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Social Interactions Among Giant Panda Cubs (*Ailuropoda Melanoleuca*): An Investigation Into The Role Of Kin Recognition

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SOCIAL INTERACTIONS AMONG GIANT PANDA CUBS (*AILUROPODA
MELANOLEUCA*): AN INVESTIGATION INTO THE ROLE OF KIN RECOGNITION

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ABSTRACT

Although giant pandas (*Ailuropoda melanoleuca*) are known to be solitary in the wild, cubs engage in frequent bouts of affiliative behavior in captive settings. The goal of the project was to investigate whether kinship or familiarity based on housing influenced the frequency of social interactions within one-year old giant panda cubs. Data were collected from June through mid-July 2016 at the Chengdu Research Base of Giant Panda Breeding, Sichuan, China. Over 113 hours of behavioral observations were recorded on four sets of twins and one singleton, focusing specifically on affiliative behaviors. Time housed together was a significant predictor of the amount of time cubs engaged in social interactions together ($F(2,33) = 6.41$, $\rho = 0.0044$, and $R^2 = 0.28$). Additionally, the longer cubs were housed together the more likely they were to eat together ($F(2,33) = 4.67$, $\rho = 0.0016$, and $R^2 = 0.22$). Kinship affected play: cubs were more likely to play with siblings regardless how often they were housed with one another ($F(2,33) = 6.83$, $\rho = 0.0033$, and $R^2 = 0.29$). This suggests that giant panda cub social engagement is based on some means of kin recognition, whether it is prior association, phenotypic matching, or a mechanism not examined within this study, such as personality. Further long term assessment needs to be conducted exploring the behavioral impacts of socially housing giant panda cubs and kinship recognition in this species.

INTRODUCTION

Kin recognition is the ability to discriminate related members among a group of individuals (Holmes and Sherman, 1982). There are two commonly proposed mechanisms about how this process occurs. One system, phenotypic matching, arises when animals learn their own distinctive phenotype. Whether it be by olfactory or visual differences, animals compare their own composition among surrounding individuals to determine who their relatives are (Holmes and Sherman, 1982; Blaustein, 1983; Mateo and Johnston, 2000; Hepper, 2005). For example, golden hamsters (*Mesocricetus auratus*) habituate themselves with their own scent during development. When placed into a group mixed with kin and non-kin, these hamsters identified whom their relatives were by pairing the odor most comparable to their own (Mateo and Johnston, 2000). In other words, animals coordinate which phenotype is most similar through this technique.

The other standard system of kin recognition is prior association, which occurs when individuals are reared together. During this stage, they will begin to familiarize themselves with those who they are raised with. An increase in time an animal spends surrounded by another may cause the two to believe they are related to one another, regardless of actual genetic association (Bekoff, 1981). In a study conducted on translocated African elephants (*Loxodonta africana*), affiliations were less prevalent with genetically related elephants, and more often with elephants they were familiar with (Pinter-Wollman et. al, 2009). Aggressive behaviors were directed towards non-kin as opposed to kin in mice (*Mus musculus*). However, an increase in the amount of time that two unrelated mice spent together decreased aggression levels between them (Kareem and Barnard, 1982).

Through kin recognition animals engage in various social behaviors, which can benefit an individual or a species. Social cohesion, or how well a group assembles together towards a common goal, leads to cooperative behaviors within several vertebrates (Clarke, 1984; Emlen et. al, 1988, Marzluff and Balda, 1990; Loeb et. al, 2000; Hain and Neff, 2009; Markman et. al, 2009). Male rhesus monkeys (*Macaca mulatta*) leave their social group after they reach sexual maturation and transfer into troops where their older brothers have established hierarchy (Meikle and Vessey, 1981). Kin who behaved noncompetitively, by not securing their own personal dominance within the group, attained higher inclusive fitness than those who acted out. Additionally, brothers who were more aggressive did not gain a substantial direct fitness. Cooperation with kin members to expand inclusive fitness is extensive within numerous species of rodents, including the Belding's ground squirrel (*Uroditellus belding*). One member within the group will alarm call, to alert relatives when a predator was heard or smelled nearby; thus, increasing their chances of survival (Sherman, 1981). All clan members within spotted hyenas (*Crocuta crocuta*) acquire the ability to identify their kin, working together to defend territories, obtain food, and raise offspring together (Holekamp et. al, 2007). These cooperative relationships between hyenas not only aid in the subsistence of individuals, but also affect reproductive decisions within the clan.

Kin recognition also influences mate choice, allowing individuals to increase their personal fitness by evading those who are genetically related to them to avoid inbreeding. Different species of rodents are well-known to avert engaging in sexual activity with related individuals (Barnard and Fitzsimons, 1988; Bolhuis et. al, 1988; Keane, 1990; Pusey and Wolf, 1996; Valsecchi, Paola et. al, 1996). For instance, wild female mice (*Mus musculus*) placed in litters

comprising of siblings and non-siblings, preferred to mate with unrelated males (Winn et. al, 1986). Inbreeding avoidance via kin recognition can further affect specific mating behaviors within species. Gombe chimpanzees (*Pan troglodytes schweinfurthii*) abstained from breeding with maternal kin in their community (Constable et. al, 2001). When these chimpanzees are young, they more than often associate with maternal siblings similar in age over others within the grouping. Thus, their sociality established when they were adolescents had implications on who they chose to mate with as adults.

Although the benefits of kin recognition are widely apparent within social species, the advantages of identifying relatives is less noted within solitary creatures. Solitary animals are perceived to isolate themselves from the rest of their species, restricting themselves from partaking in any affiliative behavior (Leyhausen, 1964). However, these organisms still interact on some level, mainly engaging in cooperative behaviors, such as acquiring food and establishing territory. A sub-social species of spider, *Stegodyphus lineatus*, groups together when foraging (Ruch et. al, 2009). The amount of food obtained was larger within groups composed of their siblings, insinuating possible recognition of relatives. Through settling into distinctive areas, inbreeding avoidance also takes place within solitary organisms. Advertisement calls, signals utilized to convey information about the quality of a mate, by unrelated males were more intriguing to females than calls from fathers of female grey mouse lemurs (*Microcebus murinus*) (Kessler et. al, 2012). These females thus would favor copulation with non-kin over individuals related to them. Although wild solitary species do engage in minimal affiliative behaviors within their lives, captive solitary animals may be shaped to engage more often in social behaviors due space restrictions within zoological institutions. For example, brown bears (*Ursus arctos*) were

often observed participating in playful interactions when housed with another individual than when placed in enclosures by themselves (Montaudouin and Le Pape, 2005). Occupying similar spaces with others could thereby lead to possible kin recognition mechanisms evolving within captive solitary species.

