The Social Behaviour of Cats Housed in

Laboratory Cages

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Thesis Abstract

Many species in the cat family, the Felidae, are listed as vulnerable to extinction. The tiger is one species facing extinction. Studies show that tigers can live in groups in captive environments and understanding the social behaviour of tigers could help tiger conservation. It is hard to study tigers in the wild and the domestic cat may be a good model to develop research methods to study tiger social behaviour.

This study focused on the social behaviour of domestic cats, and the effects of group type, sex, relatedness, age, weight, and coat colour on social behaviour. There were significantly different behaviour patterns in established groups and newly formed groups of domestic cat. As age differences increased between pairs of cats, their agonistic behaviour decreased significantly. Affiliative behaviour increased significantly as the weight differences between pairs of cats increased. Sex, relatedness, and coat colour did not influence the social behaviour of domestic cats. In addition, weather did not significantly affect normal behaviour.

Tigers were observed in three different captive environments. There were some differences in their behaviour in the three different environments. Tigers kept individually in small cages did more pacing than tigers in groups in a playground. However, a lack of data on the differences in tiger behaviour in different environments did not allow analysis.

This study was carried to develop the observation technique for cat social behaviour.

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Table of Contents

Chapter Three: Tigers in Captivities

Chapter Four: Conclusion

Chapter One: Introduction

1.1 Domestic Cats as Model to Study Social Behaviour of Tigers

1.1.1 The Social Behaviour of Big Cats

Most big cats live alone in the wild. These solitary cats are together only during the breeding season and when mothers at rearing the young cubs.

The lion is the only cat that lives in social communities (Leyhausen, 1979). They live in a pride consisting of resident lionesses, their cubs, and attending males, which share the pride territory and interact with the lionesses (Schaller, 1972). In the pride, adult females take care of the cubs and hunting. Adult males mate with the pride females and defend the territory against other males. Alien females are attacked and driven off by the females (Schaller, 1972; Leyhausen, 1979). Some young females and all male juveniles are driven away from their natal pride when they are about three-years old and become nomads. These females may set up a new pride, but this is rare (Leyhausen, 1979). Young males that are related stay together and when fully adult at about five years, they look for a female pride complete with territory to take over (Leyhausen, 1979).

In zoos, big cats such as tigers and leopards, which are normally solitary in the wild, may have to share the same territory. In the Haerbin Siberian Tiger Park, which is a conservation wild tiger park in China, tigers are kept in groups divided by age. Although adult tigers are held at a lower density than young tigers, they live in groups and share the same space.

1.1.2 Introduction to the Tiger

Many species of the Felidae are vulnerable to extinction (Bradshaw, 1992). The tiger (*Panthera tigris*) is one species in the cat family that faces extinction (Wilson and Reeder, 1993; Burton, 1987; Nowak, 1999). It belongs to the genus *Panthera*,

1

which includes five of the ten species of big cat. This genus is characterized by its ability to roar and its inability to purr since the hyoid bone at the base of the tongue is modified (Bradshaw, 1992). There are eight subspecies of tiger (Leyhausen, 1990; Macdonald, 1984). Three of these: Bali tiger, Javan tiger, and Caspian tiger are now extinct (Nowak, 1999). The Siberian tiger, South China tiger, Sumatran tiger, Indochinese tiger, and Bengal tiger are the remaining five. Tigers live in Asia, in much of this vast continent, including Iran, Afghanistan, Russia, China, India, Korea, Burma, India, Thailand, Malaysia, Bangladesh, Bhutan, Laos, Indonesia, Nepal, Thailand, Vietnam, and Pakistan (Schaller and Selsam, 1971; Wilson and Reeder, 1993; Macdonald, 1984). Their habitats include tropical and montane forests, mangrove swamps, arid grassland and savannah, and rocky semi-desert (Burton, 1987). However, as humans invaded, tigers no longer roamed over in Asia, and the population decreased dramatically to less than 7000 (Luo et al., 2004). For some subspecies, such as the South China tiger, the wild population has decreased to fewer than 100 (Nowak, 1999).

There are many reasons for the decline in tiger numbers, including loss of habitat, poaching, and declining prey abundance. As habitat loss is an important reason for the extinction of tigers (Burton, 1987), it would be useful to study the social behaviour of the tiger to find ways to keep these animals at higher densities in the wild than normal.

1.1.3 Why Use Domestic Cats as a Model to Study the Social Behaviour of Tigers

It is very difficult to study all aspects of the behaviour of a wild animal such as the tiger. However, domestic species can be studied in environments where it is easier to observe behaviour. From the basic principles of modern ethology, "species-specific behaviour patterns contain an inherited component, and therefore can be compared from species to species as if they were a morphological character" (Bradshaw, 1992). So, studying domestic cat (*Felis catus*) behaviour could provide insights into the

2

origins of many behaviour patterns by comparing them with those of wild species, such as the tiger (Bradshaw, 1992). All felids are thought to be essentially solitary, except the lion. However, some felids such as cheetahs and jungle cats are observed in the wild in small groups (Bradshaw, 1992). Moreover, nowadays wildlife parks and zoos hold some big cats such as tigers, leopards, and cheetahs, in groups similar to domestic cats in laboratory conditions. So, studying the social behaviour of domestic cats' under laboratory conditions may help in understanding the social structure of tigers and aid their conservation.

Domestic cats differ from tigers in a number of behaviours, such as a tendency to feed in the crouched position, instead of lying down. Nevertheless, domestic cats could still be good models for studying tiger behaviour since they carry all of the morphological characteristics that evolved in other wild cats, such as their progenitor the Libyian wild cat *F. lybica* (Bradshaw, 1992).

There are several reasons why one can to use domestic cats as a model to understand tigers. The behaviour of domestic cats in a laboratory setting and the behaviour of free-ranging tigers in a wildlife park are similarly in some ways.

Firstly, domestic cats in a laboratory and tigers in a free-ranging park exhibit some similar affiliative behaviours. Laboratory cats groom themselves and they also allogroom frequently. Tigers in free-ranging park groom themselves and they allogroom during the breeding season. Both cats and tigers rub and allorub. Cats are observed rubbing against their cage, and park tigers also display this behaviour. Allorubbing is observed between laboratory cats and between tigers. Cats and tigers maintain close contact with other cats and tigers. Cats often sleep together in the sunshine or in the sleeping boxes. Tigers also rest together, especially in the cold winter. Cats and tigers may share food with the others in the same group. Cats from one group in a laboratory will share food with cats in the same pen. Tigers also share food when they are fed live food. At feeding time, tigers usually get fed individually, although they all eat in the same place.

Secondly, cats and tigers show similarities in their agonistic interactions. Threatening, fighting, and displacing are observed in cats and tigers. The difference

between cats and tigers is in their response to aggressive signals. For example, cats fight more than tigers, perhaps because they are less susceptible to serious injury than tigers. Tigers show avoiding behaviour more when they receive aggressive signals.

The main difference between cats in a laboratory cage and tigers in a free-ranging park is their foraging behaviour. Cats in a laboratory only have cat food and they are not allowed live food. However, tigers, such as those in some Chinese free-ranging parks, have the opportunity to hunt live food, such as chicken, cattle, and goats. Their daily food, however, is usually chilled chicken, beef, or lamb.

1.2 Behaviour of Domestic Cats

1.2.1 History of Domestic Cats

Domestic cats (*Felis catus*) belong to the order Carnivora and the family Felidae (Case, 2003; Bradshaw, 1992). It is not clear when cats became domestic because the cat skeleton changed during its transition from a wild to a domesticated animal (Case, 2003; Bradshaw, 1992). Cats were probably domesticated in Egypt around 4000 BC. The remains of cats are found in Egyptian tombs, but it is unclear whether these early remains are from the early stages of domestication. Instead, they may have been wild animals killed for their pelts since other carnivores are also found in the Egyptian tombs. Around 1600 to 1500 BC, Egyptian painting and sculpture shows a domestic status between cats and people while cats shared many activities with people, such as eating, hunting, and relaxing in the home (Case, 2003; Bradshaw, 1992). However, cats are not the same as other domestic animals. They are "neither a man-made species like the dog, nor simply an animal made captive for utilitarian purpose, like the elephant" (Bradshaw, 1992). Domestication may have had less effect on cats than on any other domestic mammal, and it is could be determined by monitoring three kinds of change associated with domestication:

1. Reduction in brain size, which shows a reduced sensitivity to uncongenial stimuli.

2. Hormone balance modification, with a reduction in size of the adrenals

4

gland.

3. Neotony, with some juvenile behaviour characters remained by the adult (Bradshaw, 1992).

These three changes describe the process of domestication in most domestic species but not cats. For example, the social structure of feral cats shows that cats' behaviour patterns changed little since their association with people (Case, 2003; Bradshaw, 1992). Cats are unique due to the flexibility in their dependence on man. Although cats are obviously not a wild species, they do not completely depend on humans. They have the ability to return to a semi-wild state, survive, and proliferate in both urban and rural environments (Case, 2003).

Domestic cats are traditionally accepted as solitary animals and they have retained many communication patterns and signalling behaviours from their ancestor, the African wildcat (*Felis silvestris lybica*), which is an exclusively solitary and territorial species (Case, 2003). Cats come together only for mating and rearing offspring (Bradshaw, 1992). However, following domestication, domestic cats now exhibit a wide variety of social behaviours and they may live socially. The type of social system (density of cats) is decided by the food supply (Bradshaw, 1992; Case, 2003). Basically, cats are indifferent to each other (Hart, 1980) and they usually have no clear hierarchy, although sometimes, one male cat may be dominant over all the others (Hart, 1980). However, in some circumstances, female cats interact with each other and their social structure may be based on cooperation (Hart, 1980; Bradshaw, 1992).

1.2.2 Social Behaviour of Domestic Cats

As mentioned before, although domestic cats are often indifferent to one another, they may have a loose hierarchy and form a social structure. The social structure may differ according to living conditions. Cats may live as: urban cats, farm cats, rural cats, and laboratory cats, or as owned, itroy or feral cats.

1.2.2.1 Density of population

The population densities of domestic cats may vary (Case, 2003; Bradshaw, 1992; Hart, 1980) according to the availability of food, which is usually supplied by humans (Case 2003). In an urban environment, the cats' population density may be more than 50 cats/km^2 if there is a rich food supply from garbage and provisioning. In a farm or rural environment with highly clumped food resources, such as a grain store or seabird colonies, the population density of cats may raise from five to 50 cats/km^2. This may include farm cats and feral cats. On the other hand, the density of cats is less than five cats/km^2 when they live in a rural situation that has widely dispersed prey such as rodents and rabbits (Bradshaw, 1992). In a laboratory situation, which provides rich food, the density of the cats could be more than 1 million cats/km^2.

1.2.2.2 Home range

A home range is defined as "the area that an individual, pair, or group regularly occupied or repairs to, but which, in contrast to a territory, need not be defended against entry by other members of the species" (Immelmann and Beer, 1989), and "the area in which an animal normally lives, and without reference to the home ranges of other animals" (McFarland, 1987). A home range usually includes the living area and the hunting range (Case 2003), which may be an area that animals share between two or more groups, or a resource area that no one animal or group defends alone, such as an occasional resting place, a watering hole, or grazing area (Immelmann and Beer, 1989).

The size if the home range of domestic cats varies and it depends on their population density and sex. The home range for a rural cat (<5 cats/ km^2) is about one thousand ha but for an urban cat (>50 cats/km^2), it may be about 0.1 ha with the density of nearly one thousand female cats/km^2 (Bradshaw, 1992). Cats always share their home range but they are seldom present at the same place at the same time (Case 2003). They may use scent marking to arrange "time-sharing" (Bradshaw, 1992). The home ranges of male cats are larger than those of female cats (Bradshaw, 1992).

1.2.2.3 Territory

In animal behaviour, the broadest and perhaps still the best definition of "territory" is "any defended area" (Noble, 1939; from Immelmann and Beer, 1989). Also, Harre and Lamb (1986) defined territory as "many animals defend patches of ground against other individuals, usually of the same species". Normally, a territory is an area with fixed boundaries where an individual or individuals attempt to exclude access by all rival conspecifics (Immelmann and Beer, 1989). This area may be big enough to include all resources, such as food and water supply, and resting places, or it may be just a place for sleep. Animals may use territorial advertisement, threat, and even territorial fighting to protect their territory (Immelmann and Beer, 1989). Territory exclusion may not only apply to the same sex conspecifics, but also to all conspecifics and may be even to other species (Immelmann and Beer, 1989). On the other hand, Case (2003) defined territory as the normal daily activity area for cats. That may relate to house cats only since they have few chances to really define the territory.

The territory and home range are similar for cats living indoors. However, for free-living cats and indoor-outdoor cats, the home range size is usually much larger than the territory (Case, 2003). Male cats' territories usually overlap during the breeding season when they compete for breeding rights with females. On the other hand, in the non-breeding season, their territories do not overlap a lot and marking communication is used to avoid direct contact (Case, 2003). In a laboratory situation, a cat's territory may be just a place for sleep since the population density is high.

1.2.2.4 Social structure

Solitary

Solitary is defined as "a designation used in biology for species in which individuals form no enduring groups or pair bonds, but live most of their lives in a solitary state" (Immelmann and Beer, 1989). For solitary animals, males and females commonly have separate territories and meet only for mating. In rural situation with

well-dispersed prey or food, adult domestic cats are often solitary. They live and hunt alone. Urban cats that live in an environment with separate food sources may also live solitary lives (Case, 2003). House cats may be solitary if there is only one cat in the family and it does not have the chance to contact other cats.

Social

Immelmann and Beer (1989) defined social as "pertaining to behaviour or relationships involving, usually, conspecifics". As solitary animals, domestic cats only live in groups in an environment with concentrated and abundant food sources. Farm cats who are fed by the humans and urban cats who rely on a single large food supply may live in groups (Case, 2003). These groups usually consist of related female cats, and their offspring, but multi-male groups do exist (Houpt, 2005). Males do not live in these female groups, but they live around these groups and often travel between different groups while females rarely do so (Case, 2003; Bradshaw, 1992; Houpt, 2005). Immature males are included in these female groups until they reach puberty when they are driven away (Case, 2003; Bradshaw, 1992). Laboratory cats are found to live in groups in pens with varies population densities.

1.2.2.5 Hierarchy

Hierarchy is used in two contexts in ethology. One related to social organization, which is similar to rank order and the concept of social dominance is involved (Immelmann and Beer, 1989; Harre and Lamb, 1986; McFarland, 1987). Group-living animals often form more or less linear dominance hierarchies. The dominant one in the group is identified, "as measured by superiority in aggressive encounters and order of access to food, mates, resting sites, and other objects that promote survivorship and reproductive fitness" (Barrows, 2001). The other context is applied to motivation, in which hierarchy means "that control of behaviour is a system of tiered or nested units distributing causal or functional management in a stepwise manner, with the most general at the top and the most specific at the bottom"

(Immelmann and Beer, 1989; Harre and Lamb, 1986).

When cats live in groups, it is not usually a definite rank order as in social animals, such as dogs, but it is common that one tomcat in a colony is dominant over all the rest of the animals (Hart, 1980). Houpt (2005) states "a hierarchy emerges that varies with body size in females and age in males. The rank in social space of cats may be different from the rank for food (Houpt, 2005). Case (2003) suggests that the most aggressive cat in a group is the dominant one, but this dominant cat does not control the access of others to resources such as resting places, food, and mating opportunities (Case, 2003). However, Bradshaw (1992) indicated one particular laboratory group where one male cat dominated all. In this group, the dominant male "always fed first and attacked and attempted to mount all newly introduced cats, whatever their sex".

1.2.3 Communication between Cats

Communication is defined as signal transmission between individuals (Immelmann and Beer, 1989; Beaver, 1994; Harre and Lamb, 1986; Case, 2003). Animals use a variety of ways to communicate with each other for a variety of reasons, and with a variety of effects (Harre and Lamb, 1986). Most animals communicate between conspecifics. However, there are plenty of examples of communication between different species (Immelmann and Beer, 1989). Animals may use optical (visual), acoustic (vocal), chemical, tactile, or even electrical ways to communicate (Immelmann and Beer, 1989). Vocal communication is used to transmit an emotional signal rather than specific message since vocabularies in animals are limited (Beaver, 1994). Beaver (1994) also noted that body language in animals is well developed. Some species use distance-increasing silent communication postures to indicate agonistic behaviour, and distance-reducing silent communication postures are used to indicate affiliative or submissive behaviour (Beaver, 1994).

Domestic cats recognize each other in many ways, regardless of breed, size, coat length, or the presence or absence of a tail (Case, 2003). When interacting, domestic

cats use three kinds of signals, which include olfactory signals, visual signals, and auditory signals. Each of them has some advantages and disadvantages, which will be discussed below.

1.2.3.1 Olfactory signals

Olfactory signals are a very important means of communication in solitary carnivores because scents remain a long time in the wild and may not be destroyed by the weather (Bradshaw, 1992). However, this signal can not be turned off at will. So it may be a dangerous signal for prey animals (Bradshaw, 1992).

The sense of smell is very important to cats. If cats loose the ability of smell, they may change behaviours, such as appetite, toileting habits, and courtship (Bradshaw, 1992). Because cats are generally solitary, it is not certain whether or not a colony of cats share a common "colony odour" to identify them as belonging to a particular group (Bradshaw, 1992). Cats use four ways to leave olfactory signals. They are urine scent marking, anal secretions, scratching, and rubbing. Scent marking and anal secretions are used by many mammals. Scratching and rubbing use skin glands to leave odour (Bradshaw, 1992).

Urine scent marking

Urine scent marking is described as: when "the cat backs up to an object, and stands, tail erect and quivering, while urine is sprayed out backwards and upwards on to the object (Bradshaw, 1992)." Both sexes spray urine as scent marking, but males do much more than females, and neutered cats do scent marking too (Bradshaw, 1992). Houpt (2005) pointed out that cats use scent marking to arrange their activity temporally with each other. Free-ranging male cats spray twelve times in one hour, but females only spray once per hour when they are in heat. When cats come into contact with the sprayed urine, they sniff the area very intently (Case, 2003). Male cats spend more time investigating sprayed urine than females. Adult cats, especially males, seem to discriminate between the urine of unknown cats, cats from a

neighbouring group, and cats within their own group (Case, 2003; Houpt, 2005). Furthermore, cats may display a Flehmen or gape response to the odour of urine (Case, 2003).

Cats do not use scent marking as a warning signal to mark their territory (Case, 2003). However, they use spraying to get information about a female's identify, reproductive status, and territory (Case, 2003). When cats contact sprayed urine, they do not attempt to cover the urine by their own urine. Rather, they sniff the area carefully and try to get more information by the Flehmen response (Case, 2003). Outdoor cats spray on objects on their most travelled paths such as trees, bushes, and doorsteps. Indoor cats often spray on furniture, bookcases and kitchen appliances (Hart & Hart, 1985). Caged cats spray on the corner of the pens. The signal value of urine is mostly lost within 24 hours, so male cats may show more interest in fresh than older urine marks (Houpt, 2005).

Anal secretion

Many carnivores such as European otters, wolves, and dogs use their faeces to convey olfactory information (Bradshaw, 1992; Case, 2003). Whether cats use faeces as a signal is still not clear because they usually bury their faeces immediately after defecation (Bradshaw, 1992; Case, 2003; Houpt, 2005). However, when free-living cats are out hunting or on the periphery of their territories, they do not bury faeces (Case, 2003; Houpt, 2005). This may provide a territorial mark or information about their reproductive status and personal identify (Case, 2003; Houpt, 2005).

Cats may also use anal sac odour for communication (Houpt, 2005). When two strange cats meet, they spend some time on sniffing in the perianal area and circling one another (Houpt 2005).

Scratching

Cats also scratch to leaving scent. This method is considered an olfactory signal because cats may use the interdigital glands, which are located between the pads of

the feet, to leave information (Case, 2003). Scratching also leaves a visual mark (Bradshaw, 1992; Case 2003). House cats, free-living cats, and cage cats use the same scratching site repeatedly (Bradshaw, 1992; Case, 2003). Cats usually scratch surfaces that have a rough or hard texture, such as wood, or heavy cloth (Case, 2003). Cats scratch either horizontally or vertically. Free-living cats do not scratch sites on the periphery of their home range or territory, however; they choose sites that are along well-travelled paths and routes. Similarly, house cats scratch in areas where they spend most of their time (Case, 2003). In addition, cage cats scratch on the surface of wood or branches if they are provided in the pens. As with spraying, cats do not scratch for warning; instead, scratching provides reassurance and security about the territory to the resident cat (Case 2003).

Rubbing

Rubbing is a way to use skin glands to leave a message. Cats have a variety of specialized skin glands, and the functions of many of them are for communication (Bradshaw, 1992). The glands that cats use for communication are the submandibular gland beneath the chin, perioral glands at the corners of the mouth, temporal glands on the side of the forehead, and sebaceous (caudal) glands along the base of the tail (Bradshaw, 1992; Case, 2003).

When cats rub their face and head on objects that are at eye level, which is called "bunting", the secretions of these fad glands are deposited as scent marks (Bradshaw, 1992; Case, 2003; Houpt, 2005). Bunting may be performed in isolation or after a Flehmen response towards a urine or head mark. Tomcats may perform this after spraying (Bradshaw, 1992; Case, 2003). Cheek rubbing is a specific form of bunting, in which cats rub along a line from the corner of the mouth to the ear (Bradshaw, 1992; Case, 2003). Cats use their forehead and ears to mark higher objects, and objects near the ground may be marked with the underside of the chin and the side of the throat. They may also use their flanks and tails to mark inanimate objects (Bradshaw, 1992).

Free-living cats usually rub to mark their home range and they may redo it when

they visit these sites again. House cats direct bunting toward their owner's leg and on objects within their territories (Case, 2003). Cage cats usually rub along the pen eye level. As with scent marking, adult tomcats tend to rub mark more frequently than females or young cats (Case, 2003). Allorubbing is quite common between cats from the same group or same family. When cats sniff each other, they usually pay most attention to the head region (Case, 2003). The purpose of allorubbing is still not clear (Bradshaw, 1992), but by allorubbing, the cats in one group may all smell the same (Houpt 2005). Subdominant cats always rub dominant ones (Houpt 2005).

1.2.3.2 Visual signals

Visual signals provide an exact message at a moment, but they cannot be used effectively over long distances. Cats use a wide range of body postures and facial expressions to communicate with other cats and their owners. When cats are greeting or investigating, their tails are carried high (Houpt, 2005). On the other hand, the tail is held at different angles in walking, trotting, and pacing (Case, 2003). When a cat is relaxed, the tail is held hanging, and the ears are forward. If cats want to attract other individuals, their tails are raised and the ears are held erect forward (Houpt, 2005). When a cat is aggressive, it walks on tiptoe with head down, and the tail is held down but not in contact with the hocks. In this situation, a cat makes itself appear larger than reality. The ears are held erect and swivelled and the openings of the ears are pointed to the side. The aggressive cat also shows whiskers rotated forward, protruded claws, constricted pupils, and piloerection (Bradshaw, 1992; Houpt, 2005; Case, 2003). In contrast, a frightened cat had a defensive threat posture. it shows flattened ears, dilated pupils, drawn back whiskers, and bared teeth (Bradshaw, 1992; Houpt, 2005; Case, 2003). Moreover, fearful cats attempt to look as small as possible (Bradshaw, 1992; Case, 2003).

Cats also show affiliative behaviours to other cats and to people. These behaviours include greeting, rubbing, grooming, and rolling. Females in heat always roll near interested males while pet cats may roll to invite their owner to play and to

pet them (Houpt, 2005; Case, 2003). Young males who roll toward adult males are thought to be performing a sign of submission (Houpt, 2005).

Auditory signals

The advantage of auditory signals is that these signals are as effective at night as during the day, and a vocal cat may be easy to locate if the sound is frequent (Bradshaw, 1992). However, auditory signals may be dangerous if the signal attracts a predator, and they may not be efficient over long distance (Bradshaw, 1992). Domestic cats use these signals frequently and their vocalizations may be categorized into three groups: murmur patterns, vowel sound, and strained intensity calls (Case, 2003). The major vocalizations of the adult domestic cat are showed in Table 1.

Table 1 the Major vocalization of the domestic cat (from Houpt, 2005; Case 2003).

Vocalization Type	Description and Function
Murmur	Made with the mouth completely closed. It is a soft, rhythmically pulsed vocalization given on exhalation. It is the request, or greeting call, which can vary from a coax to a command, and the acknowledgment, or confirmation call.
Purr	Produced while inhaling and exhaling; most commonly associated with pleasure or contentment. It is a soft, buzzing vocalization that is easy to recognize. Cats may also purr when ill or injured.
Growl	Lowest-pitched sound made by cats; used prior to or during aggressive encounters; a low-pitched growl may have the effect of deceiving the other cat into believing the sender is more powerful than his opponent.
Squeak	A high-pitched, raspy cry given in play, in anticipation of feeding, and by the female after copulation.
Shriek	A loud, harsh, high-pitched vocalization given in intensely aggressive situation or during painful procedures.
Hiss	Primarily a defensive vocalization; uttered when frightened or cornered; spit is an intense form of the hiss, used to deter threats. It is produced while the mouth is open and the teeth exposed.
Spit	A short, explosive sound given before or after a hiss in agonistic situations. Saliva is expelled.
Chatter	A teeth-chattering sound made by some cats while hunting or more commonly when restrained from hunting by confinement.
Mating call	Uttered by female during proestrus and oestrus. It is an advertisement of reproductive status and attracting males. It is a call of variable pitch, lasting a half-second to one second. The mouth is opened and then gradually closed.
Male mating call	Uttered by male during mating or when competing with other males for oestrus females. It is a variable-pitched call.
Mew	A high-pitched, medium-amplitude vocalization. Phonetically it sounds like a long "e". It occurs in mother-kitten interactions and in the same situations as the squeak.
Moan	This is a call of low frequency and long duration. The sound is "o" or "u". It is given before regurgitating a hairball or in epimeletic situation, such as begging to be released to hunt.
Meow	Usually directed only toward caretakers; not often used between cats; uttered during amiable social encounters, to establish contact and friendly interaction, or to request interaction, play or food. The sound is "ee-ah-oo".

