



**DAILY ACTIVITY BUDGET OF COMMON
MARMOSSET (*Callithrix jacchus*) IN CAPTIVITY
AT ZOO JOHOR, JOHOR DARUL TAKZIM,
MALAYSIA**

by

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A report submitted in fulfillment of the requirements for the degree of
Bachelor of Applied Science (Natural Resources Science) With Honours

**FACULTY OF EARTH SCIENCE
UNIVERSITY MALAYSIA KELANTAN**

2017

DECLARATION

I declare that this thesis entitled Daily Activity Budget of Common Marmoset (*Callithrix jacchus*) in Captivity at Zoo Johor, Johor Darul Takzim, Malaysia is the result of my own research except as cited in the references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.

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ACKNOWLEDGEMENT

Alhamdulillah, first of all I would like to thank God as finally I am able to finish this final year project and I would like to express my sincere gratitude to my supervisor, Puan Aainaa Syazwani Bin Mohd Amir for the continuous support of my thesis project, for her patience, motivation and immense knowledge. Her valuable guidance helps me in all the time of this final year project and writing of this thesis. I could not have imagined having a better advisor and mentor for my research.

I also owe deep sense of gratitude to my beloved family especially my parents En Rohaizad and Puan Rozana for their never ending guidance, supports and motivation. My family is one of the reasons for my research completion

I thank profusely all lectures, my academic advisor and FYP coordinator, Miss Nivaarani and assessment. Besides that, I have to offer my special thanks to my teammates, Mohd Azfar, Nurul Ain, Nur Shabira and Nur Aimie for their co-operation, helps, support and motivation in order to finish this research. Besides, I also want to thanks to all my friends who never give up giving me advices and support during the process completing my work. I am thankful for all the love and caring showered on me that kept me going and finally finishing my work. Thank you all.

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**Bajet Aktiviti Harian Common Marmoset (*Callithrix Jacchus*) Dalam Kurungan
Di Zoo Johor, Johor Darul Takzim, Malaysia**

ABSTRAK

Aktiviti harian perlu dikaji bagi setiap spesies atau binatang sebelum menyediakan persekitaran yang baru di zoo. Bajet aktiviti untuk primat di zoo adalah perbezaan dari orang-orang di hutan. Satu kajian mengenai bajet aktiviti harian Common Marmoset (*Callithrix jacchus*) dalam kurungan telah dijalankan di Zoo Johor, Johor Darul Takzim dari 15 Ogos hingga 4 September 2016. Tujuan kajian ini adalah untuk menentukan aktiviti-aktiviti harian yang paling kerap dilakukan oleh Common Marmoset (*C. jacchus*) dalam keadaan tawanan dan untuk membandingkan tingkah laku Common Marmoset (*C. jacchus*) berdasarkan umur dalam keadaan kurungan. Dalam kajian ini, kaedah persampelan imbasan telah digunakan untuk 7 tingkah laku harian di kalangan 3 orang dewasa, 3 remaja dan bayi. Tingkah laku pergerakan adalah aktiviti harian yang paling kerap yang dilakukan oleh Common Marmoset manakala tingkah laku pertempuran adalah yang paling rendah tingkah laku aktiviti harian. Dengan menggunakan Chi-square, terdapat aspek isi bahawa terdapat perbezaan yang signifikan dalam kesemua tujuh tingkah laku sejak $p \leq 0.05$. Dalam kajian ini, analisis varians (ANOVA) digunakan untuk menguji perbezaan yang signifikan antara peringkat umur. Bagi orang dewasa, terdapat perbezaan yang signifikan since $p \leq 0.05$ iaitu 0.002. Bagi juvenils, terdapat juga perbezaan yang signifikan since $p \leq 0.05$ iaitu 0,001 manakala bagi bayi, tiada perbezaan yang signifikan di antara mereka. Kesimpulannya, kajian ilmiah ini adalah penting untuk menambah pengetahuan dan faham tentang bajet aktiviti harian biasa Common Marmoset di Zoo Johor yang boleh memberi sedikit pengetahuan kepada pengurusan yang berkesan dan pemuliharaan spesies ini pada masa akan datang sama ada ex-situ atau in-situ.

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**Daily Activity Budget of Common Marmoset (*Callithrix Jacchus*) In Captivity at
Zoo Johor, Johor Darul Takzim, Malaysia**

ABSTRACT

Daily activity should be studied for each species or animals before providing a new environment in the zoo. The activity budget for primates in the zoo is different from those in the forest. A study on the daily activity budget of Common Marmoset (*Callithrix jacchus*) in captivity has been conducted at Zoo Johor, Johor Darul Takzim from 15 August until 4 September 2016. The aim of this study was to determine the most frequent daily activities performed by Common Marmoset (*C. jacchus*) in captive condition and to compare the behaviours between the ages of Common Marmoset (*C. jacchus*) in captive condition. The scan sampling method was used to observe the 7 daily behaviours among the 3 adults, 3 juveniles and a baby in this study. Locomotion behaviour is the most frequent daily activity that performed by the Common Marmoset whereas the fighting behaviour is the lowest daily activity behaviours. By using Chi-square, there are shown that there are significant differences in all seven behaviours since the $p \leq 0.05$. In this research, analysis of variance (ANOVA) was used to test the significant differences among the ages. For the adult, there are significant differences since the $p \leq 0.05$ which is 0.002. For the juveniles, there are also significant differences since the $p \leq 0.05$ which is 0.001 whereas for the baby, there are no significant differences among them. As conclusion, this scientific research is important in order to add knowledge and understand about the daily activity budget of Common Marmoset in the Zoo Johor which can lead to the effective management and conservation of this species in the future either ex-situ or in-situ.

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LIST OF SYMBOLS

mm	Milimeter
in	inch
oz	ounce
g	gram
ha	hectare



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CHAPTER 1

INTRODUCTION

1.1 Background Study

Animal behaviour is the study of everything that animals do. It can help to understand when and why, the animal acts. Animal behaviour includes communication, navigation, foraging, mating, parenting and social cooperation (Hailman, 1977). According to Hailman (1977) behaviour is the key link between the animal and its environment and the way the animal establishes and maintains itself in their ecological niches. Animal behaviours are characterized by entropic and energetic transductions by organisms in which long term averages convert high entropic and low energy energetic inputs into low entropic and high energetic outputs (Hailman, 1977).

Social behaviour is the interaction that occurs between two or more individual animals of same species and response towards different species (Alcock, 1989). Behaviour can be defined in term of a goal. For example, navigating to a burrow (Wehner, 2003), escaping a predator (Roeder, 1962), courting a mate (Bradbury & Vehrencamp, 2001), or fighting a rival (Naguib & Kipper, 2006).

Strong positive social relationship has been discussed as an important factor in explaining patterns of interactions in primate social groups (Cords, 2002). Cords and Aureli (2000) introduced a complex approach designed to measure social relationships. These authors defined three components that related to the quality of

the relationship between individuals which are value, security and compatibility. Only recently has this theoretical proposal been empirically tested, although it still necessary to carry out such as test using a standardized approach. The social system is effect by three main ecological factors which are distribution of resource, group size and predation (Pough, 2005).

An understanding of how animals divide up their activities throughout the day and the years is important to understand their lifestyles and to show in a general way how primates interact with their environment and invest the energy and time for survival and reproduction (Defler, 1995) .

