ABUNDANCE OF RATS (FAMILY : MURIDAE) AT FOOD STALLS AND RESTAURANTS IN JELI, KELANTAN

by

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DECLARATION

I declare that this thesis entitled “Abundance of Rats (Family : Muridae) at Food Stalls and Restaurants in Jeli, Kelantan” 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.

Signature : _____

Name : _____

Date : _____

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ABUNDANCE OF RATS (FAMILY : MURIDAE) AT FOOD STALLS AND RESTAURANTS IN JELI, KELANTAN

ABSTRACT

Jeli, Kelantan is mainly covered with hilly forest landscape and networks of river and also surrounded with agricultural plantation, residents and infrastructure developments which indicate the potential of vast diversity and abundance of rats (Family Muridae). A study was conducted to determine the abundance of rats (Family Muridae) using cage traps technique, installed at 30 selected food stalls and restaurants at Jeli, Kelantan. This study recorded three species which are House Rat (*Rattus rattus),* Malaysian Wood Rat (*Rattus tiomanicus)* and Pacific Rat (*Rattus exulans),* all from genus *Rattus*. The total number of individuals trapped were 27 of which 12 were *R. rattus*, 10 were *R. tiomanicus* and five were *R. exulans* where all are collected from 13 sampling sites. Out of 12 *R. rattus* trapped, five were male and seven of it were female, with three of them were pregnant. *Rattus tiomanicus* consist of four male and six female with no gestation, while *R. exulans* has two male and three female with no gestation. The other 17 sampling sites recorded with no data due to the presence of limiting factors. The biological control such as pets at the sampling sites, wet condition during the trap nights, fruits season, predation, competition for the same sources and humans interference were the limiting factors as it all affecting the successful rate of the trapping. This makes the abundance of rats (Family Muridae) at food stalls and restaurants in Jeli, Kelantan was low. However, increasing the trapping effort and using different types of baits can helps to ensure the data collected in future study to be significance.

KELIMPAHAN TIKUS (KELUARGA : MURIDAE) DI GERAI MAKAN DAN RESTORAN DI JELI, KELANTAN

ABSTRAK

Kebanyakan kawasan di Jeli, Kelantan dilitupi dengan landskap bukit berhutan dan rangkaian sungai serta dikelilingi dengan ladang pertanian, perumahan penduduk dan pembangunan infrastruktur yang mununjukkan potensi kepelbagaian dan kelimpahan tikus (Keluarga Muridae) yang tinggi. Satu kajian telah dijalankan untuk mengenalpasti kelimpahan tikus (Keluarga Muridae) menggunakan teknik perangkap sangkar yang dipasang di 30 buah gerai makanan dan restoran terpilih di Jeli, Kelantan. Kajian ini merekodkan tiga spesies iaitu Tikus Rumah (*Rattus rattus*), Tikus Belukar (*Rattus tiomanicus)* dan Tikus Kecil (*Rattus exulans)*, kesemuanya dari genera *Rattus*. Jumlah keseluruhan tikus yang ditangkap ialah 27 ekor dimana, 12 ialah *R. rattus*, 10 ialah *R. tiomanicus* dan lima ialah *R. exulans* dimana kesemuanya dikumpulkan dari 13 kawasan persampelan. Daripada 12 ekor *R. rattus* terperangkap, lima adalah jantan dan tujuh daripadanya ialah betina, dengan tiga daripada mereka bunting. *Rattus tiomanicus* terdiri daripada empat ekor jantan dan enam ekor betina tidak bunting, manakala *R. exulans* mempunyai dua ekor jantan dan tiga ekor betina tidak bunting. 17 kawasan persampelan yang lain tidak merekodkan sebarang data disebabkan oleh kehadiran faktor-faktor penghalang. Kawalan biologi seperti haiwan peliharaan di kawasan persampelan, keadaan basah semasa malam perangkap, musim buah, pemangsaan, perlawanan untuk sumber yang sama dan gangguan manusia adalah faktor-faktor penghalang kerana ia semua mempengaruhi kadar kejayaan pemerangkapan. Ini membuatkan kelimpahan tikus (Keluarga Muridae) di gerai-gerai makan dan restoran-restoran di Jeli, Kelantan adalah rendah. Bagaimanapun, menambah usaha pemerangkapan dan menggunakan pelbagai jenis umpan dapat membantu memastikan data yang dikumpul dalam kajian masa hadapan menjadi penting.

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N	Total number of individuals
TL	Total length

CHAPTER 1

INTRODUCTION

1.1 Background of Study

Rat is classified under rodent group which is one of the largest groups in mammalian class and decent to the order of Rodentia. According to Lunde and Sơn (2001), rats are distinguished from the other order through its single pair of chisel-shape incisor in both upper and lower jaws which is growing throughout its life. The incisor located at the front of their mouth (Lunde & Sơn, 2001). Rat needs to keep gnawing to make sure that their incisors maintained it chisel edge because if the incisors being too long, it will risk the rat's life (Payne et al., 2007).

There are five suborders under Rodentia; Anomaluromorpha, Castorimorpha, Hystricomorpha, Myomorpha and Sciuromorpha (Wilson & Reeder, 1993; Honeycutt, 2009). Muridae is a family under suborder Myomorpha; a mouse-like rodent (Lunde & Sơn, 2001; Honeycutt, 2009). This family is able to survive at most of the environment across the world. There are certain factors that affecting its population density such as vegetation, food availability and climate. Based on DeJohn et al. (1998), the rodent population density was affected by its habitat structure. The rodents will be much abundance in areas with complex habitat structure consist of house, bushes and trees, compared to the less complex habitat structure where it only consist of bushes and thin forests (DeJohn et al., 1998).

This study had been conducted at Jeli, Kelantan (5.7007° N, 101.8432° E), situated about 98 kilometer from Kota Bharu town, Kelantan and 124 kilometer from Gerik, Perak using East-West Highway. Jeli is mainly covered with hilly forest landscape and networks of river. It also surrounded with agricultural plantation, residents and infrastructure developments. However, even when rat has a diverse group of species, very few information was recorded and documented about this Muridae Family in Jeli, Kelantan. Therefore, this study intended to provide the data for a better understanding of the rats and its abundance at Jeli, Kelantan.

With the current development happen at Jeli, Kelantan, this Muridae Family will have a wider range of habitat structure and the food sources. This can be the factors that lead to the abundance of the rat species. According to Wilson and Reeder (1993), there are more than 2000 species of rodents being recognized. Some are classified as rare species, threatened, endangered and pest. Several rodents that identified as pest in Malaysia are *Rattus argentiventer* in rice, *R. tiomanicus* in oil palm, *R. diardii* in stored grain and in oil palm, and *R. exulans* in houses, where all of them comes from Muridae Family (Singleton & Petch, 1994).

Jayaraj et al. (2016) recorded that there were only two species of Muridae at Gunung Reng, Jeli, Kelantan; *R. rattus* and *R. exulans*. Precisely, both of this species are associated with humans either in residents or agricultural sites (Payne et al., 2007). This species commonly causing losses towards the populations, agricultural practitioners and this affecting the economy of country (Singleton & Petch, 1994, Mulungu et al., 2003).

1.2 Problem Statement

The relationship between rats and environment is a very important factor on investigating the abundance of its species. Jeli, Kelantan was covered with forest, networks of rivers, agricultural sites and some part of it are being continuously developed until fragmentation can be seen clearly which it providing a good ecosystem structures for the rats. Thus, it is a great challenge to balancing the population of rats at selected location. In addition, rats have a rapid growth and become sexually matured after six weeks of birth (Sengupta, 2013). Plus, each female rats able to have up to 12 pups. This means that, rats have a high population density as it able to reproduce frequently once it matured.