The role of kin recognition has not been explored to date in the giant panda (*Ailuropoda melanoleuca*), which spends most of its life solitary consuming its main source of food, bamboo. Only a small portion of its time is thought to be devoted to social activities, such as to breed and produce offspring (Schaller et. al, 1985). However, a recent study has shown giant pandas will occupy similar spaces and share overlapping home ranges, therefore increasing the opportunity for them to interact in other ways than reproduction (Hull et al., 2015). While kinship could not be confirmed, due to a lack of genetic testing, the giant pandas examined in the study were also identified to possibly belong to a family group. This overlap of range between potential kin members expands further questioning on what mechanisms facilitate future associations.

Understanding the role of kin recognition within giant pandas may be particularly important in a captive context. Efforts have been made to further understand the extent of social behavior within wild giant pandas, but are difficult due to the lack of abundance of the species, and resources available to survey them. Previous studies that have been conducted in captive settings have examined behaviors across various types of outdoor and indoor enclosures (Liu et. al, 2003), the presence of specific stereotypies (Liu and Wang, 2017), daily activity patterns (Mainka and Zhang, 1994), detecting behavioral characteristics between males and females (Mainka and Zhang, 1994), and preferences in mating partners (Martin-Wintle et. al, 2017).

Extensive conservation efforts by the Chinese government to increase the population through habitat restoration, legislation, and captive breeding has contributed to the species being downgraded from endangered to vulnerable (Swaigood et. al, 2017). While an understanding of reproduction in giant pandas has increased within recent years, more research needs to be conducted on cub behavior, as facilities are focusing efforts towards releasing cubs into the wild. Only aspects of play between mother and cub dyads have been thoroughly investigated in captive settings (Snyder et. al, 2003; Wilson, 2005; Snyder et. al, 2006). Play is largely between dams and cubs (Wilson, 2005), but different effects occur when cubs are housed with others of a similar age. Wilson et. al (2009) found that giant panda cubs spent more time biting and pawing with other cubs, as opposed to with their mothers. However, individual differences between cubs were not noted throughout the duration of the investigation. In others words, no examination took place of exactly which cubs where interacting with one another, and whether the social behaviors were correlated with kin recognition.

Exploring the effects of housing individuals of a non-social species, such as the giant panda, together at a young age can reveal key information to further investigate management of the species. The technique staff utilize to rear giant panda cubs within zoological institutions is far different from how a mother would raise her cub in the wild. Mothers will generally have twins, but will only care for one individual in the wild, abandoning the other cub. In captivity, staff will remove twins from the mother at an early age and rotate the amount of time each infant spends with the mother to increase the survival rate of both offspring (Zhu et. al, 2001; Swaigood et. al, 2003). During the time a cub is not with its mother, it is placed into a group of other cubs similar in age, where they will have opportunity to engage in a variety of affiliative behaviors. With

endangered or vulnerable species, it is crucial to increase genetic variation (Ralls and Ballou, 1986). Discovering whether giant panda cubs interact through kin recognition could lead to further management decisions early on in life on who to house together for subsequent survival and reproductive success.

The goal of this project was to determine if kin recognition was an underlying factor facilitating interactions within giant panda cubs. An increased understanding of the social complexity of a naturally solitary creature in captive conditions was gained through the execution of the study. The hypothesis of the study claimed cubs interact with other cubs and adult females based on kin recognition, whether it be through mechanisms of phenotypic matching or prior association via familiarity. It was predicted higher amounts of affiliative interactions take place between maternally related individuals (siblings) and/or pandas with whom they are more frequently housed.

MATERIALS AND METHODS

Location and Subjects

Data collection was completed at the Chengdu Research Base of Giant Panda Breeding (from here on: Chengdu) in Sichuan, China from June through mid-July of 2016. Observations occurred in one outdoor enclosure and seven indoor rooms, which varied in size and public viewing (Figure 1).

Nine cubs were the subjects within the study, and approximately all one year in age. These cubs were born at Chengdu during the summer of 2015. One set of female twins, three sets of male twins, and one male singleton were examined over the course of six weeks (Table 1). At times subjects were housed with adult females, but the cubs were still the focus of the study. Kinship was based on maternal relatedness, or whether or not the cubs were siblings and the adults were genetic mothers. Due to a lack of genetic information in regards to the paternal relationship of seven out of the nine cubs, it could not be assessed within this study. Pandas, both adults and cubs, were differentiated by miscellaneous visual identifiers, such as shape of eye and ear size.

Recording methods

Focal sampling and continuous behavioral recording were utilized to document the duration of behaviors performed by a specific cub. The order of observed individuals was determined via a random-number generator. Each of the two recorders watched a randomly selected cub for one observation session. This observation period lasted up to thirty minutes. Sessions that ended before fifteen minutes were noted as incomplete and excluded from the data set. These partial sessions mainly occurred when keepers would remove the cubs from the outdoor enclosure.

When a session was unfinished, the recorder started a new session, watching the same cub as they had in the incomplete session if it was located within another enclosure. If it was not identified within any other area, the observer would start a new session, watching another cub for a complete time frame prior to returning to the previous incomplete session. After the focal individual had been observed for one complete session, the next cub determined by the random-number generator was then examined. This process continued until each of the nine individual cubs were observed for one session. Another random-number generation was then run, giving a

new order for the cubs to be watched and recorded. Observations occurred between either 9:00-11:00, or 14:00-15:00 each day of the week for approximately six weeks.

