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Sleeping patterns and social interactions in captive slow lorises (*Nycticebus spp.*): assessing proximity and sleeping site use as an aspect of sociality for welfare and conservation.

By

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ABSTRACT

Slow lorises are commonly traded species in pet markets across Asia, which has led to rescuing these animals from poor welfare conditions and providing rehabilitation. Captive situations results in the development of stress and altered social behaviours affecting their physiological and psychological well-being. Since the primary aim is reintroduction of these animals, there is a need to understand their sociality in captivity for the success of such programmes and for suitable rehabilitation.

This paper introduces, sleep and social interactions as distinct components of their social system. However, sleep plays an important role in the establishment and development of normal social behaviours in non-human primates and is a useful indicator of animal welfare. Thus, it is vital to identify the reasons for the formation of sleeping patterns in captivity.

The study investigates the proximity to a conspecific during sleep and sleeping site selection (sleeping patterns) and social interactions in 34 rescued slow lorises (*Nycticebus spp.*) at the International Animal Rescue Centre, Bogor, Indonesia. A control situation and two treatments, providing enriched nest boxes and removal of all sleeping enrichment devices were applied to investigate 1. If the treatments had an effect on social sleeping, choice of

sleeping sites and social interactions. 2. If the type of social interaction influenced their sleeping patterns.

The results show that social sleeping and positive interactions increased considerably during ENB treatment, and more dispersed sleep was observed during treatment R. The use of trees as sleeping sites was the lowest under treatment ENB, suggesting that captive slow lorises choose to sleep in enclosed spaces opposing existing literature on wild behaviour. A significant negative correlation between no contact sleep and negative interactions implied that dispersed sleep may have been used to manage social cohesiveness in the group. In addition, cage sizes, amount of foliage and the number of individuals in each cage influenced sleeping patterns and socialisations. Furthermore, this paper proposes the potential existence of hierarchal structures present in captivity that may facilitate in managing social relationships and sleeping patterns. Extrinsic and intrinsic factors such as predator avoidance, competition for resources, thermoregulation and maintaining social cohesiveness are discussed in relation to the formation of such patterns of sociality. In conclusion, this study aims to introduce a poorly studied aspect of sociality, sleep, in slow lorises to understand their specialist needs in their captive management.

1. **INTRODUCTION**

Gregarious animals spend most of their active period in close proximity to conspecifics (Waser and Jones, 1983). Sociality in gregarious animals is often initiated and maintained to access co-operative benefits from joint or inter-individual actions. Recent field studies have shown that complex sociability is not restricted to diurnal primates. Nocturnal primates possess an array of behaviours and social networks that differ markedly from their diurnal relatives because of their sensory and perceptual abilities (Bearder, 1999; Wiens and Zitzmann, 2003).

Among most primates, sleeping is a social affair (Anderson, 2000). While nocturnal primates living in dispersed social networks may not necessarily engage in social sleep, certain species of nocturnal primates (galagines, lorises) sleep in groups (Bearder 1999; Wiens and Zitzmann, 2003). When and why nocturnal primates sleep in social units remains an interesting question for exploration. Intrinsic factors like thermoregulation, maintaining social bonds, or extrinsic factors like limited home range or sleeping sites, may effect or alter the social nature of sleep behaviour.

This paper examines two questions; 1. Nest box enrichment treatments provided opportunities for manipulating social sleeping (choice to sleep alone or with others as a function of the type of next box provided), while the caged nature of the individuals provides opportunities for interaction as well as a lack of escape from others that might not exist in the wild. Did the slow lorises use social or solitary sleeping as a mechanism to manage their relationships? (Tests: Application of a sleeping enrichment (enriched nest box) and removal of all sleep site enrichments to observe its effect on sleeping patterns and social interactions) 2. Do the types of interactions that occur during the active period influence the social sleeping structures (neighbours and proximity) in these caged animals? (Tests: Examine the effect of social interactions on proximity to conspecifics during sleep). The paper further

explores extrinsic and intrinsic factors that may influence such behaviours in captive situations, to provide suggestions for welfare in captive management and rehabilitation for slow lorises.

$H1_0$: All individuals will sleep in contact or not in contact regardless of the type of social interaction the previous night.

$H1_a$: The type of social interaction will have an impact on sleep patterns, i.e. positive interactions will increase contact sleep and negative interactions will promote no contact sleep.

$H2_0$: There will be no change in sleeping patterns of proximity or sleep site choice with the application of enriched nest boxes.

$H2_a$ Application of enriched nest boxes will encourage individual sleep and alter sleep site choice by choosing to use enriched nest boxes.

$H3_0$ Removal of sleep site options will not change proximity of sleep in individuals.

$H3_a$ Removal of sleep site options will increase dispersed sleep.

This is the first study, to my knowledge, to study the sociality of sleep and sleep patterns in captive slow lorises (*Nycticebus* spp*.*).

2. METHODOLOGY

2.1 Ethical Statement

The study was approved by the Veterinary Ethical Review Committee of the University of Edinburgh and was granted permission in Indonesia under a research permit (KITAS-067/SIP/FRP/SM/III/2013) approved by the Kementerian Riset dan Teknologi (RISTEK), Indonesia under the supervision of an Indonesian academic counterpart, Dr. Rondang S.E Siregar.

Only behavioural data were collected, and no invasive methods for data collection were used for this study. Observations were made using infra-red lights to increase visibility in non-daylight hours from a considerable distance to avoid stress and any effects of the presence of an observer. Application of treatments did not impose any apparent suffering on the animals.

2.2 *Location*

Research was conducted at the International Animal Rescue Centre at Bogor, Indonesia between 6, March 2013 and 3, June 2013.

2.3 Animals

34 lorises of two species, *Nycticebus coucang* and *Nycticebus javanicus* were chosen as the subjects of this study, who are thought to have similar ecologies and social systems in the wild. Thirteen cages were chosen for a balanced representation of sex, species and age-group of the individuals in each cage (Table 2.1).

The individuals chosen for the study were confiscated, surrendered by pet owners or transferred from other rescue organisations and housed at the centre for rehabilitation and subsequent release. The sample size included 7 release and 27 non-release candidates. The individuals were rescued at different times, therefore the amount of time spent at the centre varied (Table 2.1).

All animals were individually studied, and recognizable through careful observations of fur colour and patterns, size and distinct facial markings in the pilot study.

Table 2.1: List of individuals in the study with information regarding their sex, species and the date of entry to the centre, where; M=Male, F=female, C= *N. coucang*, J=*N. javanicus.*

CAGE	No. of IND	NAME	SEX	SPECIES	Entry date
1	3	Jubile	F	J	14-12-12
		Maripilli	F	J	30-11-12
		Anne	F	J	14-12-12
2	2	Jasu	M	C	14-12-11
		Nunung	F	C	09-03-12
3	3	Bule	F	J	19-02-13
		Bino	F	J	19-02-13
		Albi	F	J	19-02-13
4	3	Charles	M	J	21-07-11
		Phillip	M	J	
		Pluto	M	J	09-05-11
5	3	Richard	M	J	24-05-09
		Chika	F	J	11-11-08
		Regina	F	J	28-05-09
6	4	Slash	M	C	26-08-10
		Nia	F	C	04-09-10
		Fifi	F	C	26-08-10
		Lailasari	F	C	26-05-10
7	4	Rido	M	C	19-11-09
		Tori	F	C	10-12-08
		Agnes	F	C	19-11-09
		Danica	F	C	26-08-10
8	2	Tegal	M	C	10-12-08
		Lui	M	C	26-06-12
9	2	Cepat	M	J	18-07-11
		Mars	M	J	21-04-11
10	2	Mimo	F	C	25-11-11
		Mulud	Baby	C	10-02-13
11	2	Hayang	M	C	06-09-08
		Donna	F	C	29-05-11
		Ambu	F	C	26-08-10
12	2	Jupe	F	C	19-11-09
		Sukhoi	Baby	C	14-05-12
13	2	George	M	C	27-07-10
		Lucia	F	C	26-08-10

2.4 Enclosures and management

The animals were grouped as two, three or four individuals per cage and housed in outdoor

cages. The cages were covered with a roof and a plastic sheet on the side common to an

adjacent cage. Cage walls were made of mesh with gaps of (2.5x2.5) cm. The cages varied in size and the amount and type of foliage present within each (Table 2.2). Cage floors were cemented for sanitary and health reasons. Temperature was common across all cages as they were located outdoors. A red light was hung outside and above each cage during non-daylight hours for management purposes and observation. There was minimum auditory disturbance to the animals except for occasional ambient sounds.

The enclosures were cleaned once a day at 15:30 during the sleep period. Leaves and branches were added in the cages periodically to provide varied substrates for locomotion and opportunities to hide or sleep. Sleeping enrichments such as bamboo hollows, nest boxes and baskets hung from the cage roof were provided in eight cages.

a.

b.   Figure 2.1 a. M cage. b. S cage, equipped with enrichment.

The lorises were fed with fruit and insects, twice a day at 18:00 and 23:00 and were provided with adequate amounts of food for the number of individuals per cage. Different feeding enrichments were provided every day following the second round of feeding. Water was provided ad libitum.

Table 2.2: List of size of each cage considered in study, where length, breadth and height measured in feet (ft) and volume measured as ft^3.