Rats are one of the species which frequently interact with humans in terms of economic disturbance, conservation and importantly, spread of disease which can affected human's health and the quality of life (Centers for Disease Control and Prevention, 2006). Several types of disease that caused by rats are Leptospirosis, Weil's disease, and bubonic plague (McCormick, 2003). It is either can cause injury or even worst, death. For example, Leptospirosis is a zoonotic disease that spread worldwide by the rats through its urine (Ningal et al., 2015). Based on Ningal et al. (2015), this disease usually associated with agricultural workers and farmers. One of its common symptoms is Jaundice (Icterus) (World Health Organization, 2003). As some species of rats are living among humans, there is potential that rats transfer the disease to humans through its urine, bites, feaces and droppings.

At food stalls and restaurants, the risk of having the foods or food ingredients being contaminated by rats is high. Each of the foodstuff that not properly stored was exposed to the rats, giving the chances of contamination as rats consume almost everything especially fruits and grains (Lisa, 2016). The food then is no longer fit for human consumption. When the food is consumed by humans, the disease and virus can be transmitted.

Thus, this study focused on identification of rat species and their abundance at food stalls and restaurants of Jeli, Kelantan. The results can be used in managing and controlling the rat population. In addition, the results can be used in estimating the rodent population for the future investigation.

1.3 Objective

a) To determine the abundance of rats (Family Muridae) at food stalls and restaurants in Jeli, Kelantan.

CHAPTER 2

LITERATURE REVIEW

2.1 Rodent

Rodent is a mammal that belongs to the order Rodentia, and known as a group that has great species diversity. Rodent species has a special feature which is their large, curve and chisel-shapes incisors (Figure 2.1), a single pair in each of upper and lower jaws (Payne et al., 2007), that grow continually throughout their life. It has no canines and has a toothless gap in between before the cheek teeth known as diastema. This pattern of teeth is adaptive for gnawing and chewing the seeds, woods, hard nuts and predators (Michael, 2015). Previously, rabbits, hares and pikas are members of Order Rodentia before Order Lagomorpha was recognized on 1912 (Chapman & Flux, 2008).

Lagomorphs are closely related to rodents. However, there are some distinctive features that can distinguish between these two Orders. According Chapman & Flux (2008), unlike rodents, lagomorphs have one more pair of incisors in the upper jaws, resulting on two incisors which is shown in Figure 2.2. A pair of incisor is large and more like rodents while another one pair are located behind it and much smaller in size known as peg teeth (Chapman & Flux, 2008). Canines for both rodents and lagomorphs are absent while diastema are presents as shown in Figure 2.3 and Figure 2.4 (Myers, 2001, Myers & Sorin, 2002). The diets of lagomorphs are mostly plant as they are almost strictly herbivores if compared to other rodents that survived either with plants or meat (Myers & Sorin, 2002).

Figure 2.1 : Incisors of rodent, *Abrawayaomys ruschii* (Ruschi's rat) (Myers et al., 2016a).

Figure 2.2 : Incisors of lagomorph, *Ochotona princeps* (American pika) (Myers et al., 2016b).

Figure 2.3 : Lateral view of rodent's skull, *Abrawayaomys ruschii* (Ruschi's rat) (Myers et al., 2016a)

Figure 2.4 : Lateral view of lagomorph's skull, *Ochotona princeps* (American pika) (Myers et al., 2016b).

Another order that resemble rodents is Order Insectivora. Commonly, rodents have four long, short digits on each of its front foot, with a short naily-thumb while insectivores longer digits with sharp claws instead of nails (Payne et al., 2007). Moreover, rodents are a nocturnal species where they are mainly actives during the night. This is the same as lagomorphs and insectivores.

Rodentia has five other suborders which are Anomaluromorpha, Castorimorpha, Hystricomorpha, Myomorpha and Sciuromorpha (Wilson & Reeder, 2005). This suborder consist of 34 families, but only 33 families are survive, resulting in 481 genera and 2277 species overall (Honeycutt, 2009), constituting almost half of the Class Mammalia with approximately 4,660 species (Musser, 2015). Rodent species can be found worldwide except in Antarctica (Cramb & Van Dyck, 2011), as the species cannot survive with the extreme temperature and have no adaptation towards Antarctica's condition.

Suborder Anomaluromorpha has two superfamilies, which is Pedetoidea and Anomaluroidea with four families involving springhare and scaly-tailed flying squirrels. However, two families were already extinct which are Parapedetidae and Zegdoumyidae (Musser, 2016). Suborder Castorimorpha has three families with their commonly known species are beavers and pocket gophers. Suborder Hystricomorpha has the vast numbers of families (19) including the extinct family Heptaxodontidae (Biknevicius et al., 1993, MacPhee & Flemming, 2003). This suborder members known as the porcupine-like rodents which involving porcupine and capybara (Musser, 2016). The mouse-like rodent usually comes from the suborder Myomorpha involving variety of mouse and rat species (Musser, 2016). Suborder Sciuromorpha consist of squirrel-like rodents involving chipmunk and prairie dog (Honeycutt, 2009, Musser, 2016).

The body size for each species are varies. However, according to Musser (2016), the body size for Order Rodentia was between mouse and marmot. The weight of mouse is 18 grams with 12 cm long while the marmot is 3000 grams and 50 cm long. Denaly's swamp mouse is one of the smallest rodent species with weight of seven grams with

five cm long, while capybara classifies as the largest with weight between 35 to 66 kg with a body length of 100 to 135 cm (Musser, 2016).

2.1.1 Suborder Myomorpha

Myomorpha have two superfamilies, known as Dipodoidea and Muroidea. Dipodoidea has only one family which is Dipodidae, consisting jumping mice and jerboas. While Muroidea have a total of six families, Calomyscidae, Cricetidae, Muridae, Nesomyidae, Platacanthomyidae and Spalacidae. Muroidea is basically known as the true rats and mice (Taylor, 2011). Based on Taylor (2011), this two superfamilies can be distinguished with a certain characteristics. For example, Dipodoidae has an independent lower vascular groove on the infraorbital foramen, and Muroidea has a distinct anterocone on the first molar, the absence of the fourth lower premolar, and a confluence of the masseteric and neurovascular foramina on the anterior zygoma (Jaeger, 1988).

Muroidea consist of 1500 species, with a quarter of the species are rats, mice, voles, muskrats, lemmings, hamsters, gerbils, and other members of the family (Francis, 2008). A total of 70 species of this superfamily are presently recognized in mainland of South-East Asia. Some of this species were recorded present in disturbed vegetation and human settlements (Francis, 2008).

According to Payne et al. (2007), there are five species of rats that actually associated with humans; Norway Rat (*Rattus norvegicus*), Pacific Rat (*R. exulans*), House Rat (*R. rattus*), Ricefield Mouse (*Mus caroli*) and House Mouse (*M. castaneus*).

These species usually can be found at the residential area and agriculture sites. Some of rat species are classified as pests as they cause damage either to human properties or crops. Based on Singleton & Petch (1994) there were five main pest species of rats recognized at Southeast Asia which are Rice Field Rat (*R. argentiventer*), Black Rat (*R. rattus diardii*), Wood Rat (*R. tiomanicus*), Norway Rat (*R. norvegicus*), and Polynesian Rat (*R. exulans*). From the previous study done by Singleton and Petch (1994), Malaysia had annual losses to rice caused by rats, generally around 4 to 5%. From this figure, individual farmers may lose large proportions of their crops. This shows that rats can cause catastrophic effects on the livelihood of individual farmers (Singleton & Petch, 1994).