Activity budget for primates in zoo are different from those in the forest (Krebs & Davies, 1993). Many serious ecological changes had occurred due to the increasing human population and development of agricultural areas (Else, 1991). Primates have to change their daily behaviour according to the environment to ensure their survival. Many studies have shown that the activity budgets vary by several environmental factors including diet, distribution and food sources (Passamani, 1998; Peres, 1993).

According to Angus (2005), daily activity should be studies for each species before providing a new environment in the zoo. This is because if the animal cannot adapt to a new environment, it will affect the behaviour of the animals. There are many studies that proved the activity budgets vary according to a number of environmental factors, including diet and the distribution and abundance of food sources (Milton, 1980; Rylands, 1982; Harvey, 1985; Oates, 1987; Ferrari, 1988; Mendes, 1989; Peres, 1993).

According to Atlmann (1974), Oates (1987) and Post (1981), diet and habitat structure are known to affect time spent activities because of trade-offs between obtaining food and the costs in energy of the activities. Habitat quality affects food availability and primates respond variably to changes in food availability (Defler, 1995; Li & Rogers, 2004).

The reaction of any wild animal habitat in a zoo environment will always be a challenge (Hosey & Goffrey, 2005). Historically, zoos have often housed different species together because in many cases it saves space. However, most of these exhibits did not involve mammals. It is only recently, and with much care and consideration, that zoos have begun to house mammals (especially primates) together (Hosey et al., 2009; Thomas & Maruska, 1996).

A zoological park is a location where animals are kept in captivity for study and viewing. The zoo originally evolved from the menageries of the ancient world, in which royalty would display its collection of exotic species. These were not the scientific institutions we can find today. Unfortunately not all zoos are scientific in nature, and extreme controversy has arisen over how the animals are treated. Suffice to say, regulation is necessary to ensure proper care. Conservation (not exploitation) should always be the central goal behind any legitimate zoo.

Primates attract attention of many researchers because they are closely related to human in terms of human social behavior. According to Chalmers (1979), primates are social animals and most of them interact with each other in their species. Social behavior means any behavior involving another person (Kipper & Todt, 2002). Studies have shown that primate social behavior is more or less similar to

human behavior such as eating, playing, fighting, keeping the baby and others (Rod & Preston-Mafham, 1992).

A primate is a mammal of the order Primates. The primates are an ancient and diverse eutherian group with around 233 living species under 13 families. The smallest living primate is the Pygmy Mouse Lemur which is weight around 30 g. The largest is the gorilla which weight up to around 175 kg. Primates have two great groups which are Strepsirrhines and Haplorhines (Grove, 2005)

The common marmoset (*Callithrix jacchus*) is a small New World primate. It originally comes from the Atlantic coastal forests in northeastern Brazil (Abbott *et al.*, 2003; Mansfield 2003; Carrion & Patterson 2012; Okano *et al.*, 2012; Tokuno *et al.*, 2012). Marmosets can be found in a number of forest habitats. They live in Atlantic coastal forests as well as semideciduous forests farther in land. They can also inhabit savanna forests and riverine forests (Ryland & deFaria, 1993). Marmosets are successful in dry secondary forests and edge habitats (Kinzey, 1997).

The Common marmoset monkey, *C. jacchus*, breeds more rapidly in captivity than any other primate (Mittermeier *et al.*, 1982). Marmosets adapt well to captive conditions (Mittermeier *et al.*, 1982). They are economical to maintain, usually produce twins, and because of their short generation interval, with sexual maturity at 18 months of age, can be established in captive, breeding colonies, self-sustaining in a fraction of the time and the cost of greater, more conventional, laboratory primates (Mittermeier *et al.*, 1982).

Common marmosets have a complex mating system. Though they have been studied in captive settings since the 1960s, the social structure of wild common marmosets is less well known than other reproductive and behavioral characteristics

(Digby 1995; Ferrari & Digby 1996). Long thought to be monogamous, evidence from recent field studies shows that they have a social structure that revolves around a stable, extended family unit with a few dominant breeding individuals and flexible mating behavior (Digby & Barreto, 1993; Digby, 1995; Ferrari & Digby, 1996; Sussman, 2000).

Marmosets will also eat fruits, seeds, flowers, fungi, nectar, snails, lizards, tree frogs, bird eggs, nestlings, and infant mammals (Stevenson & Rylands, 1988). One of the defining social behaviors of common marmosets is their system of cooperative breeding and infant care (Digby & Barreto, 1993; Digby, 1995; Sussman, 2000).

Common marmosets employ a number of vocal and visual communications. To signal alarm, aggression and submission, the marmosets use the "partial open mouth gaze," "frown," and "slitstare", respectively. To show fear or submission, marmosets flatten their ears near close to their heads (Stevenson & Rylands, 1988). The common marmoset remains an abundant species and are not currently threatened. However, their habitat had been degraded at great speed, with about 67% of the cerrado region cleared for human use in the 1990s and about 80% cleared for the most recent crop (Cavalcanti & Joly, 2002). In addition, marmosets are captured and traded as pets. Although popular as pets, they become difficult to control as they get older and therefore, abandoned or killed (Duarte-Quiroga & Estrada, 2003).

The genome of a female marmoset was published in 2014. According to Baylor College of Medicine (2014), it became the first nonhuman primate, among the New World Monkeys, to have its complete genome sequenced. The genome size is 2.26 Gb, and contains 21,168 genes. Segmental duplications added a total of 138

Mb of nonredundant sequences (4.7% of the whole genome), slightly less than observed in human (Venter, 2001) or chimpanzee (~5%) but more than in orangutan (3.8%) (Venter, 2001).

1.2 Problem Statement

In order to understanding the behaviour, the daily activity must be studies. This is because, according to Angus (2005), to create the new and better environment for animals, the daily activity research must be carried out. From this study, it can show if the animal is under stress or can adapt the new environment. Therefore, this study is important to develop knowledge about the social behaviour of the Common Marmoset, (*C. jacchus*), living in the zoo and to understand the budget of the daily activity of the Common Marmoset.

1.3 Objective

1. To determine the most frequent daily activities performed by Common Marmoset (*C. jacchus*) in captive condition.
2. To compare the behaviours between the ages of Common Marmoset (*C. jacchus*) in captive condition.

CHAPTER 2

LITERATURE REVIEW

2.1 Primates

A primate is a mammal of the order Primates. The primates are an ancient and diverse eutherian group with around 233 living species under 13 families. The smallest living primate is the Pygmy Mouse Lemur which is weight around 30 g. The largest is the gorilla which weight up to around 175 kg. Primates have two great groups which are Strepsirrhines and Haplorhines (Grove, 2005).

For the Strepsirrhines, it have naked nose, lower incisors forming a toothcomb and no plate separating orbit from temporal fossa. Many Strepsirrhines have 'toilet claw' to use in grooming (Thorington & Anderson, 1984).

Haplorhines are called 'higher' primates. They have furry noses and a plate separating orbit from temporal fossa and lacking of a toothcomb (Thorington & Anderson, 1984). Including many more species, the Haplorhines is widely distributes and play the most important in ecological role. Haplorhines have two major groups which are the Platyrrhini and the Catarrhini (Thorington & Anderson, 1984).

