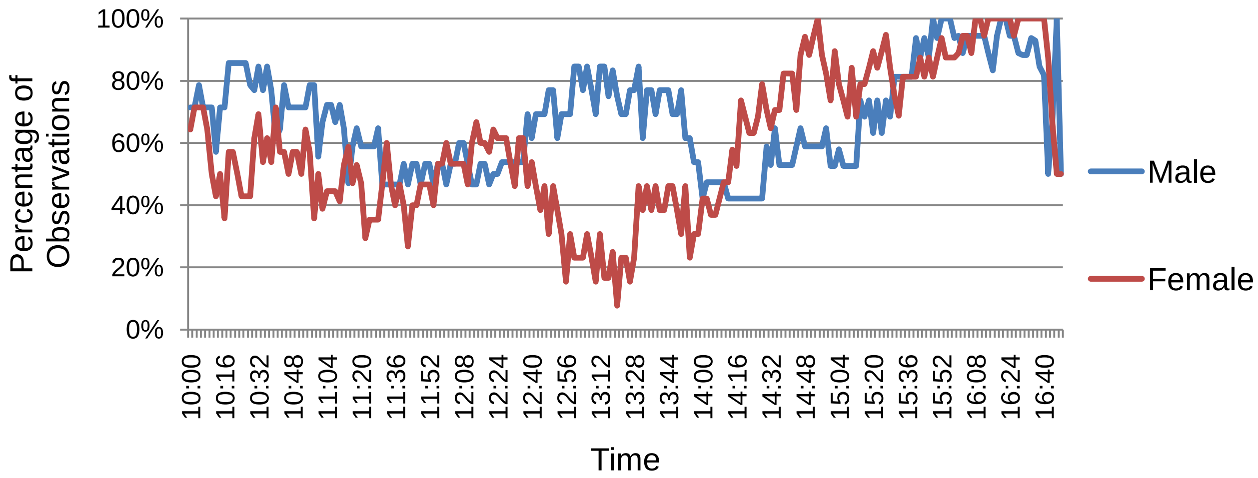


*Figure 13*. Scatterplot showing the proportion of observations that recorded locomotory behaviour in the male and female tigers throughout a day.

Figure 13 shows that locomotory behaviour is apparent across all observations for the duration of the day and has a higher occurrence than any of the other behaviour categories recorded. Data for the female tiger shows that locomotion was performed for approximately 40-60% of observations during 10:00 hours to around 12:30 hours, after which there is a decline in the amount of locomotion observed up to 14:00 hours. For the female tiger the amount of locomotion observed over the study rapidly increases to a peak of 100% around 14:30 hours and continues to be observed for over 90% of observations to approximately 16:30 hours (as the animals are taken off-show after this time there is a rapid decrease to 50%). For the male tiger locomotory behaviour is apparent in over 40% of observations and throughout the course of the day. There is a peak in how often locomotion occurs between 12:30-14:00 hours and then a rapid increase between 14:30 hours to 90-100% of observations before being taken off-show.

Finally the proportion of total observations that recorded pacing behaviour in the tigers was analysed and this data is presented in Figure 14.

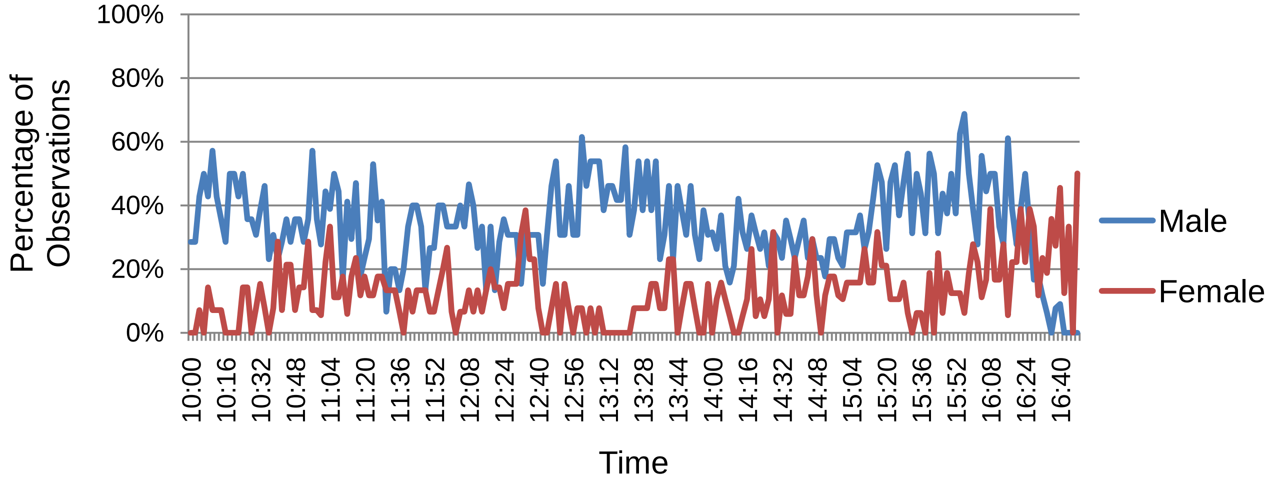


*Figure 14*. Scatterplot showing the proportion of observations that recorded pacing behaviour in the male and female tigers throughout a day.

The data in Figure 14 show that pacing behaviour is consistently observed more in the male tiger (between 30-60% of observations) than the female (most of time around 20% of observations). The female tigers pacing behaviour is observed for less than 40% of observations  throughout most of the day, with a decline around 12:30 -13:30 hours, however there is slight increase in proportion of pacing observed (to 50%) immediately prior to being taking off-show. On the other hand the male tigers pacing behaviour is observed less frequently after 16:00 hours and almost no pacing has been recorded after 16:30 hours. The males pacing behaviour throughout the rest of the day is frequently observed for more than 30% of observations and peaks around 13:00 hours and 15:45 hours.

