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Research Article

Patterns of Diurnal and Nocturnal Cub-Directed Social Interaction and Guarding Behaviour in Sumatran Tigers

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Abstract

Felids are commonly housed in zoological collections worldwide. While aspects of their behaviour are well studied, there remain questions on best practice husbandry including during reproduction and breeding scenarios. In 2016, the Zoological Society of London's (ZSL) London Zoo held a pair of Sumatran tigers (Panthera tigris sumatrae) for the purpose of breeding. While they are believed to be solitary in the wild, many collections maintain their tigers in pairs, with some keeping pairs together during parturition and rearing periods. The aim of this study was to investigate the social interactions between a male Sumatran tiger and cubs when housed in a shared enclosure. The data were collected using CCTV footage in the indoor enclosure for the tigers. The CCTV footage ran continuously throughout the day and night, allowing a more holistic overview of behaviour. These 24-hour recordings were split into 6 equal hour ranges to calculate behaviour activity budgets and proximity of the male from the cubs. Data were analysed using a Chi-squared test for association to determine differences between individual behaviour. Overall, the male spent longer than expected engaging in guarding behaviour of the cubs. The male also regularly engaged in affiliative behaviours directed towards the cubs. No cub-directed aggression was observed from the male toward the cubs. Overall, this suggests that maintaining a male tiger with its progeny may be feasible as a management approach in some zoological collections, provided the male's personality is compatible, and alternative accommodation is available.

Keywords: Felidae; Affiliative Behaviour; Guarding; Nocturnal Behaviour; Zoo; Panthera Tigris Sumatrae

Introduction

Zoos and aquaria play a role in wild animal conservation through their engagement with captive breeding, research and education [1,2]. To maintain the genetic diversity and viability of zoo animal populations, zoos are often required to set up managed breeding programmes for endangered species [3]. With over 10,000 different species housed in captive collections worldwide [4], there remain gaps in the knowledge of best practice husbandry and breeding protocols, even for commonly housed species.

Felids are commonly housed in zoological collections [1,5,6]. A February 2022 review of Species360's [7] Zoological Information

Management System (ZIMS) revealed that zoological collections maintained at least 11,000 individuals in the Felidae (cat) family. Of these, 5,000 individuals belonged to the *Panthera* genus, a genus which includes the lion (*Panthera leo)*, tiger (*Panthera tigris)*, leopard (*Panthera pardus)*, snow leopard (*Panthera uncia)*, and jaguar (*Panthera onca)* [8].

Big cats are easily recognised and popular with the public [8,9], largely irrespective of culture. The majority of species are also becoming increasingly threatened with extinction, resulting in a greater need for captive breeding [8]. There remains a key position in the zoo for a range of *Panthera* species.

The Sumatran tiger (*Panthera tigris sumatrae*) is the smallest of the six extant tiger subspecies, and is endemic to the island of Sumatra, Indonesia [10]. They are classified as "Critically Endangered" on the International Union for Conservation of Nature (IUCN) Red List of Threatened Species' [11,12]. Wild tiger behaviour and population density has been well studied, due to the introduction new technology such as camera-trapping [10]. Generally, research to date on tigers suggests that the species is solitary in nature, except during brief period when males and females come into contact for mating, and when females are rearing their cubs [8,11]. There is however some plasticity in terms of territory size, which appears to be dependant on food availability [12].

Given their apparent solitary nature in the wild, many Sumatran tigers are housed singly and mixed only for breeding purposes. However, some animal collections maintain tigers, and more widely big cats, in small social groups, typically of pairs though sometimes larger groups [13-15]. The impact of social grouping in big cats has been investigated previously by some authors, with mixed results [8].

In terms of reproduction, male and female tigers are often separated prior to the birth of cubs [8]. The decision to separate the sexes is often as an attempt to protect the offspring from unwanted aggression, or potentially infanticide, from the male [11,14,16]. The separation of the two sexes should also, in theory, better replicate the social structure that wild cubs would be exposed to [17-19].

