DIVERSITY OF BEETLES (ORDER: COLEOPTERA) AT GUNUNG RENG, JELI KELANTAN

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by

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DECLARATION

I declare that this thesis entitled Diversity of Beetles (Order: Coleoptera) at Gunung Reng, 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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Diversity of Beetles (Order: Coleoptera) at Gunung Reng, Jeli Kelantan

ABSTRACT

Gunung Reng is one of the tourism destination located at Batu Melintang subdistrict, Jeli, in the state of Kelantan, Malaysia. It has beautiful geological landscape with different geomorphological processess, and it has been conserved as natural geological attractions that contribute to benefits to the public and the states of Kelantan. A study on diversity of beetle species has been conducted at Gunung Reng, Jeli, Kelantan from August 2016 to September 2016. The aim of this study was to identify the species richness of Coleoptera in Gunung Reng and to obtain the diversity index of Coleoptera in Gunung Reng. Light trap, pitfall trap and yellow pan trap methods were used to sample the beetle. A total of 51 individuals belonging to 12 species from eight families were recorded in this study. Shannon-Wiener Diversity value is 1.88, and the Margalef's Richness index value is 2.80. This value shows low beetle diversity and also low species richness of beetle at Gunung Reng, Jeli, Kelantan. The Pielou's Evenness index value is 0.76 and this value shows that the species of beetles at Gunung Reng, Jeli, Kelantan is well distributed. The diversity of beetle in Gunung Reng, Jeli, Kelantan is considered low. As a conclusion, the diversity of beetle species at Gunung Reng, Jeli, Kelantan is quite low because of the human disturbance of beetles habitat at Gunung Reng, Jeli, Kelantan. A future research on beetle diversity at Gunung Reng, Jeli, Kelantan is recommended because there might be more species that would be collected and identified in the area.

Kepelbagaian Spesies Kumbang (Order: Coleoptera) di Gunung Reng, Jeli, Kelantan

ABSTRAK

Gunung Reng adalah salah satu destinasi pelancongan yang terletak di Batu Melintang Jeli, di negeri Kelantan, Malaysia. Ia mempunyai landskap geologi yang indah dengan proses geomorfologi yang berbeza, dan ia telah dipulihara sebagai tarikan geologi semulajadi di negeri Kelantan. Kajian mengenai kepelbagaian spesies kumbang telah dijalankan di Gunung Reng, Jeli, Kelantan dari Ogos 2016 sehingga September 2016. Tujuan kajian ini adalah untuk mengenal pasti kepelbagaian spesies Coleoptera di Gunung Reng dan untuk mendapatkan indeks kepelbagaian kumbang di Gunung Reng. Perangkap cahaya, perangkap tanah dan kaedah perangkap pan kuning digunakan untuk menangkap kumbang. Sebanyak 51 individu yang merangkumi 12 spesies, lapan keluarga telah direkodkan dalam indeks kepelbagaian Shannon-Wiener dan indeks kekayaan Margalef. Nilai bagi indeks Shannon-Wiener ialah 1.88 manakala nilai bagi indeks kekayaan Margalef ialah 2.80. Nilai indeks ini menunjukkan bahawa kepelbagaian spesies kumbang adalah rendah di Gunung Reng, Jeli, Kelantan. Nilai indeks Pielou 0.76 menunjukkan taburan spesies kumbang di Gunung Reng, Jeli, Kelantan adalah teratur dan sekata. Kesimpulannya, kepelbagaian spesies kumbang di Gunung Reng, Jeli, Kelantan adalah rendah kerana kawasan tumbuh-tumbuhan dan hutan tanah rendah sekitar kawasan gua yang menjadi habitat kumbang telah diterokai oleh manusia. Kajian untuk jangka masa yang lebih panjang pada masa akan datang adalah disarankan kerana lebih banyak spesies kumbang bakal diperolehi.

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

The Coleoptera, or beetles, includes many commonly assemble insects such as ladybird beetles (family Coccinellidae), scarab beetles (Scarabaeidae), click beetles (Elateridae), and fireflies (Lampyridae) (Ahmad, 2013). Beetles live most in the tropics and can be vary in size, and they live throughout the world (Ahmad, 2013). They have an open circulatory system that uses fluid alternatively from blood (Ahmad, 2013).

Most beetles have two pairs of wings, one pair is membraneous wing and other pair is hardened elytra (Michael et al., 2005). They have antennae that mostly used for their sense of smell (Michael et al., 2005). Breathing holes on beetle's abdomen is called spiracles, which they used for breathing (Michael et al., 2005). Most beetles feed on plants, but some other species are acquisitive (Thakare & Zade, 2012). Some species have hard exoskeleton, some species are aquatic and some other species are dimorphic (Thakare & Zade, 2012). This can be seen when males have horns on their head.

Most beetles go through complete metamorphosis. They experience several stages from the egg, the grub, the pupa and the adult (Stork & Grimbacher, 2006). Female beetles ordinarily lay dozens or hundreds of eggs. Reproduction is often regular to match the time of most available food. Adult female beetles mate and laying their eggs. The eggs incubate into a larval stage that is wingless. The larva feed and grow, and turn into a pupal stage (Thakare & Zade, 2012). The pupa does not move or

feed. Finally the pupa transform into beetles. Most beetles have a gland that induct pheromones to arrest a mate (Thakare & Zade, 2012).

Beetles are like most other insects, they have head, thorax, abdomen, and six legs (Muhaimin et al., 2015). Their bodies lean to be very solid and though. Beetles have chewing mouthparts and often have powerful jaws. Beetle larvae look like worms, but they have a hard head and six legs. Beetle pupa are covered with a leathery skin and they cannot move (Somerville, 2003). Lives of most species of beetle is completed in a single year. Some of the species especially the larger ones, live for more than a year and giving birth in summer, they become larva and pupa for a few months to a year and then rising to reproduce as an adult (Somerville, 2003).

Coleopteran is a highly wide ranging and pretty well known order of insects which is the most interest for the evaluation of arthropod diversity. Many authors have tried to sample the ground habitation species of the beetles by using pitfall trap in order to increase effectiveness (Somerville, 2003).

Diversity of beetles will be assorted in different environment such as tropical, cold, and hot weather because different degrees of environmental changes had confirmative effects on beetle species richness and abundance (Casale et al., 1998). Coleoptera are found in nearly all natural habitats, including freshwater and marine habitats, and also everywhere vegetative plant organ is found (Casale et al., 1998). But this research stressed more on the beetles surrounding the cave.