As pacing was considered a significant problem in these animals and there was a noticeable change over the Christmas holiday period, averages for pacing behaviour have been a further broken down and analysed into the following five time periods: weeks 1 and 2; weeks 3 and 4; weeks 5, 6 and 7 (consisting the Christmas holiday period); weeks 8 and 9; and weeks 10 and 11. Graphical analyses of these averages are presented in Figures 15 -19.

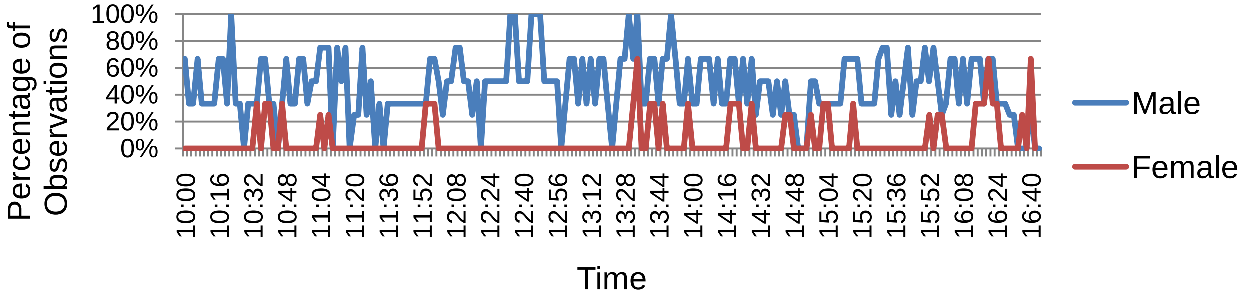


*Figure 15*. Scatterplot showing the proportion of observations that recorded pacing behaviour in the male and female tigers throughout a day for weeks 1 and 2 (for a total of 5 days observation).

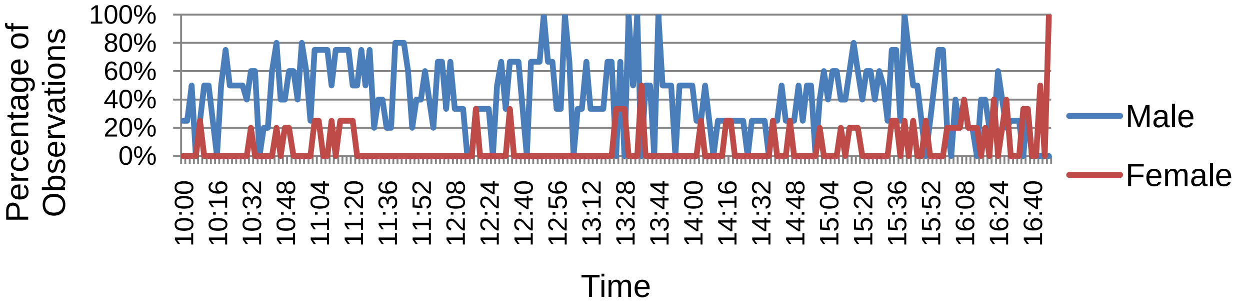


*Figure 16*. Scatterplot showing the proportion of observations that recorded pacing behaviour in the male and female tigers throughout a day for weeks 3 and 4 (for a total of 9 days observation).

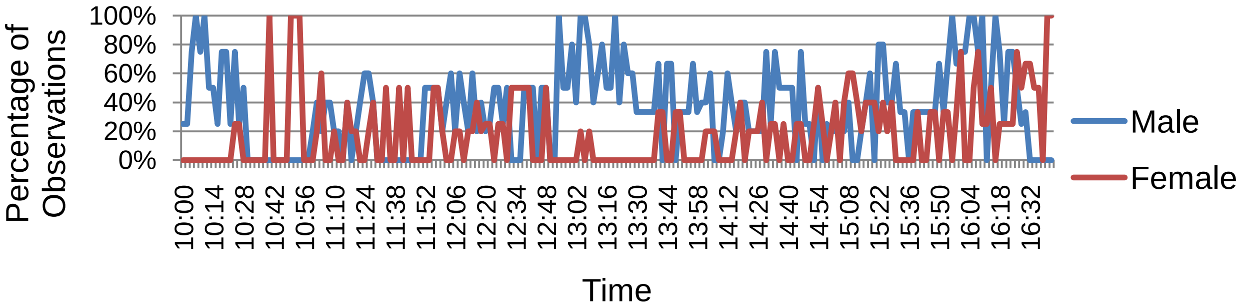


*Figure 17*. Scatterplot showing the proportion of observations that recorded pacing behaviour in the male and female tigers throughout a day for weeks 5, 6 and 7 (for a total of 7 days observation).

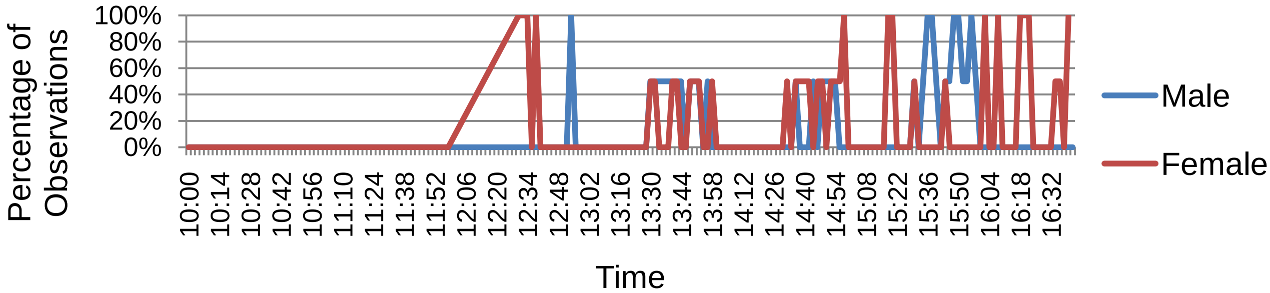


*Figure 18*. Scatterplot showing the proportion of observations that recorded pacing behaviour in the male and female tigers throughout a day for weeks 8 and 9 (for a total of 3 days observation).