Interactions between pandas were assessed based on proximity to another panda; proximity was limited to within one meter, an estimate of a cub's forelimb (Zhu et. al, 2001). An approach was defined as the cub coming within a meter to another panda (cub or adult), and a leave was when a cub traveled outside a meter to another panda. The initiation of an interaction occurred when the two pandas were within a meter of each other, and the duration of the behavior was then recorded. Table 2 references the ethogram created for the affiliative behaviors examined. Any behaviors that occurred outside of this parameter were noted as non-social behavior. No aggressive behaviors were documented throughout the duration of the study.

Data analyses

The percentage of time the cubs spent engaging in social vs. solitary behavior was discerned by dividing the time partaking in each category, affiliative or non-affiliative, by the total amount of time cubs were observed. Interactions between siblings and non-siblings were then assessed by averaging the amount of time each grouping, sibling or non-sibling, engaged per session. This value was also computed as a percentage to yield the average amount of time siblings and non-siblings spent being affiliative per session. As the null hypothesis was that siblings and non-siblings would interact at the same rate, a chi-squared test (χ^2) was utilized to determine if there was a significant difference in the mean percentage of time the cubs interacted with related and un-related individuals. This was done for all behaviors combined, and for the following

individual prevalent behaviors, eat (EW), play (PW), rest (RW), and sit (SW). Any p -values less than 0.05 determined statistical significance between the two groups.

Linear regressions were implemented through JMP software. These regressions evaluated how time housed together effected the average percentage of time being affiliative, and whether kinship also influenced interactions between pandas. Overall associations, eating, playing, resting, and sitting were analyzed and yielded a designated t -value, p -value, and standard beta. Any p -value less than 0.05 determined a significant difference in the data set. Standard betas indicated how much of an effect a single variable had on the correlation.

Inter-observer reliability was calculated between two observers through the usage of Cronbach's alpha, which ascertains how closely related items are, or in this case, how similar behaviors were seen between the two observers (Santos, 1999). An ANOVA test was utilized to compute Cronbach's alpha ($\alpha=1-[MS_E-MS_B]$), and yielded a value of 0.93, indicating fair inter-observer reliability.

RESULTS

Cub-cub interactions

A total of 113.07 hours of data was collected, and 36.68% of the time cubs partook in affiliative behaviors. Siblings spent approximately 14.57% of their time together engaging socially whereas non-siblings interacted 9.52% of time when they were housed with one another. The percent of

time spent interacting did not differ significantly for the two groups overall ($\chi^2=0.30$; $\rho=0.58$) (Figure 2), nor for any specific category of behavior (eat, play, rest, sit) (Figure 3, Table 3).

Time housed together had a significant positive relationship with the mean percent time cubs spent interacting together per session, regardless of kinship, $F(2,33)=6.41$, $\rho=0.0044$, and $R^2=0.28$ (Figure 4). Percentage of time spent eating together per session was also significantly predicted by the amount of time housed together, $F(2,33)=4.67$, $\rho=0.0016$, and $R^2=0.22$ (Figure 5). Time housed had a near significant affect on playing together, but kinship did significantly predict the amount of play that occurred on average between cubs within a session, with siblings engaging in more play than non-siblings, $F(2,33)=6.83$, $\rho=0.0033$, and $R^2=0.29$ (Figure 5). There was no significant relationship between time housed and percentage of sessions that cubs spent resting and sitting together. All t-values, ρ -values, and standard betas are listed within Table 4.

Cub-adult female interactions

Behaviors of cubs when housed with adult females were recorded for 25.51 hours out of the total time cubs were observed in the study. Approximately 21.69% of the time cubs engaged in affiliative behaviors. Kin spent 25.74% of their time together associating, while non-kin were interacting 24.61% of time when they were housed together. The percent of time engaging did not differ significantly for the two groups ($\chi^2=0.87$; $\rho=0.35$) (Figure 6), nor for any distinct category of behavior (eat, play, rest, sit) ($\chi^2=0.87$; $\rho=0.35$) (Figure 7, Table 3). Time housed and kinship did not significantly predict the amount of social interactions that occurred on average between cubs and adult females within a session (Table 4).

DISCUSSION

Time cubs spent housed with other cubs indicated higher percentages of overall affiliative behaviors, regardless of maternal relatedness. An increase in the amount of time cubs had access to engage with one another could have increased the familiarity between the two; thus, kin recognition through prior association may occur within cubs. However, kinship significantly denoted the amount of play that would occur between cubs within a session. In other words, siblings would prefer to engage in play behaviors with one another regardless of the amount of time housed together, suggesting phenotypic matching may function within cubs to identify kin. However, further investigation is needed to fully support the hypothesis of either specific recognition mechanism.

Aspects such as chemical communication within cubs and paternal relatedness should be explored as approaches to identifying kin. Scent marking, or rubbing the anogenital region to excrete pheromones, is an indicator for assessing the quality of a mate within adult giant pandas. These animals were documented to identify the distinctive scent mark of individuals (Swaigood, 1999). Throughout this study, scent marking was observed for approximately two minutes within cubs when they were housed with both cubs and adult females. The act more commonly occurs when pandas reach sexual maturity at five and a half to six years of age, as it is a means of communicating fitness status to potential partners (Zhu, et al, 2001). The cubs observed in this

study may be able to phenotypically recognize the individuals they were housed with early on in life once they reach sexual maturity, and could associate conspecific's scent at a higher capacity. Additionally, paternal kin are known to influence interactions between individuals within other species, specifically in terms of breeding behaviors. Wild baboons (*Papio cynocephalus*) spent less time courting and displaying sexual behaviors with paternally related baboons (Alberts, 1999). Paternal kinship could not be assessed within this study, due to a lack of genetic information available, but should be re-examined once an updated report is released.

Two distinct categories of behavior were indicative of social interactions: eat and play. The amount of time cubs spent eating increased the more often cubs spent housed together, regardless of genetic relation. When bamboo was placed into the enclosure, keepers would typically put the bamboo in the same location, driving pandas to travel to the same area to consume food. A larger amount of time eating with one another may have been due to food placement, rather than pandas choosing to eat with one another. Likewise, cubs may have eaten more often because they were overall nursing less. At approximately six months of age, cubs begin to wean off their mother's milk and consume small amounts of bamboo, but will suckle on the mothers when given the opportunity (Peng et. al, 2001). The cubs in this study were approximately one-year in age, and still in the transition of completely segregating themselves from dependence on their mothers' care. Therefore, a general increase in eating may be due to the pattern of development within the species, as all other behaviors did not show an increase in time when pandas were placed with one another.