Beetles interact with their ecosystems in various ways. They frequently feed on plants and fungi, break down animal and plant debris, and also eat other invertebrates. Beetles are endopterygotes, which means that they go through complete

metamorphosis, a biological process by which animal physically formulated after birth or hatching, that give change to body structure (Ribera et al., 1999).

Along with this species richness, beetles have an impressive range in form and body size. The order Coleoptera does not only comprise some of the largest and dazzling insects, but also contains some of the smallest and dull (Ribera et al., 1999). Many beetles are pests, for example bark beetles and leave beetles can influence great harm to trees, while other species can infests food stuff (Ribera et al., 1999). This great diversity make beetles one of the most abundant and productive of all insects (Ribera et al., 1999).

The diversity of order Coleoptera contributes to the complexity of writing the classification keys that embraces all exceptions. The prevalent keys that are written to cover all species of Coleoptera become very lengthy and complex. There are more than 100 families of beetles, and that this classification key is only deliberate to introduce the morphology and terminology that will be used in more comprehensive keys.

The keys are following the dichotomous key. Each couplet has 2 paragraphs of characters to select for identification of species. Identification of family is very important because individuals of the family are presenting the identical features. However, some of the larger families of Coleoptera may have many different morphotypes.

Beetle identification requires a person to become familiar with mouthparts (labial and maxillary palpi), tarsi, shapes of segments ventral characters (sterna, pleura, coxae), antennal shapes, and other morphological characters. Color and size of

specimens will not usually help in identifying beetle families because the morphological characters that identify each family is a required factor to be known.

There are a few types of beetles that can bite humans (Covington, 2003). When this happens, it is usually a result of unintentional contact between the person and the beetle. Some beetle can inflict a painful bite if threatened or provoked (Covington, 2003). Although rare, beetle bites can occur from the three following species which are blister beetles, stag beetles and Longhorn beetles (Berardi et al., 2007).

Blister beetles feed on crops and gardens, so there is human contact between beetles and humans. (Berardi et al., 2007). They are also attracted to light, making human area to be more cautions of these beetle. When the bite happens, the beetle release a chemical substance that can cause the skin to blist (Covington, 2003). The blister usually heals within a few days and cause no permanent damage (Covington, 2003).

Stag beetle are black to dark- brown color and have mandibles (Abdullah et al., 2008). The male does not have enough strength in his jaws to bite, however, the female does. A bite from the female can be painful, but does not normally require any medical treatment (Berardi et al., 2007). Longhorned beetles are named for their unusually long antennae (Muhaimin et al., 2015). Longhorned beetle feed on firewood and timber with a high moisture content. Some species also feed on leaves, nectar and pollen. A bites from this type of beetle may cause considerable pain that could last up to a day or two (Covington, 2003). Fortunately, beetle bites are not common and they are seldom harmful to humans unless the person bitten has an allergic reaction.

In Malaysia, there are a lot of species that are astonishing and lovely. Many of the Malaysian beetles can been seen by just having a leisurely walk in the gardens,

parks or rainforest of the country. Beetles in Malaysia comes in an assemblage with fascinating body colors, sizes, features and design (Muhaimin et al., 2015). Some of these beetles have bright, impresive colors that usually function as warning signs to predators to keep away (Muhaimin et al., 2015). There are also unique and elusive body colorations that help as camouflage to catch prey, and also to shield from their predator (Muhaimin et al., 2015).

1.2 Problem Statement

Over the past decade, many species of Coleopteran had been found. The Coleopteran are the invertebrate communities that inhabit caves, rainforest canopy and wood. In Kelantan, there are many caves and there will be many species that inhibit the caves and surrounding it. A research for the diversity of beetles around the cave area are needed because Malaysia also has a great diversity of beetles that consists of many species. Gunung Reng is suitable for this research because it consists of a cave and also low canopy forest surrounding it, make it a great place in Kelantan for the diversity study.

1.3 Objectives

a) To identify the species richness of Coleoptera in Gunung Reng.

b) To obtain the diversity index of Coleoptera in Gunung Reng.

CHAPTER 2

LITERATURE REVIEW

2.1 Beetles

Beetles are group of insects in the order Coleoptera. These group of insects have populated our Earth for a very long time (Ponomarenko, 1997). During the Permian period within 291.5 until 253 million years ago, the first fossils of the beetles are identified (Ponomarenko, 1997). Beetles jump out on pages of the geological record in the Permian period nearly 300 mya (Ponomarenko, 1997).

Coleopteran is one insects that have the diverse order of insects on the planet, makes up at least half of the living species on Earth (Muhaimin et al., 2015). Coleopteran has the highest diversity including some of the largest insects such as living Hercules Beetle and Dynastes Hercules (Ponomarenko 1997). Coleopteran means “sheathed wing”, which refers to the thickened and hardened fore wings which is used as protection to cover the most fragile membranous hind wings (Muhaimin et al., 2015). Because of the hard wings they have, beetle have more fossil record than most other insects. The first fossil record of beetles is back to Permian (Ponomarenko, 1997).

Since the Permian period, the group is then has varied into many different forms. The size range for feathered wing beetles (Ptliidae), the adults are as small as 0.3 mm long, to the giant Goliath and Hercules beetles (Scarabaeidae), which can be more than 15 cm (Ponomarenko, 1997). Many of them are predacious or fungivores, most species of the beetles are phytophagous, and also some of them are parasitoids.

The beetles communicate to each other through many ways, either by using chemicals such as pheromones, by sounds such as stridulation, or by visual implementation such as fireflies (Ribera et al., 1999). They live in the dries deserts, in the caves, in lakes, in the rainforest canopies and above treeline on mountains (Ribera et al., 1999).

Beetles have many distinguishable features, but the hardened fore wings from which their name is derived is the most known for beetle (Alois et al., 2003). These hardened wings, are used to shield the fragile hind wings as well as the abdomen (Ribera et al., 1999). This shield layer may help them utilize narrow passageway in their habitat (Alois et al., 2003). Many Coleopteran use their hind wings for flight by opening their elytra just enough to strech the hind wings which are folded under the elytra in a complex manner. The hardened wings is called elytra (Ribera et al., 1999). Figure 2.1 shows the abdominal parts of beetle from the upper and also the lower parts.