There is limited research available on the potential impact on maintaining male and female tigers together during the cub rearing process. There may be hidden benefits to maintaining both sexes in contact during this period: for example, the female may feel calmer if the male is not removed. There is also some evidence to suggest that big cats may be more social in the wild than has been previously documented [6]. For example, male leopards have been observed maintaining non-aggressive contact with adult offspring, suggesting possible kin recognition behaviour [11,14,20].

The purpose of this study was to closely investigate the behaviour and interactions between a Sumatran tiger breeding pair and newly born cubs at the Zoological Society of London's (ZSL) London Zoo. The study was conducted to investigate these interactions over the complete twenty-four-hour cycle.

Material and Methods

Study site and subjects

The study took place at ZSL London Zoo, England, from 27 June to 14 July 2016. The study underwent an internal ethical review prior to data collection, and focused on a pair of Sumatran tigers, which were housed in the Tiger Territory exhibit. The pair had been selected and given a breeding recommendation by the European Ex-Situ Programme (EEP) coordinator and had already produced a trio of cubs in 2014. During the study, the pair were housed with their two most recent cubs, a male and a female (Table 1).

Name (studbook identifier)	Age (at time of study).	Sex	Origin
Melati (1429)	7 Years	F	Perth Zoo
Jae Jae (1400)	7 Years	M	San Francisco Zoo
Achilles (1718)	0-1 Months	M	London Zoo
Karis (1719)	0-1 Months	F	London Zoo

Table 1: Individual information for tigers housed within ZSL Tiger Territory at the time of study.

Tiger Territory opened in March 2013. The animals had access to and indoor enclosure (Figure 1) and an outdoor area, which could be further divided by the keepers into separate enclosures. The indoor enclosure consisted of multiple areas with no public viewing. However, closed-circuit television (CCTV) cameras were set up to cover the key areas where tigers might be seen: the cubbing den, empty cubbing den and cubbing race. The outdoor enclosure consisted of a viewing experience with multiple perspectives, including a prominent, highly visible platform for the education department to deliver talks and floor to ceiling glass viewing panels topped with a fabric canopy allowing visitors to get up close with the tigers (Figure 2).

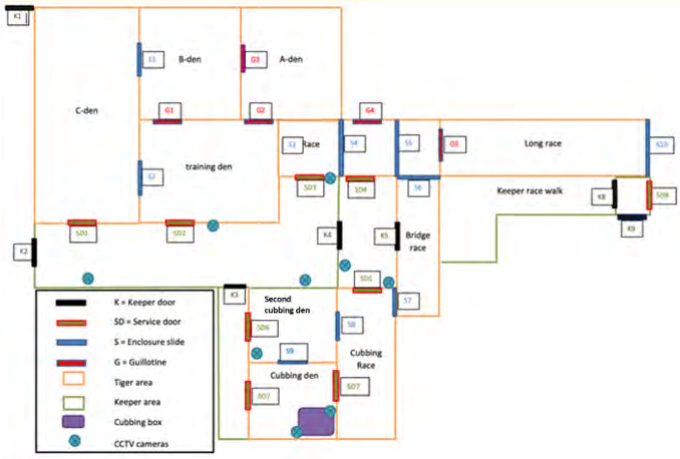

Figure 1: Enclosure blueprint (not to scale) provided by ZSL for the indoor tiger enclosure.

Figure 2: Outdoor enclosure of Tiger Territory at ZSL (Photo Credits: Base Structures). a) pond, b) grass viewing area, c) rock viewing area.

Behavioural data collection

Tiger behaviour was monitored and recorded using the 24-hour continuous CCTV system. Focal animal behavioural observations were completed from the CCTV footage to record the proximity index, state and event behaviours for each animal by one of the authors (KS). All behaviours that were observed were noted using continuous focal sampling, and information on keeper presence and the proximity of other tigers were recorded. The behaviours were recorded alongside observations on enclosure zone use, using a focal sampling method. Individual adult tigers could be identified based on their size and coat pattern. Due to similarities in their markings, small body size and resolution of the CCTV system, the two cubs could not be individually identified so behavioural observations for these individuals were pooled into the category of 'cub'.