CAGE	NAME	LENGTH	BREADTH	HEIGHT	VOLUME	VOLUME/IND
1	Anne, Jubile, Maripilli	9.5	9	6	513	171
2	Jasu, Nunung	9.5	9.5	6.0-7.0	586.625	293.31
3	Albi, Bino, Bule	9.5	9	5.5-8	598.5	149.62
4	Charles, Pluto, Phillip	9.5	9.5	6	541.5	270.75
5	Richard, Regina, Chika	9.5	9	6	513	171
6	Slash, Nia, Fifi, Laila	17.5	12.5	6	1312.5	328.125
7	Rido, Danica, Tori, Agnes	17.5	12.5	6.0-9.0	1640.625	410.15
8	Lui, Tegal	6.5	6.5	6.5-8	295.75	147.87
9	Mars, Cepat	6.5	6	7	273	136.5
10	Mimo, Mulud	6.5	8.5	6.0-7.0	359.125	179.56
11	Hayang, Donna, Ambu	6.5	8.5	6.0-7.0	359.125	119.70
12	Jupe, Sukhoi	6.5	8.5	6.0-7.0	359.125	179.56

2.5 Experimental Design

Observational data were collected on social interactions (table 2.3) in the active period (17:00 to 5:00) and records of proximity to a conspecific during sleep and location of sleep (sleep patterns) during the sleep period (5:00 to 17:00).

Two treatments and a control were applied.

Control: No changes were made to the cages. This included cages that have 1 or 2 nest boxes, cages that did not have nest boxes or enrichment devices and those that had only enrichment devices.

Treatment 1- Enriched Nest Boxes (ENB): ENBs of (35x35) cm were designed, constructed and fitted with bamboo, branches and foliage. In this treatment, the number of nest boxes placed in each cage was equal to the number of individuals, to provide the opportunity for individual sleep. In cages that were enriched with optional sleeping sites, the enriched nest boxes were provided as an addition.
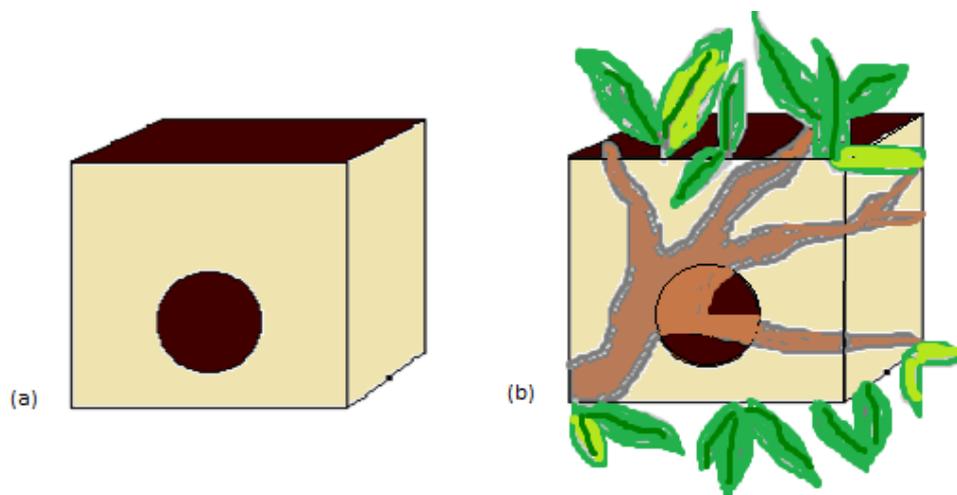

Figure 2.2: a- nest box present in control, b-Enriched Nest Box

Treatment 2 – Removal: Nest boxes and enrichments were removed from all cages under the treatment. Therefore, cages were equipped only with existing trees, branches and foliage.

To control for the order effect, the treatments were applied to 13 cages in a randomised order (Table 2.3).

Table 2.3: List of cages with the randomised application of treatments in three phases, where C=control, R=removal, ENB=enriched nest box.

Cage Number	Names of Individuals	Phase I (13 days)	Phase II (13 days)	Phase III (13 days)
1	Anne, Jubile, Maripilli	C	R	ENB
2	Jasu, Nunung	R	C	ENB
3	Albi, Bino, Bule	ENB	C	R
4	Charles, Phillip, Pluto	C	ENB	R
5	Richard, Regina, Chika	C	R	ENB
6	Slash, Nia, Fifi, Lailasari	ENB	C	R
7	Rido, Tory, Danica, Agnes	R	ENB	C
8	Lui, Tegal	R	C	ENB
9	Craight, Suji – Mars, Cepat	C	ENB	R
10	Mimo, Mulud	ENB	C	R
11	Hayang, Donna, Ambu	R	ENB	C
12	Jupe, Sukhoi	C	R	ENB
13	George, Lucia	ENB	R	C

Observations were conducted from 25, March 2013 to 5, June 2013. A pre-pilot study and a pilot study were carried out for two weeks, in order to recognise and distinguish between behaviours and individuals, to get accustomed using an infra-red light for data collection in non-light hours and to make changes to the final study or experimental design based on the results.

All observations were made by a single observer to avoid observer-bias.

2.6 Social Interactions

Observations to record social interactions were carried out during the active period between 21:00 and 4:00.

An ethogram (Table 2.3) on social interactions, stereotypies and vocalisations in lorises was set up based on the Loris Husbandary Manual (Fitch Snyder et al, 2001), IARI ethogram, and observations from my pre-pilot study. Interactions were categorised as;

- Positive/ neutral interactions (amiable) – elicited sociable behaviours such as, grooming or play and behaviours that were a part of an on-going or indirect interactions such as, leave, proximity and approach pass. friendly

- Negative interactions (agonistic) - elicited aggression or submission such as, fight, threat, snatch.

- Positive and negative vocalisations that was either directed or non-directed.

Table 2.3: Ethogram for social interactions grouped as positive/neutral and negative, positive and negative vocalisations.

BEHAVIOUR	DESCRIPTION
POSITIVE/NEUTRAL	
Social Approach	Move toward other animal to less than one body length away.
Social Approach-pass	Move within one body length of other animal and then continue to pass without pause.
Leave	Deliberate movement away from the other animal during an ongoing social Interaction
Follow	Climb behind another loris and maintain visual orientation to it.
Depart	Move more than one body length away from another animal after any physical contact.
Social Explore	Sniff body of another animal
Social Play	Attempted bite or manual attack, dangle by feet, wriggle body with arms over head. Attempted bite or manual attack, dangle by feet, wriggle body with arms over head.
Social Solicit	Hanging from the ceiling or a branch with wiggle motion. Arms usually outstretched either to elicit play or allo-grooming from conspecific.
Allo-groom	Lick or comb with toothcomb other loris' face or fur - usually while clasping him or her.
Proximity	Sit, stand or rest within one body length of another animal without engaging in social activity. Bodies touching but no clasping or other social behaviour.
Interaction with Neighbour	Sniff, follow, walk along, or reach out to a conspecific in a neighbouring cage.
NEGATIVE	
Attack	Feet stationary while head and neck are thrust suddenly at opponent.
Manual defensive threat	Push, pull and strike with hands.
Fight	Form of wrestling in which two animals manually attack and bite each other.
Aggressive Pursuit	Vigorous chase combined with attack or threat, particularly staring.
Submissive Posture	Turn head and/or body away, usually of short duration

	before retreat.
Flight	Rapid, undirected withdrawal; Often downwards during social stress.
Back away	Locomote backwards while maintaining visual orientation with another animal.
Avoid	Walk passed a conspecific 2 or more body length away, or walk in an another direction if conspecific in the path of travel.
Snatch	Take away food from the hands of another during eating
Push	Use head, hand or body to push a conspecific during a social interaction or activity such as feeding or interacting with another.
Whistle	A high-pitched, non-directional sounding vocalization emitted usually by a Receiver
Krik	Low and short, single or repeated at irregular intervals. Used to appease, usually by male pursuing female in oestrus or females appeasing an infant
Click	Series of discrete, rapid clicks and squeaks usually made by an infant during a disturbance, especially when separated from mother. May be followed by a short pant-growl.
Pant-growl	Panting, ending in a distinct growl, accompanying threats and preceding an attack.
Chitter	Rapid, repetitive clicking sound, lasting one to two seconds or longer. Intraspecific defence vocalization. Can turn into cricket-like chirping in high intensity defence situations.
Scream	High pitched sound as a submissive reaction or agonistic reaction to a conspecific.

Social interactions were recorded using continuous, all-occurrence sampling for 5 minutes per cage. Each round of observation for all the cages lasted for 1 hour ± 5 minutes. The frequency of the social behaviours displayed by the lorises in a cage for a period of five minutes and the direction of interaction (initiator-receiver) were recorded.

Data were collected in three parts to see if there were differences in the amount and type of social interactions during different activity periods;

- Before feeding – 21:30 to 22:30

- During feeding – 23:15 to 00:15

- After feeding – 2:00 to 3:00

In order to avoid a sampling bias, observations were randomised between cages for each day for the three activity periods.

2.7 Sleep Patterns

Proximity and location of sleep were recorded the following day after data collection of social interactions, to assess the possibility of an immediate effect of the type of social interaction on sleep patterns. Observations were made during the sleep period between 5:30 to 17:30.

Sleep patterns were observed twice per day, to account for cases of wakefulness resulting in a change in sleep site or proximity to a conspecific during the sleep period.