1.2.4 Behaviour Patterns

1.2.4.1 Affiliative and agonistic behaviours

Affiliative behaviour is defined as "a form of social behaviour involving an individual animal's tending to approach and remain near conspecifics" (Barrows, 2001). On the other hand, agonistic behaviour is a complex behaviour that includes aggression (attack, threat behaviour, defence) and fleeing (Immelmann and Beer, 1989; McFarland, 1987; Barrows, 2001). Beaver (1994) notes that agonistic behaviour may also be associated with distance-increasing and distance-decreasing silent communication. The following are definitions of different cat behaviours: (UK Cat Behaviour Working Group, 1995)

Rub Cat

One cat rubs another cat. It may include head rub (one cat rubs its head on another cat; the cheek and/or forehead area may be used), and body rub (one cat rubs its body on another cat; the flank and/or tail area may be used; the tails may or may not be entwined).

Allogroom

One cat licks another cat, including the head and body.

Sniff Cat

One cat smells the body of the other cat. They may touch noses and sniff the rear end (one cat smells the peri-anal area of another cat).

With Cat

One cat positions itself adjacent to, or in contact with, another cat(s).

Approach

One cat moves toward another cat whilst looking at it.

Follow

One cat moves closely behind another.

Social Roll

A cat rolls on the ground in the presence of another cat. This may be in a "friendly" and relaxed manner, or in a submissive context when the legs are splayed

apart and the belly may be exposed as the cat "freezes" its position. The speed of the roll also varies with different social context.

Move Away

One cat walks away from another cat.

Eye Interaction

Watch

One cat observes another cat. This can be distinguished by the way in which the cat's eye and head movements track what it is watching.

Stare

One cat gazes fixedly at another cat and is not easily distracted by other activity around it.

Sound Interaction

Hiss

A cat makes a drawn-out SSSS sound, which is unvoiced.

Spit

A cat makes a sudden, short, explosive exhalation, which is often accompanied by a violent movement.

Pounce

One cat leaps at or onto another cat.

Stalk

One cat attempts to approach another cat without alerting it. The belly is pressed to the ground and the head is kept low.

Fight

Two cats (or more) engage in physical combat, often grappling with one another, scratching and biting as they turn over, and including vocalization.

Wrestle

One cat struggles with another cat, raking with its hind legs and pulling the "opponent" towards its body with its forelegs. It is mainly a play behaviour, and is distinct from Fighting.

Bite

One cat snaps its teeth at or succeeds in nipping another animal.

Paw

One cat pats another individual with its forepaw but always with claws retracted.

Raise Paw

One cat lifts its forepaw as it to cuff another cat. Contact is not actually made.

Cuff

One cat strikes another cat with its forepaw, usually with the claws extended.

Rake

A bout of kicking movement by one cat at an object or another cat with one or both hind legs.

Hold

One cat grasps another cat or an object between the lower part of its forelimbs.

Chase

One cat races in pursuit of another cat.

Attack

One cat launches itself at another cat and immediately attempts physical combat.

Flee

One cat runs away from another cat.

Avoid Interaction

One cat responds to the behaviour of another cat by withdrawing, for example, avoiding eye contact or not approaching.

1.2.4.2 Sexual behaviour

Female domestic cats are seasonally polyestrous (Houpt, 2005), long-day breeders, and they cycle from early spring until late fall and they are not reproductively active during the short days of winter (Case, 2003).

During proestrus, females show a tendency to move about more than usual and an increase in object rubbing. At this stage, males approach females but prolonged

contact is not tolerated (Bradshaw, 1992; Houpt, 2005). Over the next 24 hours, females increase rubbing and bouts of rolling occur, accompanied by purring, stretching, and rhythmic opening and closing of the claws. Males now get close to females and lick them, but mounting attempts will lead to displays of aggression (Bradshaw, 1992). When females show lordosis, and males first attempt to mount. In mounting, male cats approach females and engage in nose-to-nose contact and genital investigation, and then they proceed to take a neck grip on the female by grasping in his teeth the skin over her neck (Hart, 1980). When the male cat achieves intromission, the female usually emits a loud piercing cry, and jumps away from the male, behaving aggressively to him (Bradshaw, 1992).

The only non-aggressive contact between solitary adults animals is during sexual behaviour (Bradshaw, 1992). In social groups, which contain more than one male, each of the males has a chance to copulate with the females. A lower-ranking male may displace a dominant one from a female since the hierarchy of cats is loose (Bradshaw, 1992). When a male cat is present, females in oestrus may roll to solicit the male's attention (Houpt, 2005). On the other hand, when a female cat is not in oestrus, even a familiar male cat may be attacked if he shows more than a fleeting sexual interest (Bradshaw, 1992).

Here are some definitions of sexual behaviour (UK Cat Behaviour Working Group, 1995) to help distinguish them from affiliative behaviour and agonistic behaviour.

Mount

One cat mount and attempts, but fails to achieve, intromission. This behaviour is often accompanied by treading movements of the hind legs along the flanks of the recipient cat, while holding the recipient firmly at the nape of the neck.

Copulation

A male cat mounts a female cat and achieves intromission. This behaviour is characterised by the female uttering a sharp howl at the moment of ejaculation and twisting out of the male's grasp. It is usually preceded by several mount attempts and by treading and the neck grasp. The female also treads with her hind legs and assumes

the lordosis position.

Lordosis

A female cat raises her hindquarters to present her genitals to a male when in a receptive oestrous state. Her belly is pressed close to the ground and she often treads with her hind legs. Her tail is laterally displaced, uncovering the perineum.

Oestrous Walk

A female cat in oestrus walks for short distances while jerking her tail, "soliciting" males, and often retracing her steps or going around in circles.

1.2.5 Cat--Human Relationships

By living together, cats and people change each another's lives. The relationship between cat and human is different from dog and human. Cats usually treat their human owner as if it were a member of their social group, or, as surrogate mothers in some cases (Bradshaw, 1992; Case, 2003). Living in different situations, cats show different relationships with humans.

1.2.5.1 Feral cats

Feral cat are not owned cats. They live completely or almost completely independent of direct human contact (Case, 2003). Feral cats usually live as solitary animals or in loosely structured colonies depending on the environment, population density, and availability of food. Most feral cats that live in the countryside and on the edge of human communities are not dependent on people (Case, 2003), and others have loose relationship with people because they rely on the food or shelter that people provide (Case, 2003). These cats have freedom to choose their own companions (Bradshaw, 1992). It has been found that some of these feral cats could be socialized to people and adopted as pets if they are caught and neutered, but the individual cat's personality seems to be an important factor here (Case, 2003).

1.2.5.2 Free-roaming cats

Free-roaming cats are socialized to people to some degree but are primarily free of control by people (Case, 2003). Farm cats, stray cats, and owned cats that roam without supervision are considered in this group. These cats have a certain level of dependence on people (Case, 2003). They enjoy the food, shelter, and affection that people provide, and they may even enter into people's homes. However, they are still able to choose their partners for interaction (Bradshaw, 1992).

1.2.5.3 House cats

House cats are owned and are usually considered to be members of the families as pets. People provide everything for them, but they rarely have choice of their companions (Case, 2003; Bradshaw, 1992). Because cats are thought to be solitary animals, it is common to keep them singly at home. Therefore, some house cats may not have opportunities to interact with their own kind (Bradshaw, 1992).

1.2.5.4 Cage cats

Cats in laboratories are similar to house cats. In that although they could live in groups, they have little chance to choose their own companions. However, these cats are not members of families. They rely on people for food, water, and shelter, but they do not have as close a relationship with people as house cats do.

1.3 Aims of Thesis

This study is an examination of the social behaviour of cage-held domestic cats, focusing on the effects of relatedness, age, weight, coat colour and weather on their affiliative and agonistic interactions. I also describe the social behaviour of tigers held under three different captive management regions.

Chapter Two: Social Behaviour of Domestic Cats in Laboratory Cages

The study reported here was approved by the Massy University Animal Ethics Committee. The Protocol number was 05/57.

2.1 Introduction

Domestic cats (*Felis catus*) are more aggressive to strange cats than to familiar cats (Crowell-Davis et al., 1997), and also more aggressive to unrelated cats than to related cats (Crowell-Davis et al., 2004). Sex, age and weight were not significant factors in their social behaviour (Crowell-Davis et al., 2004; Natoli et al. 2001). However, few studies have investigated the social behaviour of cat held in laboratory cage conditions.

Seven factors were investigated in this study to determine how they influence the social behaviour of laboratory cats. The factors investigated are: group type, sex, relatedness, age, weight, coat colour, and weather.

The study was separated into two parts: pilot observation and observation. Methods and results of these two parts are given separately.

2.2 Materials

2.2.1 Study Site

This study was carried out in the Heinz Wattie Feline Unit at Massey University, Palmerston North, New Zealand. Details of the unit are described by Hendriks et al. (2001, 2004) and Roesch (2003). There are approximately one hundred and fifty cats in this unit. The cats are held in pens with up to eleven cats in each pen. The cleaning and feeding work is carried out in the morning. A small group of breeding cats is maintained in the unit. Most of the cats were born and bred in the unit. To prevent

inbreeding, some new breeding cats are brought in from time to time. In the unit, most female cats are sexually entire, but only one male is sexually intact, all the others are castrated. Ten females are used for breeding each year. Most of the cats are kept in groups, which include females and neutered males. The breeding females are kept in a single sex group (Pen 1) and the entire male is kept alone except when used for breeding.

The pens in the Feline Unit are about 16.5m^3 (Width (4.6m) X Length (1.4m) X Height (2.4m)) (Weidgriaaf, 1999). Each pen has a lower and upper shelf walkway, two sleeping boxes, one wall box, a food tray, a water trough, and three to four litter boxes (Figure 1). Branches are placed in the pens to enrich the environment. Pens are adjacent. Figure 2 is a diagram of the Feline Unit.
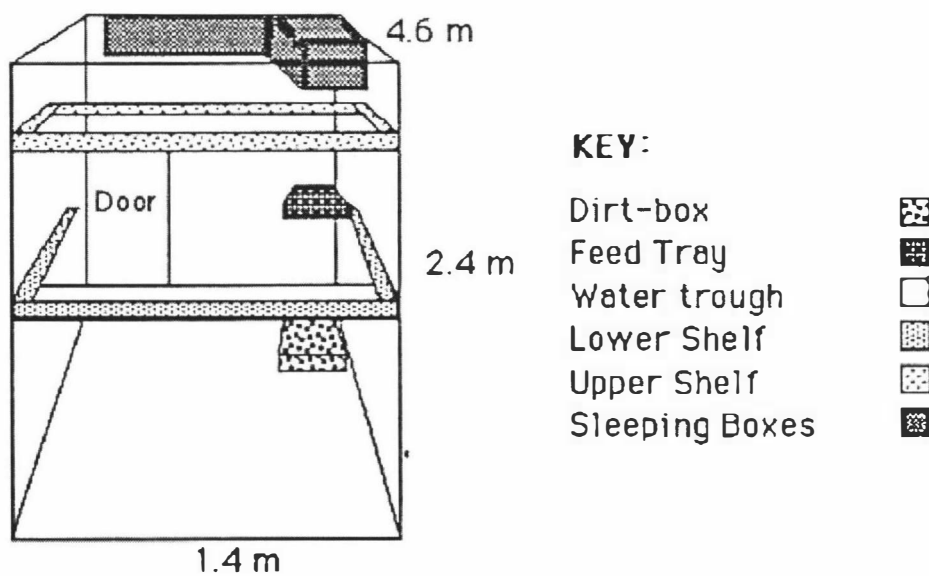
Figure 1 The design of cat pen in Heinz Wattie Feline Unit (from Kyle, 1991) (the 4.6m, 1.4m, and 2.4m are the width, length, and height of the pen).
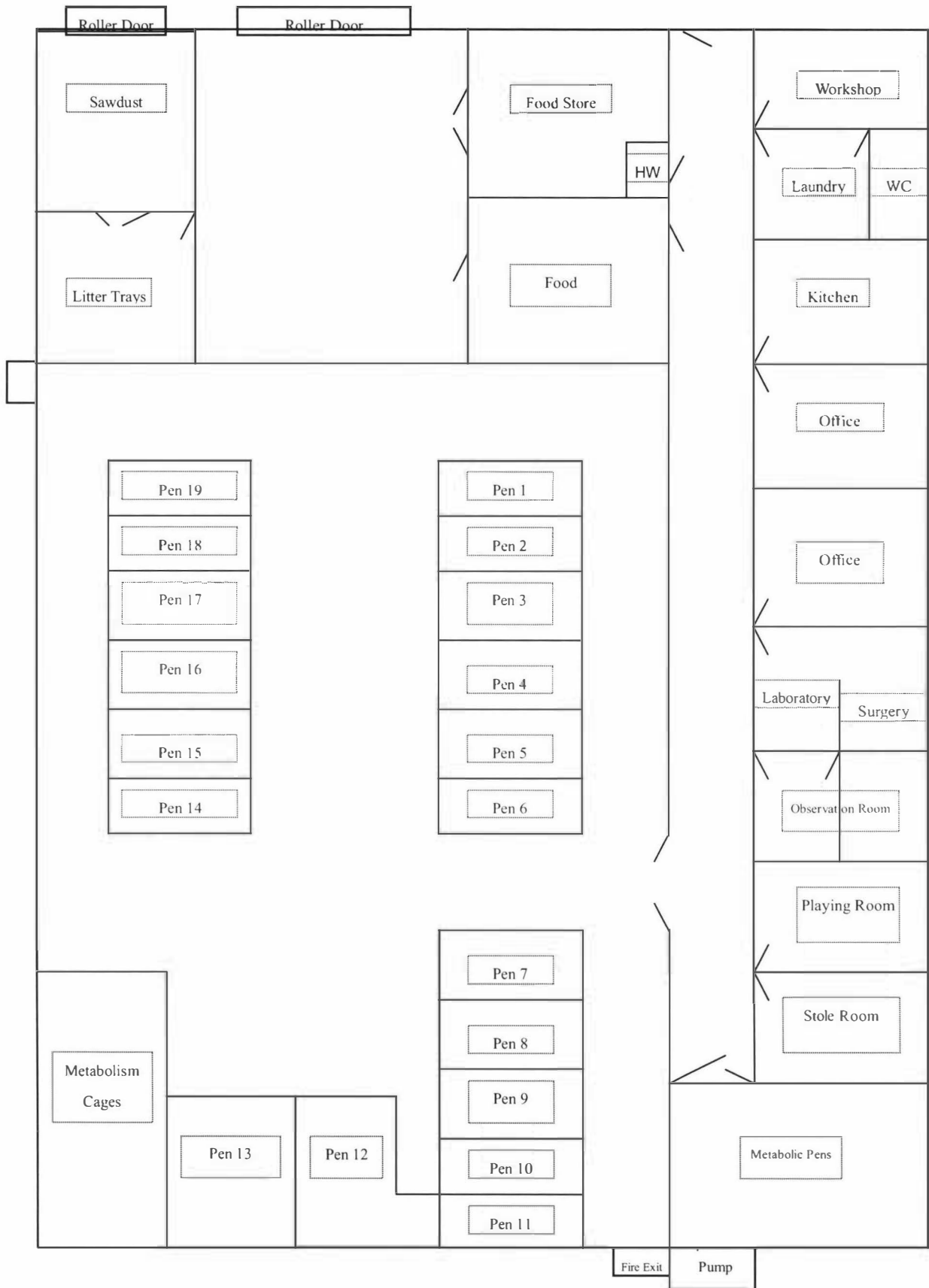
Figure 2 Schematic painting of the Feline Unit (From Weidgriaaf, 1999).

2.2.2 Animals

The cats in the unit are domestic shorthaired cats (*F. catus*). There are one hundred and fifty cats in the unit and ninety of them were used in this research. The reasons for using the ninety cats were: some of them were held in the same group for a long time and others were newly formed groups. This allowed an opportunity to observe the change of behaviour during the first month after a new group was formed. The cats, which were used, include the one entire male, entire females and castrated males. The range of the cats' body weight was from 2335grams to 6304 grams, and the cat ages ranged from two to 13 years. Many of the cats were related since most of them were bred and born in the Feline Unit. The relatedness between each pair of cats was categorised into three groups by the Family Relationships of the Feline Unit (Ugarte, 2006): 0 (non-related), 0.25 (half-sibling), and 0.5 (sibling or parents-children).

The cats were often moved between pens. The reasons for the movement include: breeding programme, other trials, and severe aggression between particular cats. There were two major movements of cats during the observation period. One was on 1 June 2005 and the other was between 17 and 23 July 2005. The first movement was to form a new breeding group. Most of the cats in the unit were moved in the first movement. Pen 1 was cleared and a new breeding group was formed, which included ten females. The groups in Pens 8, and 10 were also newly formed, but they were not for breeding and some neutered males were placed in these two pens. There were some changes in Pen 4, 5, 6, 7, and 9 but the cats were mostly the same as before. In the second major movement, the cats in Pens 4, 8, and 10 were cleared and reformed. In each of Pens 1, 7, and 9, one cat was changed and Pens 5 and 6 did not change.

Cats in eleven pens were observed during this study: Pen 1, Pen 1 (new), Pen 4, Pen 5, Pen 6, Pen 7, Pen 7 (new), Pen 8, Pen 9, Pen 10, and Pen 15. The difference between Pen 1 and Pen 1 (new) was that the one male cat (Titan) was added to Pen 1 from 4 July 2005 until the end of the study. Pen 7 and Pen 7 (new) were different because one cat (Kree) was moved out of Pen 7and another one (Dusky) was moved

in between 17 and 23 of July.

During the period of the study, twenty-two cats changed pens. They were: Zeal, Astra, Buffy, Flame, Dusky, Fya, Sox, Glade, Shine, Tori, Twink, Rach, Chyna, Kola, Deb, Crest, Asia, Kree, Libby, Jaffa, Sioux and Vanda. Two of them were observed in different pens (Table 2). Dusky was in Pen 8 from 5 June to 9 July 2005, and then in Pen 7 (new) from 24 July to 24 September. Libby was in Pen 8 from 5 June to 9 July and was moved to Pen 9 after 17 July 2005. The remaining 20 were observed in only one pen.

Table 2 Overlap of the cats in different Pens during different observation duration.

Name of Cats	Before		After	
	Pen	Observation Duration	Pen	Observation Duration
Dusky	Pen 8	5/6-9/7	Pen 7 (new)	24/7-24/9
Libby	Pen 8	5/6-9/7	Pen 9	17/7-24/9

Three cats died during the observation period. They were Kohi, Lorn, and Shade. Because of the frequent movement of cats and the death of these cats, some data were excluded from the analysis, which include all data from 30 of April to 31 of May. All data from Pen 15 were not included. Some data from Pen 4 and Pen 8 were not included in the analysis either because some cats were taken for other experiment during the daily observation.

2.3 Methods and Results of the Pilot Observation

2.3.1 Methods

An initial familiarisation period allowed the observer to gain experience with the cats and with their behaviour, and to establish which behaviours would be used in subsequence research. The pilot observation was from 30 March to 12 April 2005, with 75 hours observation included. During this period, the observations were done in

the yard of the Feline Unit, usually in the afternoon. The observer sat behind the pens near the pen door and at the division between two adjacent pens (Figure 2). Cats in both of the adjacent pens were observed four to five hours in each observation day. One all night observation was carried out to determine whether cats were active at night. All the behaviours that appeared in the two groups of the cats were recorded in a notebook.

2.3.2 Results

During the pilot observation period, the behaviours, which were later used in the research, were selected. They include, Affiliative behaviour (sniffing, playing, allgrooming, allorubbing, resting together, eating together, and inviting), and agonistic behaviour (threatening, pushing, fighting, chasing, and displacing). An ethogram and definitions for the behaviour patterns are given below.

Ethogram of cats social behaviour (some of the definition are from UK Cat Behaviour Working Group, 2005 and are identified with an asterisk *)

Affiliative behaviour

Sniffing*: One cat smells the body of the other cat, including touch noses and sniff rear (one cat smells the perianal area of another cat).

Playing: Looks like fighting, but cats show totally different emotional signs. Cats play without any aggressive voice and there are no avoiding or threatening behaviours present.

Resting Together: Cats sleep together (contact with each other for more than 0.5 minute).

Allogrooming*: One cat licks another cat, which includes head and body.

Allorubbing*: One cat rubs another cat, which includes head rub (one cat rubs its head on another cat; the cheek and/or forehead area may be used), and body rub (one cat rubs its body on another cat; the flank and/or tails area may be used; the tail may or may not be entwined).

Eating Together: Cats eat at the same time from the same food bowl.

27

Inviting: One cat using its paw to touch the other cat to ask the other cat to rub with it.

Agonistic behaviour

Threatening: One cat threatens another cat, preventing the other cat from approaching. This could be divided into two functions: Eyesight Threatening (staring) and Voice Threatening (growling and hissing)

Fighting*: Two cats engage in physical combat, often grappling with one another, scratching and biting as they turn over, and including vocalization.

Chasing*: One cat races in pursuit of another cat.

Displacing: One cat drives away other cats by approaching, staring, or voice threatening. Sometime the cat does nothing, but others walk away or run away from it.

Pushing: One cat used its paw to push another cat to prevent another cat' behaviour, sometime with threatening sound.

2.4 Methods and Results of the Observation

2.4.1 Methods

All observations were done in the yard of the Feline Unit in the afternoon. The observer sat behind the pens near the pen door and at the wall between two adjacent pens (Figure 2). Cats in one of the adjacent pens were observed. Every day, cat in one or two pens were observed. The data were recorded in a record sheet and a notebook. A mirror was used to help the observations. Noise, human activity, and human presence affected the cats' behaviour.

2.4.1.1 Preparation

The cats often rested together in sleeping boxes, especially during windy and very cold days. The position of the sleeping boxes (Figures 1 and 3) made it difficult to determine the position of each cat when they rested together in the sleeping boxes. A convex circular mirror was used to look into the boxes to determine which cats

were resting together. The mirror was hung in the middle of the roof (Figure 3).

Before every observation period, the observer spent 30 minutes learning to identify each individual cat in the pen under observation. This time also allowed the cats to become familiar with the observer.
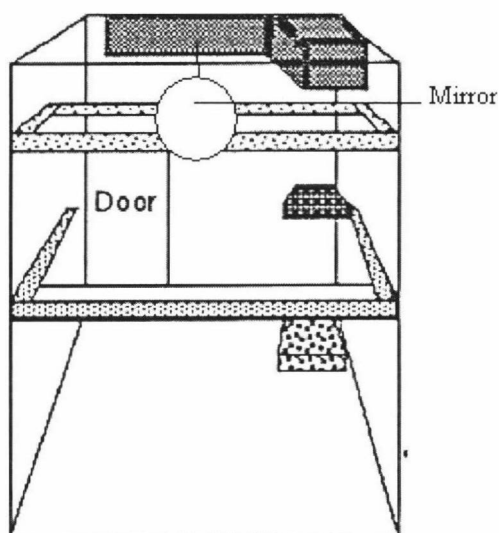
Figure 3 Pen structure with the mirror inside.

2.4.1.2 Observation time

All observations were carried out in the afternoon from 1 June to 24 September 2005. This time period includes the breeding season of the cats in New Zealand. The total observation time was 144 hours. The observation times for different pens are showed in Table 3.

On each observation day, one or two pens were observed and each pen was watched for 1.5 hours. However, due to the bad weather and non-active cat, Pen 8 and Pen 10 each had one one-hour observation session.

Table 3 the Observation times for different pens.

Time / Date	Pen1	Pen1 (new)	Pen4	Pen5	Pen6	Pen7	Pen7 (new)	Pen8	Pen9	Pen10
1/6-4/6	3h	0	1.5h	0	0	0	0	0	0	0
5/6-11/6	4.5h	0	1.5h	1.5h	1.5h	0	0	3h	0	3h
12/6-18/6	1.5h	0	1.5h	0	0	1.5h	0	3h	0	1.5h
19/6-25/6	1.5h	0	1.5h	1.5h	1.5h	1.5h	0	1.5h	0	2.5h
26/6-2/7	3h	0	3h	1.5h	1.5h	3h	0	3h	0	1.5h
3/7-9/7	0	4.5h	1.5h	0	0	0	0	1h	0	1h
10/7-16/7	0	1.5h	0	1.5h	1.5h	1.5h	0	0	0	1.5h
17/7-23/7	0	3h	1.5h	0	0	0	0	0	1.5h	0
24/7-30/7	0	0	0	1.5h	1.5h	0	1.5h	0	1.5h	0
31/7-6/8	0	0	0	3h	3h	0	3h	0	3h	0
7/8-13/8	0	0	0	0	0	0	0	0	0	0
14/8-20/8	0	0	0	1.5h	1.5h	0	1.5h	0	1.5h	0
21/8-27/8	0	0	0	3h	3h	0	3h	0	3h	0
28/8-3/9	0	0	0	3h	3h	0	3h	0	3h	0
4/9-10/9	0	0	0	0	0	0	1.5h	0	1.5h	0
11/9-17/9	0	0	0	3h	3h	0	1.5h	0	1.5h	0
18/9-24/9	0	0	0	1.5h	1.5h	0	1.5h	0	1.5h	0
Total	13.5h	9h	12h	22.5h	22.5h	7.5h	16.5h	11.5h	18h	11h

2.4.1.3 Recording data

All observations were recorded in a notebook and on data sheets. The identified cats and its behaviour patterns, observation date and time, and weather were recorded in the data sheets. However, because the data sheets (see the table example below) could not show the exact time of occurred and duration of behaviour, the notebook was used. In the notebook, the cats identified and their behaviour patterns, time of occurrence, the duration of the behaviour pattern, the date, observation time, and weather were recorded.