Behaviours were inputted into Microsoft Excel™ 2016 and categorised based on a standardized field ethogram by Stanton., *et al.* [19] that was adapted to fit the behaviours observed within this project [16,17]. The 24-hour recordings were split into 6 equal hour ranges for statistical analysis. To create activity budgets, behaviours were categorised into classes (Table 2) also based on similar research [16,17].

Class	Behaviours Included
Affiliative	Allogroom conspecific, play with conspecific, head/body rub conspecific, sniffing conspecific, chuffing, looking into nest box, carrying cub.
Aggressive	The animal engages in spitting, growling, or hissing, or bites, swipes or chases another individual.
Close Guarding Cubs	Adult standing over cubs, within the cubbing den) (including nest box), for at least three seconds.
Exploratory	Any interaction with objects, and/or looking (not in nest box).
Feeding	The animal consumes food.
Inactive	The animal lies, sits or stands without engaging in locomotory behaviour.
Locomotion	The animal walks or runs around its exhibit.
Out of Sight (OOS)	Beyond observers range of vision.
Maintenance	Defecate, urinate, self-groom.
Marking	The animal sprays its enclosure by clawing objects or through anal gland secretions.
Reproductive	Sniff anogenital region in a Flehmen response.
Shifting Guarding	Female leaving male with cubs (male alone with cubs).
Stereotypic	The animal engages in repetitive behaviour without apparent adaptive function

Table 2: Behavioural Classes categorised to create time budgets. Adapted from Stanton., *et al.* [36].

Enclosure usage

The CCTV cameras covered the study area within the indoor enclosure (Figure 1) and was split into 3 proximity categories with out of sight (OOS) added (Table 3). This was used to calculate the guarding behaviour of both the adult male tiger and adult female tiger when the cubs were in the cubbing den.

Enclosure Area	Proximity Category
Cubbing Den (including Nest Box)	Close guarding
Empty Cubbing Den	Nearby guarding
Cubbing Race	Nearby guarding
Outdoors	Out of sight (OOS)

Table 3: Proximity Categories in relation to CCTV enclosure areas in Tiger Territory at ZSL.

Statistical analysis

Graphs were created using Microsoft Excel™ and data analysis was conducted using R Studio (R Core Team, 2018, version 3.5.0). Chi squared tests were run to determine whether there were significant differences in the overall use of enclosure zones between the male and female and also to investigate differences in affiliative and guarding behaviour types.

Results

Enclosure use

The adult tigers used their enclosure significantly differently to one another (X^2 = 145.84. df = 4, p < 0.001). The adult female spent more time within the cubbing race than expected, whereas the adult male spent less time in this location. The adult male spent significantly less time than expected outdoors, out of sight of the CCTV cameras. Both individuals spent significantly longer than expected in the 'cubbing den' (Figure 3).

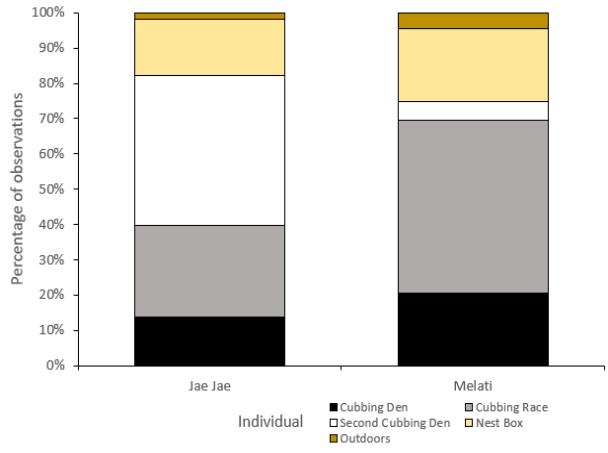

Figure 3: Enclosure use (with out of sight observations removed) for both adult male (Jae Jae) and female (Melati) tiger.