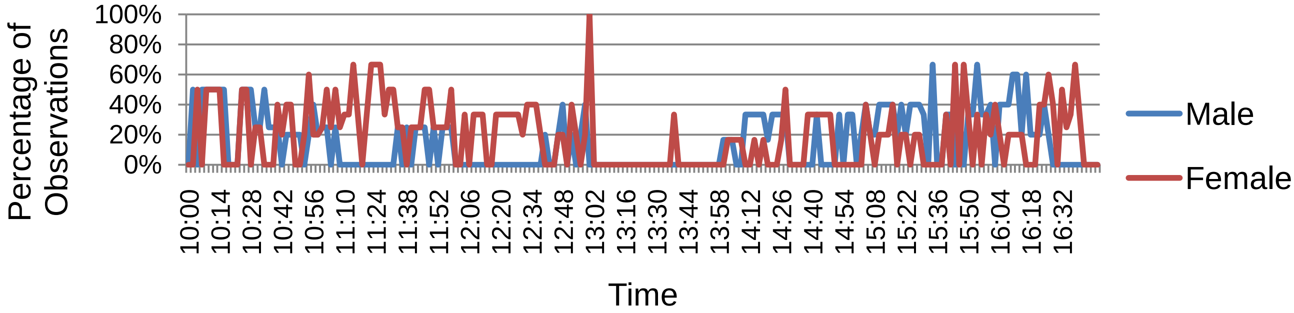


*Figure 19*. Scatterplot showing the proportion of observations that recorded pacing behaviour in the male and female tigers throughout a day for weeks 10 and 11 (for a total of 8 days observation).

The data in Figures 15-19 show more observations recorded the male tiger pacing than the female for weeks 1-7. During the first 2 weeks, the male tiger paces for about 30-70% of observations whereas pacing in the female is below 30%. More pacing is observed in the male tiger between 12:00-14:00 hours. For the female tiger pacing behaviour is more apparent after 13:00 hours and peaks after 16:00 hours prior to going off-show. During weeks 3 and 4, the tigers behaviours are very similar to the first 2 weeks, although the female does seem to be pacing more frequently throughout the day and prior to being taken off-show. The male tiger is pacing more between 12:00-14:00 hours but there are also troughs surrounding these times. For weeks 5-7 the pattern seems even more exaggerated from previous weeks. More pacing is observed in the male tiger peaking around12.30-13.30 hours with troughs either side of these peaks. However unlike previous weeks, the male tiger appears to show more pacing leading up to the time the animals are taken off-show. The female also appears to be pacing more frequently and consistently throughout a day in these weeks compared to previous observations, and more records are made around 10:30-11:00 hours and prior to being taken off-show.

The data for weeks 8-11 are noticeably different to previous weeks for both the male and female tiger. The proportion of time the male tiger is observed pacing is lower than all other observations and furthermore it is noticeably less frequent than the female tiger. For weeks 8-9 there is no pacing observed from 10:00-12:00 hours for both tigers but then sudden peaks appear around 12:00-13:00 hours for the female in weeks 8-11 and for the male in weeks 8-9. The number of times pacing is observed for both tigers then declines after 13:00 hours and increases again after 13:30 hours for weeks 8-11. Overall the female tigers pacing appears more frequent throughout the day in the weeks of 10 and 11 compared to all other observations.

*Correlations of Behaviours with Global Categories*

Further investigations have been conducted correlating some of the behaviour categories for the male and female tigers with global Busyness scores over the entire observation period. A significant positive correlation was found between global Busyness scores and locomotory behaviour for the male tiger ($r_s$ = .60, $N$ = 2992, $p$ < .01, two-tailed). There was also a significant positive correlation between global Busyness scores and locomotory behaviour for the female tiger ($r_s$ = .66, $N$ = 2984, $p$ < .01, two-tailed). Pacing and Busyness were correlated and found a significant positive correlation between global Busyness scores and pacing behaviour for the male tiger ($r_s$ = .21, $N$ = 2992, $p$ < .01, two-tailed), and a significant positive correlation between global Busyness scores and pacing behaviour for the female tiger ($r_s$ = .19, $N$ = 2992, $p$ < .01, two-tailed). These results are useful in confirming the Busyness as a partial measure of activity. However, please note that all results should be treated with caution as the high value of *N* (number of observation minutes) may have increased the likelihood of achieving a significant result.

Due to the patterns observed in pacing behaviour, busyness and staff activity, a phi correlation was used to assess the relationship between pacing behaviour and staff presence. For the male tiger a significant negative correlation was found between staff presence and pacing behaviour ($\phi$ = -.09, *N* = 2992, *p* < .01, two-tailed) and for the female tiger a significant positive correlation was found between staff presence and pacing behaviour ($\phi$ = .07, *N* = 2984, *p* < .01, two-tailed). However it must be noted that neither of these relationships are particularly strong.

**Directed gaze**

For observation weeks 5-11 the frequency of *stop and gaze* behaviour was recorded for the focal animal, and where possible the *direction of gaze* was also noted. However, the direction of gaze could not always be determined and a number of potential errors may have occurred due to misinterpreted gaze or missed data. Few practice observations were possible with this variable and during analysis many errors were discovered in recording direction of gaze. For this reason only the combined frequency for the male and female tigers of stop and gaze behaviour has been analysed and should still be treated with caution. Figure 20 shows that the overall proportion of observations that stop and gaze occurred is high throughout the day, most of the time occurring around 40% of observations, with more occurring between 10:00-11:00 hours. This variable did not merit any further analysis.