Platyrrhini has flat noses, outwardly directed nasal opening, three premolars in upper and lower jaws and anterior upper molars with three or four major crowns that found in the New World (Thorington & Anderson, 1984). Catarrhines have paired downwardly directed nasal opening and closed together. Usually, they have

two premolars in each jaw and four cups of anterior upper molars and they can found only in the Old World (Thorington & Anderson, 1984)

In 1758, the order of Primates was established by Carl Linnaeus, in the tenth edition of his book *Systema Naturae* (Linnaeus, 1758). There are two suborders which are suborder Strepsirrhini and suborder Haplorhini (Table 2.1).

Table 2.1: Order of Primates (Linnaeus, 1758)

Order	Suborder	Infraorder	Superfamily
Strepsirrhini	<ul style="list-style-type: none"> • Lemurs • Galagos • Lorisids 	<ul style="list-style-type: none"> • Lemuriforme 	<ul style="list-style-type: none"> • Lemuriformes <ul style="list-style-type: none"> ○ Family Cheirogaleidae : dawft lemurs and mouse-lemurs (34 species) ○ Family Daubentoniidae : aye aye (one species) ○ Family Lemuridae : ring-tailed lemur and allies (21 species) ○ Family Lepilemuridae : sportive lemurs (26 species) ○ Family Indriidae : woolly lemurs and allies (19 species) • Lorisioidea <ul style="list-style-type: none"> ▪ Family Lorisidae : lorisids (14 species) ▪ Family Galagidae : golagos (19 species)

Haplorhini	<ul style="list-style-type: none"> • Tarsiidae • Monkeys • Apes 	<ul style="list-style-type: none"> • Tarsiiformes • Simiiformes 	<ul style="list-style-type: none"> ▪ Family Tarsiiformes : tarsiers(11 species) • Parvorder Platyrrhini <ul style="list-style-type: none"> ▪ Family Callitrichidae: marmosets and tamarins (42 species) ▪ Family Cebidae : capuchins and squirrel monkeys (14 species) ▪ Family Aotidae : night or owl monkeys (11 species) ▪ Family Pitheciidae: titis, sakis and uakaris (43 species) ▪ Family Atelidae : howler, spider, wooly spider and woolly monkeys (29 species) • Parvorder Catarrhini <ul style="list-style-type: none"> ▪ Superfamily Cercopithecoidea <ul style="list-style-type: none"> ○ Family Cercopithecidae (138 species) ▪ Superfamily Homininoidea <ul style="list-style-type: none"> ○ Family Hylobatid
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			ae: gibbons (17 species) o Family Hominida e : great apes, including humans (7species)
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2.1.1 The Callitrichidae

The Callitrichidae are one of the families of New World monkeys, including marmosets and tamarins. At times, this group of animals has been regarded as a subfamily, called Callitrichinae, of the family Cebidae. This taxon was traditionally thought to be primate lineage, from which all the larger-bodied platyrrhines evolved (Hershkovitz, 1977). However, some works argue that callitrichids are actually a dwarfed lineage (Naish & Darren, 2012).

Ancestral stem-callitrichids likely were "normal-sized" ceboids that were dwarfed through evolutionary time. This may exemplify a rare example of insular dwarfism in a continental context, with "islands" being formed by biogeographic barriers and climatic periods in which forest distribution became uneven, and/or by extensive river networks in the Amazon Basin (Ford, 1980).

All callitrichids are arboreal. They are the smallest of the simian primates. They eat insects, fruit, and the sap or gum from trees; occasionally they take small

vertebrates. The marmosets rely quite heavily on tree exudates, with some species (e.g. *C. jacchus* and *Cebuella pygmaea*) considered obligate exudativores (Harrison & Tardif, 1994).

Callitrichids typically live in small, territorial groups of about five or six animals. Their social organization is unique among primates and is called a "cooperative polyandrous group". This communal breeding system involves groups of multiple males and females, but only one female is reproductively active. Females mate with more than one male and each share the responsibility of carrying the offspring (Sussman, 2003).

They are the only primate group that regularly produces twins, which constitute over 80% of births in species that have been studied. Unlike other male primates, male callitrichids generally provide as much parental care as females. Parental duties may include carrying, protecting, feeding, comforting, and even engaging in play behavior with offspring. In some cases, as in the cotton-top tamarin (*Saguinus oedipus*), males, particularly paternal ones, will even show a greater participation in care than females (Cleveland & Snowdon, 1984). The typical social structure seems to constitute a breeding group, with several of its previous offspring living in the group and providing significant help in raising the young.

2.1.2 Family Callitrichidae

In the Family Callitrichidae, there are 7 genera which categories in this family. The first genus is known as *Cebuella*. The species is Pygmy marmoset, (*C. pygmaea*) followed by, genus *Callibella* and its species is Roosmalens' dwarf marmoset (*C. humilis*).

The third genus is *Mico* and the species are Silvery Marmoset (*M. argentatus*), White marmoset (*M. leucippe*), Black-tailed marmoset (*M. melanurus*), Herskovitz's marmoset (*M. intermedius*), Emilia's marmoset (*M. emiliae*), Black-headed marmoset (*M. nigriceps*), Marca's marmoset (*M. marcai*), Santarem marmoset (*M. humeralifer*), Gold-and-white marmoset (*M. chrysoleucus*), Maués marmoset (*M. mauesi*), Satéré marmoset (*M. saterei*), Manicoré marmoset (*M. manicorensis*), Rio Acari marmoset (*M. acariensis*) and Randon's marmoset (*M. rondoni*).

Next is Genus *Callithrix*. The species are Common marmoset, (*Callithrix jacchus*), Black-tufted marmoset, Wied's marmoset, (*Callithrix kuhlii*), White-headed marmoset (*Callithrix geoffroyi*), Buffy-tufted marmoset (*Callithrix aurita*), Buffy-headed marmoset (*Callithrix flaviceps*). The fifth is Genus *Callimico* and the only one species is Goeldi's marmoset (*C. goeldii*).

For the sixth genus is known as Genus *Saguinus*. There are 15 species in this genus which are Black-mantled tamarin (*S. nigricollis*), Brown-mantled tamarin (*S. fuscicollis*), White-mantled tamarin (*S. melanoleucus*) Golden-mantled tamarin (*S. tripartitus*), Moustached tamarin (*S. mystax*), White-lipped tamarin (*S. labiatus*), Emperor tamarin (*S. imperator*), Red-handed tamarin (*S. midas*), Black tamarin (*S. niger*), Mottle-faced tamarin (*S. inustus*), Pied tamarin (*S. bicolor*), Martins's tamarin (*S. martinsi*), White-footed tamarin (*S. leucopus*), Cottontop tamarin (*S. oedipus*) and Geoffroy's tamarin (*S. geoffroyi*).

For the last genus is Genus *Leontopithecus*. The species that categories in these genus are Golden lion tamarin (*Leontopithecus rosalia*), Golden-headed lion

tamarin (*Leontopithecus chrysomelas*), Black lion tamarin (*Leontopithecus chrysopygus*) and Superagui lion tamarind (*Leontopithecus caissara*).

2.1.3 *Callithrix*

The name *Callithrix* is derived from the Greek words *kallos*, meaning beautiful, and *thrix*, meaning hair. *Callithrix* is a genus of New World monkeys of the family Callitrichidae that includes marmosets and tamarins. The genus contains the Atlantic Forest marmosets. The genera *Mico* and *Callibella* were formerly considered a subgenus of the genus *Callithrix* (Groves, 2005). *Callithrix* differs from *Mico* in dental morphology and in geographic distribution. *Callithrix* are distributed near the Atlantic coast of South America while *Mico* species are distributed further inland (Digby *et al.*, 2007). *Callithrix* differs from *Callibella* in these features, as well as in size, with *Callithrix* species being significantly larger (Digby *et al.*, 2007). *Callithrix* species differ from the tamarins of the genus *Saguinus* in that *Callithrix* has enlarged mandibular incisor of teeth the same size as the canine used to pierce holes in the trees to expel exudates (Rowe, 1996).