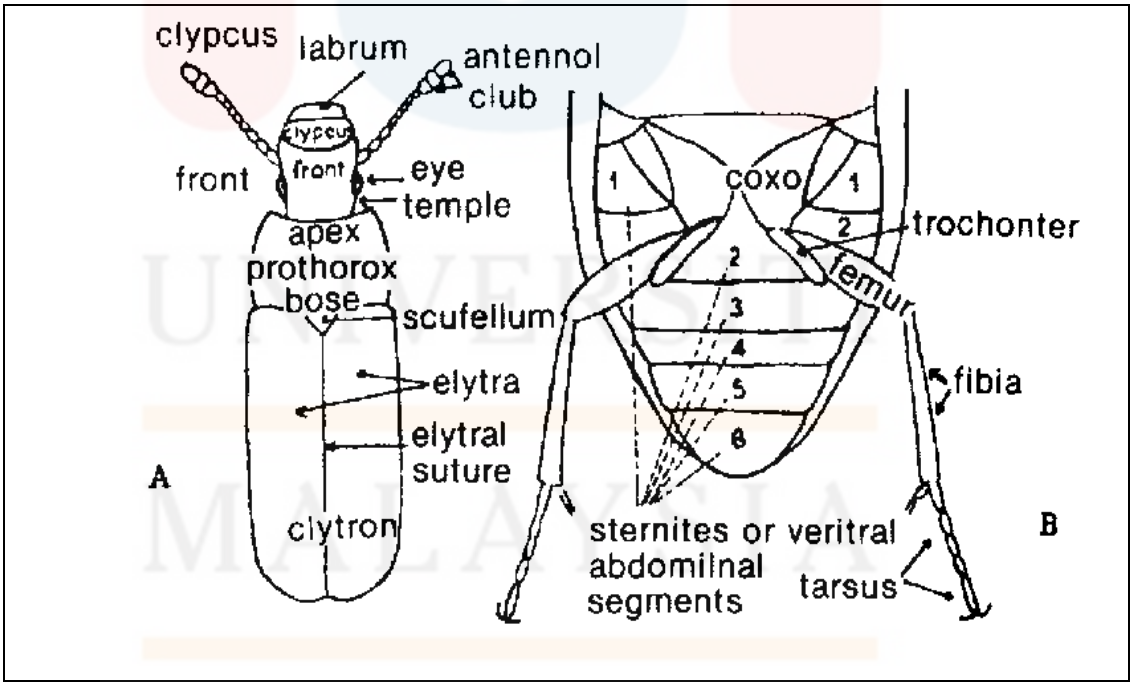

Figure 2.1 The Abdominal Parts of Beetle: A) Upper Part, B) Lower Part

(Source: Bueno & James, 2001)

Other derived characteristics is the rare body segmentation (Stork & Grimbacher, 2006). Unlike the common thorax, the segmentation of the body, and the head of the posterior Coleopterans and two thoracic segments are joined with the abdomen. The biting mouthparts of Coleopterans are usually present on the undersurface of the head. They usually have antennae with eleven articles (Thakare & Zade, 2012). Figure 2.2 shows the outer body parts of beetle.

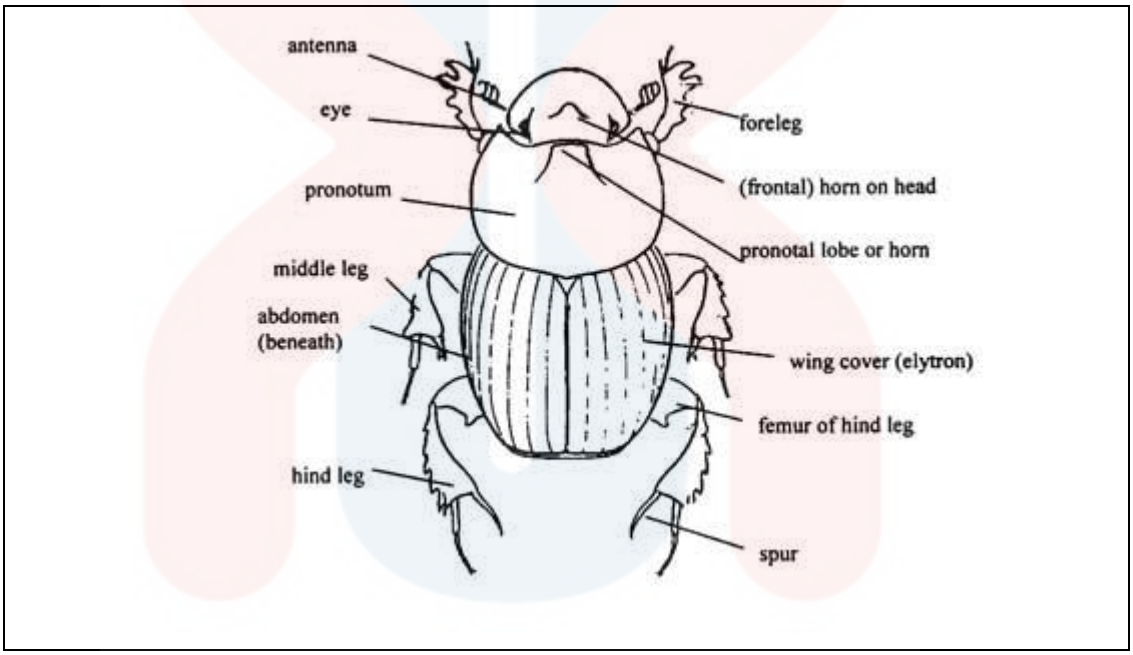

Figure 2.2 Outer Body Parts of Beetle

(Source: Bueno & James, 2001)

The larvae contain eight to ten abdominal segments, three thoracic segments and a head (Stork, 1988). The youngest larvae usually have three pairs of small thoracic legs (Stork, 1988). Pupation also occurs near the beetles's feeding places. The pupal stage always lasts about one to three weeks (Boving & Craighead, 1931). At first, the beetles is woolly and they become almost colorless once they burst (Thakare & Zade, 2012). Their elytra begins to harden and they begin to gain their color (Stork, 1988). The most outstanding factor of the coleopterans success is the development of

the elytra that shield the folded hindwings (Thakare & Zade, 2012). The differences between different species of beetle's larvae are shown in Figure 2.3.