The amount of time cubs engaged in play was not correlated to how often they were housed with one another, but was significant in regards to kinship. Siblings preferred to play with their maternal relatives despite how often they were housed together. Play is an important aspect facilitating development within bear species, as these interactions at a young age correlate to defense mechanisms (Gordon and Burghardt, 1972; Pruitt, 1976). Different compositions of biting, pawing, and swatting aid in learning to protect one's territory against unwanted predators or other bears. Engaging in play could also facilitate mating behaviors when bears become sexually mature. Male adult black bears (*Ursus americanus*) were more likely to successfully reproduce when able to outcompete other males, and fight off others for access to a female (Costello, 2008). Siblings could be playing more often with genetic relatives to increase their survival skills, and furthermore aid in expanding their inclusive fitness when they reach sexual maturity, but additional investigation is required to support this idea.

Time housed and kinship did not significantly foretell the amount of time cubs and adult females interacted per session; thus, cubs may not be able to recognize adults as their kin. Cubs are housed with their genetic mothers at a young age, and then continually moved around between different foster mothers as they develop. Therefore, they may associate all adult females as their mother, rather than discerning based on genetics or familiarity. Adult giant pandas have an extensive network of chemical communication, hence mothers may be able to differentiate between cubs as opposed to cubs recognizing cubs. Mammal mothers, especially primates, detect their offspring based on different olfactory cues (Porter, 1998; Cheney et. al, 1999; Widdig, et al, 2001; Langergraber et. al, 2009; Seyfarth et. al, 2014). Mother black bears (*Ursus americanus*) identify their young, allowing them to remain within their established territory until they can

feed on their own (Rogers, 1987). Giant panda females may utilize their potential to differentiate offspring and decide to interact more often with their own kin as opposed to ones they foster, providing benefits to increase the survival of genetic progeny. Adults were not examined as the focus of this study, but could be investigated in future studies. The effects of this unique “peer-rearing” housing situation should be explored to aid in continuing the captive management of the giant panda.

A similar trend was observed throughout the duration of the study; specific cubs continually socialized and were defined as being more affiliative towards one another. Personality, or the set of characteristics explaining why an individual acts in a particular way, was not examined in this study. Nonetheless, it could explain why certain individuals spent more time with one another (Weinstein et. al, 2008). Personality studies typically focus on how animals interact with their environment. For example, polar bears who were more interested in their surroundings exhibited less pacing (Shepherdson, 2013). Understanding what types of personalities correlate with certain actions, both within their habitat and with their conspecifics, it can lead to increased management and welfare of certain species, including the giant panda.

“Personality profiles” have been created for several adult giant pandas by providing different types of enrichment items and recording how they interacted with them (Powell and Svoke, 2008). By noting these personalities, it has led to studies involving mating success, and discovering which personalities are better suited for intercourse within the species (Martin-Wintle et. al, 2017). The giant pandas within this study had not reached sexual maturity, but examining them at a young age can provide more detail towards their “personality profile,” and

insight as to which pandas they are more likely to form a bond with. In female baboons, social bonds were highest among those who were of similar age and had a similar personality (Seyfarth, et. al, 2014). Stronger social bonds between individuals have led to increased reproductive output, and the survival of offspring (Cameron et. al, 2009; Silk et. al, 2009). Thus, examining personality within young panda cubs aids in providing information on who certain individuals should be more often housed with in order to form social bonds and increase reproduction.

CONCLUSION

Through understanding the behavior and interactions of captive populations, caretakers and staff can facilitate increasing giant panda populations. Institutions are progressing towards releasing cubs into the wild, thereby knowing who they more often associate with could guide decisions on which individuals are selected for the pre-release programs. Advancing efforts have been made within the last twenty years on extensively studying the giant panda and have specifically explored molecular and behavioral ecology (Wei, Fuwen, et. al, 2015). By furthering studying the management of the species in captivity, it can not only lead to a larger increase in population size, but also an expansion in welfare of the species.

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Table 1 Identification of cubs observed within the study. Four different sets of twins were examined; one pair consisting of females and three being males. One of the cubs was a male singleton. Nicknames were assigned to each cub, dam, and sire when applicable. MULT indicated that multiple sperm was utilized when artificially inseminating the dams.

Date of Birth	Cub	Sex	Twin	Dam	Sire
21 Jun 2015	KD	Female	KX	KL	QQ
21 Jun 2015	KX	Female	KD	KL	QQ
4 Jul 2015	MM	Male	N/A	M	MULT
2 Aug 2015	SD	Male	SX	SY	MULT
2 Aug 2015	SX	Male	SD	SY	MULT
2 Aug 2015	JD	Male	JX	JJ	MULT
2 Aug 2015	JX	Male	JD	JJ	MULT
16 Sep 2015	QD	Male	QX	QH	MULT
16 Sep 2015	QX	Male	QD	QH	MULT

Table 2 Ethogram of affiliative behaviors observed throughout study. When two cubs were within a meter of each other, it was noted as a social behavior. Any action performed outside of a meter was recorded but not included in the ethogram displayed, as it was not the focus of the study.

CW	Climb With	Move up or down a climbing structure.
EW	Eat With	Put mouth in water; chew, consume, and/or mouth bamboo.
GW	Groom With	Lick and/or scratch own fur.
NW	Nurse With	Put mouth on mother's nipple, with or without actual suckling.
OS	Out of Sight	Not visible to the observer.
PW	Play With	Bite, charge, chew, head-butt, paw, pull fur, push, sit on, and/or wrestle another panda.
RW	Rest With	Lay down with or without eyes closed, unreactive to surroundings.
SW	Sit/Stand With	Eyes open in a stationary position, attentive to surroundings.
WW	Walk With	Take two or more steps in the same direction.

Table 3 Significance of average percentage of time cubs engaged in specific behaviors with siblings, unrelated cubs, and adult females. No significant difference between kin and non-kin was noted across all behaviors.