Affiliative behaviour

Overall, there was a significant difference in the frequency of affiliative behaviour between tigers (X^2 = 36.692, df = 4, p < 0.001). A chi squared association test was conducted to investigate differences between affiliative behaviour frequencies across locations. The 'Cubbing den and nest box' were combined for this association test to reduce issues with values less than 5. Affiliative behaviour occurred significantly more often in specific areas (X^2 = 23.988, df = 12, p = 0.02).

The adult male's affiliative behaviour towards the adult female occurred less frequently in the 'cubbing race' than expected but more frequently in the 'cubbing den/nest box'. Whereas the adult female's affiliative behaviour towards the adult male was higher within the 'cubbing race' than expected but lower within the 'cubbing den/nest box'.

The adult male's affiliative behaviour towards the cubs was highest within the 'cubbing den/nest box' (Figure 4). This was also the location where the highest number of affiliative behaviours from the adult male towards the adult female occurred. The adult female's affiliative behaviour towards the cubs was highest within the 'cubbing race' and she was observed displaying affiliative behaviour across a wider range of locations than the adult male. Affiliative behaviour shown from the cubs towards the adult male was seen rarely and occurred within the 'cubbing race'.

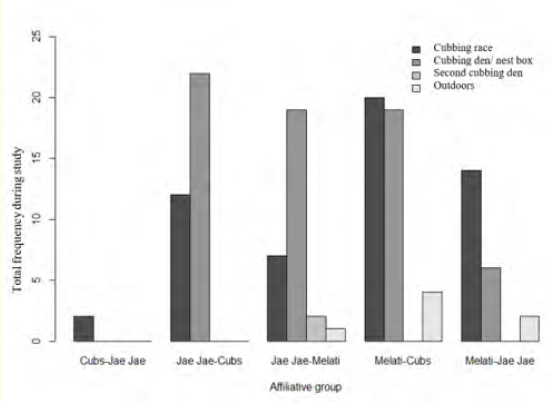

Figure 4: Total count of affiliative interactions across study period for all tigers at London Zoo.

Proximity to cubs

There was a significant difference between the two tigers in terms of their frequency of cub guarding (X^2 = 51.053, df = 2, p < 0.001). The adult male was observed close guarding the cubs more often than the adult female. He also spent more time 'guarding nearby' than expected and a significantly less amount of observations 'further away from the enclosure' than what was expected based on chi-squared expected values.

Activity budgets

Figure 5 displays the overall time budget for behavioural observations for male, female and cub tigers. Overall, both adults displayed 'inactive' as their highest behavioural frequency observed, with the adult male obtaining the highest frequency of this behaviour whilst the adult female displayed the highest frequency of 'locomotion' out of the two. Only a 1.39% difference between the adult male and the adult female was seen in 'close guarding' behaviour towards the cubs, however, the adult female's frequency observation for 'out of sight' and 'shift guarding' was substantially greater than that of the adult males.

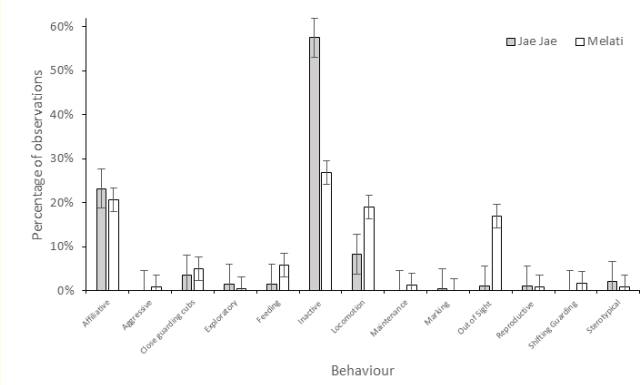

Figure 5: Time budget of overall behavioural observations for male, female and cub tigers at ZSL London Zoo (+/- standard deviation).