2.1.2 Family Muridae

Musser (2016) and Taylor (2011) stated that Muridae is the family in Order Rodentia that known as true rats and mice. It is about 1370 species with 300 genera being recognized and 188 already extinct. This family was known as the largest extant of rodent family. Back then, according to Francis (2008), there are more than 560 species in 126 genera been identified worldwide. In Peninsular Malaysia, around 27 species of rodents from this family have been identified (Liat, 2015).

As stated by Musser (2016), family Muridae was recognized with 18 subfamilies as in Table 2.1 :

Table 2.1 : Subfamilies of family Muridae (Musser, 2016).

Family	Subfamily	Examples
Muridae	Murinae	Old World rats and mice
	Sigmodontinae	New World rats and mice
	Arvicolinae	Voles, lemmings, and the muskrat
	Gerbillinae	Gerbils and jirds
	Acomyinae	African spiny mice, Congo forest mouse, brush-furred rats, and Rudd's mouse
	Dendromurinae	African climbing mice, gerbil mice, and fat mice
	Nesomyinae	Malagasy rats and mice
	Cricetinae	Hamsters
	Rhizomyinae	Bamboo rats and African mole rats
	Spalacinae	Blind mole rats
	Myospalacinae	Zokors
	Calomyscinae	Mouselike hamsters
	Cricetomyinae	African pouched rats
	Petromyscinae	Rock mice
	Platacanthomyinae	Malabar spiny tree mouse and blind tree mice
	Delanymyinae	Delany's swamp mouse
	Mystromyinae	White-tailed mouse
	Lophiomyinae	Maned rat

Muridae's average life span is between 12 to 36 months, and the average adult body weight is between 20 to 40 grams. In addition, an adult female rat is able to give birth up to 12 pups. However, their life span, body weight and number of offspring are different for each species. Common characteristics of Family Muridae members are that they have only four and five clawed digits on forefoot and hindfoot respectively (Myers, 2001).

The species in Muridae family can be found in all types of habitat such as rainforests, coniferous forests, tundra, grasslands, urban areas, wetlands and oceanic island except on Antartica (Myers, 2001). Some of Muridae species are nocturnal and some are active during the day. According to Myers and Poor (2005), Muridae family did varies in their food consumption orientation, where some of them are herbivores, carnivores and omnivores. The herbivores usually tend to store their food for the later use.

2.2 Food Stalls and Restaurants Diversity

Rats become one of the hard-to-control pests as humans keep on providing their needs, such as foods and shelters (Jahan et al., 2013). Musser (2016) stated that, humans already become the sources of foods and shelters for the animals that are able to adapt with the man-made habitats. Either in agricultural sites, residential premises or any industries warehouse, the clash and struggle between human and rodents seems to have no end.

The rat population abundance often becomes a problem to human. As human providing shelters and foods for them, food stalls and restaurants is one of the places that provide both of it at the same time. The food stalls and restaurants can become a location where high abundance of rat species can be found. This place can be categorized as complex habitat structures because they located in rural area and built near the thin forest or agricultural sites and surrounded with shrubs and residential areas.

Based on previous study at Kansas, the results show that there was high population density of rodents at woodland areas, where it is considered as a good habitat structure, compared to the population density at mowed hayfields, which is not a good habitat structure (DeJohn et al., 1998). This means that, food stalls and restaurants can probably have a high population density of rats as there is safe shelter and easy access towards the foods sources.

2.3 Disease Cause by Rats

Rat is a host for various kinds of vectors and virus which actually can affect humans and livestock (Singleton & Petch, 1994). For example, rodents serve as the intermediate host for helminth parasite (*Taenia taeniaeformis*) in form of larva (*Cysticercus fasciolaris*), where it infected by ingesting the ova in foods and bedding materials (Singla et al., 2003). Based on Wei et al. (2010), *Apodemas agrarius, R. norvegicus, R. nitidus, R. flavipectus, M. musculus, Micromys minutus* and *Anourosorex squamipes* are well known as a reservoir of plague in southwest China and a widespread

in Sichuan province. There are two forms of disease transmitted by rodents. It is either directly or indirectly. Leptospirosis, Salmonellosis, Plague and Hantavirus Pulmonary Syndrome are the diseases that being transmitted directly by rodents and Relapsing fever, Lyme disease and Murine Typhus are the example of indirectly transmitted disease.

2.3.1 Leptospirosis

Leptospirosis diseases first discovered on 1886 by Adolf Weil (World Health Organization, 2003, Ningal et al., 2015). Leptospirosis is a disease caused by *Leptospires* bacteria which affecting both human and animals where rats act as the reservoirs. The bacteria can either be pathogenic or saprophytic. It can be found in animals bodies and wet and humid environment such as water and wet soil. *R. rattus* and *R. norvegicus* are well known reservoirs of this disease (Duplantier & Rakotondravony, 1999). This disease is a potentially serious but treatable (World Health Organization, 2003). Leptospirosis often being confused with others diseases such as dengue and viral haemorrhagic fevers. According to World Health Organization (2003), Leptospirosis disease often happens at tropical and subtropical areas with a high rate of rainfalls.

Basically, the bacteria live in the kidney of the host. Humans and animals usually infected by *Leptospires* through either direct or indirect contact with the urine or blood of the rats (Machang'u et al., 2003). The transmission of bacteria occurs through the wounded skin and the mucous membrane of mouth, eyes and nose (Haake & Levett,

2015). The symptoms of infected humans sometimes invisible and it happen to have a huge range of symptoms. It is including severe headache, high fever and abdominal pain. The untreated disease, the bacteria can go to the extent of causing liver failure and respiratory distress (Ningal et al., 2015). Patient that suffering from Leptospirosis disease can be treated using antibiotics such as Ampicillin, Doxycycline and Cefotaxime for the severe cases (Ningal et al., 2015).

2.3.2 Plague

Plague is one of the diseases that associated with rodents. According to Singleton and Petch (1994), plague was once very common in Western Pacific and Southeast Asia such as Indonesia and Thailand. Humans being infected with plague when wild rodent encroach on human habitats because of food, deforestation, destruction of habitat and change in weather (Belmain, 2006). There are several clinical form of plague including carbuncular, pneumonic plague, bubonic, and plague meningitis. There are several ways on treating the disease, such as aminoglycosides, tetracyclines and chloramphenicol (Poland & Dennis, 1999).

2.3.3 Hantavirus

Hantavirus is the group of viruses that carried by rodents, either pet or wild, causing a hemorrhagic fever with renal syndrome (HFRS) (Phan et al., 2011). This disease was reported as rare but severe. Early symptoms include fatigue, headaches,

chills, fever, muscle aches, vomiting, and diarrhea. The rodent that usually involves in transmitting the viruses are Deer Mouse (*Peromyscus maniculatus*), Cotton Rat (*Sigmodon Hispidus*), Rice Rat (*Oryzomys palustris*), and White-footed Mouse (*Peromyscus leucopus*). The disease can be transmitted through the breathing in the dust contaminated with rodent urine, saliva and feces, direct contact with the rodents itself or through their urine and droppings and trough the cuts from rodents bites (Avšič-Županc, 2015). This disease is not transmitted among humans.