Samples of Data Sheets

Affiliative behaviour

Affiliative Behaviour	Nui	Puff	Wren	Tang	Argon	Misty	Rover	Puihi
Nui		S C RT	P			S		
Puff	S			R		I	P	C
Wren	RT ET				ET I	I		
Tang					RT	C RT ET	P C	
Argon		ET		C				
Misty	RT		R				RT	
Rover			R					ET
Puihi		S R	C C		RT			

C: Allogrooming, R: Allorubbing, RT: Rest together, ET: Eating together
S: Sniffing, P: Playing, I: Inviting
23/Jun/05 Sunny From 12:30-2:00PM

Agonistic behaviour

Agonistic Behaviour	Nui	Puff	Wren	Tang	Argon	Misty	Rover	Puihi
Nui						A		
Puff	T						P	
Wren		F			C			
Tang						T T		
Argon	T A F							
Misty								
Rover			F P A					
Puihi						C A P		

T: Threatening, A: Avoiding, P: Pushing, F: Fighting, C: Chasing
23/Jun/2005 Sunny From 12:30-2:00PM

2.4.1.4 Influences of the observation

Weather:

Weather changed the activity of the cats. For example, on very windy or very cold days, cats spent most of their time resting together in the sleeping boxes. However, on sunny days, cats were more active, and so eating together and playing may occur more frequently on fine days than cold days.

Human Presence:

The observer had some influence on the cats' behaviours. Some of the cats were more interested in the observer than in other cats. The observer's behaviour also influenced the cats.

Human activity:

During the observation period, the staff of the Feline Unit would walk around to check the yard and the cats. This may have caught the cats' attention and changed their behaviour, for example, when staff took cats from other pens to weigh them and play with them. Other experiments were being undertaken at the same time as the observation, and for instance, some cats were taken for a blood sample. All of these activities could get the cats' attention and change their behaviour.

Noises:

Loud noises also changed the behaviour patterns of cats. Cats were more nervous when they heard a loud noise and they fled to the sleeping boxes all together with fright. The noises include people' talking, vacuum cleaning, helicopters and cars.

2.4.1.5 Analysis

The differences in cats' social behaviour between different groups (Newly Formed vs Established Pens) were analysed by using the Mann-Whitney Test and Paired T-Test from MINITAB System. Analysis of Sequential (Type 1 Analysis) from SAS System was used to analyse the effect of sex, relatedness, age, weight, and coat colour on affiliative and agonistic behaviour. Correlation coefficients were calculated by using Excel in both age and weight differences. Weather effects on behaviour were

analysed by One-way ANOVA from MINITAB.

2.4.2 Results

2.4.2.1 Individual Pens

Pen 1

The group of cats in Pen 1 was formed on 1 June 2005. The ten female cats in this group were for breeding. Most of them had coefficients of relatedness of 0.25 (half-sibling) and 0.5 (sibling) (Table 4). Rua was related to Shine at the 0.25-level, but was not related to the other cats (Table 4). Cats in Pen 1 were observed for five weeks. Over the first few weeks of observation, agonistic behaviours predominated and the number of the agonistic interactions observed was about twice the number of affiliative behaviours. During four weeks, however, the cats' behaviour changed a lot. In the first week, every cat initiated about two agonistic interactions per hour (Figure 4), but in subsequent weeks, the agonistic behaviour decreased to about one interaction per cat per hour (Figure 4). At the same time, affiliative behaviours increased from almost no affiliative interactions in the first week to about one interaction per cat per hour in the fifth week of observation (Figure 4).

Affiliative Behaviour

In Pen 1, there were 77 affiliative interactions during 13.5 hours of observation (Table 5). Shine and Asia initiated 16.9% and 18.2% of all the affiliative interactions respectively (Table 5). Fya initiated the fewest affiliative behaviours (Table 5). She initiated only one affiliative interaction to Shine during the whole observation period. Although Rua was not related to most of the cats, she received a total of ten affiliative interactions from four other cats and together with Shine, Suede, Chyna, and Asia, received most of affiliative interactions in Pen 1 (Table 4, 5).

The affiliative behaviours observed in Pen 1 were usually Resting Together and Eating Together. Resting Together was observed 36 times (46.8%) in Pen 1, and Eating Together 30 times (39.0%). Allorubbing and Inviting were not observed. Allogrooming was observed nine times, starting one week after the group was formed.

Playing was observed twice between Chyna and Asia.

Agonistic Behaviour

In Pen 1, 164 agonistic behaviours were recorded, and most cats behaved aggressively except Fya. Fya initiated two agonistic interactions (1.2%) (Table 6), and she also received the fewest agonistic interactions, one from each of three other cats. Two of them were related to her at the 0.25-level (Table 4, 6). Deb and Kola were the most aggressive cats in Pen 1 initiating 29 and 28 agonistic interactions respectively (Table 6). Chyna and Asia were the first and second ranked receivers of aggression. Both of them received more than 15% of the total agonistic interactions (Table 6). Rua, as the unrelated cat, initiated 11 and received ten agonistic interactions, less than 7% of the 164 interactions (Table 4, 6).

Threatening was the most common agonistic behaviour, which was observed 92 of the 164 agonistic interactions. Displacing was observed 40 times (24.4%). Although most of these cats were recently placed together, Fighting was only observed twice between Shine and Suede, and Chyna and Asia. Pushing and Chasing were seen 18 times and 12 times respectively.

Table 4: Coefficients of relatedness (r) between cats in Pen 1. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

Fya **(F)** 1996									
0.25	**Suede** **(F)** 1997								
0.25	0.25	**Shine** **(F)** 1997							
0.5	0.25	0.25	**Kola** **(F)** 1996						
0.25	0.5	0.25	0.25	**Deb** **(F)** 1997					
0	0	0.25	0	0	**Rua** **(F)** 1996				
0.25	0.25	0.25	0.25	0.25	0	**Chyna** **(F)** 1998			
0.25	0.5	0.25	0.25	0.5	0	0.25	**Asia** **(F)** 1998		
0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	**Crest** **(F)** 1999	
0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.5	**Tori** **(F)** 1996

Figure 4: Affiliative and agonistic behaviour in Pen 1 by week (week 1 started on 1 June 2005).

Table 5: Affiliative interactions in Pen 1.

Affiliative Behaviour		Receiver										Total
		Rua (F) 1997	Suede (F) 1997	Kola (F) 1996	Fya (F) 1996	Tori (F) 1996	Shine (F) 1997	Deb (F) 1997	Asia (F) 1998	Chyna (F) 1998	Crest (F) 1999	
Giver	Rua	----	1	1	0	0	0	2	0	3	0	7 9.1%
	Suede	2	----	0	2	0	1	0	1	0	2	8 10.4%
	Kola	1	0	----	1	1	2	0	0	0	0	5 6.5%
	Fya	0	0	0	----	0	1	0	0	0	0	1 1.3%
	Tori	2	0	0	0	----	3	0	2	2	0	9 11.7%
	Shine	1	1	4	2	3	----	0	1	1	0	13 16.9%
	Deb	4	0	1	0	1	0	----	1	1	1	9 11.7%
	Asia	0	0	1	3	1	2	0	----	3	4	14 18.2%
	Chyna	0	0	1	0	0	1	1	2	----	2	7 9.1%
	Crest	0	0	0	0	1	0	0	3	0	----	4 5.2%
Total		10 13%	2 2.6%	8 10.4%	8 10.4%	7 9.1%	10 13%	3 3.9%	10 13%	10 13%	9 11.7%	77

Table 6: Agonistic interactions in Pen 1.

Agonistic Behaviour		Recipient										Total
		Rua (F) 1997	Suede (F) 1997	Kola (F) 1996	Fya (F) 1996	Tori (F) 1996	Shine (F) 1997	Deb (F) 1997	Asia (F) 1998	Chyna (F) 1998	Crest (F) 1999	
Giver	Rua	----	0	2	1	0	2	4	1	0	1	11 6.7%
	Suede	1	----	8	0	1	1	2	5	3	0	20 12.2%
	Kola	0	7	----	1	1	2	6	2	4	5	28 17.1%
	Fya	1	0	0	----	0	0	0	0	1	0	2 1.2%
	Tori	3	3	2	0	----	1	1	3	6	1	20 12.2%
	Shine	1	2	2	0	3	----	3	1	1	0	13 7.9%
	Deb	3	2	3	0	3	1	----	4	8	5	29 17.7%
	Asia	0	2	0	0	5	1	0	----	4	1	13 7.9%
	Chyna	1	0	3	1	6	0	1	7	----	2	21 12.8%
	Crest	0	1	1	0	0	0	1	3	2	----	7 4.3%
Total		10 6.1%	17 10.4%	21 12.8%	3 1.8%	19 11.6%	8 4.9%	17 10.4%	26 15.9%	28 17.1%	15 9.1%	164

Pen 1 (new)

The group of cats in Pen 1 (new) was formed on 4 July 2005 when Titan, the male cat, was introduced for breeding. Titan was imported into the Feline Unit in 1998, and he was unrelated to all the females in Pen 1 (new) (Table 7). After Titan moved in, the behaviours of the females changed dramatically. Agonistic behaviour remained the major behaviour pattern, at about four times the frequency of affiliative behaviour. Compared with Pen 1, agonistic behaviours in Pen 1 (new) increased markedly to about two interactions per cat per hour in the first week after Titan moved in (Figure 5), and most of those were directed at Titan. At the same time, there was a reduction in both affiliative and agonistic interactions between the females. Affiliative

interactions decreased to 0.3 per cat per hour (Figure 5). Two weeks after Titan moved in, agonistic interactions declined to about one interaction per cat per hour and affiliative behaviours reverted to about 0.5 interactions per cat per hour (Figure 5).

Affiliative Behaviour

There were 40 affiliative interactions during nine hours of observation. There was no affiliative behaviour towards Titan, but he initiated two interactions with Kola and Crest (Table 8). Tori initiated the most affiliative interactions in Pen 1 (new) (10, 25%), and all were toward the four other cats to which she was related (r=0.25) (Table 7, 8). Nevertheless, Tori only received two affiliative interactions from Suede and Asia (Table 8). Chyna initiated eight interactions (20%) (Table 8), but she only received two affiliative interactions (Table 8). In contrast, Shine initiated no affiliative interaction, but she received the most, ten affiliative interactions from five cats (Table 8). Fya only initiated two interactions to Shine and Kola, but received seven interactions from four cats (Table 8).

Resting Together was the most common affiliative behaviour in Pen 1 (new), comprising 31 of 40 interactions. Unlike Pen 1, Eating Together was infrequent, seen only four times. Allogrooming was observed five times between Tori and Suede, Asia and Fya, Chyna and Shine, Fya and Kola, and Tori and Shine. Playing, Allorubbing, and Inviting were not observed.

Agonistic Behaviour

157 agonistic interactions were observed in Pen 1 (new). 78 (49.7%) of these were directed at the male cat Titan (Table 9). All the females directed agonistic behaviour towards Titan. The most were from Deb (19), and the least were from Crest and Suede (three) (Table 9). Titan initiated the most (58; 36.9%) agonistic interactions in Pen 1 (new), directed to all these females except Shine (Table 9). Deb was the second ranked initiator in Pen 1 (new) with 24 agonistic interactions directed to four other cats (Table 9). Shine was the only cat that received no agonistic interaction, but she initiated five interactions (3.2%) to two cats, Titan and Deb.

Females directed 61 Threatening behaviours toward Titan out of the 78 agonistic interactions he received. Titan, however, directed Chasing (21 times) and Displacing

(24 times) toward females instead of other agonistic behaviours, 77.6% of the agonistic behaviour he initiated. There was some Pushing between females. No Fighting was recorded in Pen 1 (new).

Table 7: Coefficients of relatedness between cats in Pen 1 (New). The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

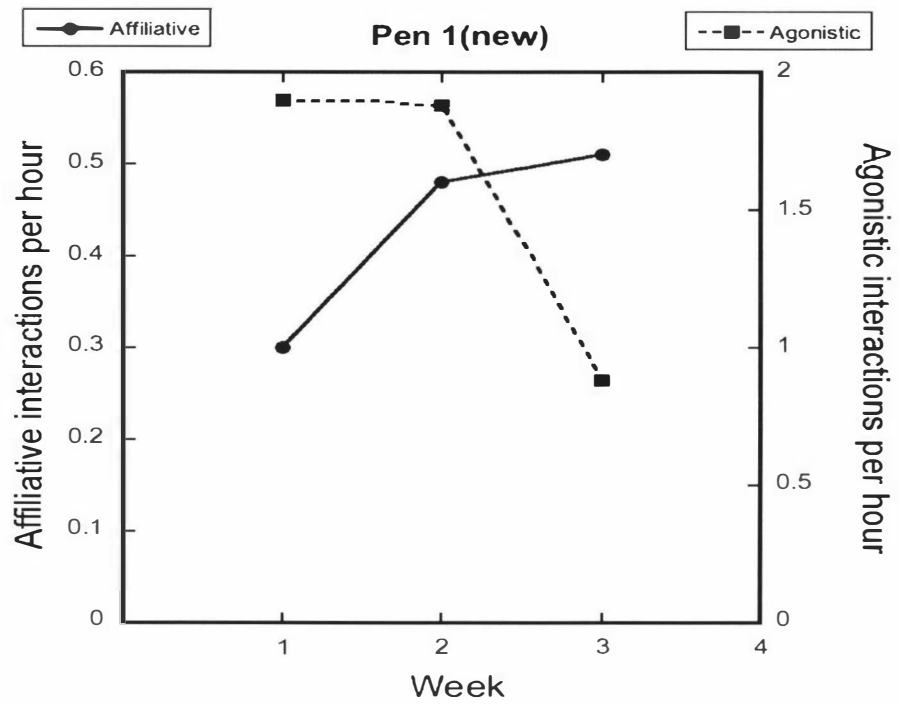| Fya (F) 1996	Suede (F) 1997	Shine (F) 1997	Kola (F) 1996	Deb (F) 1997	Rua (F) 1996	Chyna (F) 1998	Asia (F) 1998	Crest (F) 1999	Tori (F) 1996	Titan (M) 1998
0.25										
0.25	0.25									
0.5	0.25	0.25								
0.25	0.5	0.25	0.25							
0	0	0.25	0	0						
0.25	0.25	0.25	0.25	0.25	0					
0.25	0.5	0.25	0.25	0.5	0	0.25				
0.25	0.25	0.25	0.25	0.25	0	0.25	0.25			
0.25	0.25	0.25	0.25	0.25	0	0.25	0.25	0.5		
0	0	0	0	0	0	0	0	0	0	

Figure 5: Affiliative and agonistic behaviour in Pen 1 (new) by week (week 1 started on 3 July 2005).

Table 8: Affiliative interactions in Pen 1 (new).

Affiliative Behaviour		Recipient											
		Rua (F) 1997	Suede (F) 1997	Kola (F) 1996	Fya (F) 1996	Tori (F) 1996	Shine (F) 1997	Deb (F) 1997	Asia (F) 1998	Chyna (F) 1998	Crest (F) 1999	Titan (M) 1998	Total
Giver	Rua	----	0	0	0	0	0	0	0	0	0	0	0
	Suede	0	----	0	0	1	2	0	0	0	0	0	3 7.5%
	Kola	1	0	----	1	0	0	0	0	1	0	0	3 7.5%
	Fya	0	0	1	----	0	1	0	0	0	0	0	2 5%
	Tori	0	2	0	3	----	3	0	2	0	0	0	10 25%
	Shine	0	0	0	0	0	----	0	0	0	0	0	0
	Deb	1	0	0	0	0	1	----	0	0	0	0	2 5%
	Asia	0	2	0	2	1	0	0	----	0	0	0	5 12.5%
	Chyna	1	0	0	0	0	3	2	0	----	2	0	8 20%
	Crest	0	0	0	1	0	0	0	3	1	----	0	5 12.5%
	Titan	0	0	1	0	0	0	0	0	0	1	----	2 5%
Total		3 7.5%	4 10%	2 5%	7 17.5%	2 5%	10 2%	2 5%	5 12.5%	2 5%	3 7.5%	0	40

Table 9: Agonistic Interactions in Pen 1 (new)

Agonistic Behaviour		Recipient											Total
		Rua (F) 1997	Suede (F) 1997	Kola (F) 1996	Fya (F) 1996	Tori (F) 1996	Shine (F) 1997	Deb (F) 1997	Asia (F) 1998	Chyna (F) 1998	Crest (F) 1999	Titan (M) 1998	
Giver	Rua	----	0	0	0	0	0	0	0	0	0	7	7 4.5%
	Suede	0	----	0	1	0	0	0	0	0	0	3	4 2.5%
	Kola	0	1	----	0	0	0	1	0	0	0	9	11 7%
	Fya	0	0	0	----	0	0	0	0	1	0	13	14 8.9%
	Tori	0	1	0	0	----	0	2	1	2	0	7	13 8.3%
	Shine	0	0	0	0	0	----	1	0	0	0	4	5 3.2%
	Deb	0	1	0	1	2	0	----	0	0	1	19	24 15.3%
	Asia	0	0	0	0	1	0	0	----	0	0	7	8 5.1%
	Chyna	2	0	0	0	0	0	0	1	----	0	6	9 5.7%
	Crest	0	0	0	0	0	0	0	0	1	----	3	4 2.5%
	Titan	3	2	7	6	6	0	5	10	8	11	----	58 36.9%
Total		5 3.2%	5 3.2%	7 4.5%	8 5.1%	9 5.7%	0	9 5.7%	12 7.6%	12 7.6%	12 7.6%	78 49.7%	157

Pen 4

The group of cats in Pen 4 was formed on 1 June 2005. There were eight cats in this pen, four females and four neutered males. Four cats, Coppa, Mara, Rade, and Xena, had been in this pen since May, and the other four cats were placed in the pen on 1 June. Coppa and Rade were not related to the other cats, but all the others had some relatives in this pen (Table 10). Unlike pen 1, cats in Pen 4 showed more affiliative behaviour than agonistic behaviour. The number of affiliative interactions was about twice the number of agonistic interactions. The average number of

43

affiliative interactions per cat per hour was around 1.25 during the first three weeks (Figure 6). However, it dropped to 0.25 interactions per cat per hour in the fifth week and climbed to 2.2 interactions per cat per hour in the sixth week, then declined again to about 0.5 interactions per cat per hour. In the last week of observation (week eight), it was to above 1.5 interactions per cat per hour (Figure 6). The peak of agonistic behaviour was in the second week (1.5 interactions per cat per hour). For the rest of the time, agonistic behaviours were less than 0.5 interactions per cat per hour (Figure 6).

Affiliative Behaviour

There were 121 affiliative interactions in Pen 4 during 12 hours of observation. Coppa expressed the most affiliative behaviour, initiating 31 interactions (25.6%) (Table 11). He was affiliative towards all of the other cats although he was related with none of these cats (Table 10, 11). Coppa received 20 affiliative interactions from the other seven cats and was the second highest receiver. In contrast, Rade, who was also unrelated to the other seven cats, initiated the fewest interactions, five to four different cats, (Table 10, 11) and received the fewest interactions, eight from five cats (Table 11).

Eating Together, Resting Together, and Allogrooming were often observed in Pen 4. Resting Together was the most common affiliative behaviour pattern in Pen 4 (54 occurrences, 44.5% of all affiliative interactions). Allogrooming was observed 34 times out of the 121 interactions. Most of these were from Stella (8), Zeal (9), and Coppa (11). Eating Together happened 33 times during the observation. However, Allorubbing, Playing, and Inviting were not observed.

Agonistic Behaviour

There were 40 agonistic interactions in Pen 4 during 12 hours of observation (Table 12). Flame and Rade initiated more than half of the agonistic interactions. Both of them expressed more than ten agonistic interactions during the observation. In contrast, Rade, Flame and Stella received most of the agonistic interactions, each of them receiving more than 20%. Mara initiated one interaction with Astra, and he received no agonistic interactions during the observation period.

44

The most common agonistic behaviours were Threatening (16 times) and Pushing (13 times). Displacing was observed six times during the observation period. Chasing was observed twice between Rade and Stella. Fighting was not observed.

Table 10: Coefficients of relatedness between cats in Pen 4. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

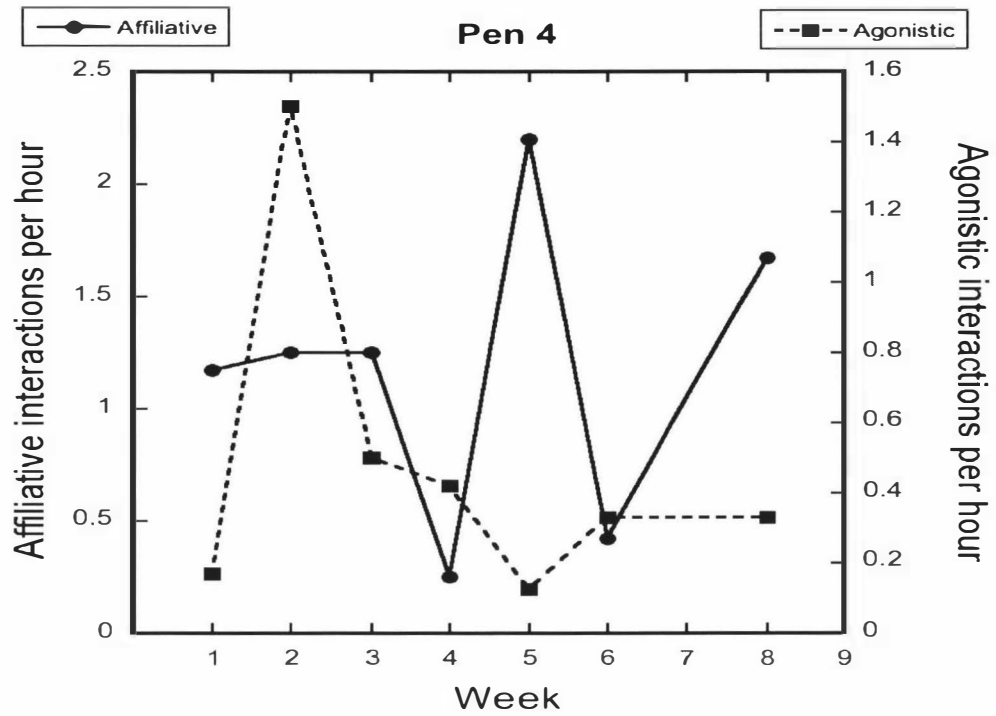| Coppa (M)	Zeal (F)	Astra (F)	Flame (M)	Stella (F)	Xena (F)	Mara (M)	Rade (M)
1995							
	Zeal (F)						
0	2003						
		Astra (F)					
0	0	1998					
			Flame (M)				
0	0.25	0	2000				
				Stella (F)			
0	0.5	0	0.25	2003			
					Xena (F)		
0	0.25	0	0.25	0.25	1999		
						Mara (M)	
0	0	0.25	0	0	0	1996	
							Rade (M)
0	0	0	0	0	0	0	2002

Figure 6: Affiliative and agonistic behaviour in Pen 4 by week (week 1 started on 1 June 2005).

Table 11: Affiliative interactions in Pen 4.

Affiliative Behaviour		Recipient								Total
		Xena (F) 1999	Stella (F) 2003	Astra (F) 1998	Zeal (F) 2003	Coppa (M) 1995	Flame (M) 2000	Mara (M) 1996	Rade (M) 2002	
Giver	Xena	----	1	3	0	1	2	3	1	13 10.7%
	Stella	3	----	2	2	1	3	0	0	11 9.1%
	Astra	1	2	----	1	2	4	2	1	13 10.7%
	Zeal	2	1	6	----	8	2	2	1	22 18.2%
	Coppa	5	2	7	7	----	5	4	1	31 25.6%
	Flame	3	2	2	3	2	----	0	4	16 13.2%
	Mara	0	0	3	3	3	1	----	0	10 8.3%
	Rade	1	0	0	1	1	0	2	----	5 4.1%
Total		15 12.4%	8 6.6%	23 19%	17 14%	20 16.5%	17 14%	13 10.7%	8 6.6%	121

Table 12: Agonistic interactions in Pen 4.