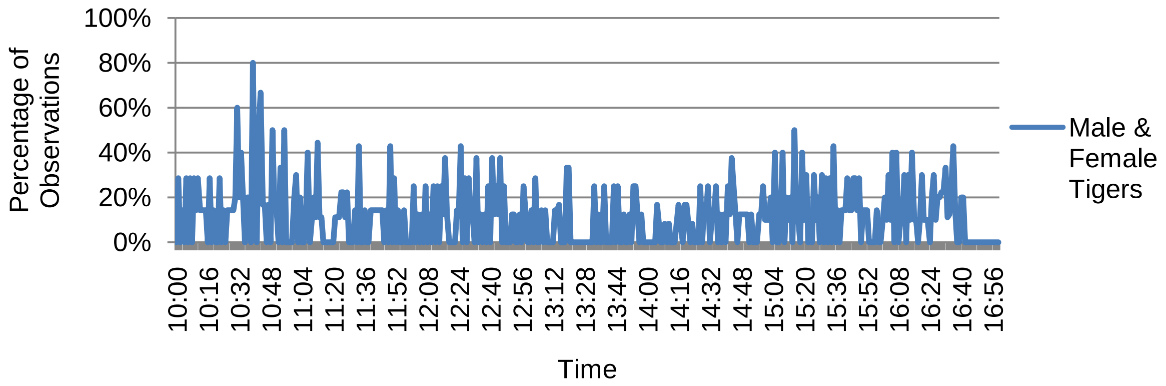


*Figure 20*. Scatterplot of the combined proportion of observations recording stop and gaze behaviour in both tigers throughout a day (for 7 weeks of observations).

**Enclosure usage: areas and sections**

In order to determine how enclosure space was used by both tigers throughout a day data was collected on the enclosure area and section in which the tiger was located. For the total 11 weeks observation this was noted as one of four enclosure areas *(areas 1* through *4* are pictured in Figure 21), and during weeks 5-11 of the study these areas were further subdivide into smaller enclosure sections. However, during analysis a number of errors were discovered with the sections. Therefore this data has been treated with caution by omitting errors and combining some of the enclosure sections to incorporate neighbouring sections. The new sections appear in Figure 21 and have been combined as follows: new section 1 combines area *A* section *i* and *4;* new section 2 combines area *A* section *W;* new section 3 combines area *A* section *P*; new section 4 combines area *A* section *F*; new section 5 combines area *B* section *i*; new section 6 combines area *B* section *4*, *FW* and *F*; new section 7 combines area *B* section *Po* and *P*; new section 9 combines area *B* section *H4* and *H*; new section 10 combines area *C* section *i*; new section 11 combines area *C* section *F*; new section 12 combines area *D* section *i*; new section 13 combines area *D* section *L*; new section 14 combines area *D* section *F*.

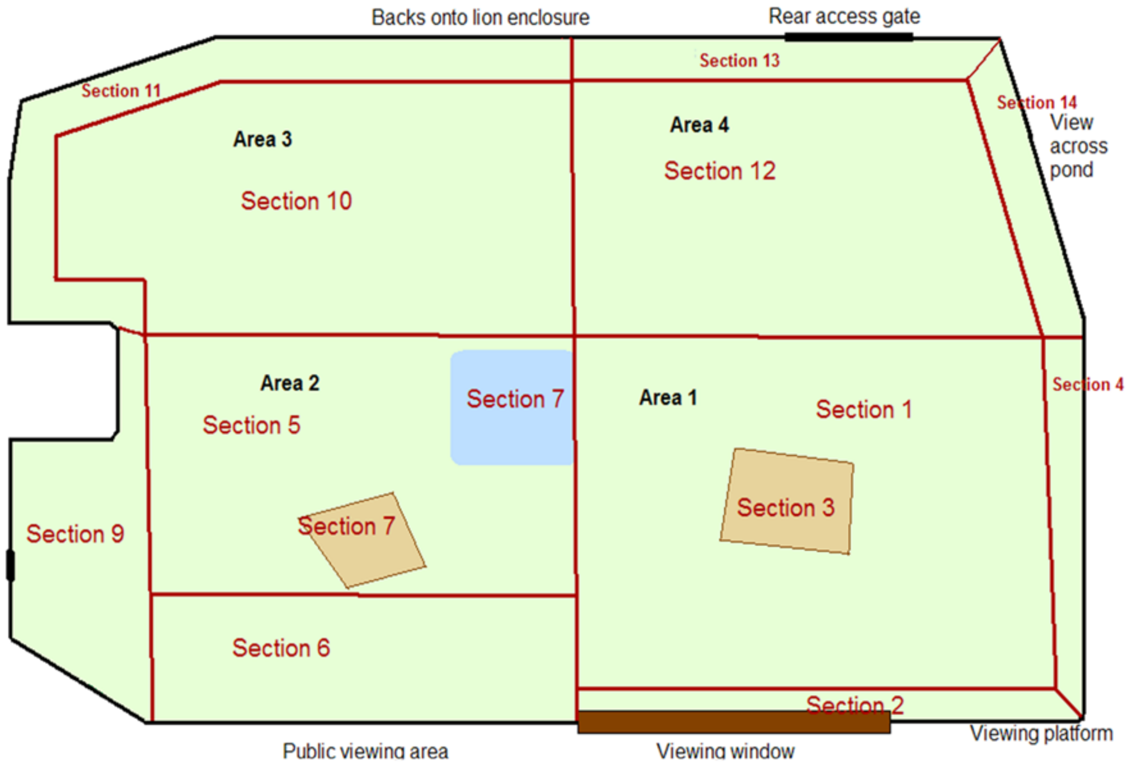


*Figure 21*. Enclosure section boundaries used for analysing enclosure usage by the male and female tigers over weeks 5-11 of observations.

The modal area and modal section of use for both the male and female tigers throughout the course of a day have been obtained and are presented in Table 3.