- Approach sleeping site – 5:30 to 6:30

- During sleep – 14:30 to 15:00

Proximity to sleep was noted as contact, at distances <1 body length (bl), =1 bl or >1bl. This was later categorised for analysis as, contact (Cont; <1bl) or no contact (Ncont; >1bl) sleep. Location of sleep was determined by the use of sleeping site i.e. nest box (NB, if in control), enriched nest box (ENB, if in treatment 1), tree/plant and other - included sleep enrichment such as bamboo hollows and baskets.

2.8 Additional Factors

Cage size and amount of foliage (depending on the number of trees and type of foliage cover) were considered, to check whether there was an effect on choosing a specific sleeping site. For data analysis, a scale was developed for both these factors. Cages were categorised as Large (L), Medium (M) and Small (S) in size and scores as 1, 2 or 3 (1 being least, 3 being most) were created for the amount of foliage and tree cover present in each cage (Table 2.4).

In addition, gender and the group size in each cage were recorded to observe their effect on socialisation, proximity and partner preference during sleeping.

Table 2.4: List of cages with categorisations of cage-size and amount of foliage. Scale for amount of foliage; 1-cage consists of creeper, one or no trees; 2-cage consists of thick and widespread creeper, large amounts of leaf cover, one or more trees; 3-cage consists of dense creeper, thick leaf cover, more than one tree and plants.

CAGE	NAME	Cage Size	Amount of Foliage
1	Anne, Jubile, Maripilli	M	1
2	Jasu, Nunung	M	2
3	Albi, Bino, Bule	M	2
4	Charles, Pluto, Phillip	M	1
5	Richard, Regina, Chika	M	2
6	Slash, Nia, Fifi, Laila	L	3
7	Rido, Danica, Tori, Agnes	L	3
8	Lui, Tegal	S	2
9	Mars, Cepat	S	1
10	Mimo, Mulud	S	2
11	Hayang, Donna, Ambu	S	2
12	Jupe, Sukhoi	S	3
13	George, Lucia	S	1

a

b

c.

Figure 2.3 a. M sized cage size with foliage amount 1; b. S sized cage with foliage amount 2; c. L sized cage with foliage amount 3.

2.9 End points

Through the study, small number individuals suffered from health and behavioural problems. Individuals who were not fit (determined by the on-site veterinarian) were removed from the study. In cases where there were two individuals in a cage and one was removed from the study, observations were terminated for the other.

2.10 Data Analysis

For analysis of the effect of additional factors, data over the period of the study were grouped according to the different factors and were scaled accordingly due to varying sample sizes for each factor (Table 2.5).

Table 2.5 List of factors; gender, cage size, number of animals per cage and scale of foliage amount (table 2.4) across the study, with sample sizes corresponding to each factor.

Gender groups in each cage	N	Cage size	N	Number of animals/cage	N	Foliage amount	N
All female	2	S	5	2 individuals	6	1	3
All male	3	M	5	3 individuals	3	2	6
Female-male	2	L	2	4 individuals	3	3	3
2 females, 1 male	2						
3 females, 1 male	3						

Data were analysed using Microsoft Excel® 2010 and Minitab® 16. Chi-square tests, paired t-tests, One-way ANOVA and correlations were applied for analysis. Contingency tables, graphs and descriptive statistics were set up using Microsoft Excel® 2010. Minitab® 16 was used for statistical test calculations.

The non-parametric alternative, Kruskall-Wallis and Spearman's rank Correlation were used when the data were not normally distributed.

The threshold value used for establishing statistical significance was considered as $p \leq 0.05$ for all analyses.

3. RESULTS

3.1 Social Interactions

3.11 Effect of treatments on type of social interaction

The treatments had a significant effect on the expression of positive and negative interactions ($X^2 = 32.29$, df=2, p<0.001). Animals engaged in more positive interactions under the control treatment (1492 vs. 1448.24), whereas more negative interactions were observed in ENB (147 vs. 109.87) and R (109 vs. 102.36) (Figure 3.1).
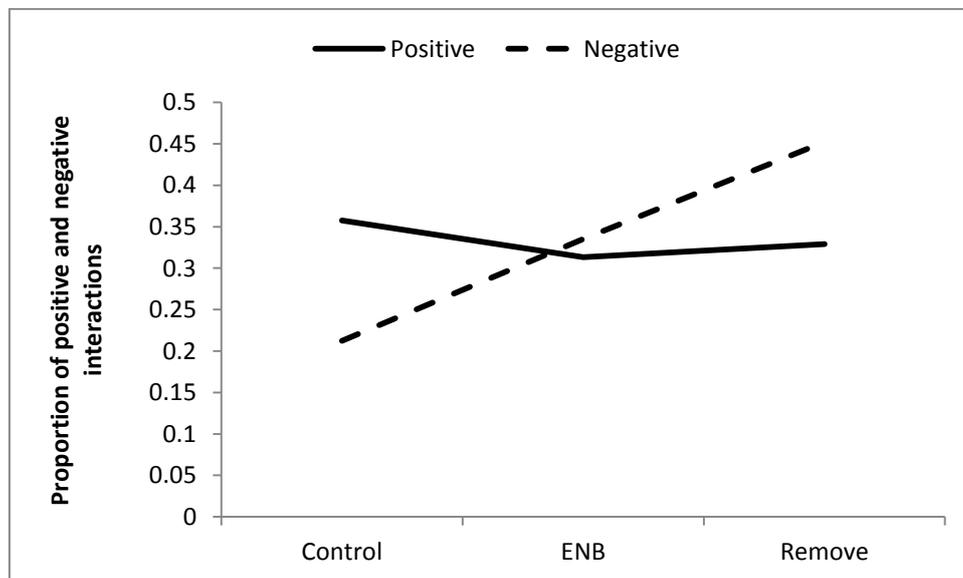

Figure 3.1: The proportion of positive and negative interactions across treatments and control.

In control conditions, animals engaged in more positive behaviours than negative. The proportion of negative interactions increased during R. However, across the two treatments and control, individuals engaged in a considerable higher proportion of positive interactions than negative.

3.12 Effect of three activity periods – before feeding, during feeding and after feeding on the type of social interaction.

There was no significant difference in positive interactions across the three activity periods ($F_{2,105}$=0.76, p=0.468).
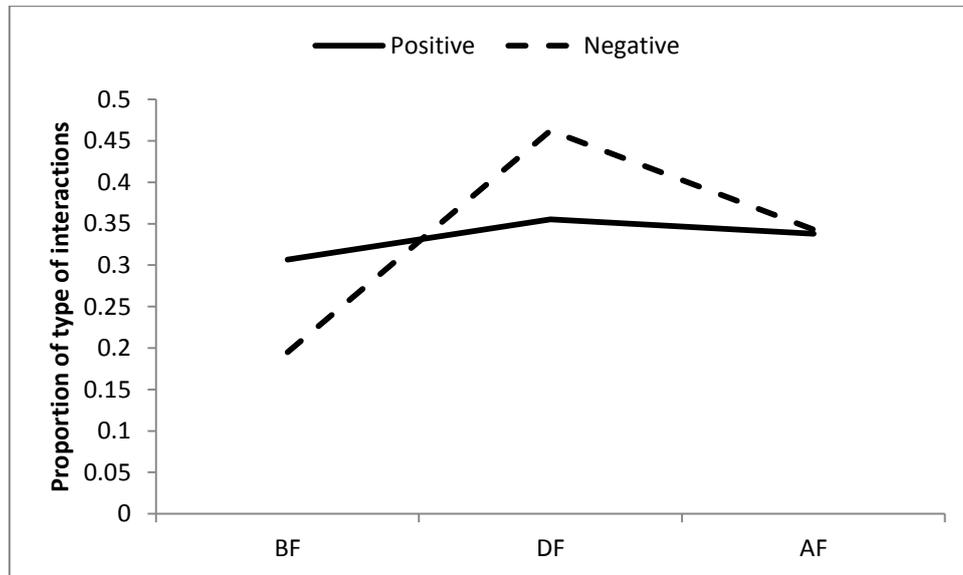

Figure 3.2 Proportion of positive and negative interactions for the three activity periods –BF-Before feeding, DF-during feeding and AF- after feeding.

However, there was a significant difference in negative interactions among the three activity periods (K-W, H=11.17, DF=2, p=0.004). Group medians suggests that most negative interactions took place during feeding (3.5), followed by after feeding (2.0) and the least amount of negative interactions were observed before feeding (1.0).

3.13 Effect of cage size, number of individuals and gender on type of social interactions.

Data of the type of interactions were scaled for more accuracy for different sample sizes (e.g. number of positive interactions/ no of individuals in that cage).
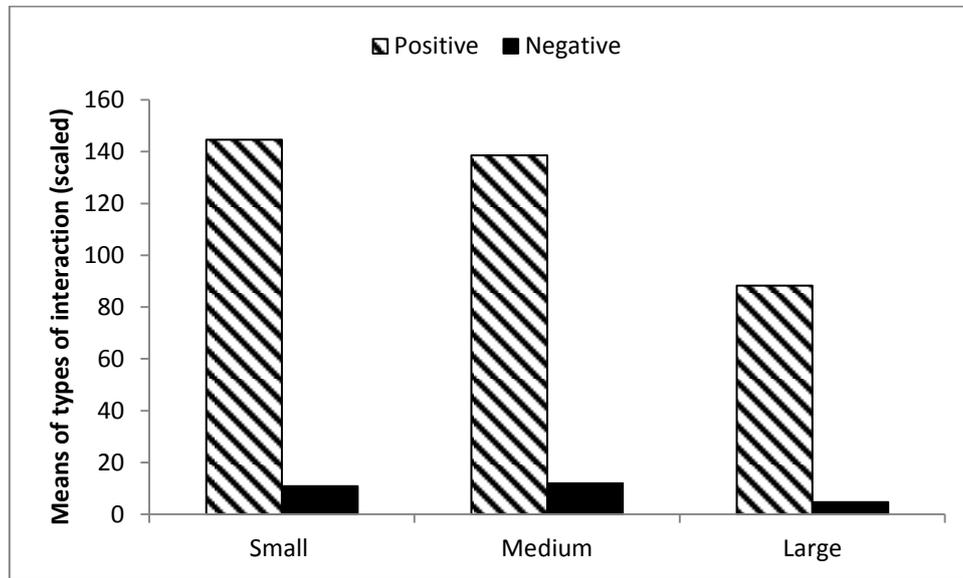

Figure 3.3 Group means of positive/negative interactions (scaled data) in three cage sizes, i.e. Medium (M), Large (L), Small (S).