2.4 Field Techniques

Based on Barnett and Dutton (1995), the type and size of the trap used was an important criteria on determining the types of animal to be caught. This is because different species often show preferences for particular types of trap, and all-metal material is generally recommended. Basically, the trapping method of rats divided into two types; dead trap or live trap. An example of dead trap is snap trap (Figure 2.5) and for live trap is cage trap (Figure 2.6). Both traps are commonly used to study the rodent species.

Snap trap is likely to be used as the rats will instantly be killed and inexpensive. The cage trap will keep the rats alive inside and quite expensive. Moreover, snap trap also lighter and less bulky if compared to cage trap making it to be easier to handle. However, the uses of snap trap often limiting the data that can be collected compared to cage trap (Barnett & Dutton, 1995). This is because the rodent will be instantly killed if

the bait was disturbed by the jaw of snap trap, changing its physical appearance while for cage trap, it is vice versa.

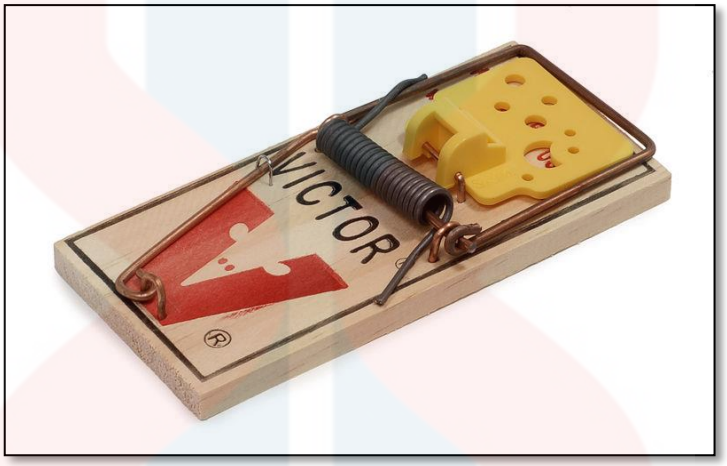

Figure 2.5 : Snap trap (Sullivan, 2014).

Figure 2.6 : Cage trap.

CHAPTER 3

MATERIALS AND METHOD

3.1 Materials

Cage trap was used as the main materials in order to capture the rats. Chloroform and Ethanol were used as the euthanized and preservation purpose. As for the bait to trap the rats, ripen banana was used. Other materials that used during the study are black cloth bag, disposable hand gloves, surgical face mask, cotton wool, chemical-resistant plastics bags, museum tags, dissecting kit and preservation bottles. GPS device used to mark the coordinate of the food stalls and restaurants while weighing balance used to weight the rat's mass and rulers for the measurement of rat's bodies. For species identification purposes, book named A Field Guide to the Mammals of South-East Asia by Francis (2008), and A Field Guide to the Mammals of Borneo by Payne et al. (2007) were used.

3.2 Methods

3.2.1 Study Area

This study was conducted at 30 different food stalls and restaurants, located at Jeli, Kelantan (5.7007° N, 101.8432° E) as in Table 3.1 and Figure 3.1, where at each location longitude and latitude were recorded. The food stalls and restaurants selected

have a complex habitats structure, which most of them situated at the edge of agricultural sites or thin forest and near residential premises.

Table 3.1 : GPS reading for all selected food stalls and restaurants.

Sampling Site Number	Latitude (N)	Longitude (E)
1	5.659890	101.865983
2	5.663290	101.853576
3	5.667651	101.851668
4	5.668078	101.851587
5	5.672974	101.851353
6	5.683025	101.850290
7	5.701101	101.835465
8	5.693878	101.847248
9	5.707703	101.843642
10	5.711246	101.849175
11	5.716957	101.746252
12	5.716376	101.746993
13	5.711394	101.760897
14	5.708847	101.778144
15	5.710484	101.779261
16	5.709835	101.779198
17	5.714250	101.787732
18	5,714324	101.790464

19	5.714268	101.853229
20	5.723687	101.858076
21	5.736940	101.860227
22	5.742294	101.861354
23	5.746441	101.863017
24	5.743203	101.866412
25	5.751778	101.861891
26	5.780268	101.871508
27	5.782358	101.881547
28	5.769488	101.868412
29	5.786561	101.862597
30	5.784252	101.888968

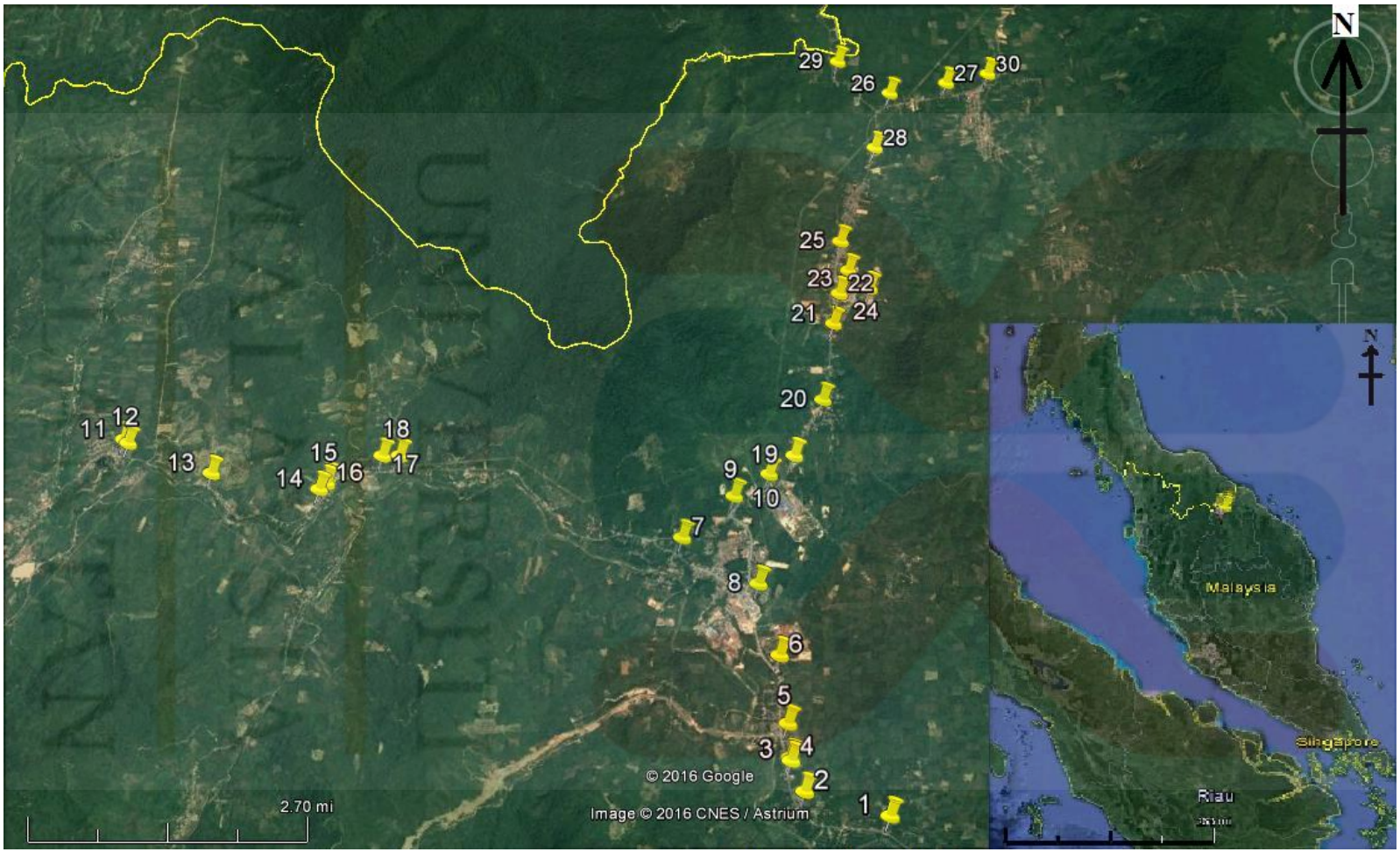

Figure 3.1 : Maps of selected food stalls and restaurants at Jeli, Kelantan (Modified from Google Earth, 2016).