Agonistic Behaviour		Recipient								Total
		Xena (F) 1999	Stella (F) 2003	Astra (F) 1998	Zeal (F) 2003	Coppa (M) 1995	Flame (M) 2000	Mara (M) 1996	Rade (M) 2002	
Giver	Xena	----	0	0	0	1	3	0	0	4 10%
	Stella	1	----	0	0	0	1	0	2	4 10%
	Astra	0	0	----	1	1	1	0	2	5 12.5%
	Zeal	0	0	0	----	0	0	0	2	2 5%
	Coppa	0	0	0	0	----	1	0	2	3 7.5%
	Flame	5	2	1	0	1	----	0	2	11 27.5%
	Mara	0	0	1	0	0	0	----	0	1 2.5%
	Rade	0	6	1	0	1	2	0	----	10 25%
Total		6 15%	8 20%	3 7.5%	1 2.5%	4 10%	8 20%	0	10 25%	40

Pen 5

There were eight cats held in Pen 5. Two were females and the others were neutered males. Most of the cats had been in this pen for long time, except one female cat, Jaffa, which was put into the pen on the 1 June 2005. All cats except Star and Evet had some relatives in this pen (Table 13). Cats in Pen 5 showed ten times more affiliative behaviours than agonistic behaviours. The average rate of affiliative behaviour was 1 to 2 interactions per cat per hour. During the last two weeks of observation, this declined to under 1 interaction per cat per hour (Figure 7). The average rate of agonistic behaviours was less than 0.4 interactions per cat per hour at all times (Figure 7).

Affiliative Behaviour

During 22.5 hours of observation, cats in Pen 5 had 231 affiliative interactions.

Although Star was not related to any cat in this pen, he acted as an initiator together with Tama and Casey (Table 13, 14). Each of these three cats initiated more than 15% of all affiliative interactions (Table 14). Hobo received the most affiliative interactions (45 times, 19.5%) (Table 14). These interactions were initiated mostly by Evet (10), Star (12), and Tama (12), although none were related to him (Table 13, 14). As the new comer, Jaffa received the least affiliative interactions (Table 14).

Resting Together was observed 164 times (71%). Other affiliative behaviours were Eating Together (51), Allogrooming (14), Allorubbing (1) and Playing (1). Allorubbing was observed between Hobo and Jaffa, and Playing occurred between Evet and Star. Inviting was not observed.

Agonistic Behaviour

In 22.5 hours of observation, agonistic behaviour occurred 24 times (Table 15). Evet initiated 12 (50%) agonistic interactions to four other cats, and eight out of the 12 were toward the new comer, Jaffa. Jaffa received the most agonistic interactions by receiving the eight agonistic interactions from Evet. Spice initiated no agonistic interactions, but he was the second highest receiver. Casey also initiated no agonistic interactions.

The most common agonistic behaviour was Threatening (9 times, 37.5%) and Pushing (11 times, 45.8%). Displacing was observed three times between Spice and Jesse, Casey and Star, and Spice and Hobo. Chasing happened only once between Hobo and Spice. Fighting was not observed.

Table 13: Coefficients of relatedness between cats in Pen 5. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

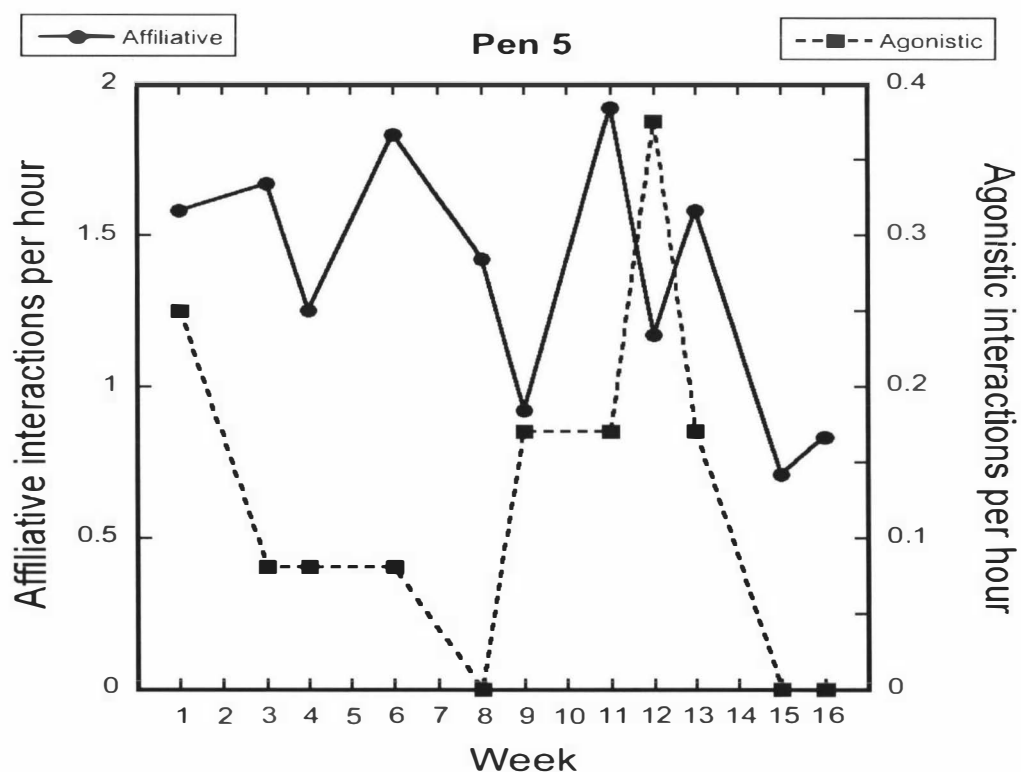| Jess (M)	Star (M)	Evet (F)	Tama (M)	Hobo (M)	Casey (M)	Jaffa (F)	Spice (M)
1996							
0	1994						
0	0	2002					
0.25	0	0	1996				
0	0	0	0	1996			
0	0	0	0	0.25	1997		
0.25	0	0	0.25	0	0	1997	
0.25	0	0	0.5	0	0	0.25	1996

Figure 7: Affiliative and agonistic behaviour in Pen 5 by week (week 1 started on 5 June 2005).

50

Table 14: Affiliative interactions in Pen 5.

Affiliative Behaviour		Recipient								Total
		Jaffa (F) 1997	Evet (F) 2002	Casey (M) 1997	Jesse (M) 1996	Star (M) 1994	Spice (M) 1996	Hobo (M) 1996	Tama (M) 1996	
Giver	Jaffa	----	3	5	5	7	6	4	2	32 13.9%
	Evet	2	----	3	3	5	2	10	2	27 11.7%
	Casey	3	5	----	5	6	5	4	7	35 15.2%
	Jesse	3	0	4	----	2	3	4	6	22 9.5%
	Star	3	7	3	5	----	3	12	7	40 17.3%
	Spice	2	3	4	1	0	----	2	1	13 5.6%
	Hobo	4	4	4	4	5	1	----	1	23 10.0%
	Tama	7	3	4	7	4	5	9	----	39 16.9%
Total		24 10.4%	25 10.8%	27 11.7%	30 13.0%	29 12.6%	25 10.8%	45 19.5%	26 11.3%	231

Table 15: Agonistic interactions in Pen 5.

Agonistic Behaviour		Recipient								Total
		Jaffa (F) 1997	Evet (F) 2002	Casey (M) 1997	Jesse (M) 1996	Star (M) 1994	Spice (M) 1996	Hobo (M) 1996	Tama (M) 1996	
Giver	Jaffa	----	1	1	0	2	0	0	0	4 16.7%
	Evet	8	----	0	0	0	1	2	1	12 50%
	Casey	0	0	----	0	0	0	0	0	0
	Jesse	0	0	0	----	0	1	0	1	2 8.3%
	Star	0	0	1	0	----	0	0	0	1 4.2%
	Spice	0	0	0	0	0	----	0	0	0
	Hobo	0	1	0	0	0	3	----	0	4 16.7%
	Tama	0	0	0	1	0	0	0	----	1 4.2%
Total		8 33.3%	2 8.3%	2 8.3%	1 4.2%	2 8.3%	5 20.8%	2 8.3%	2 8.3%	24

Pen 6

The cats held in Pen 6 were four females and four neutered males. All of them had been in this pen for long time. All of these cats had some relatives in this pen except Wren who was imported into the Feline Unit in 1998 (Table 16). Affiliative behaviours were about six times more common than agonistic behaviours. The peak rate of affiliative behaviour, about 2.5 interactions per cat per hour, occurred in the ninth to eleventh week of observation (Figure 8). For the rest of the time, affiliative interactions were around 1.25 per cat per hour. In the last week of observation, however, affiliative interactions decreased to less than one interaction per cat per hour (Figure 8). As in Pen 5, the average rate of agonistic interactions was less than one at all times (Figure 8).

Affiliative Behaviour

266 affiliative interactions were observed during 22.5 hours of observation. All cats in Pen 6 initiated and received at least one affiliative interaction with every other

cat (Table 17). Rover was the prime initiator of interactions (48 times, 18%). Of these 48 interactions, 14 were to Tang, which was 30% of his initiating and 5.3% of the total interactions in Pen 6. As the second highest initiator, Tang expressed a total of 46 affiliative interactions and most of these were directed toward Puihi (13 times) who was not related. Also, Puihi initiated 12 affiliative behaviours to Tang (Table 17), which was 32.4% of Puihi's 37 interactions. While Wren had no relationship with any cats in Pen 6, she received 39 affiliative interactions, second to Tang (51 times) and equal to Puihi (39 times) (Table 16, 17).

As in Pen 5, Resting Together was the major affiliative behaviour pattern observed in Pen 6. Resting Together was observed 157 (59%) times during the observation period. Cats in Pen 6 showed more Allogrooming than Eating Together, which was different from all other pens. Allogrooming was observed 50 times, Eating Together 44 times, and Allorubbing 11 times. Playing occurred four times between Wren and Nui, Puihi and Wren, Puihi and Rover, and Rover and Argon. Inviting was not observed.

Agonistic Behaviour

47 agonistic interactions were observed during the 22.5 hours of observation. Puihi initiated the most agonistic behaviours (19 interactions, 40.4% of all the agonistic interactions) (Table 18). He initiated 17 of these to Puff who had a 0.25-level relationship with him and 11 of these 17 were Displacing (Table 16, 18). Puff received the most agonistic interactions in Pen 6 (21 interactions, 44.7%) (Table 18). As an unrelated cat, Wren initiated a total of seven agonistic interactions (14.9%) to all the other cats except Argon and Rover, but she only received four back from Nui and Puff (Table 18).

Pushing and Displacing were observed 17 times which were 36.2% of the total agonistic interactions. 11 out of the 17 Displacing behaviours were observed between Puff and Puihi during the breeding season. Also, five out of six Chasing behaviours were observed between Puihi and Puff. Threatening occurred seven times and Fighting was not observed.

Table 16: Coefficients of relatedness between cats in Pen 6. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

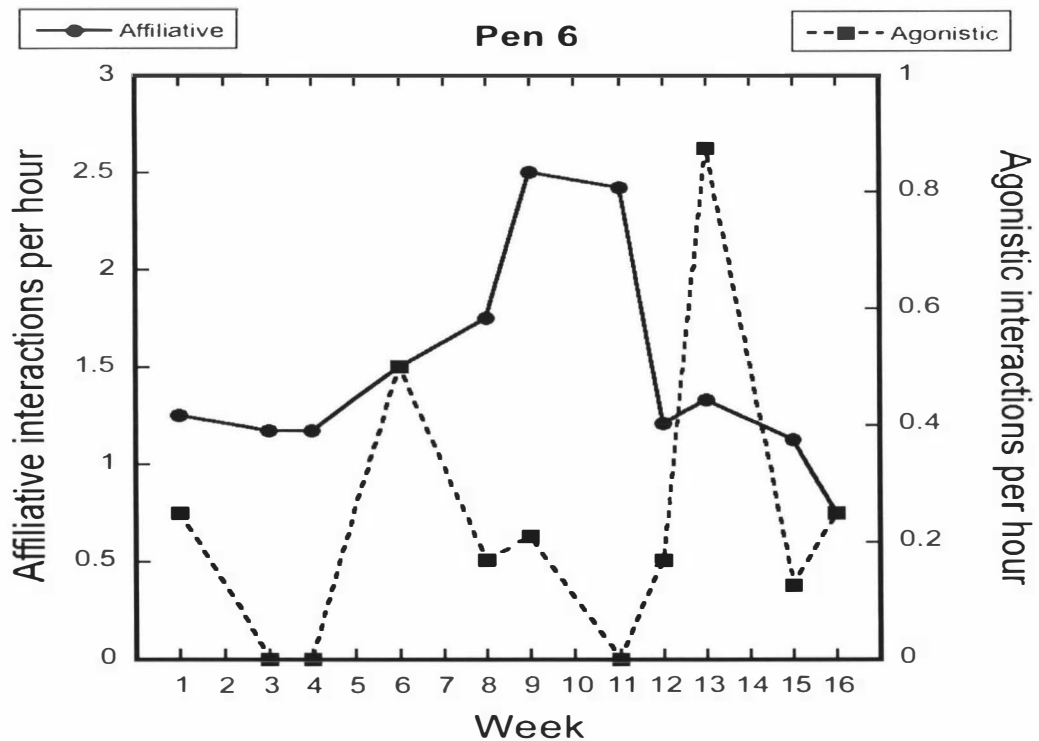| Misty (M)	Puff (F)	Puihi (M)	Rover (M)	Tang (F)	Argon (M)	Wren (F)	Nui (F)
1997							
	Puff (F)						
0	1997						
		Puihi (M)					
0	0.25	1999					
			Rover (M)				
0.25	0.25	0	1997				
				Tang (F)			
0	0.25	0	0.25	1995			
					Argon (M)		
0.25	0	0	0	0	1996		
						Wren (F)	
0	0	0	0	0	0	1998	
							Nui (F)
0.25	0.25	0	0.25	0.25	0	0	1996

Figure 8: Affiliative and agonistic behaviour in Pen 6 by week (week 1 started on 5 June 2005).

Table 17: Affiliative interactions in Pen 6.

Affiliative Behaviour		Recipient								Total
		Nui (F) 1996	Puff (F) 1997	Wren (F) 1998	Tang (F) 1995	Argon (M) 1996	Misty (M) 1997	Rover (M) 1997	Puihi (M) 1999	
Giver	Nui	----	2	2	3	3	4	6	4	24 9.2%
	Puff	4	----	2	5	2	6	4	6	29 10.9%
	Wren	3	2	----	6	1	1	2	2	17 6.4%
	Tang	6	5	9	----	7	3	3	13	46 17.3%
	Argon	4	4	6	9	----	9	3	8	43 16.2%
	Misty	2	6	7	2	2	----	2	1	22 8.3%
	Rover	6	3	7	14	6	7	----	5	48 18.0%
	Puihi	2	4	6	12	3	3	7	----	37 13.9%
Total		27 10.2%	26 10.0%	39 14.7%	51 19.2%	24 9.2%	33 12.4%	27 10.2%	39 14.7%	266

Table 18: Agonistic interactions in Pen 6.

Agonistic Behaviour		Recipient								Total
		Nui (F) 1996	Puff (F) 1997	Wren (F) 1998	Tang (F) 1995	Argon (M) 1996	Misty (M) 1997	Rover (M) 1997	Puihi (M) 1999	
Giver	Nui	----	0	3	0	0	1	0	0	4 8.5%
	Puff	0	----	1	1	0	0	1	3	6 12.8%
	Wren	2	1	----	1	0	1	0	2	7 14.9%
	Tang	0	0	0	----	0	0	1	1	2 4.3%
	Argon	1	0	0	0	----	1	0	0	2 4.3%
	Misty	1	1	0	0	1	----	1	1	4 8.5%
	Rover	0	2	0	0	1	0	----	0	3 6.4%
	Puihi	0	17	0	0	0	2	0	----	19 40.4%
Total		4 8.5%	21 44.7%	4 8.5%	2 4.3%	2 4.3%	5 10.6%	3 6.4%	6 12.8%	47

Pen 7

Four female cats and four neutered male cats were held in Pen 7. Most of the cats were held in this pen for at least one month before observations began. However, Kree, a 12 years old female, was moved in on 1 June 2005. All of the cats in Pen 7 had some relationship with at least one of the others (Table 19). Because Kree, the new comer, was a quiet cat, the behaviour patterns in this pen did not change a lot when she was moved in. In this pen, affiliative behaviours out numbered agonistic behaviours by four to one. Cats in Pen 7 expressed affiliative behaviour more in the second and third week of observation with around 1.25 interactions per cat per hour (Figure 9). By week five, average affiliative behaviours decreased to less than one interaction per cat per hour. The average agonistic behaviour in Pen 7 was under 0.6 interactions per cat per hour at all times (Figure 9).

Affiliative Behaviour

There were 52 affiliative interactions in Pen 7 during 7.5 hours of observation. Maya, Dan, and Mana initiated the same number of affiliative interactions (10, 19.2%) (Table 20). Mana received the most (12) interactions from four other cats, which was 23.1% of the total (Table 20). Broom initiated the fewest interactions, two toward Mana and Luna although she had no relationship with either of them (Table 19, 20). Lace received the fewest, two affliative interactions (3.8% of the all affiliative interactions) from Kree and Dan (Table 20).

Resting Together, Eating Together, and Allogrooming were observed in Pen 7 during the observation period. Playing, Allorubbing, and Inviting did not occur. Resting Together was the most common behaviour. It was observed 29 times between most of the cats. Allogrooming was observed ten times between Dan and Maya (twice), Mana and Dan (four times), Maya and Mana (once), and Mana and Luna (three times). Eating Together was observed 13 times.

Agonistic Behaviour

Fifteen agonistic interactions were observed in Pen 7 during 7.5 hours of observation. Lace did not initiate any agonistic interaction, but she received the most, five interactions (33.3% of the agonistic interactions) from Broom (three), and Dan (two) (Table 21). Broom initiated the most agonistic interactions (six interactions, 40%) (Table 21). Mana and Luna did not receive any agonistic interaction (Table 21).

The most common agonistic behaviour in Pen 7 was Pushing. It was observed nine times. Threatening was observed three times, between Mana and Spot (once), and Broom and Dan (twice). Displacing was observed between Lace and Broom, and Lace and Dan. Fighting and Chasing were not observed.

Table 19: Coefficients of relatedness between cats in Pen 7. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

Kree (F)	Broom (F)	Spot (M)	Maya (F)	Dan (M)	Mana (M)	Luna (M)	Lace (F)
1993							
	Broom (F)						
0.25	1997						
		Spot (M)					
0	0.25	1998					
			Maya (F)				
0	0.25	0.5	1999				
				Dan (M)			
0	0	0	0	2000			
					Mana (M)		
0	0	0.25	0.25	0	1996		
						Luna (M)	
0	0	0	0	0.25	0	2001	
							Lace (F)
0	0	0	0	0.25	0	0.5	2001

Figure 9: Affiliative and agonistic behaviour in Pen 6 by week (week 1 started on 12 June 2005).

Table 20: Affiliative interactions in Pen 7.

Affiliative Behaviour		Recipient								Total
		Kree (F) 1993	Broom (F) 1997	Spot (M) 1998	Maya (F) 1999	Dan (M) 2000	Mana (M) 1996	Luna (M) 2001	Lace (F) 2001	
Giver	Kree	----	2	0	0	0	0	0	1	3 5.8%
	Broom	0	----	0	0	0	1	1	0	2 3.8%
	Spot	1	3	----	0	1	0	2	0	7 13.4%
	Maya	0	0	3	----	2	4	1	0	10 19.2%
	Dan	0	0	2	2	----	4	1	1	10 19.2%
	Mana	2	0	0	2	2	----	4	0	10 19.2%
	Luna	1	0	0	0	1	3	----	0	5 9.6%
	Lace	0	1	1	1	0	0	2	----	5 9.6%
Total		4 7.7%	6 11.5%	6 11.5%	5 9.6%	6 11.5%	12 23.1%	11 21.2%	2 3.8%	52

59

Table 21: Agonistic interactions in Pen 7.

Agonistic Behaviour		Recipient								Total
		Kree (F) 1993	Broom (F) 1997	Spot (M) 1998	Maya (F) 1999	Dan (M) 2000	Mana (M) 1996	Luna (M) 2001	Lace (F) 2001	
Giver	Kree	----	0	0	1	0	0	0	0	1 6.7%
	Broom	0	----	1	0	2	0	0	3	6 40%
	Spot	0	1	----	0	0	0	0	0	1 6.7%
	Maya	1	0	0	----	1	0	0	0	2 13.3%
	Dan	0	1	0	0	----	0	0	2	3 20%
	Mana	0	0	1	0	0	---	0	0	1 6.7%
	Luna	1	0	0	0	0	0	----	0	1 6.7%
	Lace	0	0	0	0	0	0	0	----	0
Total		2 13.3%	2 13.3%	2 13.3%	1 6.7%	3 20%	0	0	5 33.3%	15

Pen 7 (new)

Pen 7 and Pen 7 (new) were different as one female cat (Kree) was moved out and another female (Dusky) was moved in between 17 and 23 July 2005. Because Dusky was imported to the Feline Unit, she was unrelated to the other seven cats in Pen 7 (new) (Table 22). This movement of cats changed the behaviour of cats in this pen a lot. After Dusky was moved into Pen 7, the cats showed more agonistic than affiliative behaviour. During the two weeks after Dusky moved in, agonistic behaviour was observed at about 2 interactions per cat per hour (Figure 10), and then from the fifth week to the end of the observation, there were less than 0.6 agonistic interactions per cat per hour, which was similar to other Established pens (Figure 10). At the same time, the average rate of affiliative behaviour was less than one interaction per cat per hour at all times except during the last observation week when it was 1.08 interactions per cat per hour (Figure 10).

Affiliative Behaviour

89 affiliative interactions were observed in Pen 7 (new) during 16.5 hours of observation. Dan initiated 23 affiliative interactions to other seven cats, which was 25.8% in the 89 interactions (Table 23). Most of his affiliative behaviour (8; 34.8% of Dan's initiating) was directed toward Luna who was related to him at the 0.25 level (Table 22). Luna received 30 affiliative interactions, 33.7% of the total interactions in Pen 7 (new) (Table 23). The most of Luna received were from Lace who was related to him at the 0.5-level (9; 90% of Lace's initiating) (Table 22, 23). As an unrelated new comer, Dusky initiated 17 affiliative interactions to five other cats, but she only received three interactions, two from Spot and one from Dan (Table 22, 23).

In Pen 7 (new), as in Pen 7, Resting Together was the most common affiliative behaviour, being observed 54 times (60.7% of the affiliative interactions). Eating Together was observed 22 times (24.5%) and Allogrooming occurred 11 times (12.3%). Playing was observed twice between Spot and Dusky, and Dan and Maya. Allorubbing and Inviting were not observed.

Agonistic Behaviour

107 agonistic interactions were observed during the 16.5 hours of observation. Sixty-five (60.7%) of these interactions were initiated by Dusky, the unrelated new comer (Table 22, 24). Most of Dusky's agonistic behaviour (22 interactions; 33.8%) was directed toward Mana (Table 24). Although Mana was the highest receiver of agonistic interactions (33), two-thirds of them were from Dusky (Table 24). Broom and Luna did not express any agonistic interaction during the observation (Table 24).

Cats in Pen 7 (new) showed more Threatening than any other agonistic behaviour. Threatening was observed 39 times (36.4% of the 107 agonistic interactions). Displacing occurred 31 times and 41.9% of them were toward Mana. Pushing was observed 28 times. Chasing occurred eight times and all of them were initiated by Dusky. Fighting was also observed once between Dusky and Spot.

Table 22: Coefficients of relatedness between cats in Pen 7 (new). The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

Dusky (F)	Broom (F)	Spot (M)	Maya (F)	Dan (M)	Mana (M)	Luna (M)	Lace (F)
1998							
	Broom (F)						
0	1997						
		Spot (M)					
0	0.25	1998					
			Maya (F)				
0	0.25	0.5	1999				
				Dan (M)			
0	0	0	0	2000			
					Mana (M)		
0	0	0.25	0.25	0	1996		
						Luna (M)	
0	0	0	0	0.25	0	2001	
							Lace (F)
0	0	0	0	0.25	0	0.5	2001

Figure 10: Affiliative and agonistic behaviour in Pen 7 (new) by week (week 1 started on 24 July 2005).

Table 23: Affiliative interactions in Pen 7 (new).

Affiliative Behaviour		Recipient								Total
		Dusky (F) 1998	Lace (F) 2001	Maya (F) 1999	Broom (F) 1997	Spot (M) 1998	Luna (M) 2001	Dan (M) 2000	Mana (M) 1996	
Giver	Dusky	----	6	0	1	0	3	4	3	17 19.1%
	Lace	0	----	0	0	1	9	0	0	10 11.2%
	Maya	0	2	----	1	1	3	3	0	10 11.2%
	Broom	0	0	0	----	0	1	2	1	4 4.5%
	Spot	2	1	3	1	----	0	0	0	7 7.9%
	Luna	0	2	0	1	0	----	1	1	5 5.6%
	Dan	1	3	4	4	1	8	----	2	23 25.8%
	Mana	0	2	1	0	3	6	1	----	13 14.6%
Total		3 3.4%	16 18.0%	8 9.0%	8 9.0%	6 6.7%	30 33.7%	11 12.4%	7 7.9%	89

Table 24: Agonistic interactions in Pen 7 (new).