Behavior	χ^2	p
Overall Interactions		
Cub-cub	0.30	0.58
Cub-adult female	0.87	0.35
Eat		
Cub-cub	0.68	0.41
Cub-adult female	0.22	0.64
Play		
Cub-cub	0.14	0.71
Cub-adult female	0.019	0.89
Rest		
Cub-cub	0.51	0.47
Cub-adult female	0.56	0.45
Sit		
Cub-cub	0.81	0.37
Cub-adult female	0.45	0.50

Table 4 Regression analyses of interactions between cubs. A significant difference was found in overall interactions, correlating longer housed times to social interactions and eating. Further analysis revealed a significant difference in terms of play with regards to kinship, indicating siblings more often played at higher rates regardless of time housed together.

Behavior	t	p	Std. beta
Overall Interactions		0.0044*	
Times Housed	3.20	0.0030*	0.48
Relationship	1.13	0.27	0.17
Eat		0.016*	
Times Housed	2.92	0.0062*	0.45
Relationship	-1.30	0.20	-0.20
Play		0.0033*	
Times Housed	2.01	0.05	0.30
Relationship	2.78	0.0089*	0.41
Rest		0.14	
Times Housed	1.91	0.06	0.32
Relationship	-1.01	0.32	-0.17
Sit		0.23	
Times Housed	1.59	0.12	0.27
Relationship	0.49	0.63	0.08

Figure 1 Enclosures where subjects were housed throughout the duration of the study. The outdoor enclosure, as well as rooms A, B, C, D, and E are shown. Areas F and G are not pictured to due staff accessibility only and measured 59.6 m² and 45.0 m² respectively. Other dimensions are listed below with their correlating photographs.

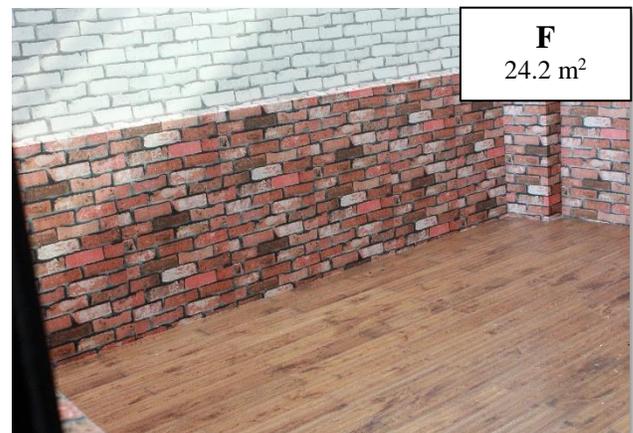
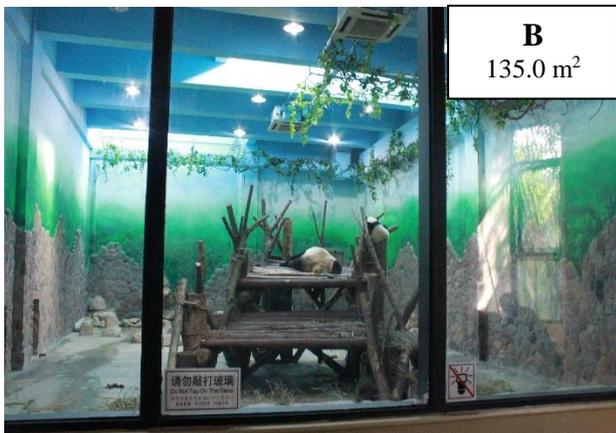
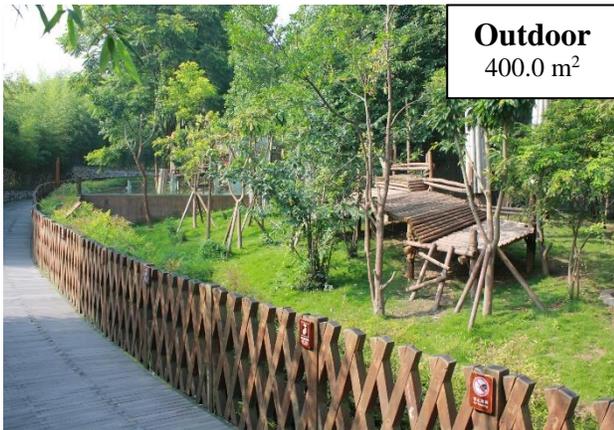


Figure 2 Average percent time cubs spent engaging in social interactions between sibling and non-sibling cubs. Related individuals spent approximately 14.57% of their time together partaking in affiliative behavior whereas unrelated cubs were interacting 9.52% of the time housed with one another. There was no significant difference between the two groupings ($\chi^2=0.30$, $p=0.58$).