Table 3. *Modal area and section of use by male and female tiger for separate periods during the day (area and section data consist of 11 and 7 weeks observations respectively).*

| Time | Area | | Section | |
|---|---|---|---|---|
| | Male tiger | Female tiger | Male tiger | Female tiger |
| 10:00-10:59 | 2 | 2 | 6 | 7 |
| 11:00-11:59 | 2 | 2 | 6 | 13 |
| 12:00-12:59 | 2 | 2 | 6 | 9 |
| 13:00-13:59 | 2 | 2 | 6 | 7 |
| 14:00-14:59 | 2 | 2 | 6 | 6 |
| 15:00-15:59 | 2 | 2 | 6 | 6 |
| 16:00 to time taken off-show | 2 | 1 | 6 | 6 & 2 |

The data in Table 3 show that for all time periods the male tiger is most frequently observed in section 6 of area 2. This is represented in Figure 22.

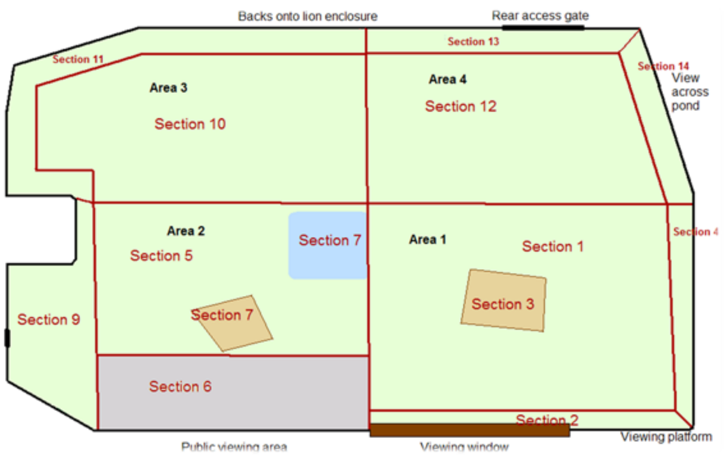


*Figure 22*. Shaded area represents the modal section (section 6) in which the male tiger was observed for all times during the day (for weeks 5-11 of observations).

The data in Table 2 also show that the female time spends the majority of the day between 10:00-16:00 hours in area 2, although prior to being taken off show (after 16:00 hours) the female spends more time in area 1. In terms of sections of the enclosure this data reveals how the female tiger moves around enclosure area 2 throughout the day and these data are represented in Figures 23-27. During 11:00-11:59 hours the modal section data also show that the female tiger spends more time in section 13 of the enclosure. Finally, for the time of 16:00 hours onwards the female tiger was observed to spend an equal amount of time between sections 6 (in area 2) and section 2 (in area 1).

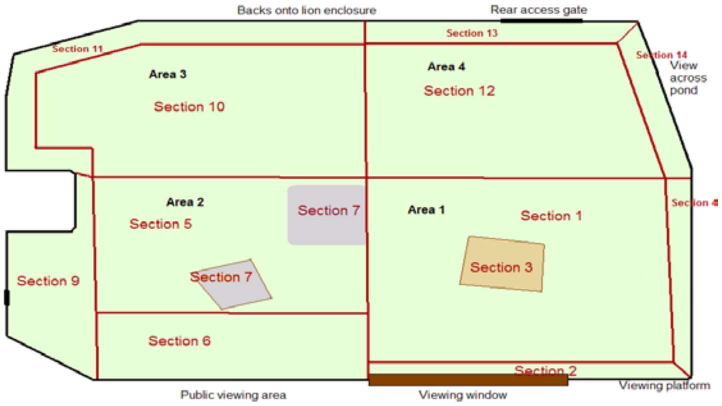


*Figure 23*. Shaded area represents the modal section (section 7) in which the female tiger was observed for 10:00-10:59 and 13:00-13:59 hours (for weeks 5-11).

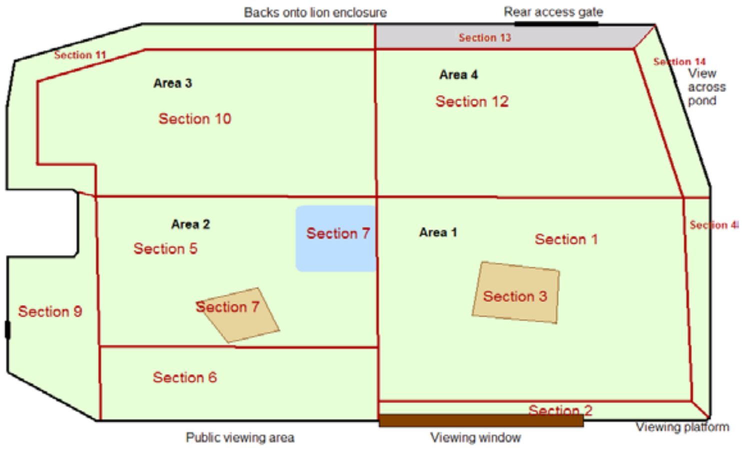


*Figure 24*. Shaded area represents the modal section (section 13) in which the female tiger was observed for 11:00-11:59 hours (for weeks 5-11 of observations).

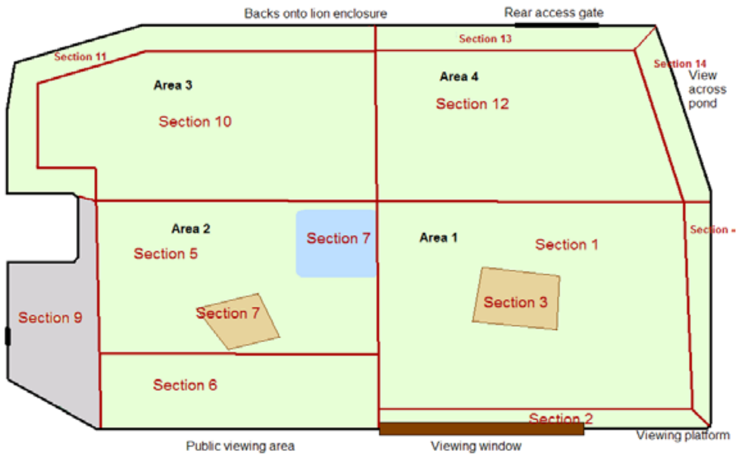


*Figure 25*. Shaded area represents the modal section (section 9) in which the female tiger was observed for 12:00-12:59 hours (for weeks 5-11 of observations).