Data for interactions were scaled and grouped for three cage sizes. This was further divided by the number of cages of the same size (e.g. Scaled data for positive interactions for cage S/Number of S cages) (Table 2.5).

Cage size had no significant effect on positive and negative interactions ($F_{2,9}$=1.38, p=0.299; $F_{2,9}$=0.71, p=0.517). However, individuals in cages S showed more positive interactions (144.63) as compared with cages M (138.63) and L (88.25). Individuals in cages L engaged in the least number of interactions (positive 88.25; negative 4.75). In cages M, most number of negative interactions were observed with a group mean of 11.98.

Though data were scaled, the rates of interactions are difficult to compare as the number of individuals in each cage and the gender composition in each group may have influenced the type of interactions. For example, the reason for more negative interactions

observed in cages M maybe due to the density of individuals in a cage. Similarly, the number of individuals to cage size L could also be a reason for the least number of interactions observed, due to the largest volume to no individuals of 328.12 and 410.15 m^3/individual (Table 2.2).
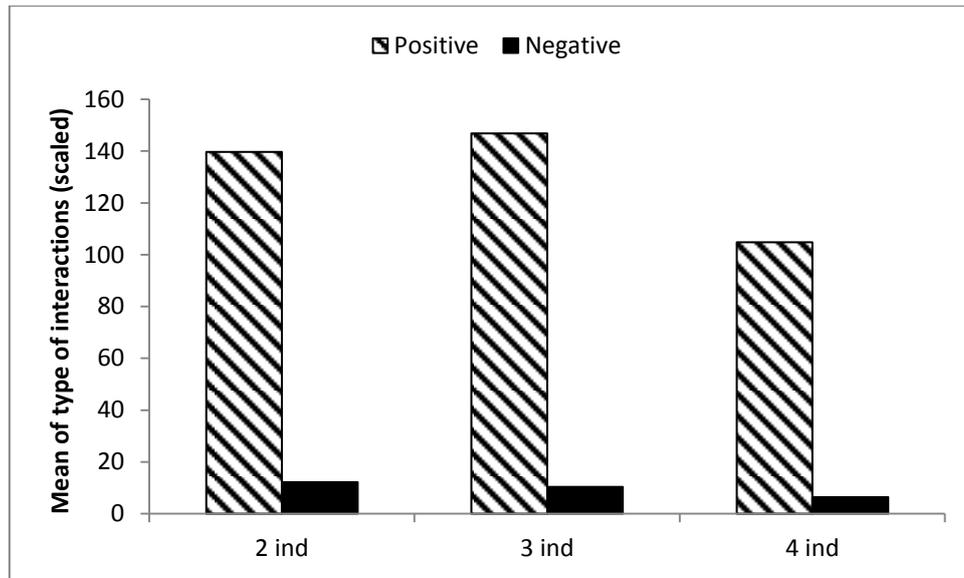

Figure 3.4 Group means for type of interactions (scaled data) for the number of individuals in each cage (cages with 2, 3 and 4 individuals).

The data for interactions were scaled by dividing the total number of positive, negative interactions by the number of individuals in the particular cage separately (Table 2.5).

There was no significant effect of the number of individuals on the type of interactions ($F_{2,9}$=0.83, p=0.466; $F_{2,9}$=0.61, p=0.564 respectively). Group means indicate that cages with three individuals showed more of positive interactions (146.78) followed by cages with two individuals (139.67). However, negative interactions in cages with two individuals were the highest (12.25), followed by cages with three individuals (10.44).
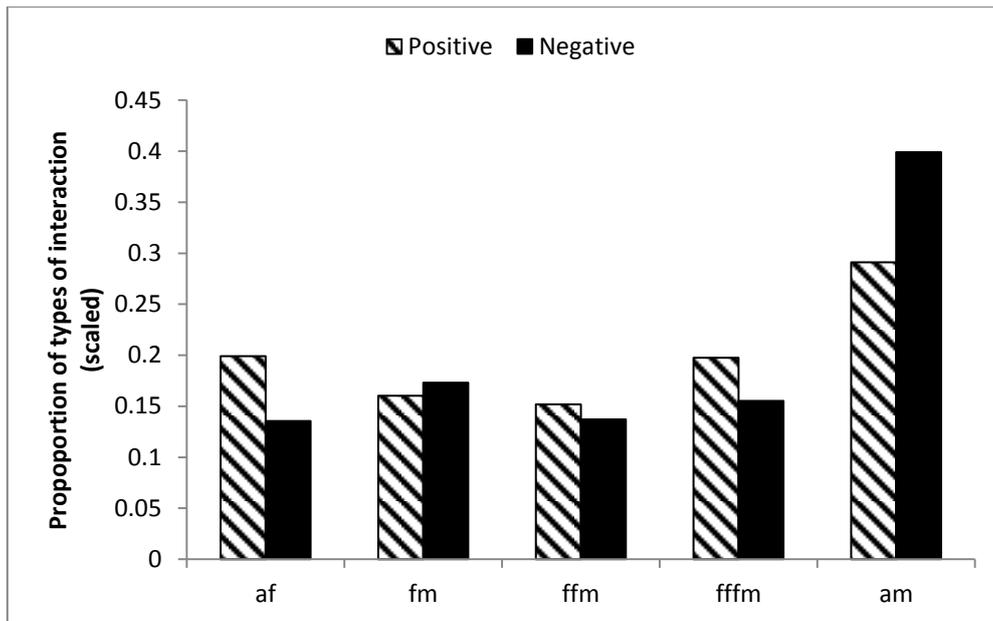
Figure 3.5 Proportion of positive and negative interactions (scaled data) for the sex of individuals in each cage, where af= all female group, fm= female-male pair, ffm= 2 females and 1 male group, fffm= 3 females and 1 male group, am= all male group.

Cages were grouped by the gender of the individuals in each cage and data were scaled (Table 2.5).

Gender did not have any significant effect on interactions. Af groups had the highest number of positive interactions (158.67) followed by am groups (154.50), ffm group showed the least number of positive interactions (104.83). However, am groups showed the highest number of negative interactions (16.5) followed by fm pairs (10.75) and fffm groups had the least (6.417).

The effect of these factors on the type of interactions are inter-related. For instance, fffm groups showed least interaction overall, and these gender groups were present in cage size L. Therefore, interactions may have been more dependent on the amount of space in each cage rather than the gender or the number of individuals in a group.

3.2 Sleep patterns

3.21 Effect of treatments on proximity to a conspecific during sleep.

There was significant effect of treatments on contact and no contact sleep ($X^2 = 22.467$, df=2, p<0.001). There was more contact (269 vs. 241.11) than no contact sleep in treatment ENB (44 vs. 71.89) (Figure 3.6).
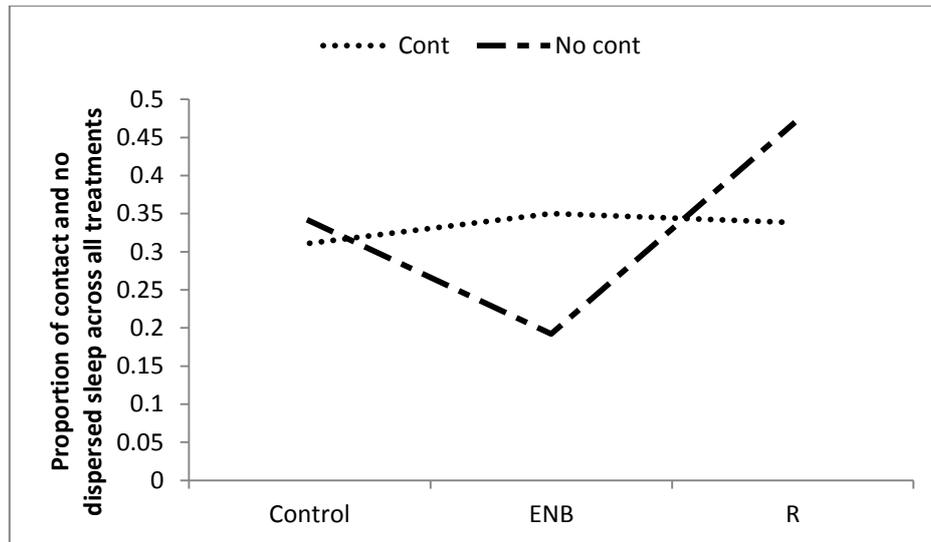

Figure 3.6 Proportion of contact and no contact sleep compared with the total contact and no contact sleep across three treatments.