Agonistic Behaviour		Recipient								Total
		Dusky (F) 1998	Lace (F) 2001	Maya (F) 1999	Broom (F) 1997	Spot (M) 1998	Luna (M) 2001	Dan (M) 2000	Mana (M) 1996	
Giver	Dusky	----	12	5	6	8	3	9	22	65 60.7%
	Lace	5	----	0	0	0	0	0	3	8 7.5%
	Maya	4	0	----	1	0	0	1	0	6 5.6%
	Broom	0	0	0	----	0	0	0	0	0
	Spot	6	0	0	0	----	0	4	8	18 16.8%
	Luna	0	0	0	0	0	----	0	0	0
	Dan	4	0	2	1	1	0	----	0	8 7.5%
	Mana	2	0	0	0	0	0	0	----	2 1.9%
Total		21 19.6%	12 11.2%	7 6.5%	8 7.5%	9 8.4%	3 2.8%	14 13.1%	33 30.8%	107

Pen 8

The group of cats in Pen 8 was formed on 1 June 2005. Seven cats were in this pen. Five of them were females and two were neutered males. Four pairs of cats had a 0.25-level relationship (Table 25). Dusky, an imported cat, was unrelated to the other cats (Table 25). As with other Newly Formed pens, agonistic behaviour was the most common behaviour pattern in Pen 8. The number of agonistic interactions was about four times as many as the number of affiliative interactions. Agonistic interactions were high (1.5 per cat per hour) in the first week after the group was formed, and increased markedly in the second week (about 3.5 agonistic interactions per cat per hour) (Figure 11). Then it decreased to about 1.5 interactions or less in the subsequent weeks. The average rate of affiliative interactions was around 0.5 interactions per cat per hour (Figure 11). In the last week of observation (week 5), the average rate of agonistic interactions declined, and no affiliative interactions occurred (Figure 11).

Affiliative Behaviour

In Pen 8, 36 affiliative interactions were observed during 11.5 hours of observation. Steel initiated the most affiliative behaviour, 11 interactions to three other cats (Table 26). He initiated seven of these to Sioux to whom he was related at the 0.25-level (Table 25, 26). Steel also received nine interactions, making him the second highest receiver. These were from all the other cats except Tilly (Table 26). The second highest initiator, Buffy, initiated eight interactions to all the cats except Dusky, but he only received one affiliative interaction back from his relative Tass (Table 25, 26). Sioux received the most (13 interactions; 36.1% of the 36 interactions) from four other cats (Table 26). Dusky, the unrelated cat, initiated one affiliative interaction, and received four interactions from three other cats (Table 26).

In Pen 8, Eating Together and Resting Together were occurred more than other affiliative behaviours. Eating Together was observed 18 times and Resting Together occurred 12 times. Playing was observed three times between Steel and Sioux. Inviting was also observed once between them. Allogrooming occurred twice between Tass and Tilly and Steel and Sioux. No Allorubbing was observed.

Agonistic Behaviour

In Pen 8, 148 agonistic interactions were observed during the observation period. Dusky, the unrelated cat, initiated the most (37 agonistic interactions; 25% of the 148) (Table 25, 27). She was also the second highest receiver with 33 agonistic interactions received from all the other cats (Table 27). Steel initiated a total of 34 agonistic interactions, and 26 out of these 34 were to Sioux who was related to him at the 0.25-level (Table 25, 27). Sioux received the most agonistic interactions (48). These were initiated by all the other cats except Tilly, and most were from Steel (26) and Dusky (12) (Table 27). Tilly initiated the fewest agonistic interactions in Pen 8 (one interaction to Dusky), and she received the fewest (six from Libby, Dusky, and Sioux) (Table 27).

Cats in Pen 8 showed all the agonistic behaviours. Threatening was observed 56 times. Displacing was observed 39 times, but 17 of them were between Sioux and Steel. Pushing and Chasing were observed 28 times and 12 times respectively, and

Fighting occurred nine times. Fighting was observed between Libby and Dusky (four times), Dusky and Sioux (once), Libby and Tass (once), Dusky and Tass (twice), and Sioux and Buffy (once).

Table 25: Coefficients of relatedness between cats in Pen 8. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

Tilly (F)	Tass (F)	Buffy (M)	Libby (F)	Sioux (F)	Steel (M)	Dusky (F)
2001						
0	1994					
0	0.25	1997				
0.25	0	0	2000			
0	0	0	0.25	2002		
0	0	0	0	0.25	2002	
0	0	0	0	0	0	1998

Figure 11: Affiliative and agonistic behaviour in Pen 8 by week (week 1 started on 5 June 2005).

Table 26: Affiliative interactions in Pen 8.

Affiliative Behaviour		Recipient							Total
		Tilly (F) 2001	Tass (F) 1994	Buffy (M) 1997	Libby (F) 2000	Sioux (F) 2002	Steel (M) 2002	Dusky (F) 1998	
Giver	Tilly	----	0	0	0	0	0	1	1 2.8%
	Tass	2	----	1	0	1	1	0	5 13.9%
	Buffy	1	1	----	2	2	2	0	8 22.2%
	Libby	1	0	0	----	3	1	0	5 13.9%
	Sioux	0	0	0	0	----	4	1	5 13.9%
	Steel	0	0	0	2	7	----	2	11 30.6%
	Dusky	0	0	0	0	0	1	----	1 2.8%
Total		4 11.1%	1 2.8%	1 2.8%	4 11.1%	13 36.1%	9 25%	4 11.1%	36

Table 27: Agonistic interactions in Pen 8.

Agonistic Behaviour		Recipient							Total
		Tilly (F) 2001	Tass (F) 1994	Buffy (M) 1997	Libby (F) 2000	Sioux (F) 2002	Steel (M) 2002	Dusky (F) 1998	
Giver	Tilly	----	0	0	0	0	0	1	1 0.7%
	Tass	0	----	4	4	2	1	11	22 14.9%
	Buffy	0	0	----	0	2	0	1	3 2.0%
	Libby	2	2	4	----	6	4	10	28 18.9%
	Sioux	2	2	3	2	----	8	7	23 15.5%
	Steel	0	1	0	4	22	----	3	34 23.0%
	Dusky	2	4	3	8	12	7	----	37 25%
Total		6 4.1%	9 6.0%	14 9.5%	18 12.2%	48 32.4%	20 13.5%	33 22.3%	148

Pen 9

There were eight cats in Pen 9, three females and five neutered males. Seven of them had been in Pen 9 for a long time before observations started. Libby was moved into Pen 9 from Pen 8 between 10 and 16 July. All of the cats had relatives in this pen except Libby (Table 28). Although data for Pen 9 before Libby moved in were not available, Feline Unit staff observed that Libby changed the behaviour in this pen. The number of affiliative behaviours in Pen 9 during the observation period was about three times as many as agonistic behaviour. Affiliative behaviour rate was about one interaction per cat per hour during the first seven observation weeks, and it declined to about 0.5 interactions in the subsequent two weeks, and then reverted back to about one for the last week of observation (Figure 12). The rate of agonistic behaviour was under one interaction per cat per hour through out the observation period (Figure 12).

Affiliative Behaviour

In Pen 9, 143 affiliative interactions were recorded during 18 hours of

observation. Roz initiated the most (36 interactions, 25.2% of the total in Pen 9) (Table 29). She initiated these interactions to all the other cats (Table 29). Kruz was both the second highest initiator and receiver of affiliative behaviour in Pen 9. He initiated 22 interactions to the other seven cats and received 23 from them (Table 29). Inga received 29 interactions from the seven other cats as the highest receiver (Table 29), and eight out of those 29 were from Libby who was not related to him (Table 28, 29). Although Jona did not receive any affiliative behaviour from Libby, five of the 11 (45.5%) affliative interactions initiated by Jona were directed to Libby.

The most common affiliative behaviour in Pen 9 was Resting Together. It was observed 98 times, 68.5% of the total affiliative interactions. Eating Together and Allogrooming were observed 26 times and 19 times respectively. Allorubbing, Playing and Inviting was not observed.

Agonistic Behaviour

There were 42 agonistic interactions observed during 18 hours of observation in Pen 9. Most of these interactions were initiated by Libby, the unrelated new comer (Table 28, 30). Libby initiated 22 agonistic interactions (52.4% of the all agonistic behaviours) to all the other cats except Lady (Table 30). Most of these 22 were toward Inga (eight) (Table 30). Roz also directed most of her agonistic behaviour at Inga (five interactions, 50% of her initiating), although they had a 0.5-level of relatedness (Table 28, 30). By receiving these agonistic behaviours, Inga received the most agonistic behaviour in Pen 9 (Table 30). Sweep did not initiate any agonistic interaction during the observation period (Table 30).

All of the agonistic behaviours occurred during the observation period in Pen 9. Pushing was the most common (16; 38.1%) of the agonistic behaviours. Threatening was observed 11 times (26.2%). Fighting was observed five times (11.9%). Fighting was between Libby and Jona (twice), Roz and Libby (twice), and Libby and Sweep (once). Chasing and Displacing were observed four times and six times respectively.

Table 28: Coefficients of relatedness between cats in Pen 9. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

Sweep (M)	Roz (F)	Inga (M)	Kruz (M)	Tor (M)	Jona (M)	Libby (F)	Lady (F)
1996							
0	1996						
0	0.5	1996					
0.5	0	0	1999				
0.25	0	0	0.25	1998			
0	0.5	0.5	0	0	1996		
0	0	0	0	0	0	2000	
0	0.25	0.25	0	0	0.25	0	1996

Figure 12: Affiliative and agonistic behaviour in Pen 9 by week (week one started on 17 July 2005).

Table 29: Affiliative interactions in Pen 9.

Affiliative Behaviour		Recipient								Total
		Libby (F) 2000	Lady (F) 1996	Roz (F) 1996	Kruz (M) 1999	Sweep (M) 1996	Jona (M) 1996	Inga (M) 1996	Tor (M) 1998	
Giver	Libby	----	1	5	1	3	0	8	1	19 13.3%
	Lady	0	----	0	1	2	0	3	3	9 6.3%
	Roz	4	6	----	6	3	5	7	5	36 25.2%
	Kruz	2	3	1	----	1	2	7	6	22 15.4%
	Sweep	1	1	2	5	----	0	1	2	12 8.4%
	Jona	5	1	1	1	1	----	1	1	11 7.7%
	Inga	0	0	7	4	1	1	----	1	14 9.8%
	Tor	1	0	6	5	2	4	2	----	20 14.0%
Total		13 9.1%	12 8.4%	22 15.4%	23 16.1%	13 9.1%	12 8.4%	29 20.3%	19 13.3%	143

Table 30: Agonistic interactions in pen 9.

Agonistic Behaviour		Recipient								Total
		Libby (F) 2000	Lady (F) 1996	Roz (F) 1996	Kruz (M) 1999	Sweep (M) 1996	Jona (M) 1996	Inga (M) 1996	Tor (M) 1998	
Giver	Libby	----	0	2	3	4	3	8	2	22 52.4%
	Lady	0	----	0	0	0	0	0	1	1 2.4%
	Roz	3	0	----	0	0	1	5	1	10 23.8%
	Kruz	0	0	0	----	0	0	0	1	1 2.4%
	Sweep	0	0	0	0	----	0	0	0	0
	Jona	1	0	0	0	0	----	0	0	1 2.4%
	Inga	3	0	3	0	0	0	----	0	6 14.3%
	Tor	0	1	0	0	0	0	0	----	1 2.4%
Total		7 16.7%	1 2.4%	5 11.9%	3 7.1%	4 9.5%	4 9.5%	13 31.0%	5 11.9%	42

Pen 10

The group of cats in Pen 10 was formed on 1 June 2005. There were seven cats in Pen 10; one neutered male and six females. Each cat had some relatives in this pen (Table 31). Most interactions between these cats were agonistic, out numbering affiliative interactions by about five times. In the first four weeks of observation, the agonistic behaviours fluctuated around 1.5 to 2 interactions per cat per hour (Figure 10). In week five, the average rate of agonistic interactions declined to 0 and then jumped to about 2.5 interactions in week six (Figure 13). The average rate of affiliative behaviours was around 0.5 per cat per hour at all times (Figure 13).

Affiliative Behaviour

The total number of affiliative interactions observed in Pen 10 was 19 during 11 hours of observation. Twink initiated the most (6) affiliative interactions in this pen (31.6% in the nineteen interactions) toward three other cats. She was related to two of

these, Glade and Sox, at the 0.25-level of relatedness, but she was not related to Vanda (Table 31, 32). Twink, however, received the fewest affiliative interactions, only one from Glade (Table 32). Ming was the second highest initiator of affiliative interactions in Pen 10 with a total of five interactions toward three other cats (Table 32). Vanda received the most, five interactions, from two other cats, Ming (twice) with whom she was related at the 0.25-level, and Twink (three times) (Table 31, 32). Rach did not initiate any affiliative interaction with the other cats, but she received two interactions from Glade and Vanda, to whom she was unrelated (Table 31, 32).

The behaviour patterns that observed in Pen 10 were Resting Together, Eating Together, and Allorubbing. Resting Together was the most common (11) affiliative behaviour in Pen 10. Allorubbing was observed once between Ming and Timothy. However, Allogrooming, Playing, and Inviting were not observed.

Agonistic Behaviour

In Pen 10, 102 agonistic interactions were observed during 11 hours of observation. Sox and Timothy initiated and received the most agonistic interactions. Timothy initiated the most (51 agonistic interactions; 50% of all the agonistic interaction) toward all the other cats (Table 33). Each of Sox, Rach, and Twink received more than ten agonistic interactions from Timothy (Table 33). Timothy was also the second highest receiver of agonistic interactions (20), received from four other cats (Table 33). Sox initiated 20 agonistic interactions and received 32 agonistic interactions (31.4% of all the agonistic interaction) from all cats except Rach (Table 33). Glade initiated and received the fewest agonistic interactions (three of each) in Pen 10 (Table 33).

Displacing was observed 33 times, and was the most common behaviour pattern in Pen 10. Pushing was observed 24 times and Threatening 21 times. Chasing was observed 16 times, but 15 of these were between Timothy and other females, in which Timothy acted as the initiator. Fighting was observed once between Ming and Timothy.

Table 31: Coefficients of relatedness between cats in Pen 10. The gender for each cat is given in parentheses (M=male, F=female), and the year of birth is also given.

Timothy (M)	Glade (F)	Ming (F)	Vanda (F)	Twink (F)	Sox (F)	Rach (F)
2002						
	Glade (F)					
0	1999					
		Ming (F)				
0	0.25	2001				
			Vanda (F)			
0	0	0	1997			
				Twink (F)		
0	0.25	0.25	0	1999		
					Sox (F)	
0	0	0.25	0.25	0.25	2002	
						Rach (F)
0.25	0	0	0	0	0	2002
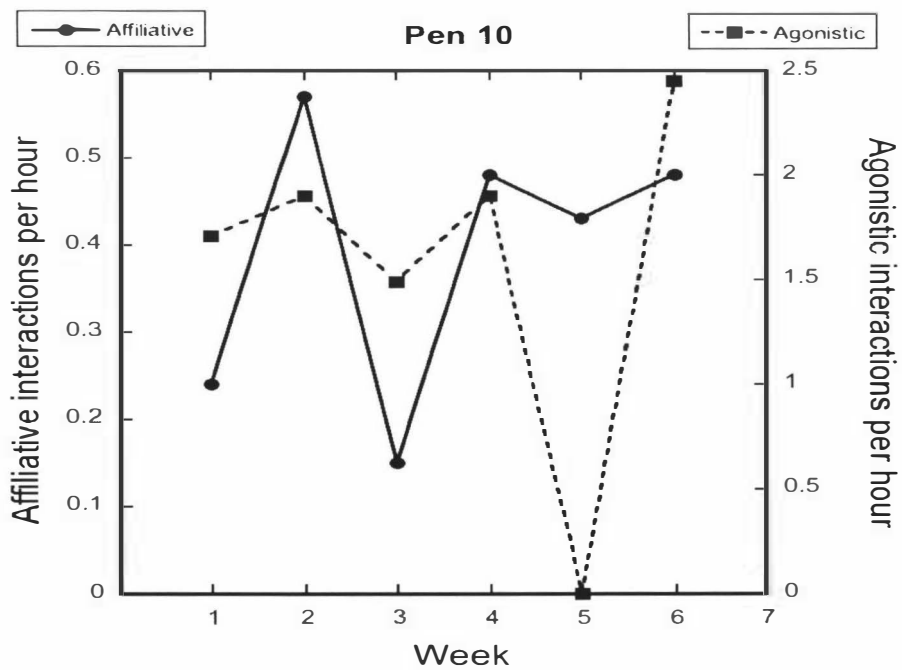
Figure 13: Affiliative and agonistic behaviour in Pen 10 by week (week one started on 5 June 2005).

Table 32: Affiliative interactions in Pen 10.

Affiliative Behaviour		Recipient							Total
		Timothy (M) 2002	Glade (F) 1999	Ming (F) 2001	Vanda (F) 1997	Twink (F) 1999	Sox (F) 2002	Rach (F) 2002	
Giver	Timothy	----	0	1	0	0	0	0	1 5.3%
	Glade	0	----	1	0	1	0	1	3 15.8%
	Ming	1	2	----	2	0	0	0	5 26.3%
	Vanda	0	0	1	----	0	1	1	3 15.8%
	Twink	0	2	0	3	----	1	0	6 31.6%
	Sox	1	0	0	0	0	----	0	1 5.3%
	Rach	0	0	0	0	0	0	----	0
Total		2 10.5%	4 21.1%	3 15.8%	5 26.3%	1 5.3%	2 10.5%	2 10.5%	19

Table 33: Agonistic interactions in Pen 10.

Agonistic Behaviour		Recipient							Total
		Timothy (M) 2002	Glade (F) 1999	Ming (F) 2001	Vanda (F) 1997	Twink (F) 1999	Sox (F) 2002	Rach (F) 2002	
Giver	Timothy	----	1	7	1	10	18	14	51 50%
	Glade	0	----	0	0	0	3	0	3 2.9%
	Ming	3	0	----	0	1	4	0	8 7.8%
	Vanda	0	0	0	----	0	6	0	6 5.9%
	Twink	3	0	0	0	----	1	2	6 5.9%
	Sox	9	2	5	4	0	----	0	20 19.6%
	Rach	5	0	0	0	3	0	----	8 7.8%
Total		20 19.6%	3 2.9%	12 11.8%	5 4.9%	14 13.7%	32 31.4%	16 15.7%	102

2.4.2.2 Observation

During the observation period, these behaviours were observed: allogrooming, allorubbing, eating together, resting together, sniffing, inviting, playing, threatening, pushing, avoiding, chasing, and fighting. Cats showed some differences in initiating and receiving these behaviours. For affiliative behaviour, which includes Allogrooming, Allorubbing, Eating Together, Resting Together, Inviting, and Playing, most cats were happy to receive them, but the initiators in each pen often directed these behaviours at only a few particular cats. Agonistic behaviour, which includes Threatening, Pushing, Chasing, Displacing, and Fighting, was initiated by some cats more than others.

There were similarities in the cats' responses to interactions from other cats. For example, most cats showed avoiding when they received Threatening, Pushing, and Fighting from other cats. However, the cats' personalities had a huge influence in their behaviour. Different cats played different roles in the pens. For instance, Dusky, a

female cat, often showed aggressive behaviours in both pen 8 and pen 7 (new), and quiet cats, such as Kree, also maintained constant affiliative behaviour.

Affiliative Behaviour

More affiliative behaviours (1074 interactions) were observed than agonistic behaviour (846 interactions). Although cats are thought to be indifferent to social contact, some cats were particularly affiliative toward other cats.

Allogrooming

Cats showed more Allogrooming on sunny days and in the breeding season. In the Established pens, such as Pen 6 and Pen 5, more Allogrooming was observed than in the Newly Formed pens. Allogrooming was usually observed with Rest Together. One cat licks the body or head of another cat, and then sleeps on the area that the cat just has licked. During the breeding season, both females and neutered males would mount females. When female cats mounted other females, they trended to do more Allogrooming than neutered males did.

Allorubbing

Cats did more Allorubbing with the cats in the adjacent pens than with cats inside their own pen. Some cats, for example, Casey in Pen 5, did Allorubbing with Rover in Pen 6, but he seldom Allorubbed with the other cats in Pen 5. Female cats did more Allorubbing to the males during the breeding season when they were on heat.

Eating Together

Cats chose particular partners to Eat Together with. This is to say that in a pen, some cats would never Eat Together. Instead, when these pairs met around the food bowl, the one that arrived later would wait for the first to finish eating, and then the later cat would eat. Cats did more Eating Together when food was put in their feeding tray and when the Feline Unit staffs were standing at the pen door.

Resting Together

In a pen, some cats usually chose Resting Together, while others did not. For example, in Pen 6, Misty and Puff did not rest with other cats as often as Puihi, Rover, and Tang did. Every pen has individual cats that seldom rested with other cats. These cats usually had their own place to rest. For example, Puff in Pen 6 usually chose the top-sleeping box to rest, and Misty chose to stay on the top of the middle-sleeping box. On the very cold days, windy days, and rainy days, cats chose sleeping boxes to rest in. Sometimes, five to six cats might rest all together in one sleeping box. On sunny days, however, cats chose the shelves to rest on. Some times five to six cats were observed Resting Together on one shelf.

Inviting

Inviting occurred infrequently, and only in some cats. It was observed between cats in adjacent pens. For example, Casey in Pen 5 often Invited Rover in Pen 6 to allorub with him. Cats seldom did this behaviour to others in the same pen.

Playing

Playing was not observed very often. Cats seemed to engage in Playing when there were no people around. When the observer was present, cats showed more interest in the observer.

Agonistic behaviour

The cats displayed fewer agonistic behaviours than affiliative behaviours. Threatening and Displacing were the two agonistic behaviours that occurred most frequently, especially in a Newly Formed group.

Threatening

Cats used Threatening much more often than other agonistic behaviours. When a cat was sensitive to the presence of another cat, both Eyesight Threatening and Voice Threatening would be used. For example, when Evet, a female in Pen 5, was sensitive

to Jaffa, she stared at Jaffa for a long period and when Jaffa was getting close to Evet, she used Voice Threatening to warn Jaffa. When cats were held in a New Formed pen, they used this behaviour more than in the Established pens. When Pen 1, the breeding pen, was newly formed, all of the cats Threatened when another approached too close. After about one week, however, the expression of this behaviour declined. Some female cats engaged in this behaviour when a neutered male tried to mount them in the breeding season. Also, cats showed this behaviour when they refused other cats' affiliative interactions, for example, when another cat attempted to initiate allogrooming. In this situation, Pushing might be used as well.

Pushing

This behaviour was often seen when one cat approached too close to, or attempted to initiate some affiliative behaviour with, another cat. For instance, when one cat was licking another, the recipient might push the giver away to stop the licking. When one cat showed Pushing to another cat, the recipient would usually respond with avoiding behaviour.

Displacing

Cats that are displaced run away, escape to the sleeping boxes, or hide under the litter boxes to avoid other cats. In the breeding season, some females avoided the neutered males that attempted to mount them. Displacing could be used to identify the hierarchy in the pen. For example, in Pen 7 (new), Spot often Displaced Mana. Wherever Spot went, if he was close to Mana, Mana would run away from Spot.

Chasing

Chasing was carried out by some cats more than others. For example, Libby, who was in Pen 8 and Pen 9, was a particularly aggressive cat. She Chased Inga and Jona in Pen 9 for no apparent reason. Chasing was also observed in the breeding season. When Titan was moved into Pen 1, he chased the females to copulate with them. In Pen 8, Steel, a neutered male, was observed to Chase Sioux, a female, for a whole

afternoon at the beginning of breeding season.

Fighting

Fighting was not seen very often during the observation period. As recipients, cats fought when they could not avoid it. Some cats were particularly aggressive, such as Libby and Dusky. For Libby, even the Voice Threatening from other pens might make her become aggressive and Fight with other cats around her. When Libby was in Pen 8, she was the dominant cat. When Tass and Dusky fought, Libby joined them and Fought together with both of them. In contrast, most other cats avoided to Fighting.

How a group formed

When cats were first placed in a Newly Formed pen, they showed aggressive behaviours, such as Threatening and Pushing. They threatened every strange cat that approached them. Some particularly sensitive cats fought to defend themselves. For example, when Rade, a neutered male in pen 4, found Timothy, a neutered male in Pen 3, which was adjacent, he showed extremely aggressive behaviours to Timothy. Although they could not fight, because they were not in the same pen, Rade used his voice and body postures to show his aggression. After about one week together, cats showed more affiliative behaviours, such as Rest Together, and Eating Together, but still, some cats showed agonistic behaviours when other cats were close. After about one month being together, cats adopted the new social environment. At this stage, affiliative behaviour would become the most common social interaction between cats. At this time, cats were familiar with each other, and except for some particularly aggressive pairs, affiliative and agonistic behaviour stabilized.

2.4.2.3 Analysis

Differences between Established and Newly Formed Pens

There were some differences between Established pens (Pen 4, 5, 6, 7, 7(new)

and 9) and Newly Formed pens (Pen 1, 1(new), 8, 10). Cats in Newly Formed pens showed less affiliative behaviour than those in Established pens (Table 34, 35, 36; Figure 14, 15). There was significant difference in the average rate of affiliative behaviour between Newly Formed pens (0.448 interactions per cat per hour) and Established pens (1.07 interactions per cat per hour) (Mann-Whitney Test, W=10.0, P=0.0142; Fisher exact test, P<0.05) (Table 35, Figure 14, 15). Agonistic behaviour was also significantly different between Newly Formed pens (1.49 interactions per cat per hour) and Established pens (0.35 interactions per cat per hour) (Mann-Whitney Test, W=34.0, P=0.0142; Fisher exact test, P<0.005) (Table 36, Figure 14, 15).

Cats in Newly Formed pens showed significantly more agonistic than affiliative behaviours (Paired t-test, t=-8.24, df=3, P=0.04). On the other hand, cats in Established pens had a significant higher rate of affiliative than agonistic interactions (Paired t-test, t=3.61, df=5, P=0.015).

Table 34 Average interaction rate (per cat per hour) of affiliative behaviour and agonistic behaviour for each pen (N=Newly Formed pen; E=Established pen).