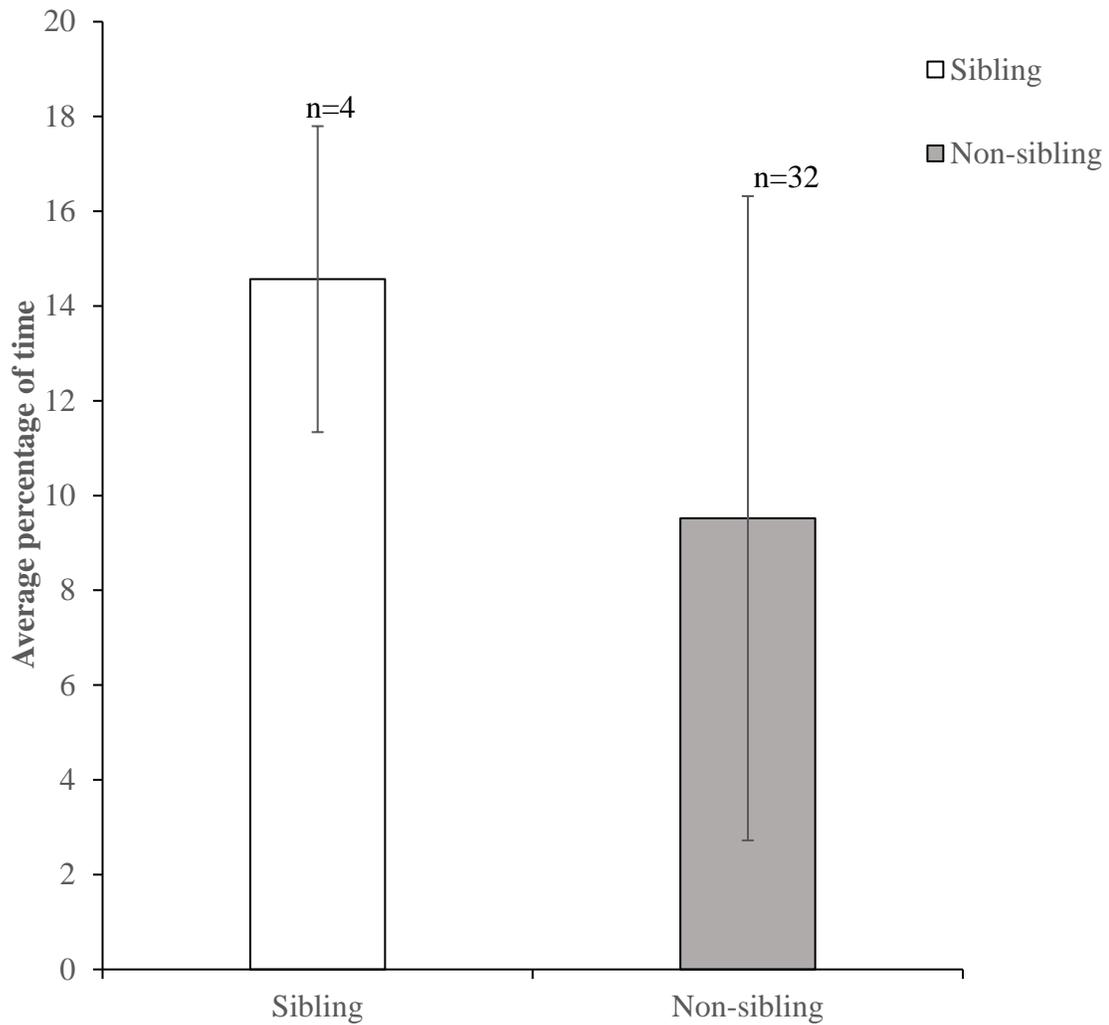


Figure 3 Breakdown of average percent time cubs spent engaging in most common social interactions between kin and non-kin cubs. There was no significant difference between any of the most common behaviors (EW: $\chi^2=0.68$, PW: $\chi^2=0.14$, RW: $\chi^2=0.51$, SW: $\chi^2=0.81$).

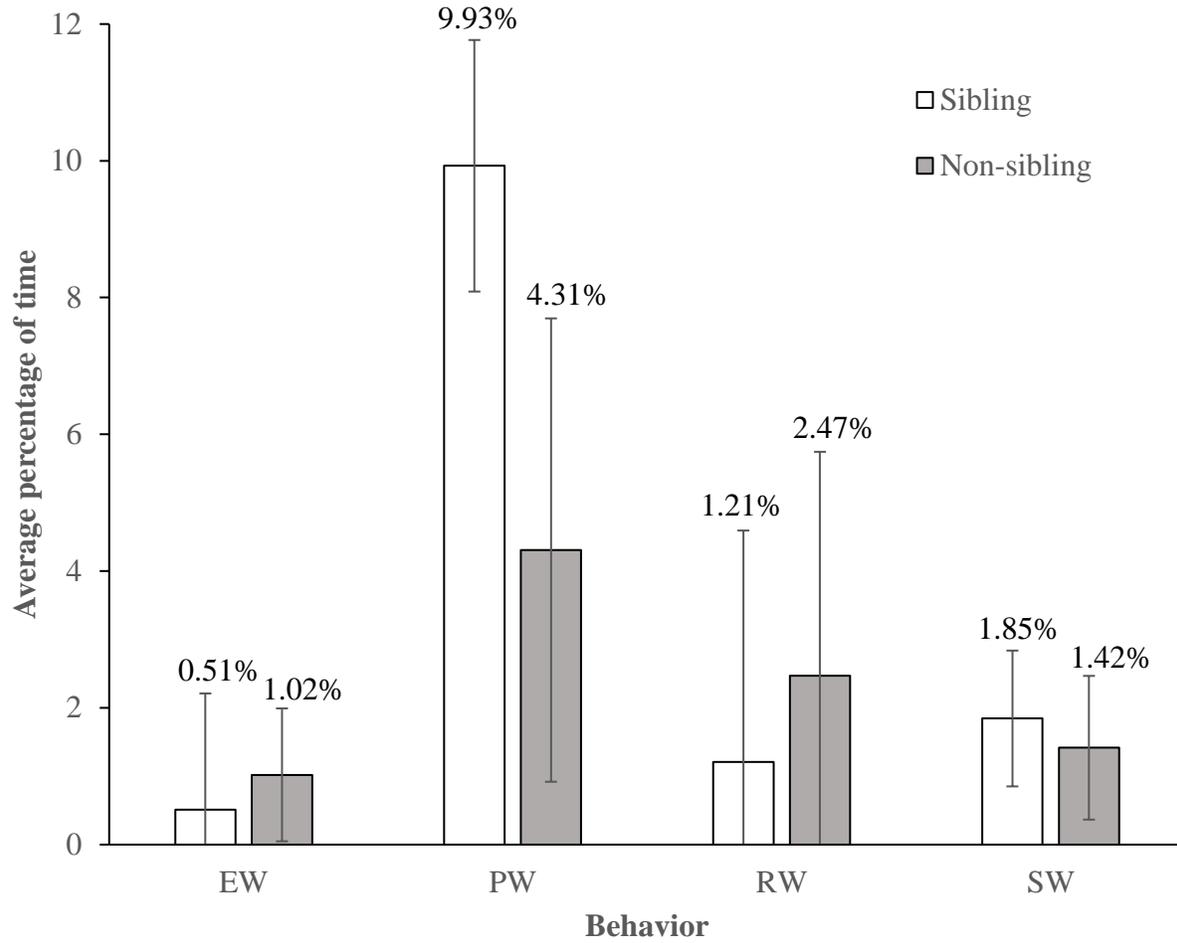


Figure 4 Correlation between time housed together and interactions within cubs. There was a significant difference between cubs interacting and time housed with one another ($\rho=0.0044$). However, kinship did not have a significant effect on the affiliative behaviors within cubs ($\rho=0.27$).