There was no significant difference in contact sleep across the three treatments (K-W, H=1.60, df=2, p=0.450). However, in an analysis of group medians, there was more contact sleep in ENB (8.0) and R (8.0) than in control (7.0). There was a significant difference in no contact sleep across the treatments (K-W, H=9.62, df=2, p=0.008). ENB had the least no contact sleep (1.0) as compared to control and treatment R.
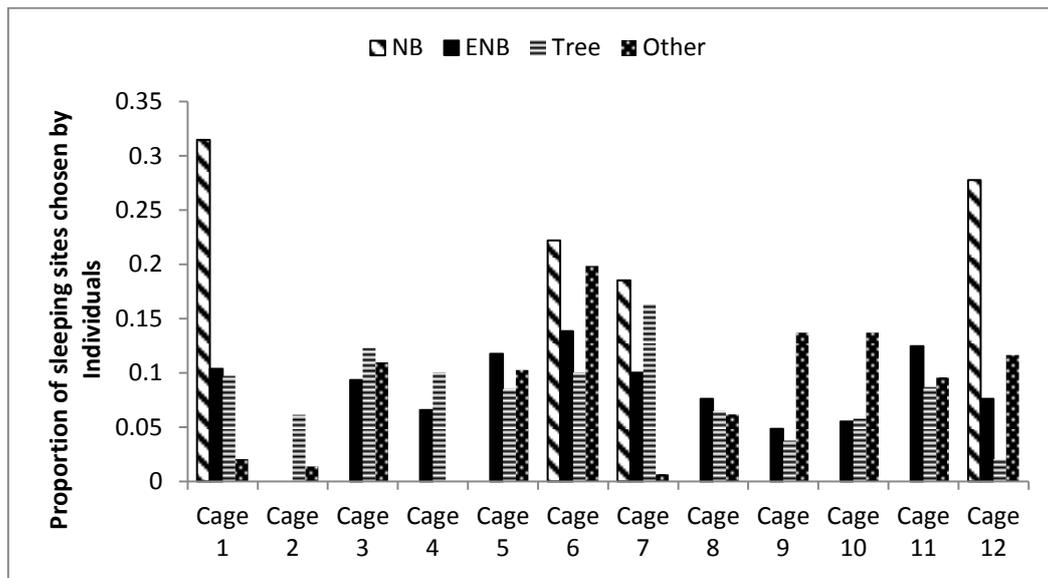
3.22 Changes in sleeping site

Figure 3.8 (a) Proportion of sleep sites chosen (NB=nest box, ENB=enriched nest box, trees, other sleeping enrichment) by individuals in each cage in total, across all three treatments.

3.8 (b) Proportion of sleep site usages to the total sleep each treatment and control.

Cages 1, 5, 6, 7 and 12 had nest boxes in control. Cages 1, 3, 9, 6, 7 and 10 had other enrichment for sleeping (bamboo hollows and baskets). 'Other' was considered for when the animals chose to sleep anywhere else within the cage other than a nest box, enriched nest box or trees.

Under control conditions, only individuals in cage 5 chose to sleep in trees or other sites in spite of being provided with a nest box (Figure 3.8). There was no significant

25

difference between choosing nest boxes or no- nest box sites (tree+other), although there was a very low tendency of choosing a nest box to sleep in (Median difference 0.109; T=59, N= 12, p=0.126). Regardless of the presence of a nest box or other sleeping enrichment, all individuals chose to sleep in trees, plants or branches.

There was no significant difference among individuals in choosing to sleep in ENB or non-ENB sites (trees+other) (Median difference 0.064; t-test, T=47; N=12; p=0.230). However, from Figure 3.8, it is evident that all individuals except individuals in cage 2 chose to sleep in an enriched nest box when they were provided.

During R, when NB's and ENB's were not available, there was no significant difference in choosing to sleep in trees and plants to other sites (no sleep enrichments provided) (Median Difference 0.0004; t-test, T=39; N=12; p=1.0).

3.23 Change in position of sleep

Figure 3.9 Percentage of contact and no contact sleep at 6:00 (retreat to sleep site) and 14:30 (during sleep) for three different treatments (C I, NC I – Contact and No contact sleep at 6:00 and C II and NC II – Contact and No contact sleep at 14:30).

Overall, from Figure 3.9, there was a very low decrease in contact sleep from 5:30 to 15:00h. In treatment R, the highest percentage increase in no contact sleep (14.17%) was observed, however, there was only a 4.08% drop in contact sleep from morning to afternoon.

This could be due to the number of individuals out of sight, or individuals that were not in contact with conspecifics during morning observations. The lowest percentage change was seen during ENB (5.128%)

3.24 Proximity to con-specific in individual cages.

Data on proximity of sleep for each individual in the study was separated and the frequency of contact or no contact sleep of an individual with a conspecific within its cage was obtained. Matrices were constructed for the individuals in each cage across all treatments applied.

CONTROL

No contact

Contact	Albi	Bino	Bule	George
Albi		2	6	4
Bino	6		6	4
Bule	2	2		5
George	3	2	2	

ENB

	Albi	Bino	Bule	George
Albi		2	2	
Bino	8			2
Bule	8	8		
George				

REMOVAL

	Albi	Bino	Bule	George
Albi		5	6	4
Bino	5		3	5
Bule	4	7		4
George	3	2	3	

Fig. 3.10 Matrices for Cage 3. Frequency of contact and no contact sleep to conspecifics for three different treatments.

Situation A

66.6% (A → B)
66.6% (A → C)
66.6% (B → C)

Situation B

45.8% (A → B)
16.6%
37.5
25%
20.81%

——— Sleeping in contact (thickness represents the strength of association)

A Adult female subordinate II ; B Adult female subordinate I ; C Adult female alpha ; D adult male
Situation A: Sleeping patterns amongst the original group composition of three adult females.
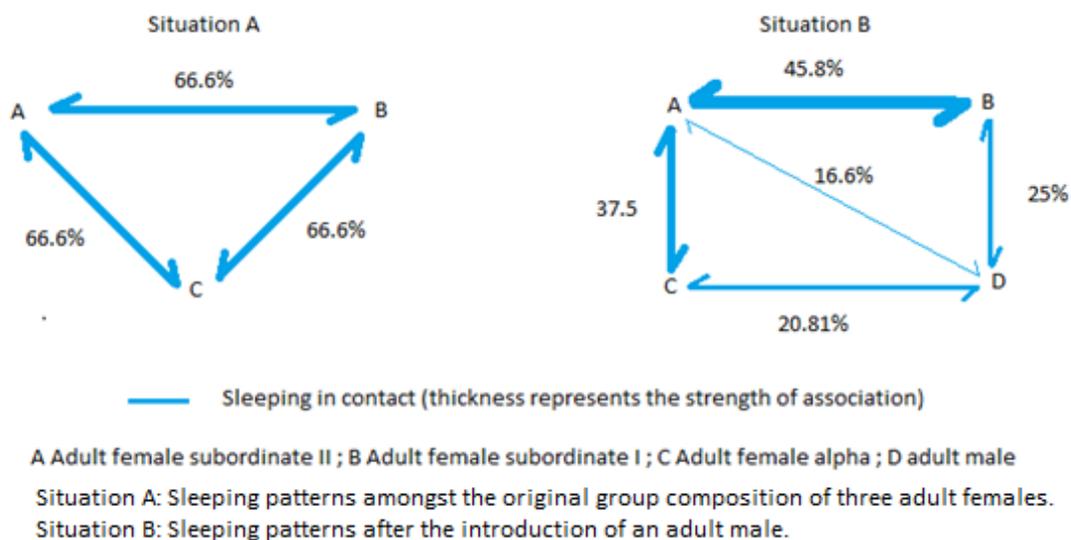Situation B: Sleeping patterns after the introduction of an adult male.

Figure 3.11 Socio-gram for proximity to a conspecific during sleep for the above (figure 3.10) matrix.

Figure 3.10 and 3.11 are a representation of the sleeping pattern (proximity) between three females and one male in cage 3. In control and treatment R females slept in contact with each other on 8 nights. However when D was introduced, the increased agonistic encounters between C and D resulted in decreased contact sleep for C with her female conspecifics. A preference of sleeping partner may also be observed, where D preferred to sleep with B. In this example there is not much difference observed in partner preference, however other cages showed a higher preference for a particular conspecific. (see Appendix I).

These matrices illustrate proximity and partner preference during sleeping depending on the sex, age and social interactions between them. A potential existence of dominance structures (C and D assumed to be dominant female and male) within each cage may be reflected in certain matrices. (Matrices have been constructed for all individuals in the study and presented in Appendix I).