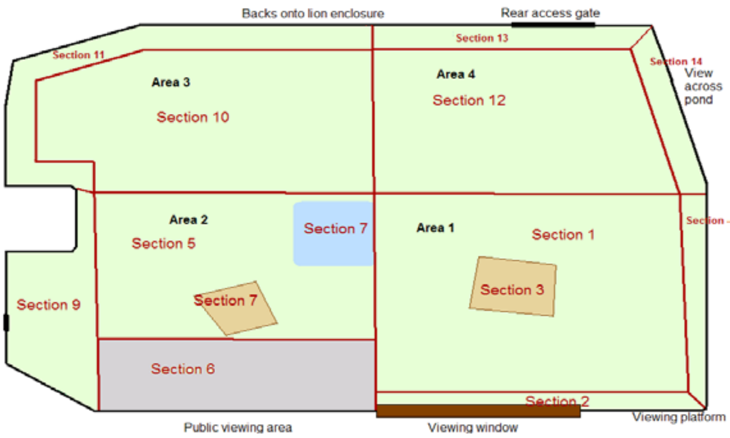


*Figure 26*. Shaded area represents the modal section (section 6) in which the female tiger was observed for 14:00-15:59 hours (for weeks 5-11 of observations).

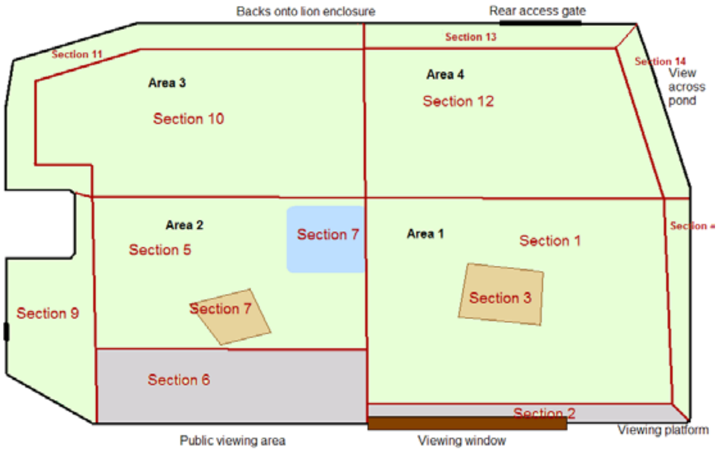


*Figure 27*. Shaded areas represents the modal sections (section 6 and 2) in which the female tiger was observed post 16:00 hours (for weeks 5-11).

## Discussion

The purpose of this study was to investigate how increased environmental predictability could impact upon the behaviour of zoo-housed animals. In particular how factors such as the temporal regularities of husbandry regimes or enclosure complexity may impact collectively upon behaviour. Reduced environmental complexity has been linked with stereotypies in some animals (e.g. Mallapur et al., 2002). Furthermore, increased temporal predictability has been associated with anticipatory behaviours; however whether these are beneficial or detrimental to welfare is debated (e.g. Bassett & Buchanan-Smith, 2007). Therefore, this study piloted Busyness as a method to measure patterns in behaviour to determine if they were related to environmental factors, such as staff activity or the physical properties of the enclosure, and monitored variability in relation to the behaviour of a focal animal. Busyness has been successfully piloted in this study obtaining data on how the activity levels within the enclosure could vary throughout a day. Furthermore, behavioural data confirmed Busyness as reliably recording activity as scores were significantly positively correlated with locomotion and pacing in both of the tigers.

In general, average scores reveal low Busyness levels around 2 during 10:00-12:00 hours and 13:00-15:00 hours (see Figures 2-8). Modal Busyness increases after 15:30 hours to a level of 3, and further increases to a level of 4 after 16:30 hours. These patterns can be connected with environmental events and particularly staff presence and activity. A significant positive correlation was found for Busyness with staff presence indicating that Busyness scores were higher when zoo staff was at the enclosure. The tiger keepers were scheduled to be present at the enclosure for two periods during day, including a 12:15 hours 'meet the keeper' talk, and again when the tigers were advertised to go off-show at 16:45 hours (see Figure 10). In this study, the animals frequently appear to display increased Busyness leading up to and around these times. It could be argued that these patterns in Busyness scores may indicate that the animals are anticipating the arrival of their keepers. Leading up to when the animals are taken off-show Busyness scores consistently show an initial increase after 15:30 hours to a level of 3 and a further increase to a level of 4 after 16:00 hours. Although Busyness scores do not show such an increase leading up to the 'meet the keeper' talk, they do show elevated levels around 12:15-12:45 hours when staff were usually present at the enclosure. However, the data in Figure 10 does indicate that staff were not always present at this time and therefore this may have lowered Busyness scores and any potential anticipation. Furthermore, the presence of the keepers at this time of day was not greatly significant to the tigers, for example by indicating that feeding was imminent, and therefore this may be why staff-directed behaviour was low during the study.

Other environmental factors were compared with Busyness including weather conditions and crowd size and noise. Data appear to show that the animals are less active during wet than dry weather, however this relationship was only slightly significant. Perhaps that Sumatran tigers are naturally a swampland species may indicate that weather should not have influenced Busyness scores. Figures for crowd size and crowd noise were not related to Busyness scores. The study did incorporate a 3 week period of the Christmas holiday season during which time visitor numbers may have been higher, and also the new viewing platform was open for public use, however average Busyness scores for these weeks are not noticeably different (See Figure 6). Further study incorporating greater variability of these factors is required to determine their effects.