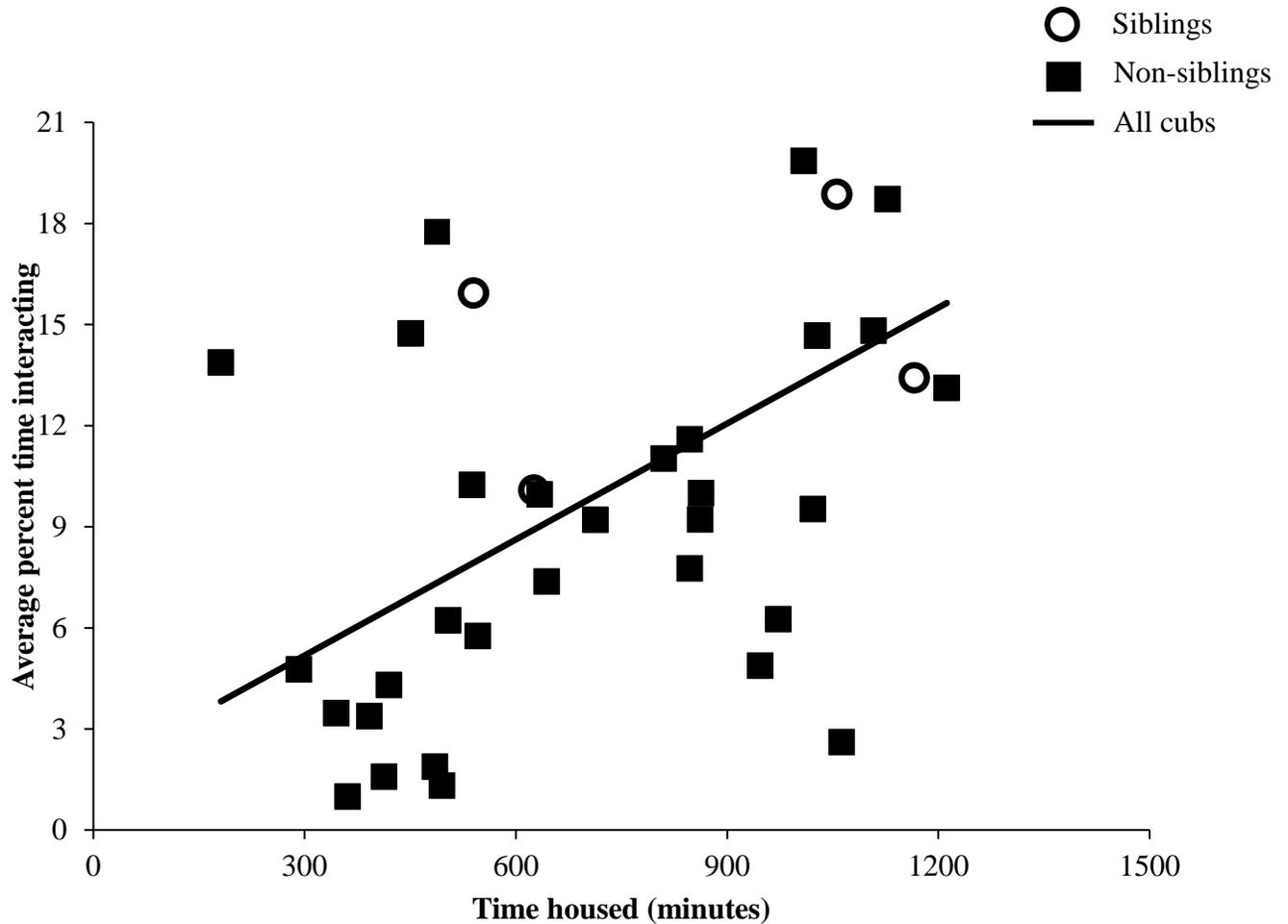


Figure 5 Correlations between time housed together and most common behaviors within cubs. There was a significant difference in time housed together, in regards to eating (A) and playing (B) ($\rho=0.016$, $\rho=0.0033$). There was no significant difference with resting (C) or sitting (D) ($\rho=0.14$, $\rho=0.23$).