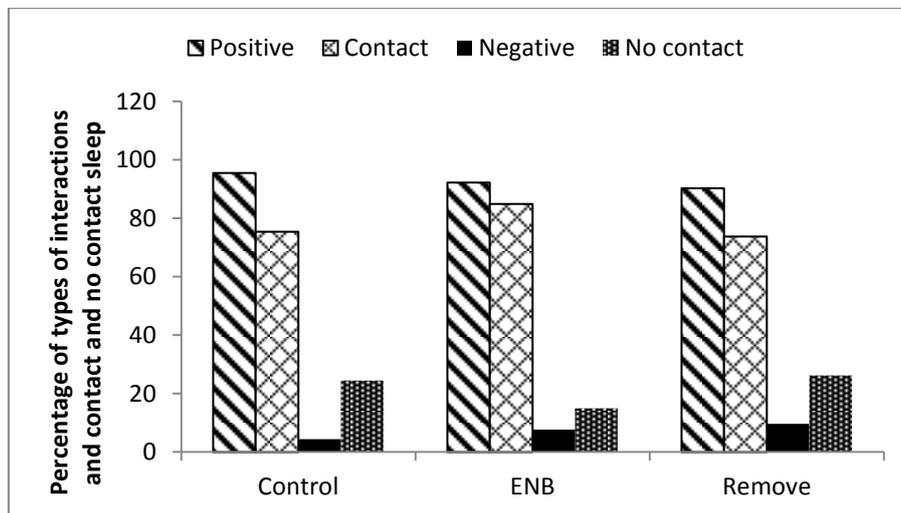*3.25 Type of social interaction and contact and dispersed sleep.*

Figure 3.11 Comparing percentage of positive interactions and contact sleep and negative interactions and no contact sleep for each treatment and control.

Positive interactions were correlated with contact sleep and negative interactions with no contact sleep. There was no positive correlation between number of positive interactions

28

and frequencies of contact sleep in control (r_p=0.485, p=0.110), ENB (r_P=-0.035, p=0.913) and R (r_s=0.330, p=0.294).

Similarly, there was no significant correlation between rates of negative interactions and frequencies of no contact sleep in control (r_p = -0.079, p=0.807), ENB (r_s=-0.354, p=0.259), but there was a significant negative correlation in R (r_s= -0.589, p=0.044) (Figure 3.11).

There was no significant correlation between positive interactions and contact sleep (r_p=-0.235, p=0.168) or negative interactions and no contact sleep (r_s= -0.156, p=0.362) across all treatments.

3.26 Effect of *foliage, cage size and gender on proximity and sleep sites*

There was no significant difference between choosing a sleep site and proximity during sleep for different cage sizes or foliage amounts. The only significant difference observed was choosing to sleep in trees. This was significantly affected by the cage sizes (K-W, H=7.11, df=2, p=0.029). Observing group medians, individuals in large cages (L) slept more in trees (0.132) followed by those in mid-size cages (M) (0.099) while small cages (S) had the least (0.058).

Overall, individuals chose to sleep in trees through all treatment schedules and preferred to sleep in ENB when provided.
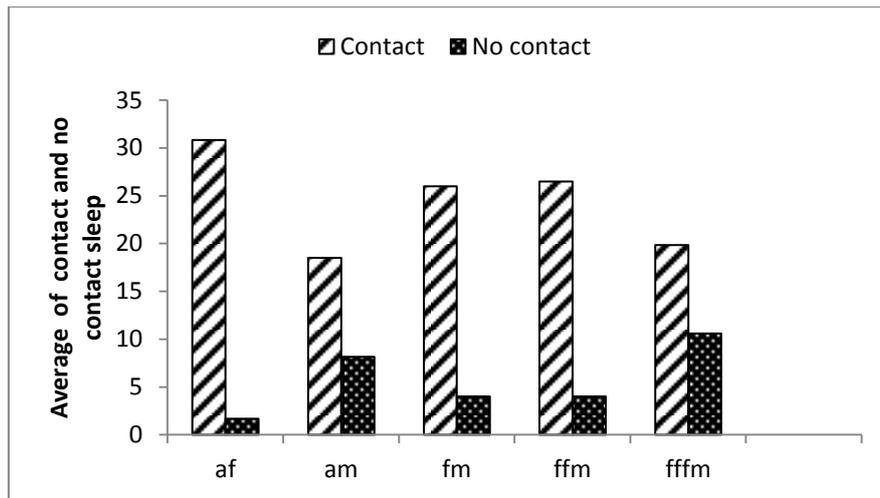
Figure 3.12 Average of contact and no contact sleep for each gender group across treatments and control.

Af groups engaged in most and am groups in least contact sleep. However, fffm group had the highest frequency of no contact sleep. There was no considerable difference in the frequency of contact and no contact sleep between fm and ffm groups. However, social sleeping was considerably higher than dispersed sleep among all group compositions in the study.

4. DISCUSSION

4.1 Hypothesis testing

This study aimed to: 1. Determine whether social or solitary sleeping was used to manage relationships during the active period in captive slow lorises 2. Assess whether the application of enriched nest box treatment and removal of sleeping enrichment devices affected sleeping patterns.

The results demonstrated that there was no significant correlation between the type of interaction and contact or dispersed sleeping. Therefore, the null hypothesis $H1_0$ (All individuals will sleep in contact or not in contact regardless of the type of social interaction) is accepted. There was however, a significant effect of the treatments on sleeping with no

contact in treatment R but not in treatment ENB. Thus, the null hypothesis $H2_0$ (No effect on sleeping patterns with ENB) and the alternative hypothesis $H3_a$ (Treatment R will result in increased dispersed sleep) were accepted.

4.2 Effect of treatments and other factors on sleeping patterns

Among many diurnal primates, distinct species-typical social systems and sleep patterns have been recognised (Crook and Garlton 1996; Eisenberg et al., 1972; Anderson, 2000; Kappeler et al., 2002). Similarly, research in nocturnal primate structures demonstrate that sleeping group compositions and sleeping sites offer important insights into nocturnal sociality (Bearder, 2003; Radespiel et al., 1998, Clark, 1985, Wiens and Zimmerman, 2003). The present study, explores the importance of the formation of sleeping patterns in slow lorises in a captive situation based on the kind of social interactions, extrinsic and intrinsic factors.

An increase in social sleeping was observed with the application of treatment ENB. Despite the options to use more than one ENB, individuals were seen huddling together in one or two ENBs, similar to that observed in NB's in the pilot study and control situation. Furthermore, tree usage as a sleeping site was the lowest under this treatment. Animals chose to sleep in ENB's over other sleeping site options. However, enclosed sleeping sites are not used by wild slow lorises, but have been observed to sleep exclusively on trees, amidst foliage (Wiens and Zimmerman, 2003). Joint defence strategies for predator avoidance and competition for resources are not exhibited by slow lorises (Wiens, 2002), but they rely on crypsis (Nekaris and Munds, 2010; Nekaris 2006) and solitary foraging due to dispersed resources and exclusive home ranges (Kappeler and van Schaik, 2002). Captive situations resulting in low predation risks and reduced competition for resources suggest that activity patterns characteristic to a solitary lifestyle are not vital for survival. The altered environment

may have resulted in increased opportunities for socialisation and the choice of enclosed spaces for sleeping without potential costs on survival. However, the use of ENBs was related to the amount of foliage in each cage. Highest ENB usage was seen in S (small) cages consisting relatively less foliage amounts compared to L (large) cages where the highest proportion of dispersed sleep occurred. Furthermore, there was no significant difference in the type of interactions in treatment ENB. Increased sleeping in contact may have stabilised interactions among group members.

A study on grey mouse lemurs (*Microcebus murinus*) demonstrated the formation of basic social units in individuals sleeping in proximity repeatedly, in stable sleeping group compositions (Rasoloharijaona et al., 2008). In the animals in this study, long-term group housing may have resulted in the formation of social units by engaging in social sleep. Individuals used the same ENB for 8±2 consecutive nights. This opposes studies that suggest that the same site was not used for more than two consecutive days (Wiens, 2002) and rarely reused (Kappeler, 1998; Nekaris, 2003). The repeated use of ENBs can be characterised by the quality of the site i.e. protection from predators and thermal insulation. However, most individuals in cages that housed 3+ individuals (provided with 3+ ENB's) used only one or two ENB's, though the number of individuals sharing one ENB varied from two, three or four individuals. This study suggests that the reason for reuse of sleeping sites may be related to the familiarity, position of the ENB in the cage or its physical comfort. The preferred use and sharing of ENB's indicate that sleeping patterns in captive slow lorises may be physically and socially functional.

It was anticipated that applying treatment R (removal) would be a simulation of wild conditions that may promote dispersed sleep. Dispersed sleep and usage of trees as sleeping sites increased in treatment R as a function of the lack of other sleeping site options. The competition for the most suitable site in limited options resulted in an increase in 'exclusive

32

use' of sleeping sites (Radespiel et al., 1998, 2003). Conversely, tree use could have potentially increased number of sleeping sites. However, the quality of these sites may may not been suitable for group sleeping (small, weak branches, lack of space, inadequate leaf cover) causing sleep dispersion or motivated individuals to choose the 'best' site rather than engaging in social sleep.

The effect of this treatment illustrates a motivational conflict between the want for physical contact during sleep and the most suitable sleeping site. Depriving animals of good substitutes for their needs could increase motivations to perform behaviours exhibited in the wild (Dawkins, 1990). Therefore, the motivation to acquire a physically comfortable sleeping site in a condition of limited options may have outweighed the need for any intrinsic factors gained through physical proximity.

4.3 Social interactions and sleep

There was a significant difference in the type of social interactions across all the treatments. Sleep is one of the fundamental aspects of sociality in primates (Anderson, 2000) thus; the relationship between individuals based on the type of interactions displayed in the active period was anticipated to be maintained during sleep through physical proximity.

In treatment R, there was a negative correlation between sleeping with no contact and negative interactions. It implies that dispersed sleep was used to manage conflict within the group by two ways, i.e. increasing physical distance from conspecifics, which decreased involvement in social activities (in this case sleeping) or by reducing stress potentially caused by sharing unsuitable sleeping sites resulting in increased agonistic encounters. However, the direction of effect cannot be determined by the negative correlation.