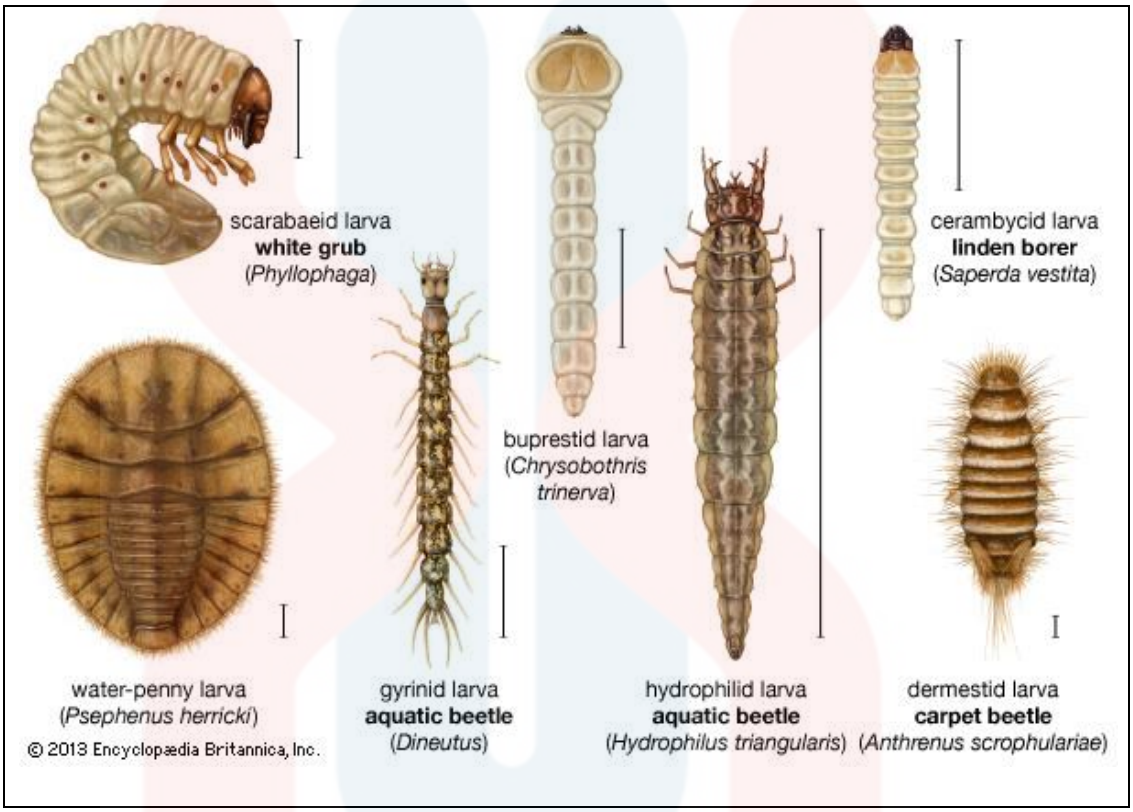

Figure 2.3 Differences between Different Species of Beetle's larvae

(Source: The Bug Clinic, 2016)

There are many thousands of beetle species that has been described and found in Malaysia (Abdullah et al., 2008). They range in size from small adults of pin-head size, like some leaf beetles, to large creatures, such as rhinoceros beetles, which can fill the palm of the hand (Abdullah et al., 2008). Just like the other beetle species, the Malaysian beetles also going through a complete metamorphosis (Abdullah et al., 2008). In general, most Malaysian beetles have the ability to fly, but there are some that are flightless or wingless, as are some species of the female fireflies (Abdullah et al., 2008).

2.2 Ground Beetles

Carabidae is the family of the ground beetle which belongs to the order Coleoptera and suborder Adephaga, which is the third largest family of beetles after Curcolionidae and Staphylinidae (Ahmad, 2013). This carabid beetles varies in shape, color and size (Abdullah et al., 2008). Adult ground beetles range in size from 2mm to over 35mm (Stork, 1988). Most of the beetles have dark color, but many of them possess of brilliant metallic colors (Ahmad, 2013). Carabidae varies up to more than 40,000 species worldwide (Michael et al., 1994). This ground beetles are usually found under the leaves, log, bark, stone or just running on the ground. Ground beetle is one of the diverse group of arthropods (Michael et al., 1994).

Carabid beetles are well advised to be the most opportunistic feeders that consume variety of foods (Michael et al., 1994). The majority ground beetles are predacious, which means that they have been observed as primarily predators (Michael et al., 1994). Some of them are specialized predators of snails and millipedes, but some feed on soft-bodies insects (Ahmad, 2013). Most species searching for food by random search, although some day-active species hunt by sight (Lovei & Sunderland, 1996). A few species have also been observed to discover chemical cues from springtails, mollusks, and aphids (Lovei & Sunderland, 1996). Adults and larvae typically have similar feeding habits. However, larval diet are more confined due to a limited search range underground (Walker & Galbreath, 1979). Several ground beetle species are phytophagous, which means they eat plants (Lovei & Sunderland, 1996). Carabidae are active mainly on the ground by walking or running (Lovei & Sunderland, 1996).

Carabid beetles possess complete metamorphosis, which means that the insect passes through four separate stages of growth being egg, larva, pupa, and then adult stages. (Ahmad, 2013). Carabid beetles produce one generation per year on average (Ahmad, 2013). After finding a suitable site, females will singly lodge 30 to 600 oval eggs within the soil or in the layer of plant residues on the soil surface (Walker & Galbreath, 1979). Young larvae have limited mobility to find food and their soft bodies are vulnerable to predators, so the safe place to protect eggs is very important (Casale et al., 1998). Figure 2.4 shows the image of the ground beetle.

Figure 2.4 The Ground Beetle (Source: Royal Entomological Society, 2016)

2.3 Cave Beetles

The cave-adapted beetles (troglobitic) belongs to the family Carabidae (Stewart et al., 1998). Due to the loss of the pigment, beetles are recognized and loss of pigmentation causes their body to appear in reddish-brown. Each species is captive to the single karst area (Stewart et al., 1998). The extinction of the ancestral superficial population is caused by the climatic change associated with several periods of glaciation and retirement of the forest cover (Peck & Thayer, 2003). This change allows each of the cave populations to evolve separately in isolation to become new distinguishable species (Peck & Thayer, 2003). Cave beetles may be seen on cave floors, walls and also from the twilight zone to the deep zone (Stewart et al., 1998). The image of the cave beetle is shown in Figure 2.5.