In general, the data for Busyness over all observations appear to show consistent patterns in activity with increases in Busyness around the same times of day. Some data were collected around the winter solstice of December 21, 2008 (weeks 5-7 of observations) and therefore leading up to the time the animals were taken off-show light conditions were deteriorating earlier in the day. However, if the rise in Busyness scores may be indicating the animals are anticipating being taken off-show, the earlier dark onset does not appear to cause the animals to anticipate earlier during these times (see Figure 6). Furthermore, the pattern of Busyness scores does not appear to vary weeks into the female tiger's pregnancy. Overall Busyness appears to be a good indicator of animal activity, and patterns in the keepers routines appear to be consistently related to patterns in Busyness scores regardless of other environmental events. However it is debatable whether changes in Busyness scores indicate anticipation of these events.

Throughout the study both tigers were observed to display stereotyped pacing behaviour and this was notably severe in the male tiger. He was observed to pace over a high proportion of observations and throughout the day for weeks 1-7 with a slight decline prior to being taken off-show (see Figures 15-17). A significant correlation revealed a negative relationship between staff presence and pacing behaviour for the male tiger. However, over the Christmas holiday period there were dramatic changes in the behaviour of this tiger with a sudden decline in pacing behaviour and this persisted through the remaining weeks of the study (see Figure 18 and Figure 19). During these weeks several events occurred that may assist an explanation, for instance, the viewing platform was made open to the public, and it is also likely that visitor numbers may have been slightly higher over the Christmas holiday period. These weeks would have been midway through the female tigers pregnancy and the time when she may have first displayed visible signs that she was expecting and showing maternal behaviours. This may have directly influenced the male tiger’s behaviour or indirectly through changes in the keeper’s behaviour.

A further explanation for these patterns in behaviour is discussed by Jenny and Schmid (2002) in terms of competition for resources. In their study of Amur tigers, stereotyped pacing was considered a result of permanently frustrated appetitive foraging and they discovered that providing increased control through feeding boxes resulted in overall reductions in pacing behaviour. However disruptions to behaviour were also observed in the male tiger as he would show an increased amount of inappropriate behaviour directed toward the feeding boxes when housed with the female tiger compared to living in isolation. Jenny and Schmid suggest that this could be due to an increased competition for food resources when in paired confinement. This coping strategy could provide further explanation for the male tiger’s behaviour in this study. Prior to the observations commencing, the male tiger had been living in isolation for approximately 2 years due to the female rearing her cub. Therefore the initial pacing observed in the male tiger could be considered an active coping strategy for being reintroduced with another tiger and facing unfamiliar competition for resources. The female tiger on the other hand, was used to the company of her cub. This idea has also been discussed by other researchers; Ruiz-Miranda, Wells, Golden and Seidenstricker (1998) studied the behaviour of cheetahs, *Acinonyx jubatus*, housed in isolation and together, and from their observations they suggest that the ability to cope with increased competition can vary between individual animals and their personal history.

This study was interested in what elements of a captive environment may contribute to stereotyped behaviours and in the case of the male tiger all explanations offered are purely speculative. On the other hand for the female tiger, a significant positive correlation was found between pacing behaviour and staff presence. Figures 14-19 show that the female tiger would consistently pace more in the time leading up to being taken off-show, although the time that this would commence appeared to vary over weeks of the study. The female tiger was observed to pace more in the latter weeks of the study, particularly around the time of the ‘meet the keeper’ talk, and pacing would commence earlier as the study progressed (see Figure 18 and Figure 19). For the female tiger if pacing could be considered an indicator of anticipation then she appeared to anticipate being taken off-show earlier in the day as her pregnancy progressed. It must be noted that during observations although the stereotyped pacing observed in both tigers conformed to the operational definitions, the majority of pacing displayed by the male and female tiger did appear to be qualitatively different. While the male tiger appeared to be oblivious to all external stimuli while he was pacing, the female tigers pacing appeared to be highly aroused and directed towards a particular area.

As an additional measure not investigated in great detail by other researchers, directed gaze behaviour was added to observations midway through the study, although the potential for errors in observing this behaviour were too great to merit a detailed analysis. However this behaviour should be investigated further as a potential indicator of anticipation in certain species. In addition, midway through observations the initial enclosure areas observed were further subdivided into specific sections and this was deemed a far more valuable method to record how the sections may correspond with behaviours. During weeks 5-11, the male tiger spends most of the day in Section 6 (see Figure 22) which is where he was also observed to pace more frequently. Sections 2 and 6 were noted to provide the greatest proximity to visitors and the best view of keepers approaching the enclosure. The female tiger uses a greater area of the entire enclosure throughout a day. However leading up to the time she is taken off-show she will spend more time in Sections 2 and 6 (see Figure 26 and Figure 27) and during the time of the 'meet the keeper' talk she spends more time in Section 9. Furthermore, according to Figure 14 the female tiger will pace more during these times. Overall, these observations provide a good insight into behaviour and a successful starting point for further investigation, however as these categories were added midway through the study, only providing a small data set and little opportunity for practice and revisions to be made, the data must be treated more cautiously.

The potential for Busyness to be used as a future method for collecting observational data on behaviour has successfully demonstrated in this study monitoring the collective behaviour of a small sample of animals; indeed it could also be used to observe the behaviour of larger groups or even focal animals and could possibly be transferred to different species. However there are some concerns regarding the subjectivity of Busyness. The first thing that is noticeable from the outcome of this study is how all observers who assisted in data collection learnt how to measure Busyness with minimal instruction, thus reducing the amount of time necessary to develop complex observation skills that are often species specific, and increasing the time available to collect more data. This also highlights how easily it could be employed by busy zoo staff. However, what should be noted is that not all the inter-observer reliability scores achieved a particularly high concordance level. Although this data was not favoured in compiling results for analysis, this does indicate that perhaps using Busyness may not be as simple as intended. Busyness can be an easy concept to learn and use with minimal training, however maybe observational experience of a species is equally important in order to understand the potential range of behaviours and activity levels that the subject can display. Furthermore, using Busyness to measure anticipation may not be appropriate for all species, for instance reptiles are a good example of a species that Busyness scores would not be practical for. In general, this study may inspire ideas for future research to investigate, however Busyness needs further exploration in order to assess its reliability, especially with regard to anticipation.