Most interactions observed through the study were positive or neutral and overall there was more social sleeping in individuals, suggesting that these two aspects of sociality

had a certain degree of association. This contributes in validating the potential formation of social units through social sleeping and interactions.

4.4 Proximtiy

In many cages, an individual chose to sleep with particular conspecific(s) repeatedly. Studies on *L. Malabaricus* and *L. tardigradus* have reported behavioural differentiation based on social hierarchal structures (Nash, 2005, Nekaris and Jayawardane, 2003). However, wild slow lorises are not known to form a dominance hierarchy, since group compositions commonly consist of an adult male, adult female and a maximum of three sub-adults/infants and limited interactions with conspecifics of the same sex (Wiens, 2002). Except for three cages, all other cages housed individuals without kinship. Therefore, with two or more adults of the same sex in the same cage, hierarchal structures may have developed, expressed through submissive or aggressive behaviours, access to food and resources (Bramblet, 1973), and access to suitable sleeping sites. The formation of these structures may have resulted in partner preference among groups of same or different genders.

Females were observed to be the core of sleeping groups (Rasmussen, 1986). All females groups showed the most amount of social sleeping. Groups with female(s) and one male (f-m and ff-m) also exhibited more social sleeping than all male groups which is similar to the increased affiliation shown by females sharing their home-range with a male in *L. tardigradus* (Nekaris, 2006). Though all males groups showed high gregariousness, they exhibited the least social sleeping that can be linked to low interactions and home-range overlaps between wild male lorises (Wiens, 2002).

4.5 Wakefulness during daytime sleep

It is clear that lorises are exclusively nocturnal in their activity patterns. They do not show wakefulness during daytime sleeping except for thermoregulatory purposes, foraging during scarcity or predator avoidance (Nekaris and Bearder, 2007). However, these factors are not entirely applicable in captive situations. A small percentage of wakefulness observed in this study, may have been influenced by thermoregulation or effect of direct sunlight. Observations were made before the cages were cleaned, minimizing the potential effect of external sources of disturbance. The only observable difference of a change in proximity to a conspecific from 5:30h to 15:00h was seen in treatment R. However, the smallest percentage change was observed in treatment ENB suggesting that ENBs were preferred for sleep and may have been the most suitable sleep site for protection against temperature, sunlight and heat, outweighing the need to change sites.

4.6 Extrinsic and intrinsic factors

Socio-ecological theory suggests that predation pressure, availability of resources form sociality in animals (van Hooff and van Schaik, 1992; Anderson, 1998a). In captivity, these factors are diluted, which may alter the form of interactions from that observed in the wild.

In captivity, the limited space and lack of opportunities for escape may lead to forced interactions among individuals. Captive studies in tree shrews and galagos, show an increase in agonisitic interactions (Ehrlich and Musicant, 1977; Daschbach, 1982) due to stress in group housed individuals. However, slow lorises, engaged in affiliative interactions with a very low proportion of agonistic encounters. To attribute their high degree of association to captive situations alone may not be relevant, but could possibly be a feature of social cohesiveness of these species in the wild, which is yet to be well observed.

In woolly lemurs (*Avahi occidentalis*) competition for resources considerably decreased group sizes therefore, reducing the number of interactions between individuals (Schulke, 2005). In addition, Prey Renewal Hypothesis proposed by Waser (1981) suggests reduced competition results in higher tolerance of conspecifics, supporting the high rates of affiliation in reduced competitive environments in captivity as observed in this study. However, it is worth noting that the highest number of negative interactions occurred during feeding, suggesting a low competition for food resources.

Past experiences in poor welfare environments (as pets or in trade) have a significant effect in shaping behaviour and socialisations (Champagne and Curly, 2005). The need for protection against stressors may have influenced animals to choose enclosed spaces for sleeping. This behaviour may have been represented in the preference for ENB's as opposed to trees.

In captivity, animals are devoid of opportunities to choose their own groups or partners. Forced grouping (age and gender) may result in the need to maintain social cohesion amongst individuals to avoid injuries or increased stress. Therefore, the potential formation of a dominance hierarchy among adults housed together may influence the type of interactions and proximity of sleep to maintain group dynamics and affiliation.

Similar to other nocturnal primates, slow lorises have very low basal metabolic rates which warrants for long and undisrupted sleeping to manage energy levels (Knutson et al., 2007). For these reasons, sportive lemurs (*Lepilemur mustelinus*) profit from suitable sleep sites by choosing tree hollows and cavities (Rasoloharijaona et al., 2008). This intrinsic factor may have influenced the preference of ENB's in slow lorises.

5. SUGGESTIONS FOR ENHANCING CAPTIVE WELFARE

It is evident that sleep is an important aspect of the sociality in slow lorises. However, sleep is a commonly disregarded aspect of behaviour in rehabilitation, though it is an important indicator of animal welfare. Sleep deprivation results in behavioural abnormalities, weight loss (Brock et al., 1994) and reduced cognitive functioning (Aneshensel et al., 1993) that pose as welfare problems in captive management. Understanding sleeping site usage and the interactions between conspecifics based on gender, availability of resources, and social relationships is important in deciding where and how to reintroduce animals for their long-term success (Reading et al., 2013). Extension of this study would prove to evaluate the reasons to encourage social sleep in captivity. However if it is not a commonly observed in the wild, using effective rehabilitation practices or training programmes to decrease the development of stress (Morgan and Tromborg, 2007) by the reduction of social sleeping must be implemented.
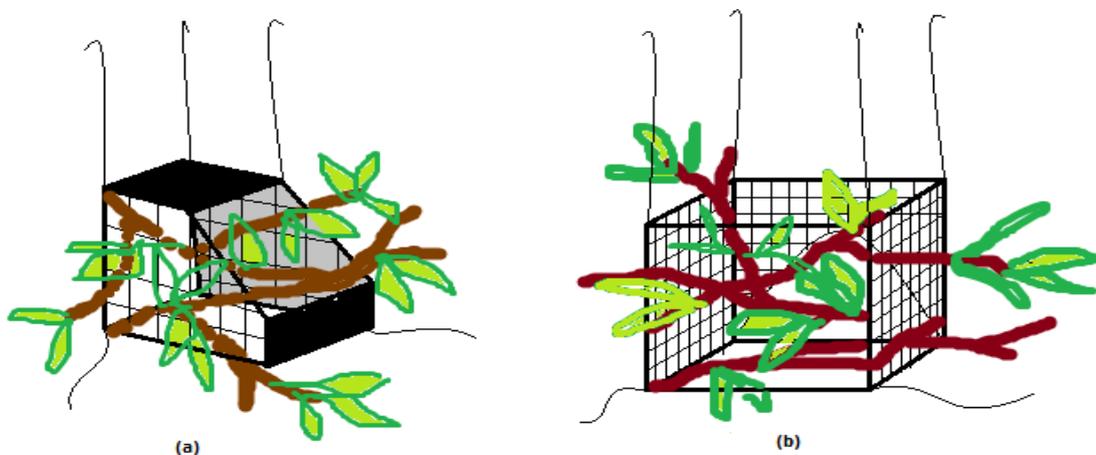
Gender of the group greatly influences social sleeping and the type of interactions, it may not be sufficient to group individuals who may only tolerate each other. Creating groups similar to the group compositions in the wild is vital for both long term and captive welfare of the animals.

Foliage cover significantly influenced the sleeping site selection and proximity during sleep, thus increasing the foliage cover within the cages to encourage dispersed sleep may benefit reintroduced individuals. However, monitoring behaviours is important as dispersion of sleep may cause stress and development of stereotypies in captivity (Clubb and Mason, 2003).

Group densities (number of individual depending on cage size) can be controlled to avoid unwanted behaviours such as stereotypies and increased agonistic encounters due to sharing confined spaces (Draper and Bernstein, 1963) and being in constant proximity to

conspecifics. In particular, group sizes have a significant effect on an animal's ability to develop concrete/abstract social relationships and acquisition of information on social relationships and social mediated learning in captivity (Croney and Newberry, 2007) (e.g. Cage 11, 3 individuals in a S cage showed increased negative interactions and one individual was involved in severe stereotypic behaviour).

If nest boxes are to be used in captivity, designing it to be more open without solid walls, adding foliage and placing them amidst bamboo or on trees can be considered.

Nest boxes (a) and (b) are designed using mesh instead of wooden planks and enriched with foliage and branches as supports for sleep. The front and back can be left open or partially closed as demonstrated in (b). Both nest boxes are open from the bottom. Nest box (a) has a partially covered roof, to provide a closed and open option.

Figure 4.2 Suggestions for nest box designs

6. CONCLUSION

This is the first study looking at sleeping patterns and its relationship to sociality in captive slow lorises. It demonstrates that slow lorises are not entirely solitary but possess various forms of social interaction via direct contact, vocalisations and sleeping proximity. In slow lorises social interactions may not necessarily influence their sleeping patterns. Negative interactions were resolved within a short period and did not affect social sleep substantially. Social sleeping may be associated with which conspecific an individual chooses to sleep with, based on what I propose, a form of social hierarchy linked to gender compositions of

groups and partner preferences in captive slow lorises. Furthermore, sleeping site choice may be of more importance than proximity. The preference of choosing enclosed spaces over tress or other sites is of importance for rehabilitation for reintroduction, however the reason for discrepancies between wild and captive sleeping behaviour is still unresolved. The study also shows trends of using sleeping patterns of proximity to manage social relationships maintained in the active period. However, large number of extrinsic and intrinsic factors may have been of more relevance. Furthermore, this study suggests a need to consider various aspects of sleep and sociality for welfare of individuals during rehabilitation and post-release. The present study significantly contributes to imminent literature suggesting the existence of social complexity shifting from initial assumptions of a solitary lifestyle led by slow lorises.