Pens Rate	Pen 1 N	Pen 1 (new) N	Pen 4 E	Pen 5 E	Pen 6 E	Pen 7 E	Pen7 (new) E	Pen 8 N	Pen 9 E	Pen 10 N	Mean
Affiliative Behaviour	0.573	0.43	1.17	1.35	1.47	0.87	0.62	0.40	0.90	0.39	0.817
Agonistic Behaviour	1.24	1.55	0.48	0.125	0.23	0.25	0.73	1.60	0.26	1.58	0.805

Table 35 The number of Newly Formed pens and Established pens with affiiative behaviour rate above or below the overall mean (mean=interactions per cat per hour) (Fisher exact test, P<0.05).

Mean 0.8173	Number of Newly Formed Pens	Number of Established Pens
>Mean	0	5
<Mean	4	1

Table 36 The number of Newly Formed pens and Established pens with agonistic behaviour rate above or below the overall mean (mean=interactions per cat per hour) (Fisher exact test, P<0.005).

Mean 0.8045	NO. of Newly Formed Pens	NO. of Established Pens
>Mean	4	0
<Mean	0	6
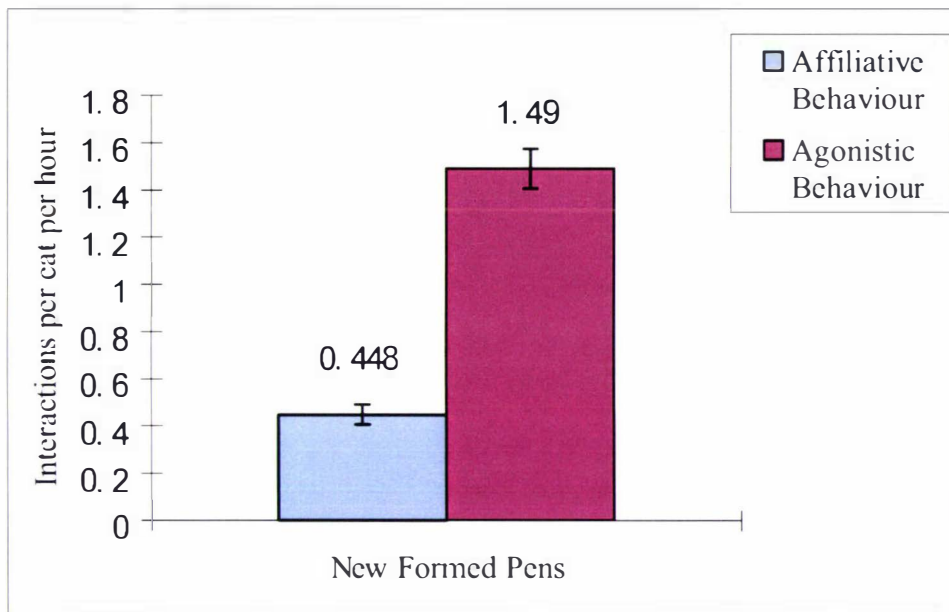
Figure 14 Mean of affiliative and agonistic behaviour in Newly Formed pens (SE=0.042 for affiliative behaviour and 0.084 for agonistic behaviour).
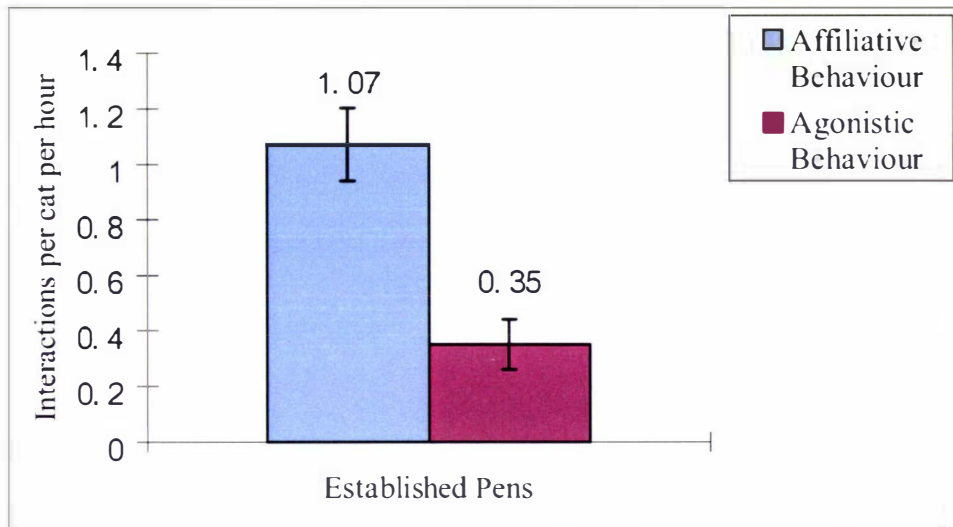
Figure 15 Mean of affiliative and agonistic behaviour in Established pens (SE=0.1316 for affiliative behaviour and 0.0898 for agonistic behaviour).

The effect of relatedness on social behaviour

Relatedness did not have a strong influence on the cats' social behaviour. Unrelated cats showed the same rate of affiliative behaviour as cats related at the 0.5-level while cats at the 0.25-level of relatedness showed less affiliative interactions than the other two groups (Figure 16, 17). Although cats at 0.5-level of relatedness showed less agonistic behaviour than unrelated cats and cats related at 0.25-level (Figure 16), unrelated cats showed less aggression to each other than the cats related at the 0.25-level (Figure 16). Pairs of unrelated cats and cats related at the 0.5-level expressed more affiliative behaviour than agonistic behaviour (Figure 17). However, cats related at the 0.25-level had more agonistic interactions than affiliative interactions (Figure 17). None of these differences were significant (Type I Analysis, $P>0.05$).
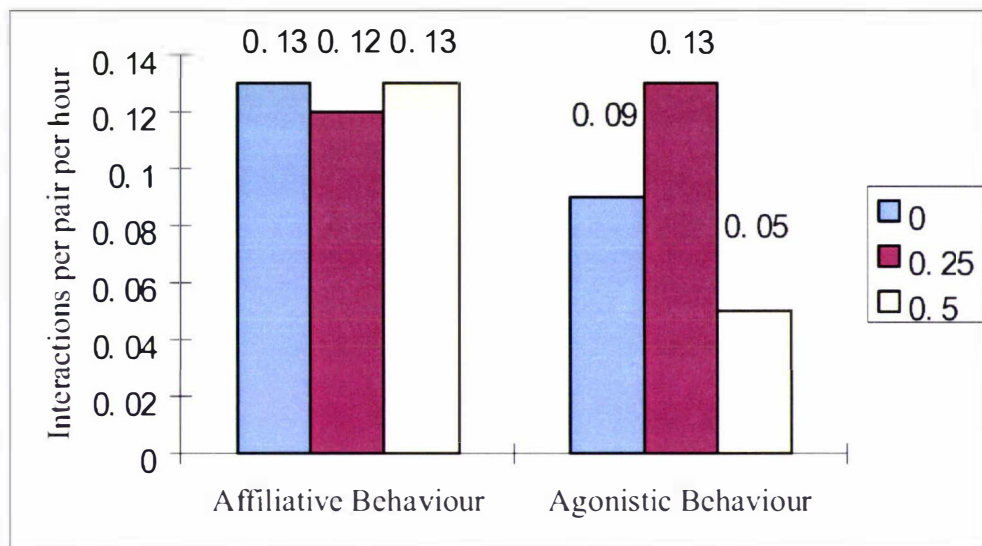
Figure 16 Rates of affiliative and agonistic behaviour categorised by different relatedness level (0: unrelated cats; 0.25: cats related at the 0.25-level; 0.5: cats related at the 0.5-level).
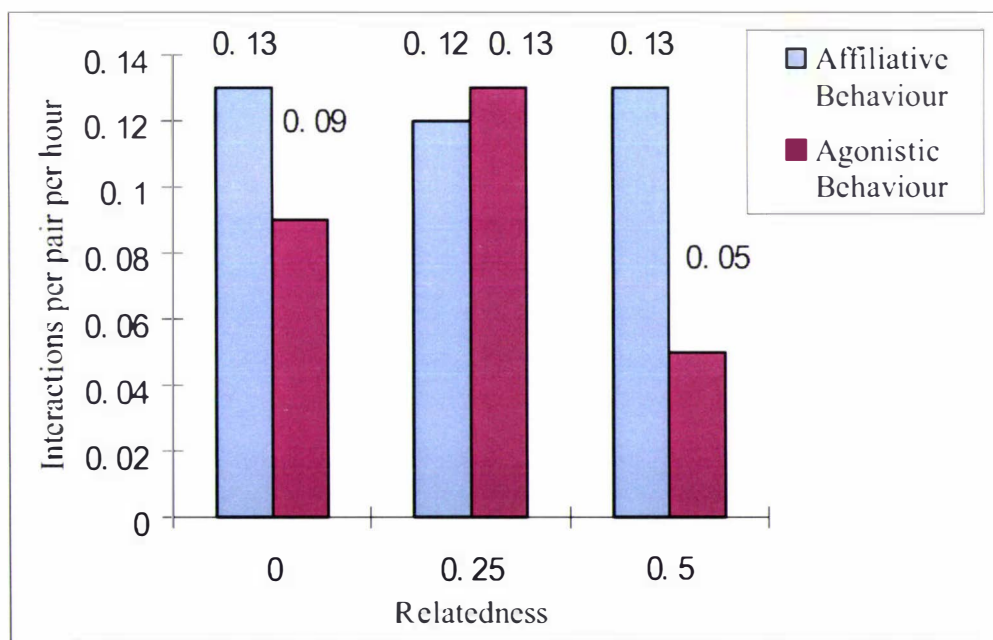
Figure 17 Rates of affiliative and agonistic behaviour categorised by different relatedness level (0: unrelated cats; 0.25: cats related at the 0.25-level; 0.5: cats related at the 0.5-level).

The effect of sex on social behaviour

Male and female cats did not differ in their rates of initiation of affiliative

behaviours or agonistic behaviours (Type 1 Analysis, P=0.0634, and 0.0637, respectively). The trend, however, was that male cats were more affiliative and less aggressive than female cats (Figure 18, 19, 20). Males initiated more affiliative behaviours and fewer agonistic behaviours than females (Figure 18, 20; Table 37). Males initiated 0.16 affiliative and 0.07 agonistic interactions per hour, compared with 0.1 affiliative and 0.12 agonistic interactions per hour by females (Figure 20).

Males expressed more affiliative interactions and fewer agonistic interactions to males (0.17 interactions per pair per hour and 0.02 interactions per pair per hour, respectively) than to females (0.15 interactions per pair per hour and 0.11 interactions per pair per hour, respectively) (Figure 18, 19). Females, however, initiated fewer affiliative behaviours and more agonistic behaviours to females than to males (Figure 18, 19). Females expressed 0.07 interactions per pair per hour in affiliative behaviour and 0.13 interactions per pair per hour in agonistic behaviour to females, compared with 0.15 interactions per pair per hour in affiliative behaviour and 0.11 interactions per pair per hour in agonistic behaviour to males (Figure 18, 19). Females and males expressed the same rate of interaction to each other for both affiliative behaviour and agonistic behaviour (Figure 18, 19). Overall, males showed a higher rate of affiliative behaviour to both females and males. Females expressed more agonistic interactions than affiliative interactions to each other (Figure 19), but they were friendlier to males (Figure 19).

The rate of male to male affiliative interaction was higher than female toward female, female toward male, or male toward female. This was consistent across male –male dyads, where the coefficient of variation was 0.798, the lowest in the four groups (Table 37). Compared with male toward male group, female toward female group expressed the fewest affiliative interactions, with the mean of 0.07 interactions per pair per hour. The coefficient of variation was 1.297, which was the highest in the four groups (Table 37). In contrast, although the female toward female pairs expressed the most agonistic behaviour, the coefficient of variation was the lowest, 1.449. However, the coefficient of variation of male toward male group for agonistic behaviour was 2.956, the highest, with the fewest mean number of agonistic

behaviour, 0.02 (Table 37). Although male toward female group had the same level of agonistic interaction as female toward male group, the coefficient variation for male toward male group (2.814) was higher, which was similar as the coefficient variation of male toward male group (Table 37).

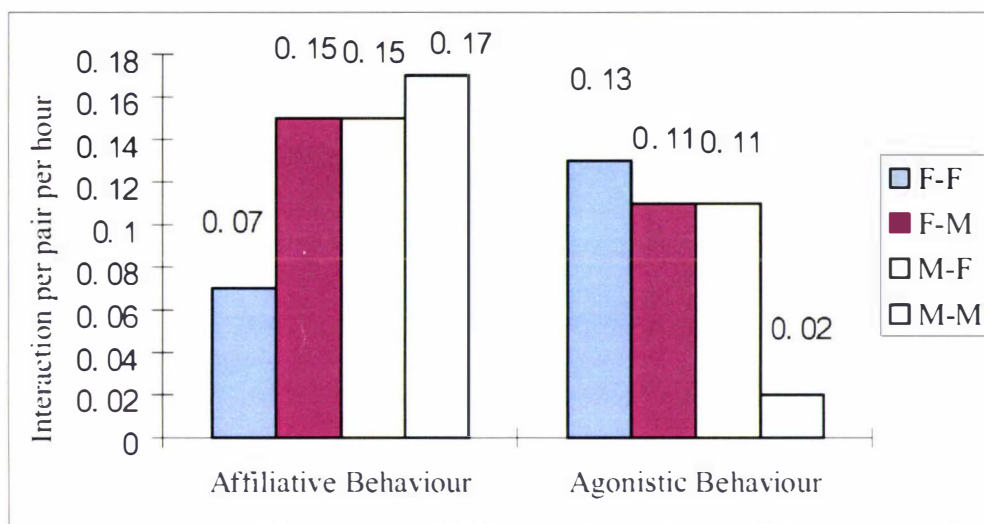Although males received more affiliative behaviour than females, the difference was not significant (Type I Analysis, $P=0.1672$) (Figure 18, 19, 20). On the other hand, males received much less agonistic behaviour than females and the difference was nearly significant (Type I Analysis, $P=0.067$) (Figure 18, 19, 20).

Figure 18 Rates of affiliative and agonistic behaviour categorised by sex of initiator and recipient (F-F: female to female; F-M: female to male; M-F: male to female; M-M: male to male).
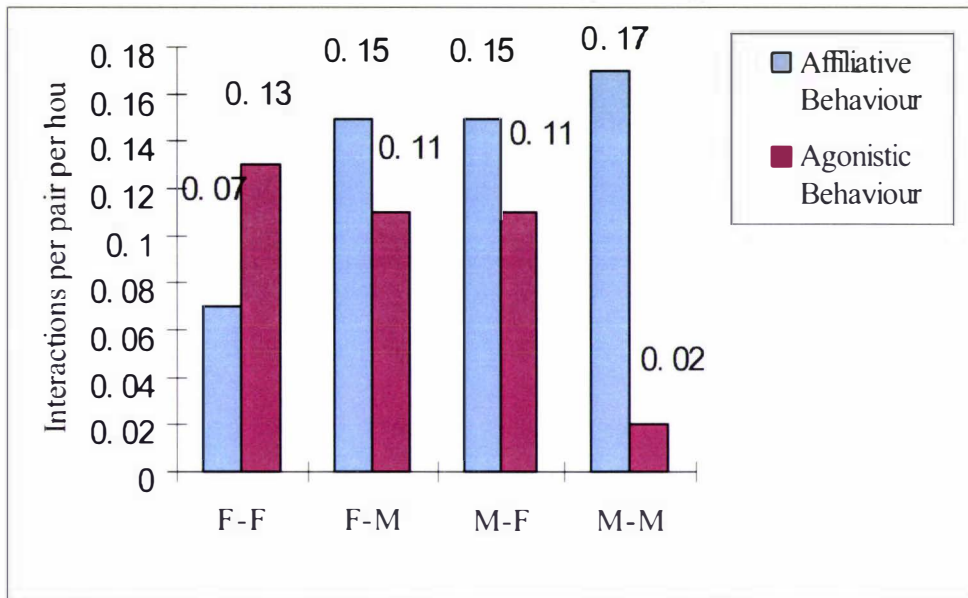
Figure 19 Rate of affiliative and agonistic behaviour for different sex pairs (F-F: females to female; F-M: females to males; M-F: males to females; M-M: males to males).
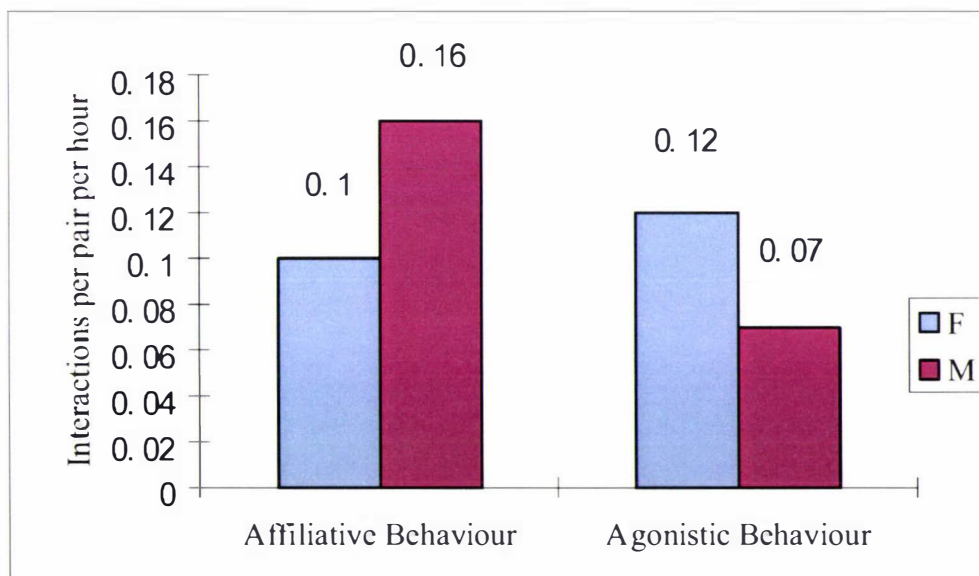
Figure 20 Rates of affiliative and agonistic behaviour for each sex as initiator (F: female as initiator; M: male as initiator).

Table 37 The mean, SD, and CV for each sex groups (F-F: female as initiator and female as recipient; F-M: female as initiator and male as receiver; M-F: male as initiator and female as receiver; M-M: male as initiator and male as receiver).

		F-F	F-M	M-F	M-M
Affiliative Behaviour	Mean	0.07	0.15	0.15	0.17
	SD	0.096	0.141	0.148	0.136
	CV	1.297	0.912	1.002	0.798
Agonistic Behaviour	Mean	0.13	0.11	0.11	0.02
	SD	0.189	0.20	0.322	0.064
	CV	1.449	1.869	2.814	2.956

The effect of coat colour on social behaviour

Cats of the same coat colour had more affiliative interactions and fewer agonistic interactions than cats of different colours (Figure 21). However, the differences were not significant (Type 1 Analysis, $P>0.05$). Cats of the same colour displayed more affiliative than agonistic behaviour (0.14 interactions per pair per hour for affiliative behaviour and 0.09 interactions per pair per hour for agonistic behaviour), but cats of different colours had the same rate of both affiliative interaction and agonistic interaction (0.11 interactions per pair per hour) (Figure 21).
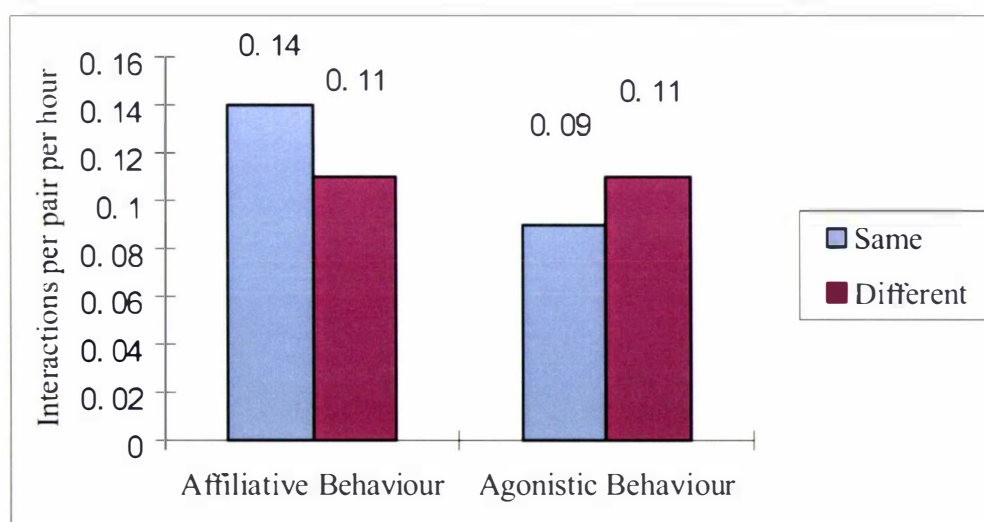
Figure 21 Rates of affiliative and agonistic behaviour for cats in same and different coat colours (Same: cats of same colour; Different: cats of different colour).
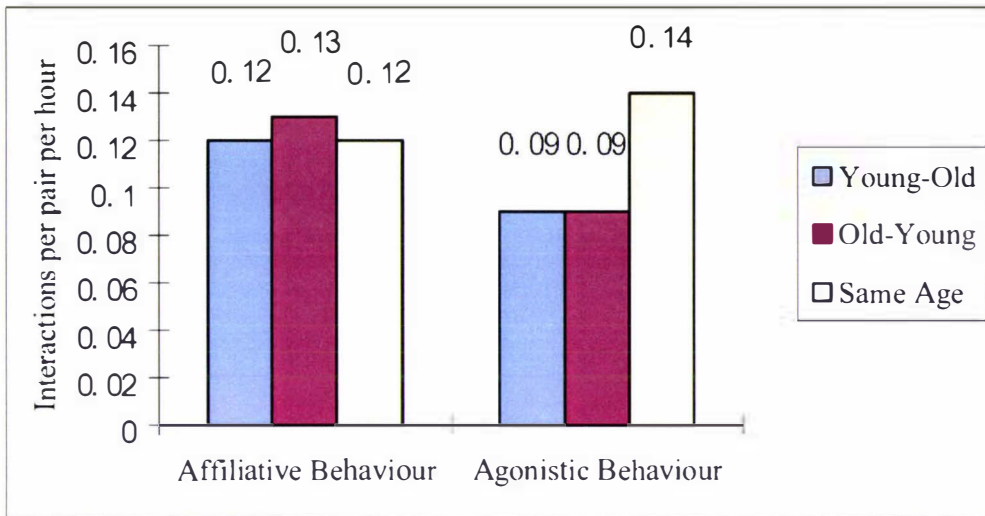
Figure 22 Rates of affiliative and agonistic behaviour for cats in different ages (Young-Old: initiators were younger than the receivers; Old-Young: initiators were older than the receivers; Same Age: initiators were at the same age as the receivers).
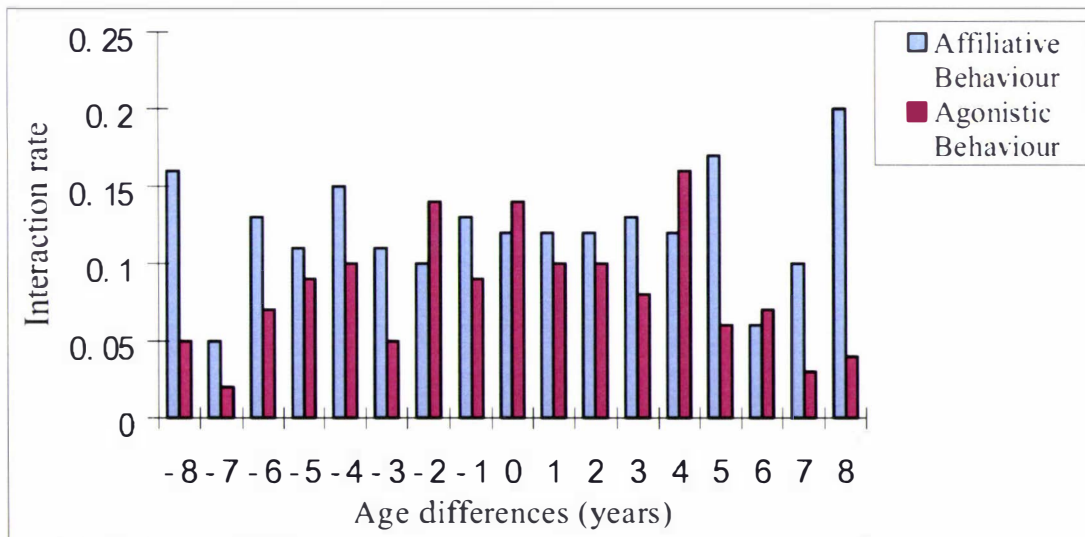

Figure 23 Interaction rate of affiliative and agonistic behaviour between cats of different ages (interaction rate: per pair per hour; age differences: the age differences between the initiators and the receivers).
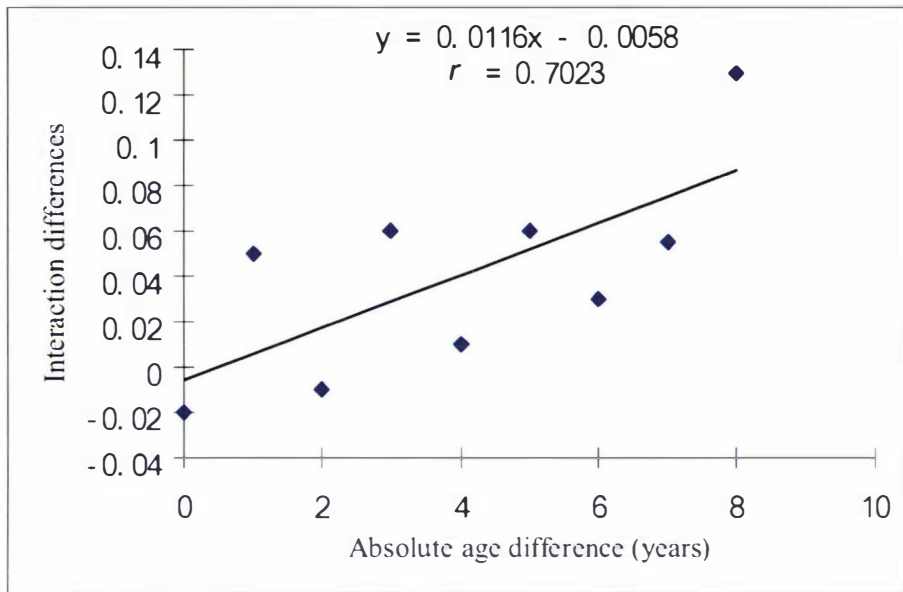
Figure 24 Interaction differences (per cat per hour) between affiliative and agonistic behaviour for absolute age differences between initiators and receivers (the interaction differences equal the rate of affiliative interactions minus agonistic interactions).
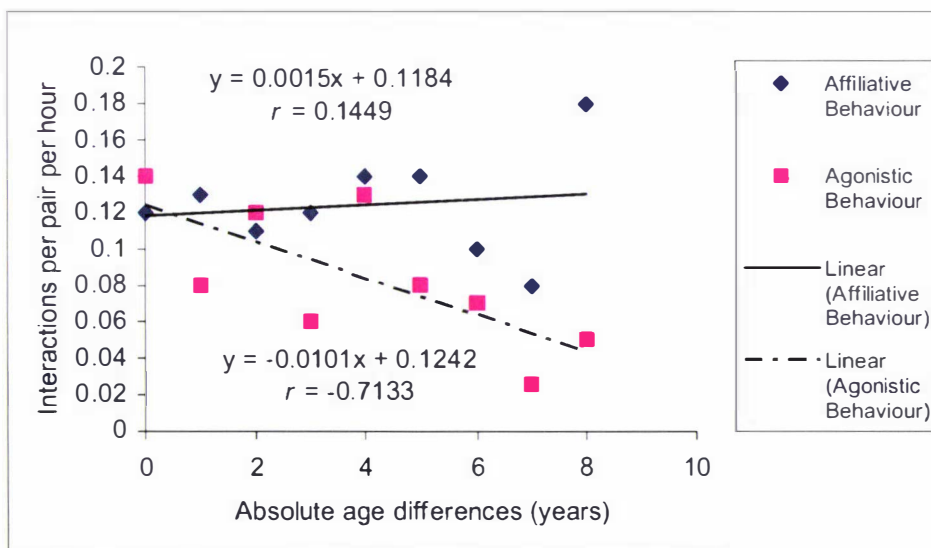
Figure 25 Rate of affiliative and agonistic behaviour for pairs of cats in different absolute age differences between initiators and receivers.