There are some limitations to the data that has been collected which is often unavoidable conducting research of this nature. Firstly, it would have been favourable to start observations prior to the many changes that occurred for the tigers in order to make comparisons with baseline data. Some of the changes that were known included building of the viewing platform and previous housing arrangements with the cub, however there were suspected changes to feeding regimes with the tigers sometimes receiving food at the 12:15 hours 'meet the keeper' talk although this is unconfirmed. Therefore as no baseline data exists for the study, in addition to the small sample size, this restricts conclusions that can be made from the data. In addition, little was known what happened to the animals in their off-show area, or how and when feeding was conducted. The problem with zoo-based research is that there are too many potential variables that could influence behaviour and although information was collected on several environmental factors, it would be impossible to monitor them all. This makes it difficult to generalise the outcome of a study and provide answers to research questions. On the other hand, research such as this does have greater applied value than controlled laboratory-based studies and can be very beneficial for the subjects that were studied. However, overall the outcomes have highlighted the need for further investigation and provided potential alternative methods to collect behavioural data.

Modern zoos are essential in educating about different species and their conservation, for example, there are less than 400 Sumatran tigers left in the wild (WWF, 2008). However it is essential that in conserving species, efforts are also made to promote and retain their species-appropriate behaviours. Research has demonstrated that generations of captive breeding has resulted in morphological changes in carnivores, such as reduced jaw strength, often suggested to be due to a lack of use in captivity (e.g. Erickson, Lappin, & Vliet, 2003). It has been discussed how increased predictability in captive environments can restrict natural behaviours and encourage problem behaviours, such as stereotypies or anticipatory behaviours. In this study predictable staff routines appear to have influenced behaviour with the tigers showing increased activity in the hour leading up to being taken off-show. Furthermore, such events also appear to be related to an increase in stereotyped pacing in the female tiger but a decrease in the male. On the other hand the male tiger shows stereotyped pacing throughout the day, typically along enclosure edges also demonstrated in previous studies (e.g. Lyons et al, 1997) that suggest reduced environmental complexity contributes to this behaviour. It might be interesting to investigate for the animals in this study if providing food in a more varied way may encourage more explorative use of the enclosure by the male tiger and reduce the anticipatory pacing leading up to feeding time in the female tiger. This demonstrates the importance of taking into account individual differences and personal history when addressing such behaviour.

Research has investigated various ways to reduce unwanted behaviours such as those observed in this study. For example, some suggest that husbandry regimes should be conducted on a highly unpredictable schedule in order to reduce anticipatory behaviours (e.g. Waitt & Buchanan-Smith, 2001). Alternatively, zoos use environmental enrichment as a way to promote species-appropriate behaviours and this has been found to affect the presence of stereotypies. For example, Mallapur et al., (2002) found that a more complex enclosure will stimulate the animal to use more space, and suggest that provisioning enclosures with more enriched features reduces abnormal behaviour patterns and increases positive active and resting behaviours. Nevertheless, the role of predictability has even been demonstrated as important to enrichment provisioning in terms of scheduling and variety. For instance, habituation to certain types of enrichment over time has been found to affect levels of pacing behaviour (e.g. Plowman & Knowles, 2003). Furthermore, for events that can become anticipated, research has investigated the role of signalled predictability as a way of increasing an animal’s sense of perceived control. For example, in their study Jenny and Schmid (2002) suggested that introducing a signal at times when the feeding boxes were active may help to reduce abnormal behaviours directed toward the boxes seen in the male tiger. If signalling could be demonstrated to effectively reduce anticipatory behaviours then this may provide a more practical alternative for animal keepers rather than changing their husbandry schedules. Indeed, it may be interesting to observe if Busyness scores are able to capture the reduction of these behaviours, or whether current behavioural measures, such as monitoring rates of stereotyped behaviours, are sufficient.

Indeed further research is required into the role of predictability in terms of management regimes, and perhaps with more emphasis on individual variables rather than differences across species. For example, if husbandry regimes are discovered to be preferred on an unpredictable schedule for an individual, how variable would they need to be in order to prevent anticipation? On the other hand, if variable schedules are not preferred or are inconvenient for animal carers, what kind of predictable schedule would be preferable for welfare? For instance, Law, Boyle, Johnston, and MacDonald (1990) discovered that polar bears, *Ursus martitmus*, would show differences in stereotyped behaviour when fed in the morning or evening. Moreover, as illustrated in the research of Jenny and Schmid (2002), any further investigation that may involve manipulating environmental predictability should be approached with caution in order to prevent the development of new problem behaviours or potential stereotypies.

Overall, this research has highlighted some of the confusion that zoo staff are often faced with to maintain the optimal welfare of their animals. Previous research has shown that variability that can exist across species to fixed or variable husbandry schedules; however this study has highlighted how great variability may also exist for individuals of the same species. Furthermore this research lends support to previous studies that stress the importance of investigating ways to enhance enclosures that encourages greater behavioural diversity and prevents stereotypies. It is important that zoos attempt to monitor and control problem behaviours and suggestions have been made for the direction of further research of this nature. For animals displaying abnormal patterns in behaviour, not only is their individual welfare compromised but their behaviour can influence the perceptions of visitors to zoo establishments and for some people can even be distressing to watch. Therefore further research would help to prevent this and should also aim to contribute to educating public opinion on the benefits of zoo environments and zoo-based research.

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