Diurnal and nocturnal behaviour

The adult male's behaviour was tracked across the over 24-hour observation period divided into four-hour ranges (Figure 6). The hour range 00.00-04.00 only observed 'inactive' behaviour at 100% during this period followed with another high observed frequency at 20.00-24.00. The adult male's behavioural frequency for 'affiliative' was highest during the hour range of, 16.00-20.00 followed by 04.00-08.00 and then 12.00-16.00. Furthermore his 'close guarding' observed frequency was seen at its highest during the hour ranges of 12.00-16.00 and 08.00-12.00. The adult male was rarely seen 'out of sight' during the hour ranges of 04.00-08.00, 08.00-12.00 and 12.00-16.00.

Figure 7 displays a time budget of the adult female's behaviour across the over 24-hour observation period divided into four-hour ranges. The adult female's affiliative behaviour was highest in the hour range 0.00-0.400 followed by a closely shared frequency during 04.00-08.00 and 16.00-20.00 and further followed by the hour range 12.00-16.00. 'Close guarding' was observed with a shared frequency of 18.18% during 0.00-04.00 and 20.00-24.00 followed by 04.00-08.00. Unlike the adult male, the adult female has a near even spread of 'inactive' behaviour across all hour ranges apart from the lowest frequencies seen during 0.00-04.00 and 04.00-08.00.

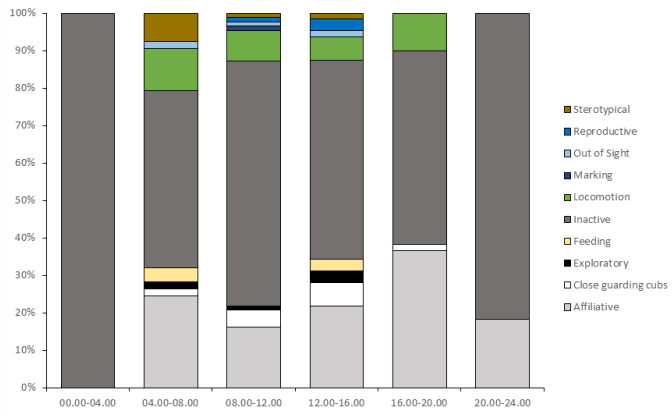

Figure 6: Time budget of male (Jae Jae) tiger behaviour across the over 24-hour observation period divided into four-hour ranges.

Discussion

A sound understanding of the social interactions between animals and their offspring is important for those wishing to breed endangered species in captivity [3]. It is especially important to assess the compatibility of males, who might otherwise pose a threat to the safety of their progeny. In the wild, male felids often present a threat to infants [20-23]. Overall, this study identified no substantiation of threats from the male tiger, the adult male, to the two

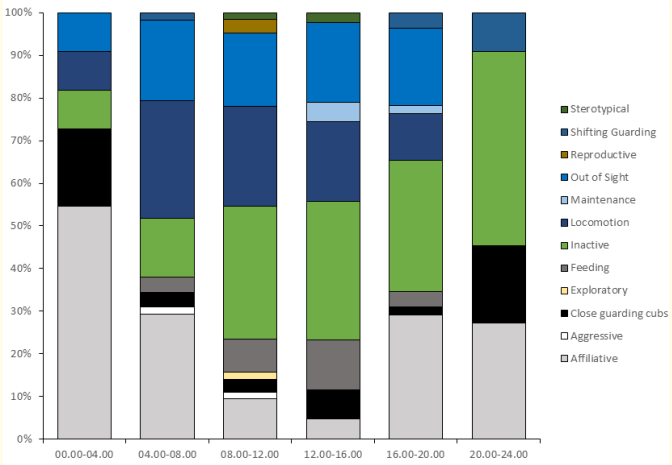

Figure 7: Time budget of female (Melati) behaviour across the over 24-hour observation period divided into four-hour ranges.

Sumatran tiger cubs. Furthermore, the male displayed evidence of both cub guarding and affiliative behaviour directed toward his offspring.