The effect of weight on social behaviour

Weight was not a strong factor in cats' social behaviour. Whatever their weight

differences, cats showed similar rates of affiliative and agonistic interaction as both initiator and receiver (Figure 26). However, cats that were more than 2000 grams heavier than the others were likely to express more agonistic behaviour than to receive it (0.27 interactions per pair per hour and 0.12 interactions per pair per hour, respectively) (Figure 26). None of these differences were significant (Type 1 Analysis, $P>0.05$).

There was no significant change in the rate of affiliative and agonistic behaviours as the absolute weight differences of cats increased (correlation coefficient, $r=0.12$, $df=3$, $P>0.05$) (Figure 27). The rate of agonistic interaction fluctuated as the weight difference between the cats increased. Although the rate of agonistic interactions was high when there was more than 2000 grams differences in cats weights, the differences between weight groups were not significant (correlation coefficient, $r=0.3985$, $df=3$, $P>0.05$) (Figure 28). On the other hand, cats showed significantly more affiliative interactions as their absolute weight differences increased (correlation coefficient, $r=0.9535$, $df=3$, $P<0.05$) (Figure 26, 28).
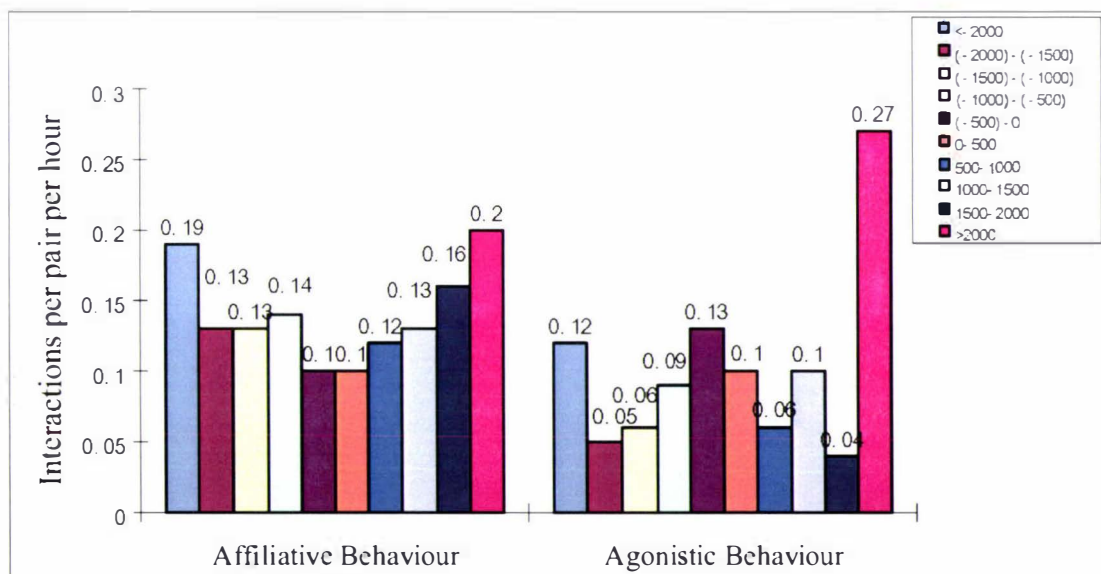

Figure 26 Interaction differences between cats with different weight differences (the cats were separated into 10 groups by weight differences (grams) between initiators and receivers).
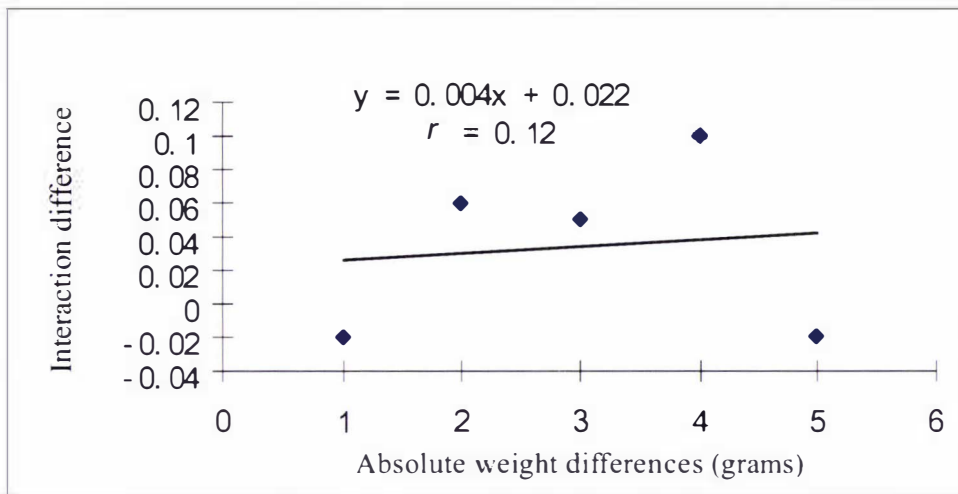
Figure 27 Interaction differences (per cat per hour) between affiliative and agonistic behaviour for absolute weight differences between initiators and receivers (the interaction differences equal the rate of affiliative interactions minus the rate of agonistic interactions; 1=the absolute weight differences between initiators and receivers were less than 500 grams, 2=500-1000 grams, 3=1000-1500 grams, 4=1500-2000 grams, 5=more than 2000 grams).
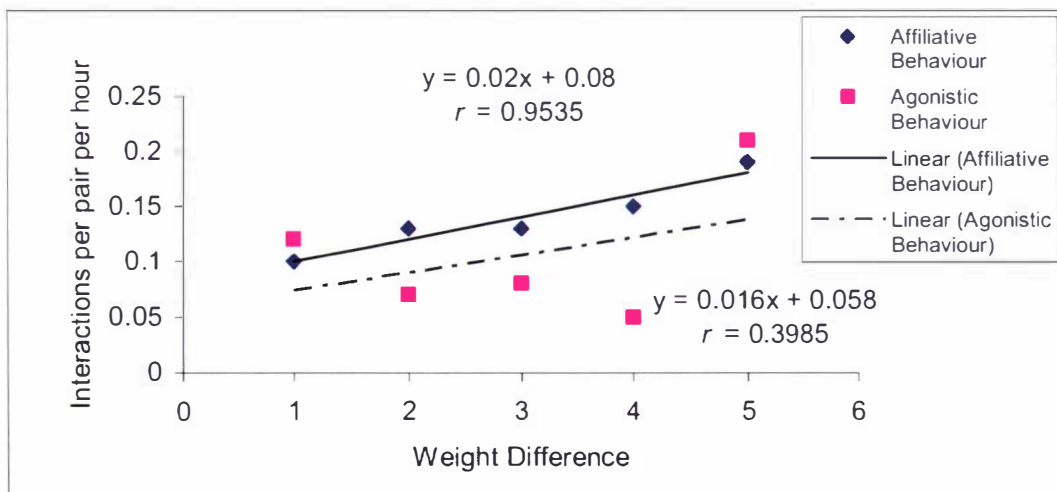

Figure 28 Rate of affiliative and agonistic behaviour for pairs of cats in different absolute weight differences (weight differences: 1=initiators and receivers had less than 500 grams weight difference; 2=500-1000; 3=1000-1500; 4=1500-2000; 5=more than 2000 grams).

The effect of weather on social behaviour

Weather seemed to influence cats' behaviour. Cats showed more agonistic than affiliative behaviour on cloudy days, and cloudy windy days (Table 38). The highest rates of agonistic interaction occurred on cloudy days, and this effect of weather was nearly significant (One-way ANOVA, $P=0.063$) (Table 38). On the other hand, although the lowest affiliative interaction rate also occurred on cloudy days, it was not significant differently from other days (One-way ANOVA, $P>0.05$) (Table 38). In total, cats were less active on rainy windy days and more active in cloudy days comparing with other types of weather, but the differences were not significant (One-way ANOVA, $P>0.05$) (Table 37).

Table 38 Average affiliative behaviour and agonistic behaviour per hour ($\pm$ SD) in different weather.

Weather / Interactions/h	Rainy	Rainy Windy	Sunny	Sunny Windy	Cloudy	Cloudy Windy
Affiliative Behaviour	9.39±2.72	9.11±1.98	8.31±0.82	7.5±0.79	4.98±1.07	7.15±1.40
Agonistic Behaviour	3.57±1.57	1.78±1.18	5.37±1.02	4.44±1.49	11.23±2.23	7.84±3.83
Total	12.96±2.37	10.89±3.09	13.68±0.95	11.94±1.49	16.21±1.93	15±3.60

2. 5 Discussion

The social behaviour of cats in 10 pens was observed, recorded and analysed. The social behaviours, which were recorded, included six affiliative behaviours (Eating Together, Resting Together, Allogrooming, Allorubbing, Playing, and Inviting) and five agonistic behaviours (Fighting, Pushing, Chasing, Displacing, and Threatening).

There are five major findings:

1. Cats in Established pens expressed more affiliative than agonistic behaviour, but cats from Newly Formed pens had more agonistic than affiliative behaviour. Cats

from Established pens showed significantly more affiliative behaviour and less agonistic behaviour than cats from Newly Formed pens.

2. As the absolute age differences increased between pairs of cats, the agonistic behaviour decreased significantly.

3. Affiliative interactions increased as the absolute weight difference between pairs of cats increased.

4. The cats' relatedness and coat colour were not correlated with differences social behaviour.

5. The weather did not affect cats' behaviour significantly. However, some weather-related factors approached statistical significance.

The management regime of the Feline Unit constrained the design of this study. Cats were often moved to and from pens, which meant that the observation times for pens varied from 7.5 hours to 22.5 hours. Some pens were used twice. Some cats were observed in two different pens. For example, Dusky was in both Pen 8 and Pen 7(new), while Libby was in both Pen 8 and Pen 9. All of these may result in a low level of pseudo replication.

2.5.1 Newly Formed Groups and Established Groups

The introduction of new cats into an established group often results in aggressive behaviours (Crowell-Davis et al., 1997; Burks et al., 2004). Cats recognize familiar and unfamiliar conspecifics, and most individuals from a colony are aggressive toward an unfamiliar cat (Crowell-Davis et al., 2004). This was exactly what happened in my study. Cats in Established groups (Pens 4, 5, 6, 7, 7(new), and 9) were familiar with each other, so they expressed significantly more affiliative behaviour and less agonistic behaviour than cats in newly formed groups (Pens 1, 1(new), 8, and 10). On the other hand, the introduction of just one new cat into an Established group may alter the cats' behaviour patterns (Crowell-Davis et al., 1997). When Dusky was introduced into Pen 7 from Pen 8, forming Pen 7 (new), agonistic interactions in Pen 7 (new) increased. Compared with Pen 7, the average rate of

agonistic behaviours in Pen 7(new) increased from 0.25 to 0.73 interactions per cat per hour. Pen 7(new) was the only Established pen that showed more agonistic behaviour (0.73 interaction per cat per hour) than affiliative behaviour (0.62 interactions per cat per hour). In contrast, the introduction of Libby to Pen 9 from Pen 8 did not change the behaviour patterns as much as Dusky's move to Pen 7 (new). This may be because Dusky was imported into the Feline Unit, while Libby was born and reared in the Feline Unit. It is possible that Libby may share "a colony odour" (Crowell-Davis et al., 2004) with other cats while Dusky does not.

The method of introduction could affect behaviour of cats (Burks et al., 2004; Crowell-Davis et al., 1997). Burks et al. (2004) showed that if the animals could have some visual and limited tactile contact before they were kept together in the same group, the aggression and stress seen with introduction were reduced. This was found in my study. Jaffa was a new member in Pen 5. However, because Jaffa was moved from Pen 4, which was adjacent to Pen 5, Jaffa's introduction to Pen 5 did not precipitate an increase in agonistic behaviour. When Jaffa was in Pen 4, she had visual and limited tactile contact with cats in Pen 5. Therefore, when Jaffa moved into Pen 5, the overall behaviour patterns did not change. Also, this may be the reason why Libby did not change the overall behaviour patterns in Pen 9, since she had contact with these cats in Pen 9 when she was in Pen 8.

Allorubbing and Allogrooming are important affiliative behaviours. Both are more likely to occur between certain pairs of cats than randomly in a group of cat. Cats appear to have preferred partners for these two behaviours (Crowell-Davis et al., 1997; Crowell-Davis et al., 2004; Wolfe, 2001). However, in my study, in Established pens, there were no preferred partners for Allogrooming. Allogrooming was often followed by Resting Together. A cat may use another cat as a "pillow" (Crowell-Davis et al., 2004) when they rest together. Cats in Established pens often groomed another cat and then used the cleaned part of the other cat as a "pillow". The same behaviour was also observed in Newly Formed groups, but in these groups, it occurred between preferred pairs, which were more likely to be related pairs or more familiar with each other than with the rest of the group. In my study, Allorubbing occurred infrequently

between cats in the same pen, whether it was an Established or a Newly Formed group. However, cats did Allorub with particular partners in adjacent pens. For example, Casey in Pen 5 only rubbed with Rover in Pen 6.

Playing is a behaviour that is thought to show a friendly relationship between two cats. Adult free-living cats within a social group have been observed to play together (Crowell-Davis et al., 1997), and cats do not have preferred partners for playing (Wolfe, 2001). In my study, cats did not do much Playing. There was no difference in the amount of Playing seen in Newly Formed groups and Established groups. However, two pairs of cats in Newly Formed pens showed playing. Both of these pairs were born in the same year and reared together in the Feline Unit. Furthermore, both pairs were related at the 0.25-level. Steel, observed playing with Sioux three times in Pen 8, was a male cat who was neutered about one month before my study began. Because my study was conducted at the beginning of the breeding season, Steel might have played with Sioux as a precursor to breeding. In addition, six pairs of cats played together in Established pens and none of them were related, and except for Spot and Dusky, none of them were born in the same year. This suggests that the more familiar cats are to each other, the more affiliative they are (Crowell-Davis et al., 2004). Sharpe (2005) pointed out that play did not enhance social cohesion in cooperative mammals such as meerkats. This may explain why cats in my study played little. Sharp (2005) compared the playing rate and the group size, and found there was no relationship between them. In my study, all groups were of a similar size, so I have no evidence to support whether or not the playing rate is related to group size.

Cats may form small groups within a colony (Crowell-Davis et al., 2004). Members of these small groups may be found close together and show more affiliative behaviour to each other than to others in the colony (Crowell-Davis et al., 2004). In my study, there was no evidence that cats associated in small groups, but some cats were more active than others, and these cats gave more affiliative interactions than they received. For example, Argon in Pen 6 gave 43 affiliative interactions to the other seven cats, which was 16.2% of the total affiliative

interactions in that pen. Argon, however, only received 24 interactions back, which was 9.2% of the affiliative interaction in Pen 6.

2.5.2 Sex

In general, gender has no effect on the way that domestic cats socialise with each other except females in oestrus (Crowell-Davis et al., 2004). Male intact cats are less likely to associate with other cats than female intact cats, but in a colony of neutered cats, there is no effect of gender (Crowell-Davis et al., 2004; Wolfe, 2001). In my study, sex did not affect the rates of affiliative or agonistic behaviours. Most of the male cats in my study were neutered and the one intact cat, Titan in Pen 1 (new), was not included in the analysis of the effect of sex on social behaviour. Although some females in my study were in oestrus during the observations, they did not show significant differences in expressing or receiving interactions from neutered males.

In free-living colonies, females exhibit more affiliative interactions than intact males (Crowell-Davis et al., 1997). Males may be involved in aggressive conflict with other males, especially in the presence of an oestrous female (Crowell-Davis et al., 2004). However, in my study, females expressed the least affiliative behaviour and the most agonistic behaviour toward other females. In contrast, neutered males expressed the most affiliative and the least agonistic behaviour toward other neutered males. This may be because the males were neutered, and neutering may increase affiliative behaviour and decrease agonistic behaviour (Crowell-Davis et al., 1997; Brown 1993). In addition, the females were all intact and some of my observations were carried out during the breeding season, when females may be in oestrus and be more aggressive.

Previous studies have shown that females engage in affiliative interactions with both males and females, but intact males are more affiliative to females than to intact males (Crowell-Davis et al., 1997). In my study, females and neutered males exhibited the same number of affiliative and agonistic behaviours toward each other. The rate of the interaction between females and neutered males was less than neutered males toward neutered males and more than females toward females. Female cats in my

study were more affiliative toward neutered males than females, which might indicate that affiliative behaviours occur more often between the two genders than within the same gender (Crowell-Davis et al., 1997). On the other hand, because the male cats in my study were neutered, males showed affiliative behaviour to both female and neutered male cats. Females in my study expressed more agonistic behaviour to each other than to males. Again, this may be because the some females were in oestrus and the males were neutered.

Females are considered to be the primary social units in a cat colony because cat social structure is based on cooperation between females during the rearing of kittens (Crowell-Davis et al., 2004; Hart, 1980; Bradshaw, 1992). The reason that female-female pairs did not interact more in an affiliative way in my study may be that they did not rear kittens together. Cats were moved out of the breeding pen (Pen 1) before they gave birth, and reared their kittens with human help away from other cats. The other reason might be that they did not form the group by their choice.

The females in my study were more aggressive than the neutered males. This might be due to some especially aggressive female cats, such as, Libby, a particularly aggressive cat. When Libby was in Pen 8, she behaved like she was the dominant cat. Libby was involved in five of nine fights in the pen, and when she moved into Pen 9, she was involved with all of the fighting (five times) recorded. Dusky was another aggressive cat and participated in seven fights in Pen 8, four of which were with Libby. When Dusky was moved into Pen 7, she was the most aggressive cat in that pen, and she was involved in 60.7% of the agonistic interactions.

The relative numbers of males and females may influence the expression of social behaviour. In my study, there were 98 female-female pairs, which was nearly twice as many as male-male pairs. Although the interaction rate is expressed as interactions per pair per hour, females still had more chances to interact with each other than males did. That may lead to high rate of agonistic interaction in female-female pairs.

Being in an Established group or a Newly Formed group may affect the behaviour of the two sexes differently. Most of the members of Newly Formed groups

were females (only three of them were neutered males). The number of neutered males in Established pens was 27, which was six more than females. Because cats in Established pens showed more affiliative behaviour and less agonistic behaviour than Newly Formed pens, males may have had more chances to show friendship to each other and to other females in the same pen than females did. Moreover, the aggression level decreased after about one month in Newly Formed groups. This may explain why female to female aggression was high as they were observed mostly within the first month after they had been moved into new pens.

2.5.3 Relatedness

Kinship is a significant factor in shaping social and reproductive interactions in vertebrates (Lacey and Wieczorek, 2004). Kinship is a strong correlate of affiliative interaction in free-ranging rhesus monkeys (*Macaca mulatta*) (Kapsalis and Berman, 1996a). In one lemur species (*Lemur catta*), closely related female pairs had higher levels of agonistic interactions than non-kin dyads (Kappeler, 1993). Female wild house mice are generally more aggressive toward neighbouring-group juveniles (all unrelated to the female) and toward their own-group juveniles that had been sired by the neighbouring dominant males (Hurst and Barnard, 1995). The degus (*Octodon degus*), a rodent, paired more significantly to relatives than to strangers (Ebensperger et al., 2004). When cats live with both relatives and non-relatives, they are more likely to be close to and allogroom with relatives than non-relatives (Crowell-Davis et al., 2004). However, that was not the case in my study. Non-related cats had a higher level of affiliative behaviour than cats related at the 0.25-level, and had the same level as cats related at 0.5-level. Kappeler (1993) indicated that one lemur species, *Eulemur fulvus*, showed higher level of agonistic behaviour between relative pairs than non-relative pairs. This was similar to my study. Cats related at 0.25-level expressed higher level of aggression to each other than cats that were not related. However, cats related at 0.5-level had the fewest agonistic interactions.

One reason why kinship may not have played a significant role in my study is

that most of the cats in the Feline Unit share the same ancestors as most of them were born and reared there. For instance, Coppa, a neutered male, shared seven affiliative interactions with Mara, the other neutered male in Pen 4. They did not share the same parents, but their mothers were the original cats in the unit, through their relationship is unknown. Coppa and Mara may be related. In contrast, imported cats, which are not related to other cats at all, expressed less affiliative and more agonistic behaviour to other cats. This was similar to the result of Crowell-Davis et al. (2004). Although Wren, an imported female cat in Pen 6, initiated affiliative behaviour toward all the other cats in this pen, she expressed the least. Similar to Wren, Dusky, another imported cat, was the most aggressive cat in both Pen 8 and Pen 7(new), and she also expressed the least affiliative interactions in Pen 8.

Familiarity may be another reason why the cats in my study did not show significantly more affiliative and less agonistic behaviour to their relatives. Cats in the Unit lived altogether in the big yard. Although they were divided into groups, they could still share odour and communicate with each other as neighbours. Hare (1998) found that neighbouring ground squirrels (*Spermophilus richardsonii*) interacted more than strangers but less than littermates. When ground squirrels that are separated from their own litters at weaning were mixed with both littermates and others that they grew with, they interacted more with other conspecifics than littermates (Hare, 1998). In the Feline Unit, same age cats were reared together, and some siblings may be separated and reared by other females because of problems with their natural mother. Therefore, when these same year cats moved into the same pen, they might be too familiar to be aggressive to each other.

Although cats of the Feline Unit did not show differences in affiliative behaviour according to their relatedness, closely related (r=0.5) cats did express less agonistic behaviour than unrelated pairs and 0.25-level pairs. Kapsalis and Berman (1996a, 1996b) indicated that in free-ranging rhesus monkeys, close kin are more likely to support one another in agonistic interactions than distant kin. Widdig et al. (2002) illustrated that the more related adult female rhesus macaques were, the higher the rate of interaction with each other in both affiliative and aggressive behaviour. This

may explain why cats related at the 0.25-level had the highest agonistic interaction rate, but could not be a reason for the low level of aggression for cats related at the 0.5-level.

2.5.4 Age

There are few studies that relate differences in social interaction to the age of the animals. Some studies indicate that age might play an important role in mating behaviour and social rank. For example, prime-aged male ungulates have a higher reproductive success than younger males (Mysterud et al., 2004). Male brown antechinuses (*Antechinus stuartii*) show no age differences in reproductive success (Fisher and Cockburn, 2005).