Species included in the genus *Callithrix* include:

- Common marmoset, *Callithrix jacchus*
- Black-tufted marmoset, *Callithrix penicillata*
- Wied's marmoset, *Callithrix kuhlii*
- White-headed marmoset, *Callithrix geoffroyi*
- Buffy-headed marmoset, *Callithrix flaviceps*
- Buffy-tufted marmoset, *Callithrix aurita*

Some authorities, including Rosenberger (1981), believe that the pygmy marmoset, genus *Cebuella*, should be included within *Callithrix* based on genetic studies, although *Cebuella* is significantly smaller than *Callithrix*.

In general, *Callithrix* and *Mico* species tend to form larger groups and live in smaller home ranges, and therefore live at higher population densities, than other Callitrichids. But these statistics can vary dramatically among various *Callithrix* species. *C. jacchus* and *C. pincillata* usually have home territories of origin of less than 10 hectares, while other *Callithrix* species tend to have larger home territories of origin (Digby *et al.*, 2007).

Exudates such as gum and sap, fruit, nectar and fungus make up most of the diet of *Callithrix* species, but also feed on animal prey such as arthropods, young birds, lizards and frogs. They are specialized to exploit the exudates by their elongated, lower incisor chisels and a broad jaw that allows them to cut the bark of the gum producing trees. Their intestines also have an enlarged and complex cecum that allows them to digest the gums more efficiently than most other animals. *Callithrix*' ability to feed on exudates allows it to survive in areas where fruit is highly seasonal or not readily available. Some species, such as *C. jacchus* and *C. pincillata* have been known to inhabit the city parks, backyards and coconut plantations (Digby *et al.*, 2007).

2.2 Social Behaviour

Social behaviour is the interaction that occurs between two or more individual animals of same species (Alcock, 1989). Behaviour can be defined in term of a goal. For example, navigate to a burrow (Wehner, 2003), escape from a predator

(Roeder, 1962), courting with mate (Bradbury & Vehrencamp, 2001), or defeating a rival (Naguib & Kipper, 2006).

Strong positive social relationship has been discussed as an important factor in explaining patterns of interactions in primate social groups (Cords, 2002). Cords and Aureli (2000) introduced a complex approach designed to measure social relationships. These authors defined three components that related to the quality of the relationship between individuals which are value, security and compatibility. Only recently has this theoretical proposal been tested empirically, although it remains for such tests to be carried out using a standardized approach. The social system is effect by three main ecological factors which are distribution of resource, group size and predation (Pough, 2005).

2.3 Common Marmoset

The common marmoset (*Callithrix jacchus*) is a New World monkey. It originally lived on the Northeastern coast of Brazil, in the states of Piauí, Paraíba, Ceará, Rio Grande do Norte, Pernambuco, Alagoas and Bahia (Macdonald & David, 1985). Through release (both intentional and unintentional) of captive individuals, it has expanded its range since the 1920s to Southeast Brazil and the first sighting in the wild for Rio de Janeiro was in 1929 and became invasive, raising concerns about genetic pollution of similar species, such as the buffy-tufted marmoset (*Callithrix aurita*), and predation upon bird nestlings and eggs (Brandao & Tulio, 2006).

The whole-genome sequence of a female common marmoset was published on 20 July 2014. It became the first New World Monkey to have its genome sequenced (Baylor, 2014).

2.3.1 Physical Description and Morphology

Common marmosets are very small monkeys with relatively long tails. Males and females are of similar size with males being slightly larger. Males have an average height of 188 mm (7.40 in) and females have an average height of 185 mm (7.28 in). Males weigh 256 g (9.03 oz) on average and females weigh 236 g (8.32 oz) on average (Rowe, 1996). The pelage of the marmoset is multicolour, being sprinkled with brown, grey, and yellow. It also has white ear tufts and the tail is banded. Their faces have black across their nose area skin and have a white blaze on the forehead (Grove, 2001). The coats of infants are brown and yellow coats with the ear tuft developing later.

As with other members of the genus *Callithrix*, the common marmosets have claw-like nails known as tegulae on most of their fingers. Only their halluces (big toes) have the flat nails or ungulae that most other primates have (Garber *et al.*, 1996). Marmosets have an arboreal locomotion similar to squirrels. They can hang on to trees vertically and leap between them, as well as run across branches quadrupedally (Rowe, 1996; Kinzey 1997). Tegulae are an adaptation of this type of locomotion. Other *Callithrix* traits shared include enlarged, chisel-shaped incisors and specialized cecums for their diet (Rowe, 1996).

2.3.2 Range and Ecology

Common marmoset is commonly found in gallery forest, semi deciduous and deciduous scrub forest and humid Atlantic forest of north-eastern Brazil. It is very adaptable, being able to live in urban parks and gardens and rural villages where it is not persecuted and has sufficient food. It has been introduced into many areas

outside of its natural range, where it is able to thrive and is believed to compete with and displace other (native) marmosets.

Marmosets and tamarins are distinguished from the other monkeys of the New World by their small size, modified claws rather than nails on all digits except the big toe, the presence of two as opposed to three molar teeth in either side of each jaw, and by the occurrence of twin births. They eat fruits, flowers, nectar, plant exudates (gums, saps, latex) and animal prey (including frogs, snails, lizards, spiders and insects).

Marmosets have morphological and behavioural adaptations for gouging trees trunks, branches and vines of certain species to stimulate the flow of gum, which they eat, and in some species form a notable component of the diet (Filho, 1972 & Rylands, 1994). They live in extended family groups of between four and 15 individuals. Generally, only one female per group breeds during a particular breeding season. *Callithrix jacchus* is a gum feeding specialist, with gouging lower incisors to excavate holes in gum producing trees to guarantee gum year round. This allows it to live in very seasonal habitats, including deciduous forests and scrub in the northeast of Brazil.

Associated with its specialization in gum feeding, it defends home ranges that are much smaller than are typical of the genus: 0.72 to 5.2 ha. Castro (2003) recorded home ranges of 0.3 to 2.4 ha at Nísia Floresta National Forest, Rio Grande do Norte. Maier *et al.* (1982) and Alonso and Langguth (1989) recorded home ranges of 25 ha in the urban district of João Pessoa, Paraíba, and according to Mendes Pontes and Monteiro da Cruz (1995), they recorded home range of 4 ha in an urban park in Recife, Pernambuco. Group sizes have been recorded to range from 2 to 15 at the

Tapacurá State Ecological Station, Pernambuco (Hubrecht 1985; Scanlon *et al.*, 1988). Usually one female breeds in each group. Twins are produced twice a year.

2.3.3 Diet

The common marmoset's claw-like nails, incisor shape, and gut specialization reflect their unique diet which is primarily made of plant exudates and insects. Common marmosets feed on gum, sap, latex, and resin (Kinzey, 1997; Rylands & de Faria, 1993). They use their nails to cling to the side of a tree and, with their long lower incisors, chew a hole in the tree (Ferrari & Lopes, 1989). The marmoset will lick up the exudates or swoop them with the teeth (Stevenson & Rylands, 1988). 20-70% of the marmoset's feeding behaviour is made of eating exudates (Rowe, 1996; Ferrari & Lopes, 1989).