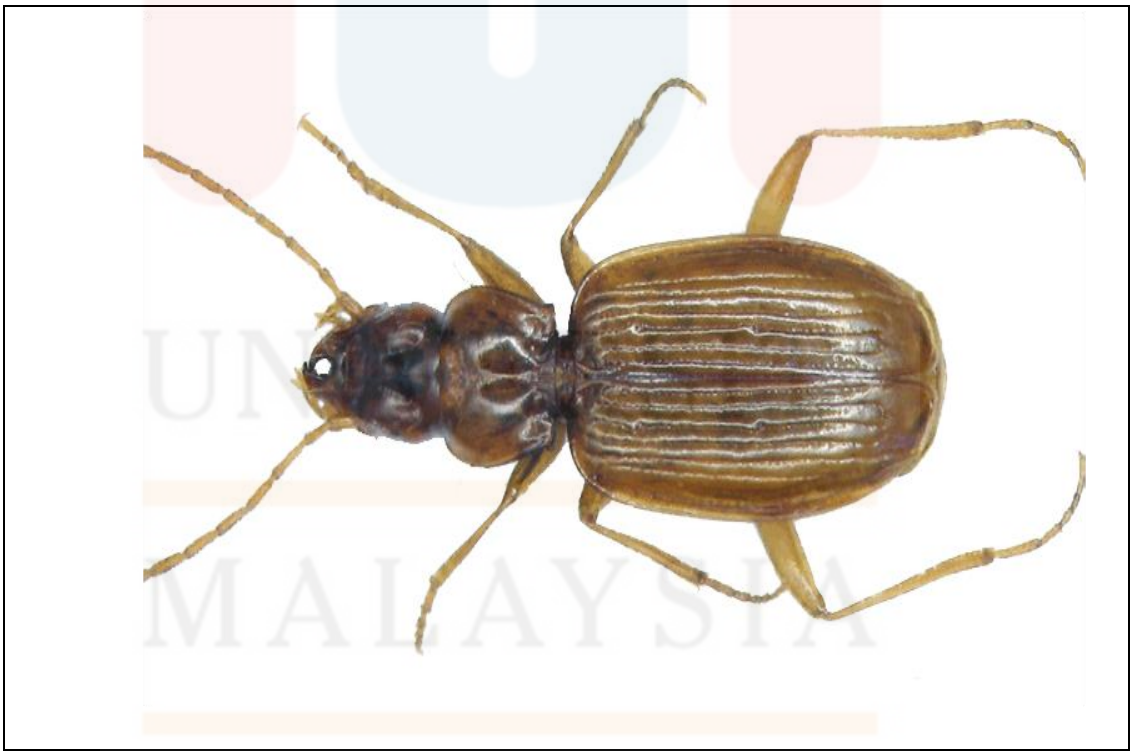

Figure 2.5 The Cave Beetle

(Source: Stallard, 2014)

There are six cave beetles that is uncommon and they've been considered for addiction to the federal endangered species list (Joan et al., 2003). Six cave beetles are Fowler's cave beetle (*Pseudanophthalmus fowlerae*), Insular cave beetle or baker Station cave beetle (*P. insularis*), Noblett's cave beetle (*P. paulus*), Coleman Cave beetle (*P. colemanensis*), Inquirer cave beetle (*P. inquisitor*), and Soothsayer cave beetle or Indian Grave Point beetle (*P. tiresias*) (Joan et al., 2003).

These beetles are predatory ground beetles, feeding on small cave invertebrates like spiders, mites, and millipedes and cave-dependent (Stewart et al., 1998). All of the cave beetles are reddish brown insects, have fairly small bodies and eyeless (Stewart et al., 1998). They have a body that consists of thorax, head and abdomen and also six legs (Joan et al., 2003). Depending on the species, body length ranges from 3.0 to 8.0 millimeters (mm). Differences in the shape and size of various parts of the body, especially the shape of some of the male beetles make the beetle distinguishable (Stewart et al., 1998). Limestone caves are fragile environments, supporting a variety of species that have evolved to reproduce and survive under the demanding conditions of the cave (Kirk et al., 2014). All organisms adapted to the life inside a cave depend on the food that comes from the surface of the earth inside the cave because photosynthesis does not take place inside the dark zone of a cave (Stewart et al., 1998). This can be in the form of woody debris, leaf litter or small pieces of organic matter that washed from falls in the cave, or deposited by bats dependent on the caves that feed on the surface and return to the cave to roost (Kirk et al., 2014).

2.4 Blister Beetles

Insects in the family Meloidae are commonly referred to as a blister or oil beetles (Berardi et al., 2007). Different species vary in color and size, but they are easily recognized by their narrow, cylindrical, elongated, soft bodies (Figure 2.6). The constriction between the back of the head and the narrow anterior end of the thorax causing the blister beetle to have a pronounced neck (Berardi et al., 2007). Larvae of some species of beetles feed on grasshopper eggs while the adult blister beetle feeds on plant foliage (Covington, 2003).

Figure 2.6 The Blister Beetle

(Source: Bug Guide, 2016)

Blister beetles have a complex life cycle. This complete life cycle is characterized by several immature forms. During the summer, egg clusters containing up to 100 eggs are deposited in the ground. Within two weeks eggs hatch and tiny larvae, called triungulins, are looking for food, mainly grasshopper egg pods (Berardi

et al., 2007). Triungulins have legs designed for active movement. Within a month of finding suitable food, the larvae go through three more stages. In order to pass the winter, the larvae that are now called pseudo pupae develop thickened skin and lose their legs, allowing them to resist bad weather. They will remain in this stage for the next seven months. When favorable condition of temperature and humidity return at the end of spring, the final immature phase that the pup, develops. In two more weeks, new adults emerge, begin feeding, and lay eggs for the next generation of blister beetles (Berardi et al., 2007).

Blister beetles contain a substance called cantharidin (Covington, 2003). This chemical is an irritant capable of blistering external and internal body tissues exposed to the chemical. Livestock most frequently come into contact with blister beetles as they consume alfalfa that hay containing dead beetles (Covington, 2003). Horses are especially susceptible to blister beetle poisoning (cantharidiasis). Blister beetles can be crushed and killed as alfalfa is swathed. When hay is packed, bodies of dead beetles (which still contain cantharidin) are sometimes incorporated into the bales. Cantharidin may contaminate hay without the beetle bodies being evident if the beetles are squashed during hay making (Covington, 2003). Once contaminated, the hay probably does not lose its toxicity since the cantharidin is a stable compound, it resists the degradation by drying or heating.

2.5 Lycid Beetles

In the beginning, beetle watchers often fail to recognize members of the family Lycidae as beetles. The elytra of family Lycidae are soft, and they are also pretty flat, and held flat like some moth species hold their wings (American Insects, 2016). The

Lycidae family usually broader elytra in the rear than in the front. The Lycidae often have saw-toothed antennae and sometimes thread-like antennae.