The social behaviour of the cats in my study did not change significantly with age. This is consistent with some other studies of cats (Natoli et al., 2001; Knowles et al., 2004). However, I found that as the absolute age differences between members of dyads increased, the frequency of agonistic interactions decreased significantly. Results from other species suggest a possible mechanism. Kawanaka (1993) showed that chimpanzees were in proximity with others of a similar age. Jennings et al. (2006) demonstrated that although age did not play a significant role in the fighting of the fallow deer (*Dama dama*), same year deer were more agonistic to each other due to their similar rank in the social group. This may explain why cats of the same or similar age expressed more agonistic interactions. First, older cats may not be in close proximity to the younger cats, compared with cats in the same age group. For example, a 15-year-old male cat rarely interacted with the other members of the group, but he was still "respected" by the others and was the second dominant one (Natoli et al., 2001). Second, cats of similar age interacted more aggressively to compete for a higher rank in the group. On the other hand, older cats may be more often successful in agonistic interactions (Knowles et al., 2004); therefore, young cats may avoid aggressive interactions with old cats.

Finally, the assignment of cats to different cages may have affected the results.

For example, cats in Pen 1 were all born between 1996 and 1998. As a Newly Formed pen, there were more agonistic than affiliative interactions between those cats. On the other hand, the age differences in Pen 4 were from 0 to eight years, and as an Established pen, cats in Pen 4 expressed much less agonistic behaviour than cats in Pen 1. As a result, cats of a similar age were more aggressive toward each other than cats of different ages because more similar age cats were in Newly Formed pens than in Established pens.

2.5.5 Weight

Weight plays a role in the mate choice of many animals. Female brown antechinuses (*Antechinus stuartii*) use weight as a criterion for mate choice (Fisher and Cockburn, 2005). Female blind cave tetras *Astyanax fasciatus* (*Characidae, Teleostei*) preferred large males as their mates (Plath et al., 2006). Male ungulates have increased reproductive success with an increase of body size (Mysterud et al., 2004). Weight is also correlated with position in a dominance hierarchy. However, there are few studies on the relationship between weight and social interactions. Sneddon et al. (2006) agreed that larger body size could benefit dominant individuals by reducing aggression from the lower ranks. Lindstrom et al. (2005) pointed out that house sparrows (*Passer domesticus*) with small body size had high costs in maintaining dominance and the birds with large body size had increased costs as subordinates. Studies in cats also demonstrate that heavier cats have higher rank (Vandenbos and Buning, 1994; Knowles et al., 2004). Therefore, as body weight differences increase, the aggression between cats should decrease. However, this did not happen in my study. When the absolute body weight differences between the cats were more than 2kg, the aggression level within dyads was the highest. This may be influenced by some other factors in my study, such as the pen differences and the oestrus effect of the females.

On the other hand, I found that affiliative behaviour increased significantly as the absolute weight difference increased. No previous study has investigated the

relationship between affiliative interactions and weight or body size. However, Vandenbos and Buning (1994) indicated that higher-ranking cats tended to initiate more social licking and receive more social sniffing and social rubbing because higher-ranking cats tended to gain weight and lower-ranking cats tended to loose weight. This may explain what happened in my study. Because cats of similar weight tended to have similar ranks, they would show more agonistic behaviour to each other than to cats of different weight. As the weight differences increase, the rank differences widen, and more affiliative interactions occur.

2.5.6 Colour

Many species use body or coat colour as a criterion for mate choice. Examples include guppies (*Poecilia reticulata*) (Godin and McDonough, 2003; Millar et al., 2006), gerbils (*Meriones unguiculatus*) (Wong et al. 1990), and rhesus macaques (Waitt et al., 2003). On the other hand, colour may not play a special role in social interaction. Brockelman (2004) found no evidence for any selection based on colour in white-handed gibbons (*Hylobates lar*). Zebrafish also showed no interest in red body coloration in choosing a social partner (Snekser et al., 2006). However, Pryke and Griffith (2006) found that the red-headed Gouldian finch (*Erythrura gouldiae*) was the dominant one in the group. Gerald (2001) also noted that vervet monkeys (*Cercopithecus aethiops sabaeus*) were more aggressive toward similar colour group members. In my study, the cats expressed more affiliative behaviour toward cats of a similar colour, but the result was not statistically significant. Thus, cats may not choose social partners by colour.

2.5.7 Weather

Weather may have some influence on an animal's behaviour and life. Krebs and Chitty (1995) found that weather could be a factor explaining why and when house mouse plagues occur. Rabbits in central Otago, New Zealand, showed significant differences in emergence behaviour between different seasons (Fraser, 1992).

Temperature and wind also had some effect on this behaviour (Fraser, 1992). Marai and Rashwan (2004) demonstrated that hot climate was the main cause for abnormal maternal and sexual behaviour in domestic rabbits. Red deer spend significantly different time using shade and shelter, and show significant differences in activity patterns between "dry" days and "wet" days (Pollard and Littelejohn, 1999). Almaraz and Amat (2004) demonstrated that climatic forcing is a major process in the spatio-temporal dynamics of the white-headed duck. The survival of the Serengeti cheetahs was also influenced by other animals' behaviour that was controlled by the weather (Durant et al., 2004).

From my study, while the static analysis showed no significant effect of weather on cats' social behaviour, there were some differences in agonistic behaviour in different weather situations. For example, cats showed the least agonistic behaviour on rainy windy days. This may be because the observation period was during the winter. On rainy windy winter days, the temperature was really low, so cats were less active and often rested together in the sleeping boxes. Fraser (1992) found that rabbits changed their emergence behaviour depending on both weather conditions and season. In most of the weather conditions, cats showed more affiliative behaviour than agonistic behaviour. The exception was cloudy days and cloudy windy days when cats expressed the most agonistic behaviour and the least affiliative behaviour. However, this may be a biased result because Newly Formed pens were observed more on cloudy days than Established pens.

Chapter Three: Tigers in Captivity

3.1 Introduction

Tigers are thought to be solitary animals. However, Rouck et al. (2005) indicate that "tigers may not be as solitary as was previously thought" since many of their observations were of tigers associated in the wild. Moreover, in captivity, tigers kept in groups with plenty of food in limited space live peacefully as do domestic cats in laboratory cages. Tigers are now facing extinction, and their habitat loss is a major problem. If prey are plentiful, it may be possible to keep tigers at fairly high population densities in the wild, and this may help with tiger conservation.

I observed captive tigers in three different zoos and parks in China. I compared the behaviour patterns of tigers in these three settings to see how management affects the tigers' behaviour.

3.2 Materials and Methods

3.2.1 Study Sites and Animals

Tiger behaviour was observed at three different captive facilities in China during November and December 2004. They were Beijing Zoo, Beijing Wildlife Park, and Haerbin Siberia Tiger Park.

3.2.1.1 Beijing Zoo

Beijing Zoo is located in Beijing City. It covers an area of about 0.9 km^2. Large numbers of people visit this zoo everyday. Nine tigers are kept in this zoo in the Lion-Tiger Mountain. Six of these are Siberian tigers (*Pathera tigris altaica*), and the other three are Bengal tigers (*Pathera tigris tigris*). Tigers were kept individually in 30 m^2 (6m X 5m) pens except the two female Bengal tigers, which shared two pens together. Tigers had the opportunity to stay outside in their playground for some time

each day. Two tigers shared a playground, which they used alternatively. Tigers were fed at about 1500h everyday. Each tiger was given about four kg beef and two kg lamb, but no live food. Once a week, they had a non-feeding day. There was a breeding program at this zoo, with the primary aim of maintaining the number of the tigers at the zoo.

3.2.1.2 Beijing Wildlife Park

Beijing Wildlife Park is in the South of Beijing. The park covers about 0.36 km^2. There are not many visitors during the winter, but during holidays there are many visitors. There were 19 tigers in this park. Two were Bengal tigers, and nine were Siberian tigers. There were also eight cubs of undetermined species. At night, the adult tigers were kept in individual pens. The adult tigers were divided into two main groups according to their origins, that is, the groups from which they were imported into the park. In daytime, the two groups would go into a large playground alternatively. When tigers from one group were in the playground, three or four of them would share it together.

All of the cubs were kept together. They shared two pens during the night and shared one small playground during the day. Tigers were fed at about 1600h. As at the Beijing Zoo, adult tigers had one day per week with no food. The food for adults was four kg beef and 1.5 kg lamb ribs for one male per day and 3.5 kg beef and 1.5 kg lamb ribs for one female per day. Adult tigers could also get live food during the day when they were in the playground. Each cub got two kg beef and one kg lamb ribs per day, and they did not have a non-feeding day. Cubs received live food once a week. The Beijing Wildlife Park pursued a breeding programme, but as at the Beijing Zoo, This was not for conservation.

3.2.1.3 Haerbin Siberia Tiger Park

The Haerbin Siberia Tiger Park is the main conservation park for Siberian tigers in China. It is located in Haerbin, Heilongjiang Province, in Northeast of China. This

park comprises 1.44 km^2. Similar to the Beijing Wildlife Park, there are few visitors in winter, but a lot during holidays. There were more than 300 tigers in this park. Tigers here were usually kept outside after they were more than one-year of age. They shared huge playgrounds. These tigers were divided into groups by their age and function. These groups were a one-year-old group, a two-three-year-old group, a breeding group, an adult group, an elder group, and a tiger-lion group. Tigers were fed in the afternoon at about 1600h. Tigers would get live food everyday if visitors ordered it for them and they did not have a non-feeding day during a week. Breeding programmes were carried on in this park specifically for conservation. Tigers from here may be sent back to the wild in the future.

3.2.2 Observation

The total time spent in tiger observation was three weeks. One week (Monday to Friday) was spent in each facility. I observed both the individual and social behaviour of these tigers.

3.2.2.1 Individual observation

At the Beijing Zoo, each tiger was held in isolation. I chose five Siberian tigers to observe. Each tiger was observed for one day from about 0800h-1700h. Four of the tigers were observed inside, and the other one outside. For those inside, I sat near the pen of the tiger, and recorded everything the tiger did during the observation period, including eating, resting, sleeping, drinking, rubbing, pacing, vocal communication, playing with toys, and urinating. Outside, I sat where I could see the tiger clearly on the playground, and recorded everything the tiger did.

3.2.2.2 Group observation

I observed group behaviour at both the Beijing Wildlife Park and the Haerbin Siberia Tiger Park. The tigers could hide themselves in the playgrounds, and it was hard to find a good place to observe the tigers and record everything. Therefore, I

sometimes went into the playground in a car driven by a staff member and recorded behaviour patterns from the car. When outside of the playgrounds, I observed from sites with a view of some tigers, and recorded their behaviour.

At the Haerbin Siberia Tiger Park, I spent two hours (1120h-1320h) with the Breeding Group. I stayed in a car with a Park staff member and we did not move the car during these two hours. The tigers' behaviours were recorded every five minutes. Because the playground was big and there were eight tigers, it was not possible to record every tiger every time. However, I recorded the behaviour of all the tigers that I could see.

3.3 Results

3.3.1 Tigers at Beijing Zoo

The tigers held inside spend a lot of their daytime resting. Furthermore, they did stereotypic pacing. During the normal workdays (0800h-1600h, Monday to Friday), tigers had a rest time from about 1000h to about 1300h. The stereotypic pacing peaked in the morning, about 0800h-0900h, and around feeding time from about 1400h-1600h.The stereotypic pacing was either along the bars from side to side; or around the pen along the walls. When tigers were pacing along the pen, they rubbed their head against the cage. Although there were always many noisy visitors at Beijing Zoo, the tigers did not appear to be disturbed. Some of them would sleep despite the noise. Some pens were enriched with branches, tyres and beds, and the tigers appeared to enjoy this enrichment, especially a female Siberian tiger called Jiajia. She was observed to play with a tyre eight times during the day. The tigers at the Beijing Zoo often cleaned themselves, used their voice to communicate with other tigers and zoo staff, and used their paws to push at the doors that led to outside playground.

The outside tigers spent all their time at rest. They were released into the playground at about 0830h. They would find a place where visitors could not disturb them and then sleep for most of the day. These tigers only moved in the afternoon at about 1500h, before the feeding time, and they paced around the door. The feeding

time for outside tigers, about 1630h, was later than for inside tigers. Outside tigers did much less stereotypic pacing then inside tigers. For outside tigers, the stereotypic pacing peak time was in the morning when they were just released into the playground. This was also the time when outside tigers were most active. They walked around the playground and did scent marking on trees and the corners of the playground. Cleaning behaviour, voice communication and door pushing were also observed in outside tigers. They used voice communication and door pushing more often together when they wanted to go back to the inside.

3.3.2 Tigers in Beijing Wildlife Park

The tigers that were kept inside during the day had fewer interruptions from humans, compared with the tigers in Beijing Zoo. Voice communication, rubbing, and playing with staff were observed.

The outside tigers in Beijing Wildlife Park rarely did stereotypic pacing, and they did not really have a sleep time during the day although they often did nothing. Because the playground for these tigers was big, they could choose to isolate themselves from other tigers. However, some of these tigers were observed to stay together peacefully. Perhaps because the observation period was just before the breeding season, breeding behaviour was observed between some tigers, even between male tigers. Because the two groups went to the playground alternatively, tigers in both groups did a lot of scent marking in the playground after the other group. They sprayed on trees and rubbed the trees with their heads and bodies. All these tigers would pace around the entrance door at feeding time, which was about 1600h-1630h. During the day, if visitors went into the playground, the tigers would be more active if the visitors brought them live food, such as a chicken. However, zoo staff reported that in the hot season, tigers would ignore the visitors and chose to rest.

Cubs less than one year old were kept together both inside and outside. They were kept separately from the adult tigers, but they could see each other. One female Bengal tiger tried to play and teach these cubs since they were kept adjacent. These

cubs had live food once a week. It was common for them to play together just as kittens do.

3.3.3 Tigers in Haerbin Siberia Tiger Park

Most of the tigers in the groups at the park were friendly with each other. There were still some sensitive animals, but they could choose their own space in the huge playground and avoid each other. In the one-year-old group and the two-three-year-old group, most of the tigers were observed resting together in cold winter in the morning before staff and visitors entered the park. The behaviour of adult groups, however, was different. In the adult groups, tigers stayed together, but they did not have physical contact with each other, and they divided into small groups. Playing was observed in young age groups, but not in adult groups. Because the observation period was in December, which was near the breeding season, mounting behaviour was observed between young tigers, especially young males, and adult couples. When tigers rested together, some of them would allogroom each other. Since the tigers usually stayed in the same playground for a long time, scent marking was not observed a lot. Stereotypic pacing was not observed in Haerbin Siberia Tiger Park.

The tigers at Haerbin Siberia Tiger Park were not observed to rest during the day. During one noontime rest observation, tigers in the breeding group showed more pacing than resting. The behaviour of tigers in Haerbin Siberia Tiger Park was similar to the behaviour of tigers Beijing Wildlife Park. They were more active when visitors went into the playgrounds since they might get live food from them. From my observation, the reason that tigers were less active during noontime was because there were few visitors around.

Tigers were fed at about 1600h in the afternoon. Before the feeding car went into the playgrounds, most of the tigers would gather around the door, pacing, and when the car was in their playground, tigers would run after the car until they got the food.

3.4 Discussion

The captive environment influences the behaviour of the animals. Tigers showed different behaviour patterns in the different captive regimes. Siberian tigers, which were kept in cages at all-times, expressed significantly more resting behaviour during the day than the tigers that were kept outside (Liu et al., 2004). Tigers from Beijing Zoo showed more resting than tigers at the other two parks. Teng et al. (2003) indicated that Siberian tigers in Haerbin Zoo had a resting peak around 1000-1400h and pacing peaks around 0500-1000h and again from 1400-1700h. Tigers in Beijing Zoo showed similar pacing peak times to the tigers in Haerbin Zoo. Teng et al. (2003) found that Siberian tigers rested less during the day in winter than at other seasons. This might be the reason why the peak time for resting of tigers in Beijing Zoo was less than for the tigers from Haerbin Zoo, since my observation was carried on in the winter. Liu et al. (2002) found that tigers from Haerbin Siberia Tiger Park had a resting peak around noontime. However, from my observation, tigers in both Beijing Wildlife Park and Haerbin Siberia Tiger Park did not have this resting peak, but were less active at midday. The reason why tigers were less active at noontime was probably because few visitors were around, and fewer visitors meant less live food for the tigers.

Rouck et al. (2005) found that tigers kept in different social housing conditions showed different behaviour patters. When tigers were kept in pairs, they expressed less pacing than tigers kept singly. This may explain why tigers in parks paced less than tigers outside during the day in Beijing Zoo. That is, the groups of tigers may be in a similar condition to the pair described in Rouck et al.'s study. Rouck et al. (2005) also indicated that when tigers were kept individually with neighbouring conspecifics, they showed more stressful behaviour, such as pacing. Although tigers from Beijing Zoo showed more pacing than the other two parks, it could not be concluded that the reason was that tigers in Beijing Zoo had neighbouring conspecifics. There are also be other possible reasons, such as limited cage captivity and more visitors.

Chapter Four: Conclusion

4.1 Thesis conclusion

Most species of wild cats are solitary. However, in captivity, these cats are often held in groups and most of them adapt to it reasonable well. Because habitat loss is considered to be a reason for the population decline of wild cats, especially the big cats, such as tigers (Burton, 1987), keeping wild cats at higher population densities would be useful for wildlife conservation. Thus, we need to understand the social behaviour of wild cats at high population densities in order to pursue one avenue of conservation management. It is impossible, however, to study the social behaviour of wild cats easily in the wild. Thus, it would be good study them in captivity and to use domestic cats as a model to study cat social behaviour in general. Domestic cats are usually accepted as living solitary animals. However, colonies of free living domestic cats are often observed, when the food supply is plenty (Bradshaw, 1992; Case, 2003). Domestic cats retain some of the wild behaviours of their ancestor, the African wild cat (Case, 2003). Moreover, observations from my study show that domestic cats in laboratory cages and tigers in free-ranging parks share many social behaviour patterns, such as allogrooming, allorubbing, resting together, eating together, threatening, fighting, and displacing. Therefore, the domestic cat is a good model to develop techniques to study the behaviour of tigers.

I observed tiger behaviour at three different captive facilities in China (the Beijing Zoo, the Beijing Wildlife Park, and the Haerbin Siberia Tiger Park) and domestic cats at the Heinz Wattie Feline Unit at Massey University, Palmerston North, New Zealand.

My study showed that domestic cats are significantly more aggressive to strange cats than to familiar group members. This suggests that when tigers are formed into groups, it is better to let the tigers have visual contact and limited tactile contact before moving them together, because the process of familiarisation could reduce aggression level (Burks et al., 2004).

I found that as the age differences between domestic cats increased, the rate of agonistic behaviour decreased significantly. Age may be related to the hierarchy of the animal group (Knowles et al., 2004; Jennings et al., 2006), i.e., animals of a similar age may be more aggressive to each other in order to compete for a higher rank in the group. Weight may also relate to the hierarchy of the animal group. Animals of similar weight may compete for a higher rank just as animals of similar age do (Vandenbos and Buning, 1994). My study shows that domestic cats had significantly more affiliative interactions as the weight difference between members of the dyads increased. Therefore, it would be helpful to form tiger groups comprising animals of different ages (young adults, adults, and old adults) to reduce the rates of aggression. Moreover, different age tigers may have different body weight, and this may further reduce aggression in the formed groups.

Neutered male and intact female domestic cats do not show behavioural differences in my study, which is similar to the results from other studies (Crowell-Davis et al, 2004; Wolfe, 2001). However, intact females were more aggressive in oestrus, which suggests that when female tigers are in oestrus, it would be better to keep them apart.

Kinship plays a significant role in an animal's social and reproductive interaction (Lacey and Wieczorek, 2004). Domestic cats in my study, however, showed no significant differences in their rates of affiliative or agonistic interactions between different relatedness levels (coefficient of relatedness: 0, 0.25, 0.5). This may be a result of the breeding management of the Feline Unit and the familiarity between every individual. Despite the insignificant result, domestic cats related at the 0.5-level had a lower rate of agonistic interaction than cats less related to one another. This indicates that close relatives may be less aggressive toward each other (Kapsalis and Berman, 1996a; Kapsalis and Berman, 1996b). This suggests that when keep tigers in groups, it might be good to keep siblings or relatives together before they are mature. However, to avoid inbreeding, relatives should be separated during breeding season.

My observations from the three captive tiger facilities suggest that big cats in captivities need comparatively more space than just small cages. Also, they need more

natural elements in their playground enrichment. Those kept in small cages particularly need enrichment such as branches and toys.

My study indicates that observation time would be better at early evening and early morning because at these times, cats are more active. The following affiliative and agonistic behaviours are recommended for use in social behaviour observation: allogrooming, allorubbing, resting together, eating together, fighting, displacing, chasing, and threatening. Observation is better to be done without other people around because cats may change their behaviour when people are around. Identification of individual animals is necessary when observing social behaviour; therefore, pilot observations are necessary to learn how to identify every individual.

Further study needs to be done to understand kinship and sex influences on domestic cats' social behaviour. These were different to investigate in my study because there are some biases, such as the neutered males, the related ancestors, and the familiarity of all the cats. Also, because there are some limits in my observation of tigers, such as limited time, too many visitors, lack of data, and special observation season, more observation of tigers in free-ranging parks needs to be carried out, especially without visitors and staff around, to help release tigers back to the wild.

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Appendix.

Information about the cats

*: Titan is the only entire male in the observed cats

**: The data about these cats was not used in the analysis

Name	Sex	Age	Weight (gram)	Pen	Pen (Previously)
Rua	Female	9	3599	1, 1(new)	1
Suede	Female	8	3348	1, 1(new)	1
Kola	Female	9	3617	1, 1(new)	5
Fya	Female	9	3099	1, 1(new)	10
Tori	Female	9	3018	1, 1(new)	15
Shine	Female	8	3040	1, 1(new)	9
Deb	Female	8	3161	1, 1(new)	6
Asia	Female	7	3399	1, 1(new)	7
Chyna	Female	7	3796	1, 1(new)	5
Crest	Female	6	3465	1, 1(new)	7
Titan	Male*	7	4096	1(new)	13
Coppa	Male	10	5895	4	4
Zeal	Female	2	3751	4	1
Astra	Female	7	3295	4	1
Flame	Male	5	6036	4	1
Stella	Female	2	4215	4	18
Xena	Female	6	5096	4	4
Mara	Male	9	4612	4	4
Rade	Male	3	5041	4	4
Jesse	Male	9	4163	5	5
Star	Male	11	4566	5	5
Evet	Female	3	4792	5	5
Tama	Male	9	3738	5	5
Hobo	Male	9	4672	5	5
Casey	Male	8	3423	5	5
Jaffa	Female	8	3562	5	4
Spice	Male	9	4299	5	5
Misty	Male	8	3944	6	6
Puff	Female	8	3525	6	6
Puihi	Male	6	6304	6	6
Rover	Male	8	4779	6	6
Tang	Female	10	3782	6	6
Argon	Male	9	5561	6	6
Wren	Female	7	3732	6	6
Nui	Female	9	2635	6	6
Kree	Female	12	2853	7	4

Name	Sex	Age	Weight (gram)	Pen	Pen (Previously)
Lace	Female	4	4291	7, 7(new)	7
Maya	Female	6	3694	7, 7(new)	7
Broom	Female	8	3408	7, 7(new)	7
Spot	Male	7	4099	7, 7(new)	7
Luna	Male	4	4944	7, 7(new)	7
Dan	Male	5	4300	7, 7(new)	7
Mana	Male	9	4174	7, 7(new)	7
Dusky	Female	7	3922	7(new), 8	3
Buffy	Male	8	3818	8	1
Tass	Female	11	3272	8	8
Sioux	Female	3	3729	8	4
Tilly	Female	4	3394	8	11
Steel	Male	3	5050	8	14
Libby	Female	5	3444	8, 9	4
Sweep	Male	9	4267	9	9
Roz	Female	9	3059	9	9
Inga	Male	9	4242	9	9
Kruz	Male	6	3455	9	9
Tor	Male	7	4999	9	9
Jona	Male	9	3633	9	9
Lady	Female	6	2335	9	9
Vanda	Female	8	2915	10	4
Twink	Female	6	3572	10	15
Sox	Female	3	3203	10	8
Rach	Female	3	2936	10	15
Glade	Female	6	4200	10	8
Timothy	Male	3	5580	10	3
Ming	Female	4	3519	10	Metabolic
Mirim	Female	11	3332	**	15
Tea	Male	9	3748	**	15
Kaos	Male	6	4686	**	15
Zoe	Female	11	3172	**	9
Candy	Female	8	2889	**	8
Cody	Male	10	4798	**	8
Haze	Male	6	4805	**	8
Ryal	Male	7	5234	**	8
Peppa	Male	3	5082	**	8
Kahn	Male	8	4068	**	10
Coal	Male	6	4898	**	10
Jade	Female	5	2959	**	10
Onyx	Male	4	4581	**	10

Name	Sex	Age	Weight (gram)	Pen	Pen (Previously)
Ziggy	Female	8	2691	**	3
Kane	Male	7	5252	**	3
Kodak	Male	10	4151	**	3
Roil	Male	6	5245	**	3
Shade	Female	10	2480	**	3
Muffy	Female	8	2584	**	2
Tyla	Male	11	3047	**	2
Kala	Female	13	2698	**	2
Shay	Male	13	3862	**	2
Lorn	Male	10	3218	**	2
Shan	Male	4	4445	**	2
Kohi	Male	11	3764	**	1
Indy	Male	7	3513	**	15