Exudates provide marmosets with a reliable food source in the marmoset's seasonal habitat. They rely on these foods particularly between January and April, when fruit is not abundant. A marmoset may visit a tree hole multiple times; including those made by other animals. In addition to exudates, insects also prove an important food source for marmosets, making 24-30% of their feeding time. The small size of the marmoset allows them to subsist on insects, as well as stalking and ambush them (Ryland & de Faria, 1993) Marmosets will also eat fruits, seeds, flowers, fungi, nectar, snails, lizards, tree frogs, bird eggs, nestlings, and infant mammals (Stevenson & Rylands, 1988). It is possible that marmosets compete for fruit with birds, such as parrots and toucans, and with woolly opossums (Stevenson & Rylands, 1988).

2.3.4 Communication

Like all primates, vocal and visual communication is important to common marmosets. Facial expressions and vocalizations convey information about social status, emotional state, and intent to other individuals (Stevenson & Rylands, 1988). Because of their small size and the natural habitats they are found in, visual signals are important in close range communication while vocal communication is more important over longer distances (Jones, 1997). Some expressive facial and postural positions include the "partial open mouth stare," "frown," and "slit stare" which are used to signify alarm, aggression, and submission. When common marmosets flatten their ear tufts close to their heads in "tuft flatten" position, this signifies submission, fear, and sometimes curiosity of new objects (Stevenson & Rylands, 1988).

Common marmosets use vocal signals in a variety of situations including in response to unexpected movements and in threatening situations (Jones, 1997). Alarm calls in response to sudden movement include "staccatos," which are a series of short ascending calls, and "tsiks," that are brief descending calls given either alone or in a series. Alarm calls are brief, high pitched vocalizations that elicit fleeing behaviour from other group members and are given in response to threatening situations (Lazaro-Perea, 2001). There are some calls that are generally used and which lack obvious contextual connection including "phee" and "trill" calls (Jones, 1997). "Phee" calls have high sound intensity and sound like very loud, high pitched whistles. They are usually given in a series of one to five notes that last about two seconds each. They are important for long range vocal contact and play a role in mate attraction, maintenance of group cohesion, territorial defense, and location of lost group members (Jones, 1997).

"Trill" calls are also generic vocalizations, but sound much different from "phees." They have lower pitch and have cyclic frequency fluctuations that give them a distinctive vibrato sound. These calls are given by all animals of any age, sex, and status and their main purpose probably is to monitor group members by identifying and locating their position in low visibility areas (Jones, 1997).

Unlike the apes and Old World monkeys, smell is very important to New World monkeys. They have a specialized organ in their nasal cavity called the vomero nasal organ that allows them to process chemical signals in a focused manner and discern information about other animals (Evans, 2003). Because of the presence of this "second nose," scents are very important tools of communication in New World monkeys, and common marmosets convey information by marking objects with secretions from specialized scent glands on their chests and around their anus and genitals (Lazaro Perea *et al.*, 1999). The main information conveyed by scent marking includes demarcating home range and resources within that range, signifying social status, and advertising reproductive status (Stevenson & Rylands, 1988; Lazaro Perea *et al.*, 1999; Ziegler *et al.*, 2005).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Site

Established in 1928 by the late Johor King, Sultan Ibrahim Ibni Almarhum Sultan Abu Bakar, Zoo Johor is one of the oldest zoos in the country and also in Asia. Originally called an “animal garden”, the medium-sized zoo was handed over to the state government to manage in the 1960s. The Zoo Johor is located at Jalan Gertak Merah. It is at the heart of Johor Bahru. It is situated near to the Royal Museum and the Johor Bahru Palace Grounds. Still, the nearest landmark to the zoo is a mosque named Masjid Abu Bakar.

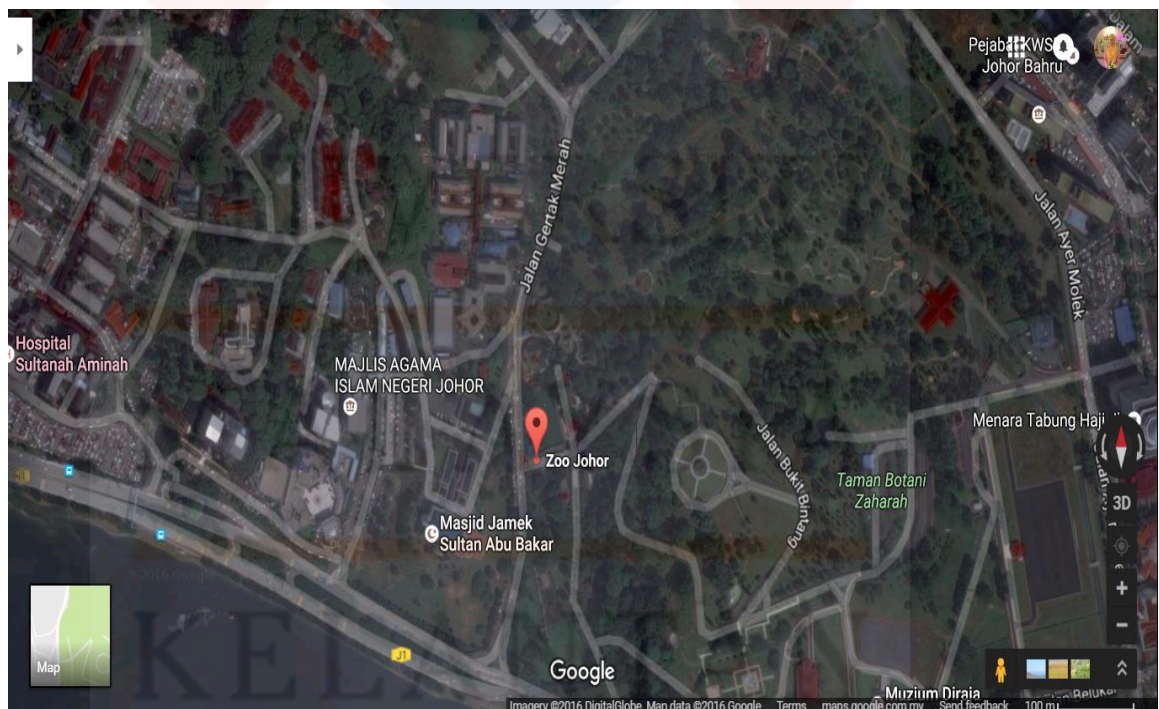


Figure 3.1: Map of Zoo Johor (Source: Google map)

There are more than 100 species of animals living in Zoo Johor including some endangered species. They are gorillas, elephants, flamingos, horses, lions and much more. Zoo Johor is open daily from 8 am to 6 pm and the entrance fee is just RM3. The zoo is clean and well organized with clean food selling around the stalls.



Figure 3.2: Front gate Zoo Johor (Source: <http://blog.pulaisprings.com/wp-content/uploads/2014/11/johor-zoo.jpg>)

3.2 Behaviour Sampling Method

3.2.1 Behaviour Observation

Behaviour observation was the main process that was being used to collect the data on the daily activity budget of common marmoset. The data observation was collected in every ten minutes interval and the observation data was collected by scan sampling. Scan sampling is the method for measuring primate activity budgets. In scan sampling, the behaviours of the whole individuals in a group of animals are recorded at predetermined time intervals (Altmann, 1974; Lehner, 1992). In order to reduce the bias, the surveys were stopped during rain.