Lycid beetles feed at flowers or on decaying plant material, but some adult net-winged beetles are predacious. The lycid beetles may be nectar-feeders, but some adults might not feed at all, just fly around and mate (American Insects, 2016). The larvae are found under bark where they feed on other small invertebrates. Because so many predators have learned to leave net-winged beetles alone, many other creatures have evolved to mimic them in body shapes and forms. The Lycid beetles mimics include other types of beetles such as Longhorns, also moths, flies, and true bugs (American Insects, 2016).

The Lycid beetles commonly seen flying at dusk and may be found on foliage or in flowers. Lycid beetles are offensive in taste and toxic to most predators, which they advertise by the orange and black colours. Many other insects mimic Lycid beetles. The head is triangular and the antennae are serrate and long thick (American Insects, 2016).

2.6 Longhorn Beetles

Longhorned Beetle, common name for any member of a family of beetles known for their horns or long antennae, and the wood-boring habits of the larvae. The larvae are known as roundheaded wood borers (Parker et al., 2012). Longhorned beetles live throughout the world. There are about 20,000 species of longhorned beetles (Gilbert, 2013)

Adult longhorned beetles vary greatly in size, color, and shape. In general they are cylindrical and rather long-bodied. Some tropical species are among the world's largest beetles, reaching 15 cm (6 in) or more in length. But most species measure 8 to 50 mm (0.33 to 2.00 in) long (Gilbert, 2013). Some species of longhorned beetles have bright colors or intricate patterns on their wing covers, and some have opaque brown color. In some species the antennae are longer than the body, and some of them have prominent antennaes that are at least two-thirds as long as the body (Parker et al., 2012). Males have longer antennae than females (Gilbert, 2013). Longhorned beetles can run quickly or are strong fliers, but some species of longhorned beetles are slow-moving. Depending on the species, adults may be observed feeding on flower parts, leaves, or bark.

Like all beetles, longhorned beetles have complete metamorphosis. Larvae commonly pupate in a chamber they construct under bark. Most species require one to three years to complete a generation, although some can develop from egg to adult in as little as two or three months (Stork & Grimbacher, 2006). Mature larvae of a few species can remain inactive in wood for many years. There are records of long-horned beetles emerging from wooden beams or furniture in homes after remaining dormant for more than two decades (Gilbert, 2013).

Some species of longhorned beetles are pests of fruit trees, forests or shades and certain shrubs. Longhorned beetles help to decompose dead and dying trees, thereby making nutrients and sunlight available for new plant growth (Gilbert, 2013). Longhorned beetles have many natural enemies, especially the larvae of certain other beetles and parasitic wasps. Many birds feed on adults and woodpeckers are fond of the larvae (Gilbert, 2013). Lizards sometimes lie in wait and capture adults when the beetles land on bark to mate or lay eggs.

2.7 Beetle Collection Method

There are several sampling methods available to detect beetles and any other insects. Many types of sampling methods is possible to be used to collect the greatest variety of sample.

Light trapping is the general term that covers all methods of fascinating nocturnal insects with use of lamps that have strong emission (Cedric & Jean, 2014). Beetles are fascinate to the light source of a light trap, and are guided into the center of the trap where they drop down into the collecting container (Marshall, 1994). Most light traps use UV lights which are easily portable and inexpensive. It works best on humid, warm and dark nights (Marshall, 1994). The traps are based on two type of general construction, although there are several commonly used light trap designs (Bauer, 1958). Automatic light trap also become a standard equipment for beetles and insect pest control and pest management (Bauer, 1958). Light trapping method has its own benefits. The main advantage of light trapping is the large number of species can be recorded in one time during a relatively short period (Steiner & Hauser, 2010).

Some wood boring beetles and other insects are attracted to turpentine. Sometimes, a combination of turpentine and Lindgren funnel trap will attract beetles, especially some bark beetles (Lovei & Sunderland, 1996). Pitfall trap also can be used to collect beetles. There are many variations of the pitfall trap, but the basic consist of the cup or container, which is submerged in the soil, and the cup is filled with the preservative (Fagundes et al., 2011). It is inexpensive, easy to make, portable, commonly used and provides excellent results. Beetles and insects that crawling on the ground will fall into the cup and cannot get out (Lovei & Sunderland 1996). Pitfall traps will trapped beetles that do not fly such as scarab beetles, rove beetles, ground

beetles, and some insects such as springtails, wasps, and flies (Joshua & Hanula, 2007).

If pitfall traps are to be employed, several considerations must be made because there are many factors that can affect the taxa that will be collected (Skvarla et al., 2014). Different diameter of pitfall trap will collect different taxa at different rates. Large traps caught more wolf spiders while small traps caught more small carabids and staphylinids (Skvarla et al., 2014). Another aspect of size is the depth of the trap. Deeper pitfalls are preferred for larger vertebrates while shallow pitfalls are preferred small vertebrates (Joshua & Hanula, 2007). Pitfall traps that have a circular inlet and integrated cap captured 80% of carabid species compared to other conventional traps. Pitfall traps is not suitable for environment with steep slopes, rugged and high density of roots or rocks in the soil where traps are difficult to set up (Marshall, 1994).

Next method is using beating tray. Beating trays take advantage of the behavior of beetles that feign death and fall down to the ground when vegetation is jarred (Marshall, 1994). The tray or sheet is held under a tree branch which is knocked with a stick. The beetles are dislodged, fall of the branch, and are easily seen against the light background (Marshall, 1994). This method is especially effective in cold climates or in fresh air in the early morning or in the afternoon when beetles are inactive and hide in vegetation (Marshall, 1994).

Next method is using malaise trap. When many beetles fly in a barrier like the mesh wall of malaise trap, they tend to crawl or fly upwards while trying to escape, and end up trapped in the highest part in the collection jar (Joshua & Hanula, 2007). The malaise trap collects strong-flying beetles that are attracted to light (Cedric &

Jean, 2014). The malaise trap capture large numbers and great diversity of flying beetles and have been widely used in surveys of insect and beetles abundance and biodiversity (Marshall, 1994).

Besides that, pan trap also can be used to collect beetles. A pan trap is similar to pitfall trap, but yellow pan trap is much shallower. Organizer trays or plastic microwave cup can be used and dig into the floor of the surface of the litter, or set at the top of the ground (Marshall, 1994). Yellow-painted traps attract more beetles, wasps and homopterans, while white traps attract more flies (Joshua & Hanula, 2007). Pan trap also can be set beneath malaise trap to catch insects that fall of or crawl on the mesh netting. Pan traps consisting of colored pans that is filled with water and additive such as detergent to break surface tension. The most common type of colored pan traps and yellow colored pans has been widely used to attract diversity of insects such as beetles (Joshua & Hanula, 2007).