3.2.2 Sample Collection with Cage Trap Technique

Five cage traps were installed at each of the food stalls and restaurants loaded with banana as the bait. The traps were placed at the presumed pathways of the rats and left overnight. However, if there is no sign of the rat pathways, all the traps were randomly installed. The traps were washed thoroughly with water each times after used, to remove the scents left by the rats before. All of the traps were placed at the evening of the day before sun sets, and checked at the morning of the next day. Each of rats that were caught in cage trap was transferred to laboratory for analysis. Next, the rat was moved into chemical-resistant plastic bag before the chloroform was applied in order to euthanize the rat. This study was conducted from May to September 2016. The data collection was repeated as much as three times for each food stalls and restaurants that being chose prior after the first completion. This is because the rats are able to reproduce at approximately 30 days of age and they tend to produce a great number of offspring at a time.

3.2.3 Sample Identification

The process of rodents identification consist of sex, age, female gestation, and species identification, involving body weight, total body length, head-body length, ear length, hind foot length and tail length. Several types of books were used in order to identify the rodent species such as A Field Guide to the Mammals of South-East Asia by Francis (2008), and A Field Guide to the Mammals of Borneo by Payne et al. (2007). The sex of rodent was determined through the distance between anus and urogenital

opening. Females have a shorter distance compared to males. Another ways was by checking the presents of testicles under the rat's tail. If there is present of the testicles, then the rat was male, and if don't, it's a female. Next, to determine the female gestation, the female rats were dissected to find the embryos (Jahan et al., 2013) (Figure 3.2). The body weight of the each rodent was measured using the weighing balance while the body length, head-body length, ear length, hind foot length and tail length measured by ruler as in Figure 3.3.

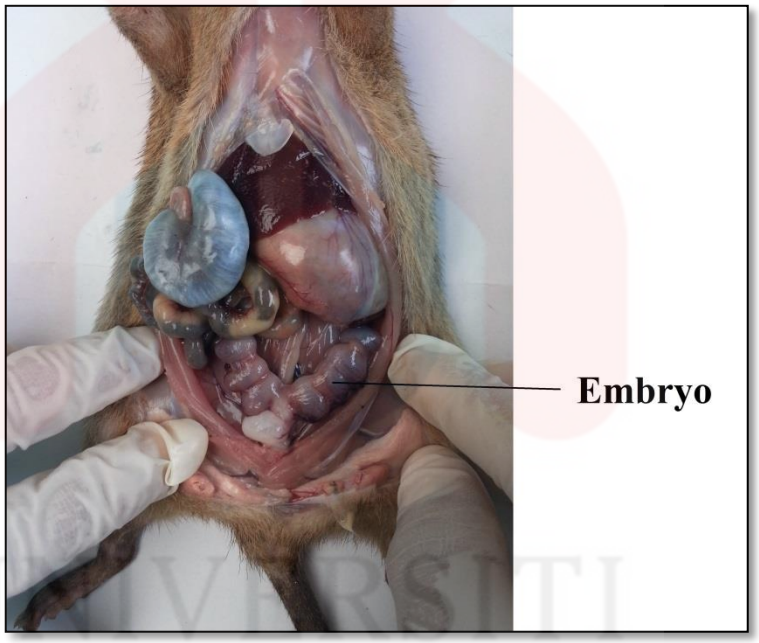

Figure 3.2 : Female *R. rattus* with newly developed embryos.

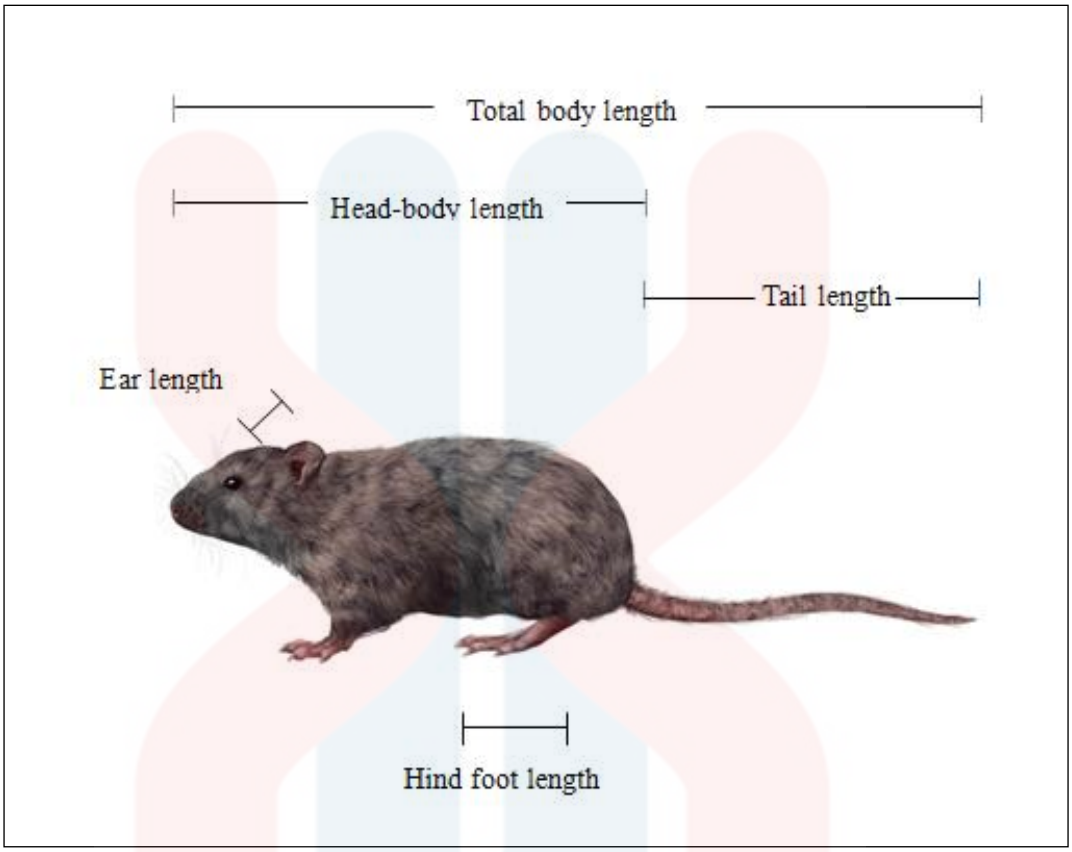

Figure 3.3 : Measurements of rat (Zagrobelna, 2014).

3.2.4 Specimen Preservation

The rats were euthanized by using Chloroform in chemical-resistant plastics bags before being dissected using dissecting kit. Small intestine, large intestine and the stomach of the sample was removed. The rats then was washed using the tap water to removes the blood stains. Then, the sample was preserved using ethanol in preservation bottle after labeled with museum tag.