The daily activity budget observation was made from morning, 0800 hours until 1800 hours. The observation started from 15 August until 4 September 2016. Preliminary non formal observation was carried out to determine the behaviour categories of the subjects (Md-Zain *et.al.*, 2008). Preliminary observation is critical for the observer to be familiar with the subjects and their behaviours, thus enabling them to choose the right measures and recording methods (Martin & Bateson, 1993).

A total of seven common marmosets which are three adult, three juvenile and a baby were kept captive in a cage. Behaviour observed included play, grooming, feeding / forage, rest, locomotion, communication and fight (Table 3.1).

Table 3.1 Description of the general behaviour of the Common Marmoset

Behaviour	Description
Resting	The animal is sitting or lying, with its tail hanging or coiled between the legs. The eyes may be open, half-closed or closed (Stevenson and Pool, 1976; Alonso and Langguth, 1989)
Grooming	The animal inspects the fur of another or own fur with the fingers to removes small residue for examples, ectoparasites with its hands or mouth (Stevenson and Pool, 1976; Alonso & Langguth, 1989).
Locomotion	The animal is moving from one place to another by climbing, jumping, walking and running (Alonso and Langguth, 1989)
Foraging	The activity related to the search for food, which can be plant or animal (Souto <i>et al.</i> , 2007; Schiel <i>et al.</i> , 2010)

Feeding	The act of eating or ingesting food such as animal and/or plant
Playing	The individual or social act that in a range of voluntary, motivated activities normally associated with recreational pleasure and enjoyment (Garvey, 1990)
Communication	The transferring information from one or group animals (sender or senders) to one or other group animals (receiver or receivers).
Fighting	Any social behaviour that related to aggressive behaviour which includes threats, displays, retreats placation and conciliation (Barrows & Edward, 2001)

3.3 Statistic Analysis

3.3.1 Analysis of Variance (ANOVA)

ANOVA is use to determine whether there are any difference between groups on some variable is tasted. ANOVA is available for parametric (score data) and non-parametric (ranking/ordering) data. In this research, the ANOVA was used to find any significance difference of difference behaviour between ages of Common Marmoset.

3.3.2 Chi-square

Chi-square is a statistical test commonly used to compare observed data with data we would expect to obtain according to a specific hypothesis. The chi-square test is always testing what scientists call the null hypothesis, which states that there is no significant difference between the expected and observed result. In this research, chi-square test will apply to analyse the behaviour data set obtained. This nonparametric test is suitable to analyse the significance of activity budgets that did not follow the normal distribution.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Introduction

The purposes of this scientific research are to determine the most frequent daily activities performed by Common Marmoset (*Callithrix jacchus*) in captive condition and to compare the daily activities among the ages of Common Marmoset (*C. jacchus*) in captive condition.

This research was made from 0800 hours in the morning until 1800 hours in the afternoon at Zoo Johor, Johor Darul Takzim. There are twenty-one days of observation had been done starting from 15 August until 4 September 2016. These observations were carried out to determine the daily activity budget of the Common Marmoset by using the scan sampling method. Scan sampling method is the method for measuring Primate Activity budget. The scan sampling technique is most appropriate for collecting data in this research to compare the behaviour pattern of different ages of Common Marmoset. It is because this technique can be used to produces the estimation of the percentages of time engaged in specific activities by members of each group of ages. There are seven in the total of Common Marmoset which are three adults, three juvenile and a baby that had been observed.

4.2 The frequent daily activities performed by Common Marmoset

Seven daily behaviours of Common Marmoset were monitored during observation. Based on the observations in figure 4.1, the Common Marmoset provides a lot of their time to perform locomotion or moving activities (45.32%) followed by grooming behaviour (15.74%), resting or not moving (10.92%), playing (10.87%), communication (9.47%), forage or feeding (7.17%) and the lowest daily activities is fighting (0.78%). From the Chi-square test, the results showed that all seven daily activities have the significant difference. (Chi-square = 4651.857, $p \leq 0.05$, $df = 6$).

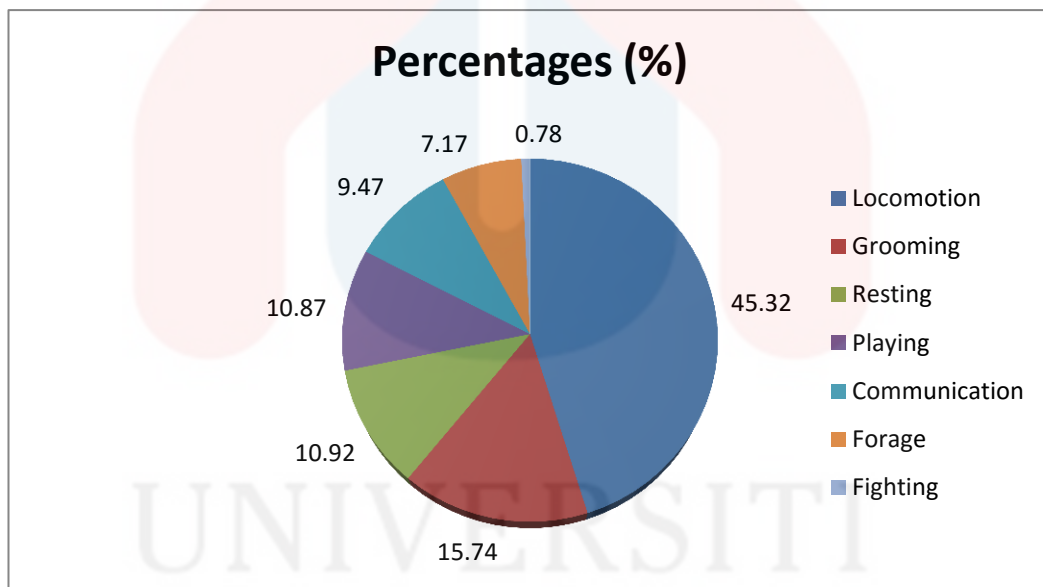


Figure 4.1: Percentage of time allocated to different activities.

4.2.1 Locomotion

In ethology, animal locomotion is any of variety of movements or methods that animals use to move from one place to another place (George, 2016). Locomotion is the most observed daily activity of Common Marmoset. Common Marmosets have an arboreal or tree-living locomotion similar to squirrels (Rowe,

1996). According to Stern and Oxnard (1973), primates can stand, sit lie, walk run, hop, leap, climb, hang, swing, swim and engage in other activities too many to mention. They may do these activities often or several times, quickly or slowl, with agility or clumsiness, on the ground or in the trees, on difference size of branches with all appendages or only some (Stern & Oxnard, 1973). For the Common Marmoset, they can hang on trees vertically and leap between them and can run across branches quadrupedally (Rowe, 1996; Kinzey, 1997). Quadrupedally or quadrupedalism is the one of the spectrum of primate locomotor modes (Napier & Napier, 1967). Quadrupedalism is an animal that walking or moving by using their four limbs.

From the observation, the Common Marmoset usually moving in order to forage or feeding the baby, to fight or playing.