2.8 Different Light Sources for Beetle

Previous research had examined the attraction of stored-product pests to various wavelengths of light. From the Division of Entomology, Indian Agricultural Research Institute experiment, only certain wavelengths can be perceived by the red flour beetle because it lacks the blue (B)-opsin that detects wavelengths between 400 and 500 nm. When a selection of wavelengths was presented, the red flour beetle was attracted to green lights, although the dominant wavelengths did not include those of less than 400nm (Duehl et al., 2011).

Based on Duehl et al., (2011), the mixture of green light and UV was more attractive to the red flour beetle as fluorescent lamps emitting relatively wide ranges

of wavelengths. Based on visual cues and behavioral tendencies, bees are more attracted to flowers that reflect near UV light, while beetles are more likely to pollinate red flowers. Adults small hive beetles are positively phototactic when they emerge from the soil but when they grow older, they become negatively phototactic (Somerville, 2003).

The use of artificial light sources is one of the commonly used techniques to attract an active night-timed Coleoptera for the study of taxonomy, biogeography and biodiversity (Walker & Galbreath, 1979). Light trapping method yields a large number of specimens with only minimum effort (Holloway et al., 2001). This statement is definitely true for the automatic light traps, which does not require the presence of the researcher during trapping insects (Abdullah et al., 2008). There are two approaches in using light trap. The qualitative approaches aim at maximizing the record or catch efficiency. As for faunistic purposes, it is usually preferable to choose high powered lights to get maximum effect (Somerville, 2003).

2.9 Communication of Beetles

Beetles have a variety of ways to communicate, that include a sophisticated chemical language through the usage of pheromones (Moseley, 2009). From the host tree, mountain pine beetles have many forms of communication. They can emit an anti-aggregative pheromone and an aggregative pheromone (Moseley, 2009). The aggregative pheromone is the phenomenon that attracts other beetles to the tree, and the anti-aggregative pheromone neutralizes the aggregative pheromone (Moseley, 2009). This phenomenon helps to avoid the harmful effects of having too many beetles on one tree that compete for resources (Moseley, 2009).

The mountain pine beetle can also stridulate to communicate, or rub body parts together to create sound (Peck et al., 1998). They have a "scraper" on their abdomen rubbing against a grooved surface at the bottom of their left cover to create a sound that is not audible to humans (Peck et al. 1998). Once the female beetles have reached a suitable pine host, they begin to stridulate and produce aggregating pheromones to attract other males and females.

New females arrive and do the same as they land and bore into the tree (Peck et al., 1998). When the males arrive, both male and females begin to stridulate for the females to know they have arrived, and also to warn others that the female in that gallery is taken. At this point, the female stops producing aggregative pheromones and starts producing anti-aggregative pheromone to deter more beetles from coming (Fagundes et al., 2011).

Coleoptera are affected by the climate and their communication could be affected as well because they use environmental stimuli to communicate (Peck et al., 1998). Climates such as wind or temperature, can disturb the use of pheromones, wind would blow the pheromones while they travel through the air (Peck et al., 1998).

2.10 Feeding of Beetles

Besides being verdant and varied, beetles are able to exploit the wide diversity of food sources available in their many habitats. Some of them are omnivores, eating both plants and animals. Other beetles are highly specific in their diet. Many species of leaf beetles, longhorn beetles, and weevils are very host-specific, feeding just on a single species of plant (Jameson et al., 2009). Ground beetles and rove beetles (Staphylinidae), are primarily carnivorous. They catch and feed on many other

arthropods and small prey, such as earthworms and snails (Jameson et al., 2009). While most predatory beetles are generalists, a few species have more unique prey requirements or preferences. Adult beetles do not feed and are readily captivate to lights at night (Jameson et al., 2009).

2.11 Benefit of Beetles

Beetles can also be beneficial such as ladybugs (Coccinellidae). Both of the larvae and adults are found consuming on aphid colonies. Other ladybugs consume on scale insects and bugs (Abdullah et al., 2008). If normal food origin are scarce, they may feed on small caterpillars, young plant bugs, or honeydew and nectar. Ground beetles (Carabidae) are the common predators of many incompatible insects and other arthropods, including fly eggs, caterpillars, wireworms, and others (Abdullah et al., 2008).

Dung beetles (Scarabidae) can be used to lessen the populations of pestilent flies and parasitic worms that breed in cattle dung. Beetles make the manure unattainable for breeding pests by rolling it up quickly and bury it in the soil, with the added effect of improving soil fertility and nutrient cycling (Jameson et al., 2009).

Dung beetles also play a role in agriculture (Casale et al., 1998). By burying and feeding dung, they repair nutrient recycling and soil structure (Jameson et al., 2009). They also guard livestock, such as cattle, by removing dung. If this left, it could equip habitat for pests (Jameson et al., 2009). Nowadays, many countries have present the creatures for the benefit of animal husbandry. In developing countries, the beetle

is especially valuable as an adjunct for improving standards of hygiene (Casale et al., 1998).

Carabid beetles develop a major role in agroecosystems by contributing to the mortality of weed seeds, insects, and slugs (Lovei & Sunderland, 1996). They can consume up their body weight daily, and also eat a wide selection of pest organisms including aphids, moth larvae, beetle larvae, mites and spring tails (Lovei & Sunderland, 1996). They also have been used effectively to manage slugs in greenhouses (Lovei & Sunderland, 1996). Studies have also shown that utilizing various species at different times of the year can improve biological control (Stork & Grimbacher, 2006).

There are several species of Malaysian beetles that consume only on one or a certain type of plant such as leaf beetles (Alois et al., 2003). When these food plants are devastated, they will not have food to eat and therefore their unique species will also be destroyed (Alois et al., 2003). If human disturb and exterminate beetle's habitat, they cannot fly very far to search for their food plant in a new area (Alois et al., 2003). It is crucial and critical for us humans to ensure that we maintain tracts of their habitat forest to preserve their species. So that future generations of human can still discover and be delighted by these wonderful, amazing God creatures.

2.12 Damage Caused by Beetles

Beetles can cause damage in many ways, mostly attached to field crops, stored products and trees (Kirk et al., 2014). Economic damage can caused by larvae, adults or both, but often the larvae create most damage. Some larvae feed externally on their hosts, leaves, roots and other plant parts (Kirk et al., 2014). Some beetles, like leaf-

miners, are tiny and feed in the thin space between leaf surfaces. Their mines can leave shaft marks and cause leaf loss (Kirk et al., 2014).