Behaviour and enclosure use

Individual activity budgets showed that tigers regularly engaged in affiliative behaviour. This is particularly surprising, given that the males are not believed to interact with their cubs in the wild [10]. A slight 'shift guarding' pattern was recognised from the female observations, with the male 'close guarding' the cubs alongside the female during the day and early evening, and affiliation and inactivity during the night. During times when the male engaged in close guarding behaviour, high frequencies of affiliative behaviours directed toward the cubs also occurred. While the female tiger was almost always close to the cubs, it is surprising that the male was permitted to be close and to interact with its offspring. Other studies, focusing on adult tigers, have found similar affiliative interactions between related individuals. De Rouck., et al. [11] found that tigers which were housed with a relative (brother, sister or half-sister) were more likely to display affiliative behaviour between littermates. Similar findings have been revealed in group-housed domestic cats (Felis catus) [24], suggesting that behavioural plasticity in terms of group size may be more widespread across felids than has previously been cited. The affiliative interactions between father and offspring are promising in terms of alternative strategies for housing felids in captivity [25].

Time budgets for overall behavioural frequency showed that the adult male spent less time displaying 'locomotion' along with more observed frequency of 'inactive' and 'affiliative' behaviour. Tigers are known to spend up to 75% of the day inactive, however males are normally more active than females [14,25,26]. Therefore, it could be suggested that the adult male was more inactive than the adult female due to the adult female's vigilance and care of her cubs. Hour range time budgets suggest that due to the adult female's frequent 'out of sight' and 'shift guarding' behaviours being substantially greater than that of the adult males, there is a possibility that the adult female allowed the adult male to guard the cubs whilst she ventured into further parts of the enclosure.

Enclosure use has been well studied in zoo literature, with many indices available to the practitioner [26,28-30]. It is surprising that despite the relatively large size of the outdoor zones, the male tiger chose to spend his time inside during the observation period. This is especially interesting as the study was conducted during summer, in which conditions outside were warm, with minimal rain. This suggests that the male was choosing to spend his time close to the youngsters. Future studies investigating exhibit use for tigers both during cub rearing, and during control periods, would be beneficial in investigating this further.

Future directions

Aside from the lion, *Panthera* species are rarely documented spending time in the wild in social groups [8] but see Pirie., *et al*. [6]. Furthermore, there is limited evidence to suggest that wild *Panthera* males engage in care of their offspring [8]. Indeed, some species regularly practice infanticide in the wild (usually from unrelated males), in order to reduce the amount of time before females become receptive [21,23]. The defence of cubs by the female may therefore be a biologically driven strategy [8]. Despite this, there appeared to be little evidence of aggression, either between the two adults or directed at the cubs, during this study. There was, by contrast, good evidence of affiliative interactions from the adult male to the cubs and also to the adult female.

In terms of future directions, further research should be conducted on a wider range of typically solitary felids [31,32]. At current, this paper is a case study to investigate whether pair-housing during breeding is a feasible strategy, to provide welfare evidence for a management system that is already in practice in some insti-

tutions. It is important, therefore, to use multiple assessments of welfare, both for adults and cubs in future studies in this topic area [33-39]. Assessment of the personality of both parents may also be critical; anecdotally, it has been suggested that the male tiger, the adult male, had a stable and outgoing personality that meant aggression was unlikely to occur [35] (Figure 8).

Figure 8: CCTV still frame of the adult female (Left) and the adult male (Right) displaying affiliative behaviour towards newly born cub (Photo Credits: Base Structures).

Conclusion

It is unlikely that this research paper documents the first occasion in which a male tiger was able to share an exhibit with his newborn offspring. However, this is, to the authors' knowledge, the first journal paper covering the behaviour and interactions between the father and offspring. It is possible that big cats in general may have much greater behavioural and social plasticity than has previously been documented, allowing them to adapt to social housing conditions when maintained in captivity. Allowing a well-established male to stay in an exhibit during cub rearing, particularly where personalities between the male and female are compatible, may be feasible in some zoological collections. There is a possibility that this management protocol may improve the resulting compatibility of the cubs upon their reaching of adulthood. Before attempting this in zoos in the future, it is advisable for keepers to assess the reactions between the male and female tiger before allowing the male to remain in the exhibit. Further exploration of this topic, covering a wider range of felids, would have merit in further evidence-basing the work of zoological collections.

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