4.2.2 Grooming

The second highest activity that has been observed was grooming behaviour. Usually, the Common Marmoset in the Zoo Johor will do grooming one another while resting. Most of the grooming activities were carried out by the females, especially for adult females with baby. The affiliative interaction such as grooming behaviour between mother and baby is related to establishment and maintaining of pair-bond and can strengthen the relationship between them (Epple, 1970; Evans & Poole, 1983; Soini, 1987; Mota *et al.*, 1995). At certain times, the younger of Common Marmoset can be observed grooming the other adults Common Marmoset. This may be due to the hierarchy factor where the higher Common Marmoset gets more grooming than the lower hierarchy.



Figure 4.2: Self-grooming

4.2.3 Resting

The third highest activity that has been observed was resting. Normally, the Common Marmoset taking rest in the afternoon which is very hot at that time. The place which is common for the Common Marmoset to rest is at the branches of trees, and also under trees. While resting, Common Marmoset would normally take a nap by lying on the tree branch.

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Figure 4.3: Resting Behaviour

4.2.4 Playing

The next daily activity that had been observed was playing behaviour. This behaviour is often done by the infant and juvenile categories. The playing behaviour may form a social competition and juveniles are in their active age period to learn on social relations. The adult of Common Marmoset appears to be always monitoring their infant during play and sometimes they also play with their infant. This is intended to keep their children from attacks by predators and also to teach them to live in their society. The behaviours that can be categorized as playing in the study area are wrestling, chasing, swinging on the tree branches, playing with objects, biting mockery, playing with water, and pulling their tails to play with one another.



Figure 4.4: Playing behaviour

4.2.5 Communication

Vocalization behaviour or communication becomes the fifth highest behaviour that has been observed at the study location. Usually, the common marmosets produced the vocal during playing, mating and fighting. The common marmosets are also found to produce vocal warnings to inform members of the group that there are predators around. Alarm calls in response to sudden movement include "staccatos," which are a series of short ascending calls, and "tsiks," that are brief descending calls given either alone or in a series. Alarm calls are brief, high pitched vocalizations that elicit fleeing behaviour from other group members and are given in response to threatening situations (Lazaro-Perea, 2001).

There are some calls that are generally used and which lack obvious contextual connection including "phee" and "trill" calls (Jones, 1997). "Phee" calls have high sound intensity and sound like very loud, high pitched whistles. They are usually given in a series of one to five notes that last about two seconds each. They

are important for long range vocal contact and play a role in mate attraction, maintenance of group cohesion, territorial defence, and location of lost group members (Jones, 1997). "Trill" calls are also generic vocalizations, but sound much different from "phees."

They have the lower pitch and have cyclic frequency fluctuations that give them a distinctive vibrato sound. These calls are given by all animals of any age, sex, and status and their main purpose probably is to monitor group members by identifying and locating their position in low visibility areas (Jones, 1997).

4.2.6 Feeding or Forage

The seventh highest activity that has been observed was feeding or forage. In the wild, marmosets primarily eat plant exudates and insects along with fruits, seeds, flowers, snails, lizards, and infant mammals (Abbott *et al.*, 2003). In the Zoo Johor, the Common Marmoset eats vegetable and fruits which are given by zoo keeper every morning at 0800 hours and 1800 hours in the afternoon.



Figure 4.5: Forage



Figure 4.6: Self-feeding

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4.2.7 Fighting

Fighting behaviour is the last behaviour and least observed at the study area. Fighting behaviour in the study area is usually done by common marmoset to snatch food. Fighting behaviour is often committed by males Common Marmoset compared to females. This is because the males want to be the leader or to be dominant in the group.

4.3 Behaviour among the ages

In this research, analysis of variance (ANOVA) was used to test the significant differences among the ages. From the table 4.1, for the adult, there are significant differences since the $p \leq 0.05$ which is 0.002. For the juvenils, there also significant differences since the $p \leq 0.05$ which is 0.001 whereas for the baby, there are no significant differences among them because the significant values is 0.092 which is more than 0.05.

4.3.1 Adult Common Marmoset

According to the figure 4.8, the adult of Common Marmosets spend a large part of their day in locomotion activity while for the least activity that made by the Common Marmosets were fight. According to Alanso and Langguth (1989), locomotion is defined as the animal moves from one site by climbing, jumping, walking and running, resulting in displacement to distant sites. The adult of Common Marmoset made a lot of movement in order to forage or feeding the baby, to fight or playing. They are jumping or climbing from one branch to another.

For the second highest behaviour that made by the adult Common Marmoset is grooming. Grooming is the animal inspects the fur of another with its fingers and

apparently removes small residue for examples, ectoparasites by using its mouth or hands. Usually, these residues are eaten (Stevenson & Pool, 1976; Alonso & Langguth, 1989). Grooming behaviours have two sub-categories which are self-grooming and allo-grooming. Among the Callitrichidae, grooming is an important behaviour observed among all combinations of individuals and sometimes, it can occupy as much as 14% of daily time budget of individuals monkeys (Porter & Garber, 2009).

From the observation, the adult Common Marmoset commonly undergoes allogrooming rather than self-grooming. According to Woodcock (1978), the adult Common Marmosets are usually grooming the other member of social group; baby and juveniles. From the figure 4.8, the graph showed that the adult frequently undergo grooming behaviour than the younger animal. This statement was proven by Simons (1974) and Goosen (1989). They point out that the adult of non-human primates spend more time on grooming activities than do younger animals. Silva and Sousa (1997) suggested the allogrooming was part of male Common Marmosets reproductive strategy but Schino *et al.* (1988) described the situation as a tension-reduction mechanism.

The third highest of daily activities budget among the Common Marmosets is communication. From figure 4.8, the result show that the adult of Common Marmosets communicate more frequently than younger animals. From the observation, mostly Common Marmoset uses their vocal signal to communicate with others or warning signal when it's felt dangerous coming around their surroundings. According to Jones (1997), the Common Marmosets usually use vocal signal in a diverse of situations in order to response to unexpected movement and in dangerous or threatening situations.

The previous researches had done about Common Marmosets that have been shown to exhibit a rich vocal repertoire in both captivity (Epple, 1968, Pistorio *et al.*, 2006) and their natural habitats (Bezzerra & Souto, 2008).

The fourth highest of daily activity budgets among the Common Marmosets is forage or feeding. From the figure 4.8, the result is shown that the adult of Common Marmosets are mostly spent time in forage or feeding than the young Common Marmosets. Normally, the Common Marmosets will eat fruit, seed or small insects. According to Rylands and deFaria (1993), the insects are also known as one of the important food sources for Common Marmosets which is made 24-30% of their feeding times. In Zoo Johor, the zoo keeper will feed the Common Marmosets in early the morning around 8 am and another one at the end of afternoon which is at 6 pm.

The least daily activity budgets among the adult of Common Marmosets are resting and playing behaviours. The adults of Common Marmosets are more prefer to rest than playing. This is because the adults are less energetic than the juveniles and baby of Common Marmoset (Aldis, 1975). According to Burghardt (2005), the adult play is relatively uncommon in primates as well as in other mammals. In primate, for example Common Marmoset, the playing behaviour has a role in mitigation tension and preventing escalation between the group members (Norscia & Palagi, 2011). According to Palagi (2009), playing behaviour is an interesting behaviour for examining the role of signals as communication systems.

The last daily activity budget among the adult of Common Marmoset is fighting or aggressive behaviour. Aggressive or fighting behaviour in adult of Common Marmosets normally occurs under many different circumstances. During

the observation, the adult of Common Marmoset usually fight each other because of food or territory and sometimes they fight for maintaining their social rank.