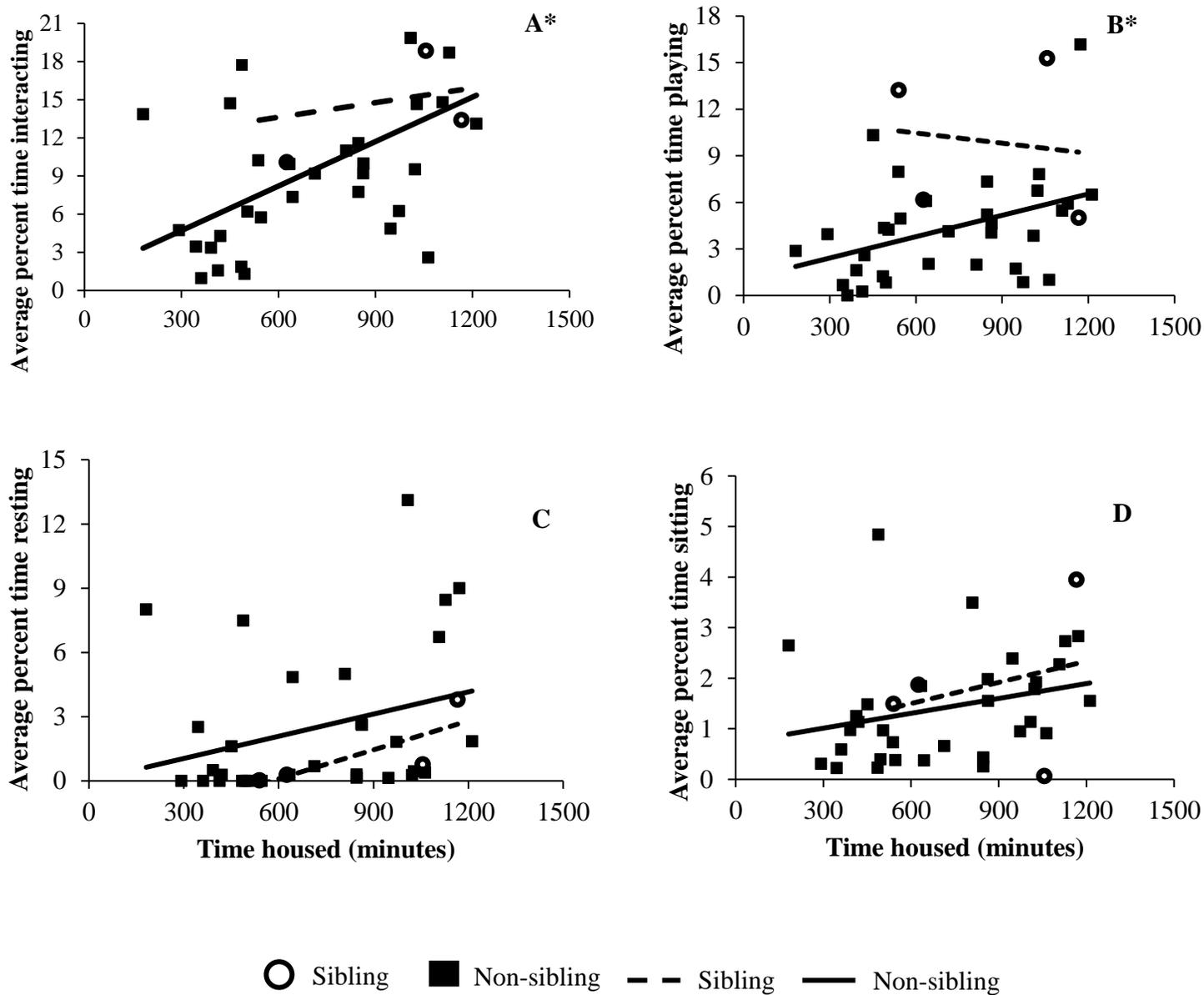


Figure 6 Average percent time cubs spent engaging in social interactions between kin and non-kin adult females. Related individuals spent approximately 25.74% of their time together partaking in affiliative behavior whereas unrelated adult females and cubs were interacting 26.60% of the time housed with one another. There was no significant difference between the two groupings ($\chi^2= 0.87, \rho=0.35$).

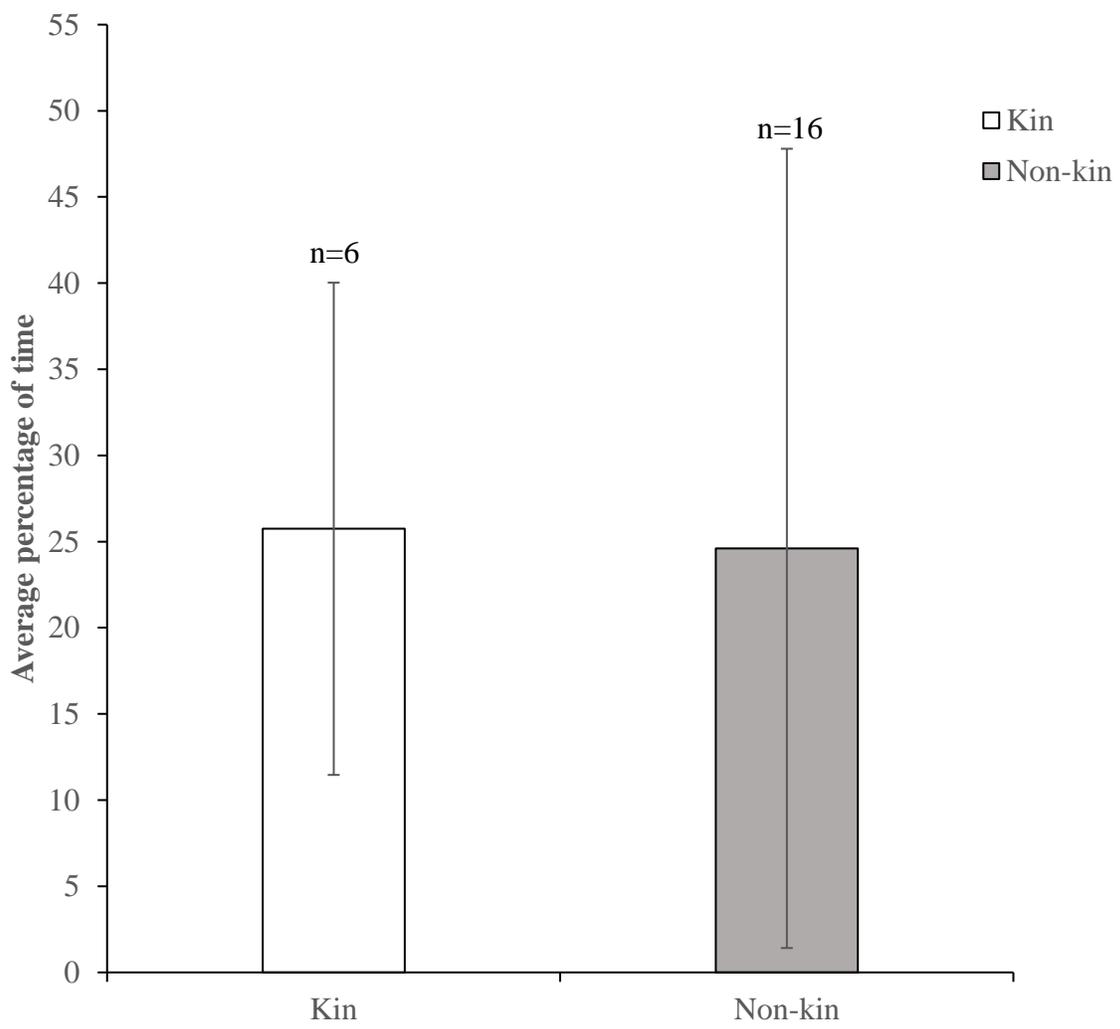


Figure 7 Breakdown of average percent time cubs spent engaging in most common social interactions between kin and non-kin adult females. There was no significant difference between any of the most common behaviors (EW: $\chi^2=0.22$, PW: $\chi^2=0.019$, RW: $\chi^2=0.56$, SW: $\chi^2=0.45$).