3.3 Data Analysis

The abundance of rats captured was recorded and the calculation of the relative abundance was made using the equation below (Dash & Dash, 2011; Kim & Diong, 2012):

$$\text{Relative abundance} = \frac{\text{Total number of individuals per species}}{\text{Total number of individuals of all species}} \text{ x } 100$$

CHAPTER 4

RESULT AND DISCUSSION

4.1 Species of Rats Caught

Through the 640 trap nights from 30 selected food stalls and restaurants, the presence of three species of rats which used to associate with humans were recorded. It is *R. rattus* (Figure 4.1), *R. tiomanicus* (Figure 4.2) and *R. exulans* (Figure 4.3). All this three species are classified in Family Muridae, under Genus *Rattus*. Rats in genus *Rattus* are often smaller in size than the rats that been classified as large rats like Lesser Bandicoot Rat (*Bandicota bengalensis*) and Müller's Rat (*Sundamys muelleri*) (Francis, 2008). The head body length of *R. rattus* caught in this study is between 13.2 cm and 20.5 cm, *R. tiomanicus* is between 15.4 cm and 19.7 cm and *R. exulans* between 11.5 cm and 14.0 cm.

According to Payne et al. (2007) and Francis (2008), species in Genus *Rattus* usually have all dark tail with numerous spines on upper parts of rat body. The mammary glands number of pairs for female rats was varies based on the species, where *R. rattus* usually have 2 + 3 or 3 + 3, *R. tiomanicus* have 2 + 3 and *R. exulans* have 2 + 2 based on its axillary and inguinal (Francis, 2008).

Figure 4.1 : Lateral view of female (Left) (TL : 39.7 cm) and male (Right) (TL : 39.2 cm) *R. rattus.*

Figure 4.2 : Lateral view of female (Left) (TL : 32.5 cm) and male (Right) (TL : 38.7 cm) *R. tiomanicus*.

Figure 4.3 : Lateral view of female (Left) (TL : 23.9 cm) and male (Right) (TL : 23.6 cm) *R. exulans*.

4.2 Relative Abundance of Rats Species

According to Table 4.1, there were 27 individuals were caught where 12 were *R. rattus*, 10 were *R. tiomanicus* and five were *R. exulans*. *Rattus rattus* was recognized as the most abundance and dominant species in this study if compared to the other two species. The highest frequency of *R. rattus* caught at sites was three, from site 2 (5.663290, 101.853576) and site 26 (5.780268, 101.871508), followed with two individuals caught from site 17 (5.714250, 101.787732) and one individual at site 5 (5.672974, 101.851353), 11 (5.716957, 101.746252), 13 (5.711394, 101.760897) and 19 (5.714268, 101.853229) respectively. From the 12 individuals seven are female with three of them are pregnant and five male. The relative abundance of *R. rattus* was 44.44.

This means that, *R. rattus* was likely to be more abundance compared to *R. tiomanicus* and *R. exulans* at Jeli, Kelantan.

Compared to *R. rattus*, *R. tiomanicus* was less abundance with the total of 10 individuals caught (Table 4.1). Three individuals was caught at site 7 (5.701101, 101.835465) and one individual at site 2 (5.663290, 101.853576), 11 (5.716957, 101.746252), 13 (5.711394, 101.760897), 14 (5.708847, 101.778144), 19 (5.714268, 101.853229), 23 (5.746441, 101.863017) and 28 (5.769488, 101.868412) respectively. Six female and four male were captured. Although there were six female captured, none was pregnant, making the probability of *R. tiomanicus* to have lower abundance compared to *R. rattus*. The relative abundance of this species was 37.04.

Out of the three species recorded in this study, *R. exulans* is the species with the least relative abundance; 18.52, half the relative abundance of *R. tiomanicus*. With only five individuals being caught, three of them were female and two male, which none of the female was pregnant. Three individuals was caught at site 1 (5.659890, 101.865983), one individual at both site 14 (5.708847, 101.778144) and 29 (5.786561, 101.862597) respectively.

This capture pattern may reflect the habitat structure and the breeding seasons of the rats (Harper, 2006). The food stalls and restaurant choses poses almost similar environmental condition where each sites was consist the combination of houses, thin forest, scrubs, or agricultural sites. This are the habitat features that inhabited by *R. rattus*, *R. tiomanicus*, and *R. exulans* (Gillespie, 2004; Warren, 2004; Aplin, 2016), making it possible to capture them.

In addition, *R. rattus* that has the highest relative abundance is the only species that caught with three pregnant female with eight litters, four litters and five litters respectively. This shows that the breeding rates of *R. rattus*, is higher than *R. tiomanicus* and *R. exulans*. The birth rates of the species were related to the food availability (Puan et al., 2011) and weather (Warren, 2004).

Table 4.1 : Relative abundance of rat species.

Species	***R. rattus***	***R. tiomanicus***	***R. exulans***	**Total**
Male	5	4	2	11
Female	7	6	3	16
Total	12	10	5	27
Relative Abundance	44.44	37.04	18.52	100

4.3 Distribution of Rat Species

Based on the data collected, it shows that *R. rattus* and *R. tiomanicus* has the same range of species distribution as both species were found at Kuala Balah, Jeli, Batu Melintang and Ayer Lanas area (Table 4.2). However, *R. exulans* has smaller range of distribution compared to the other two species. According the data recorded, *R. exulans* were found only at Kuala Balah, Batu Melintang and Ayer Lanas area and none in Jeli. This indicates that *R. rattus* and *R. tiomanicus* had a wider range of distribution rather than *R. exulans* as it can be found at four locations instead of three at Jeli, Kelantan.

According to Table 4.2, *R. rattus* was much abundant at Kuala Balah and Batu Melintang with 4 individuals at each site compared to other areas. *Rattus tiomanicus* was abundant at Jeli with 5 individuals and *R. exulans* at Kuala Balah with 3 individuals caught. It shows that, *R. rattus* are more superior in species distribution as the individuals caught at each location were higher than another two species except for Jeli area. Jeli was mainly dominated by *R. tiomanicus* where there is five individuals were caught with only one individuals of *R. rattus* and none from *R. exulans*. It means that the variety of rat species at foot stalls and restaurants in Jeli was limited to only two species instead of other areas with all three species presence.

As the three species often occupying the same habitat which are agricultural sites, houses and forested areas (Gillespie, 2004; Warren, 2004), the home range of each species can be altered with time (Innes & Skipworth, 1983). This resulting the *R. exulans* to be removed from the areas habitat by *R. rattus* and *R. tiomanicus* due to the competition occurs (Harper et al., 2005; Harper, 2006). However, cage trap technique was not able to provide sufficient data to prove the rat's home range (Innes & Skipworth, 1983).

In this study, Kuala Balah and Batu Melintang were the area with highest number or individuals caught (eight individuals). This is due to the environment around the sampling sites that consist of houses, thin forests, scrubs, plantations and sugarcane field. The environment provided a good habitat with the stable availability of foods and shelters for all the species caught.

Table 4.2 : The distribution of rat species at Jeli, Kelantan.

Species	Location				Total
	Kuala Balah	Jeli	Batu Melintang	Ayer Lanas	
R. rattus	4	1	4	3	12
R. tiomanicus	1	5	3	1	10
R. exulans	3	0	1	1	5
Total	8	6	8	5	27

4.4 Influence of Environmental Factors

Comparison between each month of sampling shows that the successful of trapping was high during June (10 individuals), followed by August (8 individuals), September (7 individuals), and July (2 individuals) as in Figure 4.4. The pattern was affected by several factors and one of it was the weather (Daud et al., 2014). During the data collection process, July facing the highest precipitation rate compared to June, August and September. However, each month still experiencing wet condition due to the rainfall but not as often as July, result the low number of individuals caught and also less number of pregnant female rats. A study done by Barnett and Dutton (1995) shows that the rats become less active during the cold night and as most of the day of sampling on July was disturbed with the rainfall, the low trap success is expected.