Figure 4.7: Adult common marmoset

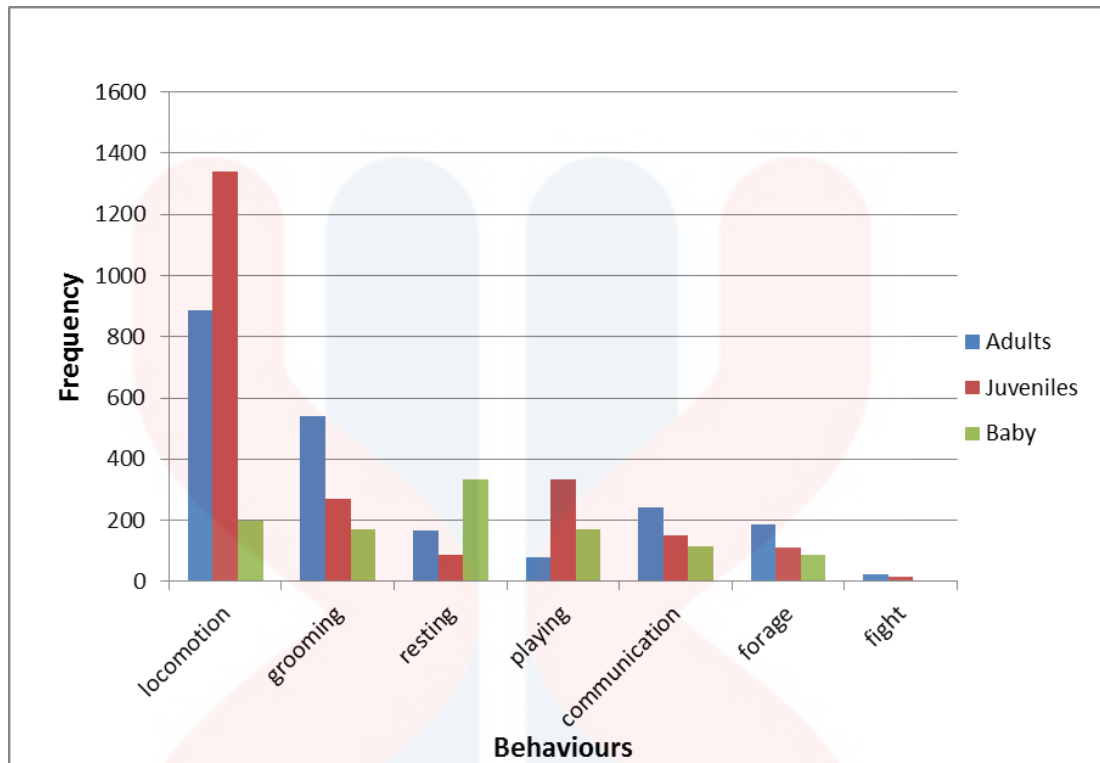


Figure 4.8: Daily activities versus ages

4.3.2 Juveniles

From the figure 4.8, locomotion behaviour in juveniles is the highest behaviour compare to other behaviours and ages. This is because, compare to adults, the juveniles have more energy to climbing, jumping, walking or running for whole days. They usually locomotors when feeding, forage, playing and fight.

The least daily activity budget which performed by the juveniles were fighting or aggressive behaviours. From the observation, the juveniles usually fight with other Common Marmosets because of the food. They compete and fight with each other but injured rarely happen.



Figure 4.9: Juvenile Common Marmoset

4.3.3 Baby

From figure 4.8, the highest behaviour that performed by baby is resting. From the observation, the baby of Common Marmoset is usually had been carried at the back of the adult Common Marmoset. According to Stevenson and Rylands (1988), Common Marmosets have a very strong cling reflex and do not leave their carrier's back for two weeks of life. Starting in the second week, they become very active; crawling on their carrier's back and began to investigating their surroundings. The infancy stage will lasts until about four to five months of age and then it's followed by the juvenile stages (Stevenson & Rylands, 1988).



Figure 4.10: Baby common marmoset

CHAPTER 5

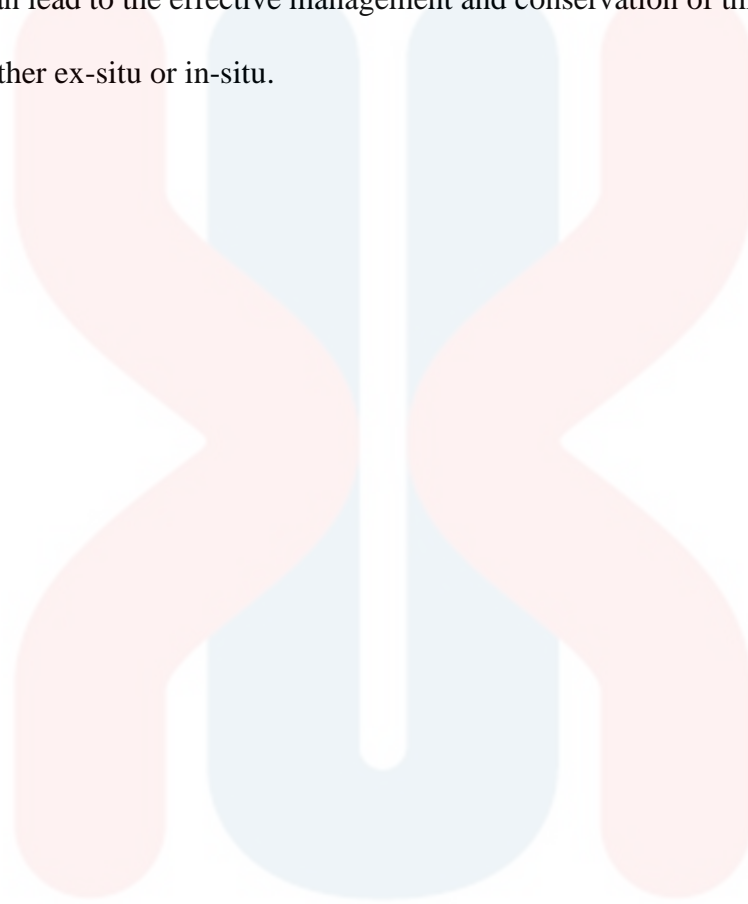
CONCLUSION AND RECOMMENDATIONS

The observation had been done starting from 15 August until 4 September 2016 at Zoo Johor, Johor Darul Takzim. The purpose of the observation were to determine the most frequent daily activities performed by Common Marmoset (*C. jacchus*) in captive condition and to compare their behaviour among the ages of Common Marmoset (*C. jacchus*) in captive condition.

The result showed that the Common Marmoset provides a lot of their time to perform locomotion or moving activities followed by grooming behaviour, resting or not moving, playing, communication, forage or feeding and the lowest daily activities is fighting. Those significant difference results of all seven daily activities were tested by Chi-square test ($\chi^2 = 4651.857, p \leq 0.05, df = 6$).

To compare the daily activities among the ages of Common Marmoset (*C. jacchus*) in captive condition, the ANOVA test was used to calculate the differences. From the ANOVA test, the results show that there are significant differences between the adult and juveniles whereas for baby, there are no significant differences. From the result, the juveniles made the highest totals of daily activity than the adults and baby. The results also showed that the least activity was made the baby Common Marmoset.

This scientific research is important in order to add knowledge and understand about the daily activity budget of Common Marmoset in the Zoo Johor which can lead to the effective management and conservation of this species in the future either ex-situ or in-situ.



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