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CRITISM OF METHODOLOGY

There were certain problems with the methodology, which may have resulted in the insignificance of the results in this study.

The focus of the experimental design remained the same, however there were certain details changed upon arrival at the centre. Collecting data for three different activity periods and for two rounds of sleeping (morning and afternoon) were not included in the initial idea. This helped in obtaining a good representation of different activity periods, which resulted in varying levels of interactions observed between individuals.

I could not choose from individuals that were under medical treatment, or scheduled for release, for this study. This limited my options of choosing individuals with different backgrounds depending on when they were rescued and how long they had stayed at the centre. Furthermore, animals who suffered from health and behavioural problems were removed and housed in individual cages. This affected my sample size and altered interactions between individuals when an animal was introduced or removed from the groups, which may have contributed to a large number of single events of increased interactions of either type.

34 individuals were considered for this study. Though this may have been a reasonable sample size, they were spread across 13 cages. Thus I had to consider n=13 (n=12, when individuals were removed from the study) as the sample size for most statistical analyses. However, to analyse the effect of factors such as cage size, foliage amounts, number of individuals and the gender differences in each cage , the sample sizes varied and were reduced to n=2 to7 for different factors, therefore affecting the results of the statistical tests. This also made it very difficult to compare across different factors in the discussion of the results.

There were variations in the position of cages, therefore the effect of sunlight or potential sources of disturbance may have varied across individuals. Similarly, all the cages had different environmental enrichment such as sleeping sites and locomotory enrichment. Some cages did not have any enrichment and were equipped only with trees or plants. These factors may have affected their sociality or sleeping patterns. To account for this, I had to scale my data for many of the statistical analysis, which further reduced the data of the frequency of behaviours observed.

The observation sessions for social interactions, though spread across three different activity periods, was short − 5 minutes per cage. This holds a bias towards whether the observed interactions were truly representative of the formation of social networks or relationships.

Observations were randomised between cages. This was beneficial in acquiring data of the social interactions in their active period, however, for morning observations of approach to a sleeping site, I could not get an equal representation of interactions and behaviours for individuals in different cages, due to individual variations in the time of the onset of sleep.

I had only two treatments of ENB and removal of all sleeping sites in this study. Though these had interesting effects on sleeping patterns, I believe it lacked certain aspects that could have been incorporated. For example, the initial idea was to apply another phase of a treatment where the position of the ENBs would be changed every two or three days based on existing literature reporting that slow lorises spent a maximum two days in one sleeping site (Wiens, 2002). However, this treatment schedule was not considered as it may have resulted in causing certain amounts of stress in the animals. However, a treatment involving the application of more foliage or branches of different girths to determine the preference of

sleep site usage would have contributed to studying sleeping site choices of captive slow lorises. In addition, treatments were applied only for 12 days each. Though this indicated a trend in change of interactions and sleeping patterns, it may not have been sufficient. The trends observed, may have been an effect of the novelty of the treatments and not completely related to the function of the treatments itself. I would have liked to apply each treatment twice to each cage to check whether it was the effect of treatments alone or any other factors that may have contributed to the results and to inspect the effect of the order of treatments applied.

180 hours of observations were carried out for both social interactions and sleeping patterns. However, the frequency of social behaviours exhibited by the slow lorises is low. This combined with a short observation period for each cage resulted in the lack of data for each behaviour (listed in the ethogram). Therefore, there was insufficient data for many factors to run statistical tests. The discussion of many of the results is based on descriptive statistics that show trends in the effects of factors or treatments on behaviours.

In conclusion, the aim was to try to understand sleep as an aspect of sociality in slow lorises. This study succeeds in correlating social interactions and sleep to an extent. It was assuring to have been able to get significance in the relationship between negative interactions and other factors on dispersed sleep. Since lorises are nocturnal primates, and a dispersed lifestyle (Bearder, 1999) and sleep is characteristic to these species, the importance of trying to understand the need to encourage, discourage or to identify reasons for the expression of such behaviours in a captive situation was required and discussed for captive and post-release welfare and the management of slow lorises in captivity.

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PERSONAL CONTRIBUTION

The experimental design, design of the enrichment (Enriched Nest Boxes), data collection and interpretation of results were performed by Namrata B. Anirudh under the supervision of Dr. Phyllis Lee. A randomised table for the application of treatments and all statistical calculations were created and performed by Namrata B. Anirudh under the guidance of Dr. Ian Handel and Dr. Phyllis Lee.

Sections of the ethogram apart from portions that were adapted from Loris Husbandary Manual and International Animal Rescue were developed by Namrata B. Anirudh through the pilot study.

ENB's were made by a loris keeper, Mastur Jakaria at the IARI centre with the assistance of Namrata B. Anirudh. The modifications of these nest boxes and placement within the cages was done by Namrata B. Anirudh with the assistance of the animal keepers.

months and left Indonesia and IARI with so many memories to treasure and many new fields and ideas to explore.

Team Kukang! They made me nocturnal, fed me all sorts of food, laughed with me through the night, had discussions over too many cups of coffee, woke me up when I fell asleep by the cages, taught me so much regarding the slow lorises at the centre, in the wild, survival skills (lighting fire, working with bamboo and wood), taught me Bahasa Indonesia and made me feel like I was one of them. Terimakasih banyak unutk bantalan dengan 'banyak cepret' dari saya dan banyak bantu sama project saya!

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APPENDIX

50

APPENDIX I. Proximity of sleep for each individual in each under control condition and two treatments cage. (Refer to the following pages for the matrices)

CAGE NO.	CONTROL	ENB	REMOVAL
	No contact	No contact	No contact

Cage 1

CONTROL — contact (rows) × No contact (columns)

	Anne	Jubile	Maripili
Anne		1	1
Jubile	9		2
Maripili	7	8	

ENB

	Anne	Jubile	Maripili
Anne		1	3
Jubile	10		3
Maripili	8	8	

REMOVAL

	Anne	Jubile	Maripili
Anne		2	2
Jubile	9		0
Maripili	9	11	

Cage 3

CONTROL — contact (rows) × No contact (columns)

	Charles	Pluto	Phillip
Charles		3	0
Pluto	7		0
Phillip	0	0	

ENB

	Charles	Pluto	Phillip
Charles		6	0
Pluto	5		0
Phillip	0	0	

REMOVAL

	Charles	Pluto	Phillip
Charles		3	3
Pluto	7		3
Phillip	0	0	

Cage 4

CONTROL — contact (rows) × No contact (columns)

	Albi	Bino	Bule	George
Albi		2	6	4
Bino	6		6	4
Bule	2	2		5
George	3	2	2	

ENB

	Albi	Bino	Bule	George
Albi		2	2	
Bino	8			2
Bule	8	8		
George				

REMOVAL

	Albi	Bino	Bule	George
Albi		5	6	4
Bino	5		3	5
Bule	4	7		4
George	3	2	3	

Cage 5

CONTROL — contact (rows) × No contact (columns)

	Richard	Regi	Chika
Richard		1	0
Regina	7		1
Chika	8	7	

ENB

	Richard	Regi	Chika
Richard		2	
Regina	7		2
Chika	9	8	

REMOVAL

	Richard	Regi	Chika
Richard		2	1
Regina	9		1
Chika	10	10	

Cage 6 — contact

	Slash	Nia	Fifi	Laila
Slash		3	5	4
Nia	8		4	2
Fifi	6	7		4
Laila	7	10	7	

	Slash	Nia	Fifi	Laila
Slash		3	3	2
Nia	6		2	2
Fifi	6	6		2
Laila	8	7	7	

	Slash	Nia	Fifi	Laila
Slash		6	10	5
Nia	5		9	7
Fifi	1	2		7
Laila	6	4	4	

Cage 7 — contact

	Rido	Tori	Danica	Agnes
Rido		8	8	7
Tori	3		6	10
Danica	3	5		9
Agnes	3	1	2	

	Rido	Tori	Danica	Agnes
Rido		3	2	7
Tori	8		3	7
Danica	9	8		6
Agnes	4	4	5	

	Rido	Tori	Danica	Agnes
Rido		5	8	8
Tori	5		8	9
Danica	2	2		8
Agnes	2	1	2	

Cage 8 — contact

	Lui	Tegal
Lui		3
Tegal	7	

	Lui	Tegal
Lui		3
Tegal	8	

	Lui	Tegal
Lui		3
Tegal	8	

Cage 10 — contact

	Mimo	Mulud
Mimo		0
Mulud	11	

	Mimo	Mulud
Mimo		0
Mulud	10	

	Mimo	Mulud
Mimo		0
Mulud	11	

Cage 11 — contact

	Hayang	Donna	Ambu
Hayang		5	3
Donna	4		3
Ambu	6	6	

	Hayang	Donna	Ambu
Hayang		0	0
Donna	11		0
Ambu	11	11	

	Hayang	Donna	Ambu
Hayang		2	6
Donna	8		6
Ambu	4	4	

Cage 12 — contact

	Jupe	Sukhoi
Jupe		1
Sukhoi	9	

	Jupe	Sukhoi
Jupe		1
Sukhoi	8	

	Jupe	Sukhoi
Jupe		2
Sukhoi	9	