According to Figure 4.4, the frequency of *R. rattus* was the highest in June with five individuals, followed by August with four individuals, July with two individuals

and September with one individual. Even so, the *R. tiomanicus* species experiencing different pattern in population growth where after two month (July and August), the rats were able to recover the individual loss in September. Based on Figure 4.4, the numbers of *R. tiomanicus* trapped on June were four, none in July, two in August and four in September. This shows that, the rat population of *R. tiomanicus* is reduced before increase during August. *R. exulans* however experiencing the increasing pattern which one individuals trapped in the first month of sampling (June), none in July and has a constant pattern on August and September. It means that, this species population was in constant number and able to recover from the prior loss.

The small number of individuals caught in this study also related to the heavy fruits season throughout the month of sampling especially in July and August (Puan et al, 2011). Based on Puan et al., (2011) the fruits act as the food sources for rats lowered the potential of them to attract to the bait prepared in the cage traps. This is because the food availability for rats was abundant and easy to be access.

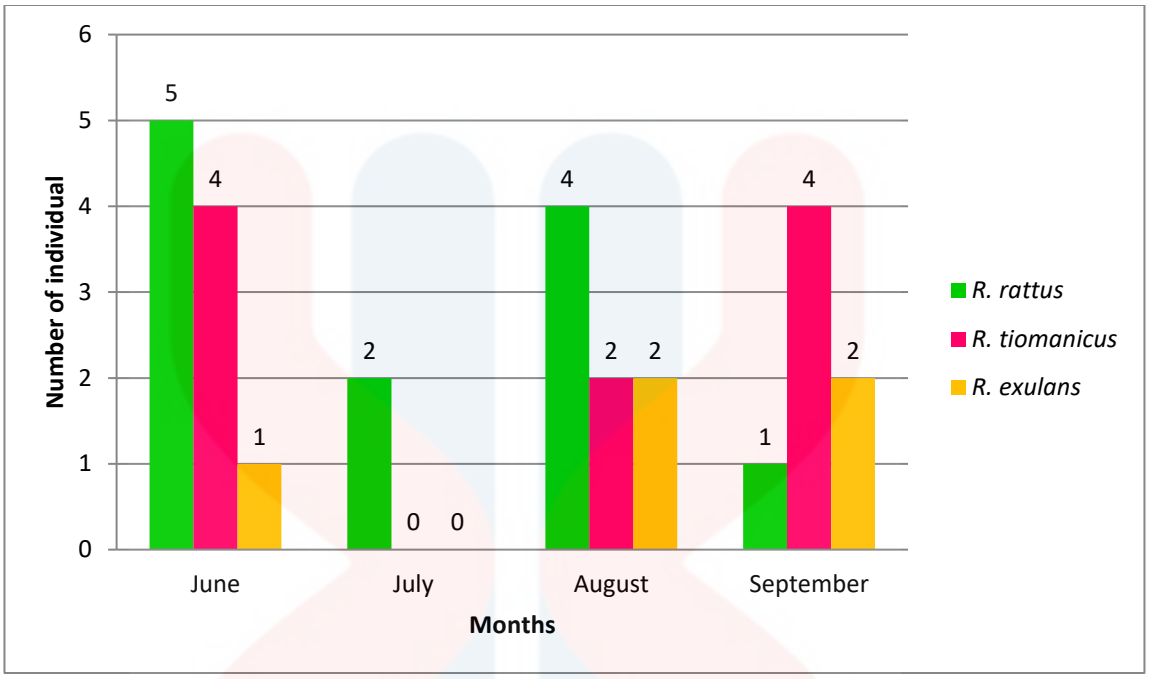

Figure 4.4 : The total number of individuals for each species caught by months.

4.5 Influence of Biological Factors

Through the data collected, there were 17 food stalls and restaurants recorded with no data or captured (Figure 4.5). This is because there were limiting factor that preventing any data to be recorded. It was the biological control at sampling sites such as predation and competition between the animals. Throughout the days of sampling at each of this 17 site, there were pets that cared by the nearest residence who acts as one of the biological control for the rat abundance. The pet such as domestic cat (*Felis catus*) play an important role in controlling the rat populations as it known to be the predators for rats and also in higher position in food chain compared to the rats (Gillespie, 2004; Harper, 2006).

Plus, the location of selected food stalls and restaurants provides a suitable environment for other kind of predators such as snake and birds. However, at the same time, the number of rat species will gradually decreased if there is competition occurs for the same foods, shelters and other. For example, bigger rats such as *R. rattus* and *R. tiomanicus* are able to affect the abundance of much smaller rats such as *R. exulans*. So, the predation and competition leads to no data recorded for the 17 food stalls and restaurants making the rats abundance lower (Harper, 2006).

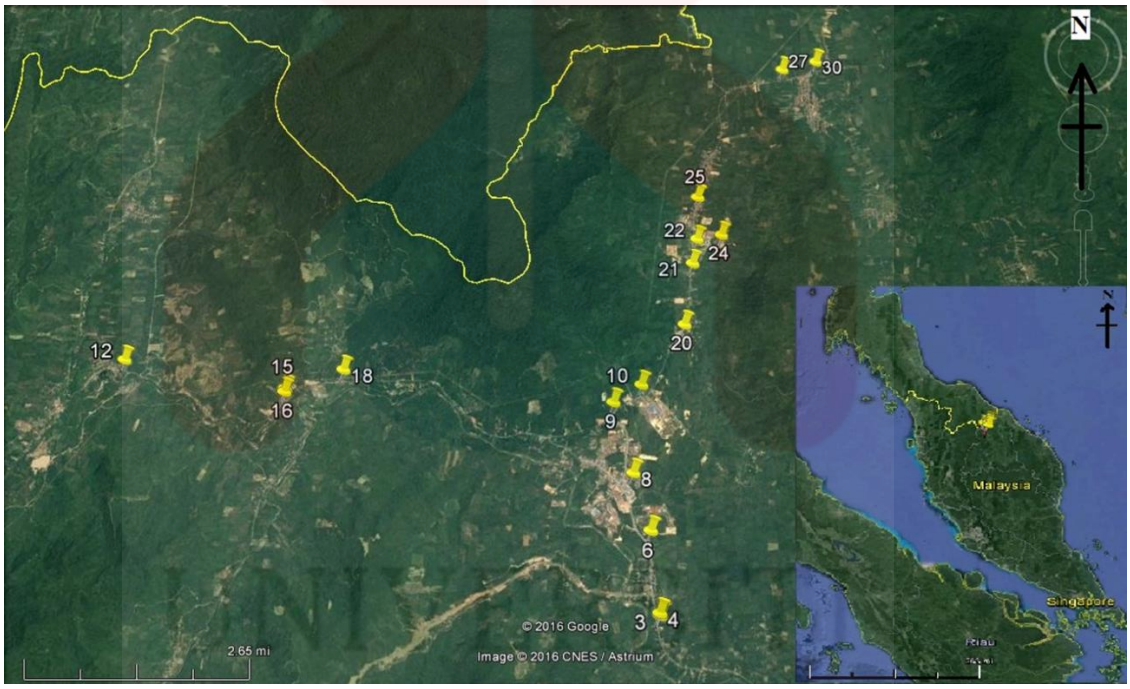

Figure 4.5 : Maps of selected food stalls and restaurants at Jeli, Kelantan without any sample caught (Modified from Google Earth, 2016).

Other than that, collecting data at human settlements area possess as a threat to the trap success. This is because, the humans tends to disturb the cage traps left at

sampling point by removing the traps from its original place or worst, set the trapped rats free. This probably will alter the real data that should be recorded.

4.6 Effects of Rats Abundance

Rattus rattus, R. tiomanicus and *R. exulans* are known as the main pest species at Malaysia (Singleton & Petch, 1994; Gillespie, 2004; Warren, 2004). The rats tend to disturb and destroyed the environment even with their low abundance and causes loses to the agricultural product and human property. However, as the rat abundance at Jeli, Kelantan was low, the predator abundance also low (Harper, 2006). This is because the predator population is directly proportional to the prey population. This is due to the predation is one of the factors that influencing the rats population (Gese & Knowlton, 2001; Warren, 2004).

Next, the low abundance of rats at the sampling site reduced the risk of disease outbreak transmitted by the rats. For example, *R. rattus* is the host for variety of parasites and responsible for the outbreak of bubonic plague and other disease (Gillespie, 2004). When the rats consuming foods, the rats tend to spread the disease by contaminated the human food sources with the parasites from their body, urines, feaces and dropping. As the abundance of rats is low, the probability of disease spread by the rats also low.

CHAPTER 5

CONCLUSIONS AND RECOMMENDATION

5.1 Conclusions

The small number of rats caught (N=27) at the 30 selected sampling sites indicates that the abundance of rat species at Jeli, Kelantan was low even though it was estimated to be higher. The rats captured identified as 12 *R. rattus* (44.44), 10 *R. tiomanicus* (37.04) and five *R. exulans* (18.52) for 640 trap night. This happens due to the limitation of the biological control of the sampling sites surrounding and also its physical environments such as the habitat structure, weather, fruits season, predation, competition and human interference. 17 sampling site was recorded with no data for the four months of sampling, and July has the lowest total number of rat caught with only two individuals compared to June with 10 individuals, August with eight individuals and September with seven individuals respectively.

5.2 Recommendations

Since the rats has wide species diversity, several suggestion can be take into account to ensure that the data collected in future study to be significance. First, the trapping effort should be increased. This is because, as the trapping effort increase the probability to have higher number of individual caught also increased (Barnet & Dutton,

1995). Moreover, the rats are tends to avoids strange objects for a while. So, increasing the trap effort might help in getting a good capture rate.

Second, varies the type of baits used. There are varieties of baits that can be used to capture the rats such as coconut (Tobin and Sugihara, 1992; Sugihara, 1997), pineapples (Jayaraj et al., 2012), salted fish and oil palm fruit (Daud et al., 2014). Next, deploy the traps at suitable location instead of installed it randomly or at open areas. According to Barnet and Dutton (1995), the small mammals prefer to run around the edge of things instead of open areas.

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APPENDICES

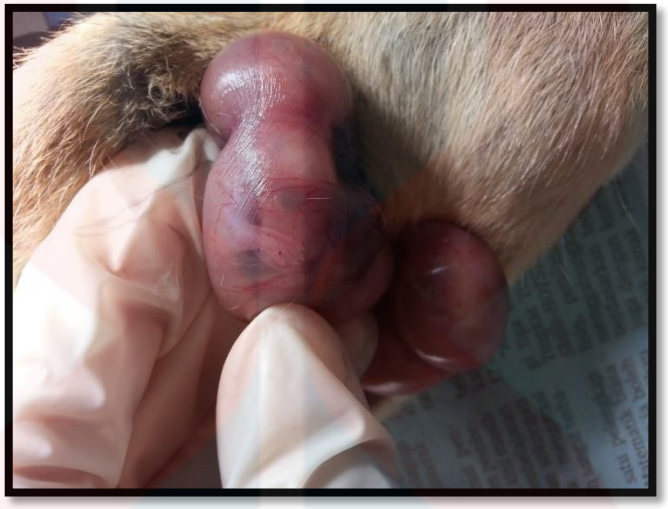
APPENDIX A

DATA COLLECTED FROM SAMPLING SITES.

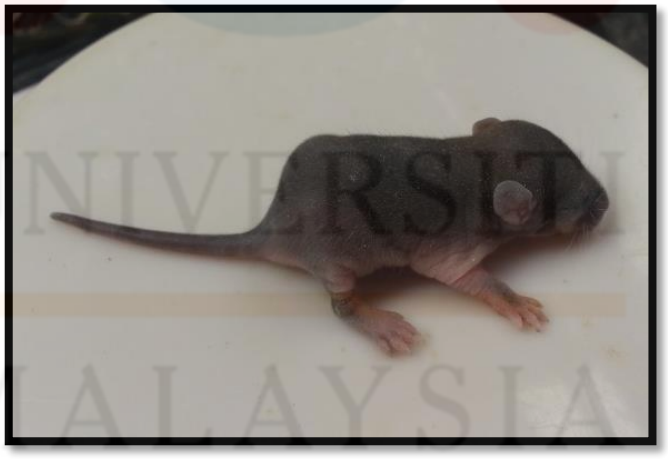
Sampling Site Number	Rats Species			Total
	Rattus rattus	*Rattus tiomanicus*	*Rattus exulans*	
1	0	0	3	3
2	3	1	0	4
3	0	0	0	0
4	0	0	0	0
5	1	0	0	1
6	0	0	0	0
7	0	3	0	3
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	1	1	0	2
12	0	0	0	0
13	1	1	0	2
14	0	1	1	2
15	0	0	0	0
16	0	0	0	0
17	2	0	0	2
18	0	0	0	0
19	1	1	0	2
20	0	0	0	0
21	0	0	0	0
22	0	0	0	0
23	0	1	0	1
24	0	0	0	0
25	0	0	0	0
26	3	0	0	3
27	0	0	0	0
28	0	1	0	1
29	0	0	1	1
30	0	0	0	0
Total	12	10	5	27

APPENDIX B

FIGURE OF RATS



Developed embryo of female *R. rattus.*



Lateral view of new born *R. rattus*. (TL : 8.1 cm)

Ventral view of female *R. rattus*.

(TL : 39.7 cm)

Ventral view of male *R. rattus.*

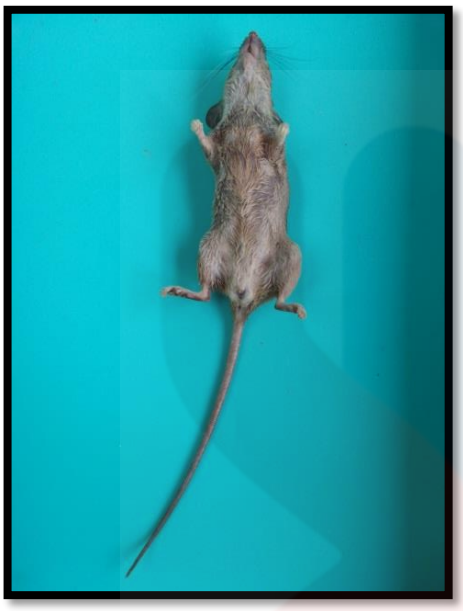
(TL : 39.2 cm)

Ventral view of female *R. tiomanicus.*

(TL : 32.5 cm)

Ventral view of male *R. tiomanicus.*

(TL : 38.7 cm)



Ventral view of female *R. exulans*.

(TL : 23.9 cm)

Ventral view of male *R. exulans.*

(TL : 23.6 cm)