Certain bark beetles (Scolytinae) and metallic wood borers (Buprestidae), as well as the other beetles, hollow just below the surface of the barks on the trees (Joan et al., 2003). The pests can also occupy the wood used in buildup structure such as homes, boats, and fences. Some species of beetle girdle stems causing branch loss, and some species of beetles make galls in plants (Joan et al., 2003).

Lastly, many beetle species are important because they live in and supply on grains and materials that human keep in storage facilities and homes (Kirk et al., 2014). This will deflate products even after harvest. Some beetles also feed on cloth and fabric materials. Beetles also trigger infections of plants through their feeding (Kirk et al., 2014).

Some cucumber beetles can transfer bacterial wilts to vegetables through their saliva (Ahmad, 2013). In some cases, like in bark and ambrosia beetles (Scolytinae), the insects intentionally infect the plant with fungi on which they feed (Ahmad, 2013). Pathogens often weaken the tree and trigger the tree to become susceptible to other beetle attacks. Many types of pathogens can be terminate by beetles, including viruses, bacteria, fungi, and nematode worms (Ahmad, 2013).

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

3.1.1 Beetle Collection

Pitfall trap set (leaves or any bark as roof for the trap), equal size containers that have lids, auger, detergent), yellow pan trap set (same size plastic yellow bowl, detergent), light trap (white cloth, mercury bulb, generator), killing jar, headlamp, alcohol, cotton ball, forceps, gloves, turpentine, brown sugar yeast bait.

3.1.2 Sorting and preservation:

Alcohol, storage jar.

3.1.3 Relaxing the beetle before setting:

Hot water, plastic container, tissue.

3.1.4 Setting the beetle:

White latex based glue, entomological pins size 3 and 5, preparation needle, mounting paper cards, display box.

3.2 Method

3.2.1 Study site

The experiment had been conducted at Gunung Reng, Jeli Kelantan (5.7158° N, 101.7444° E). Gunung Reng is about 15 km from Universiti Malaysia Kelantan Kampus Jeli, 15 min driving by car. Figure 3.1 below shows the map of Gunung Reng.

Gunung Reng is one of the tourism destination located at Batu Melintang subdistrict, Jeli, in the state of Kelantan, Malaysia. It has beautiful geological landscape with different geomorphological processes. Gunung Reng has its own potential specifically in speleo tourism sector. Many study have been done in order to conserved, exposed, and develop Gunung Reng as natural geological attractions also supporting the mogote hill in contributing benefits to the public and the state of Kelantan. The cave also have the unique structure of stalactites and stalagmites. The fact is, certain rock formations, granite or limestone cave are the same as found in Gua Musang.

This experiment had been conducted at Gunung Reng starting from August until September 2016. Sampling was not been made if the weather is bad such as strong winds and rain.

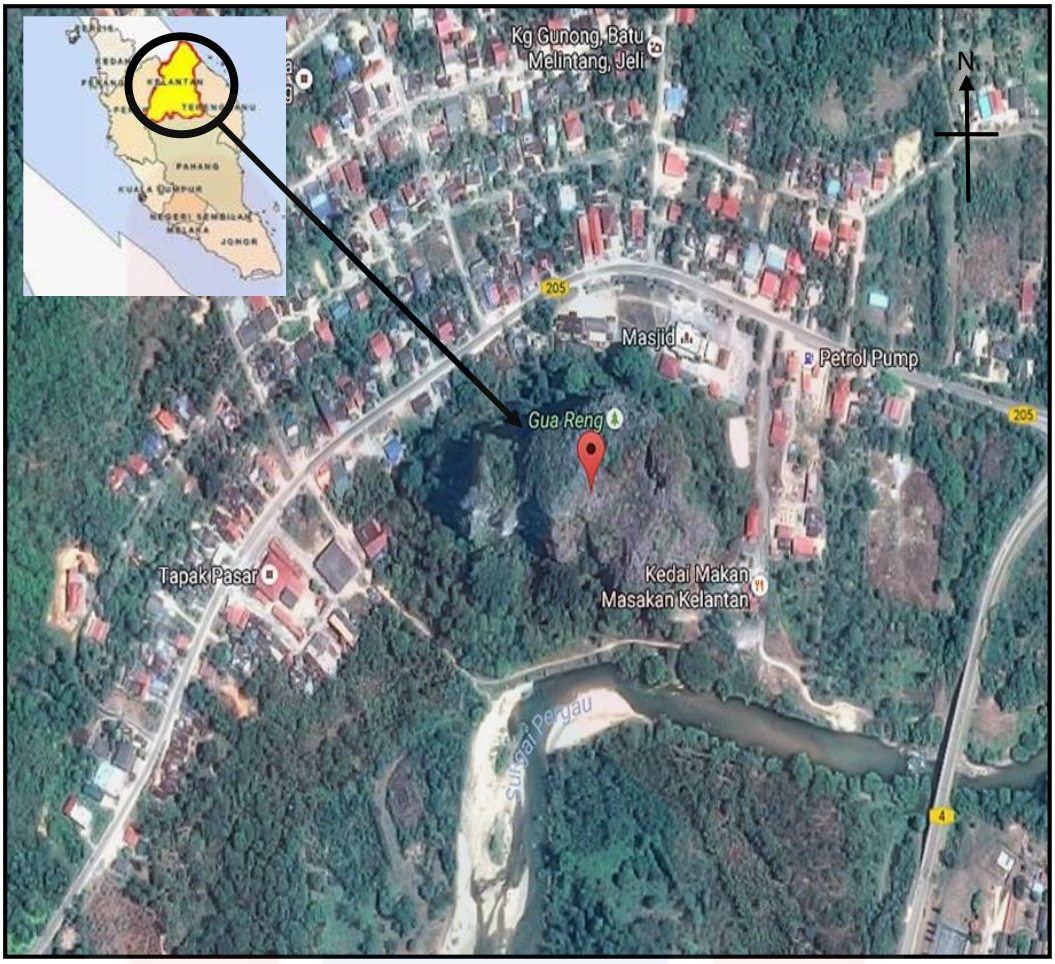

Figure 3.1 Maps of Gunung Reng

(Source: Google Maps, 2016; Photobucket, 2016)

3.2.2 Beetle Collection

Light trap, pitfall trap and yellow pan trap were located around the cave of Gunung Reng during the daytime and nighttime. Pitfall trap and yellow pan trap was positioned. The gap between each trap was at least 10 m from another. The beetles that crawl on the ground or on the caves wall had been collected by using hands.

a) Light Trap

Light trapping is made up white cloth and mercury bulb. The mercury bulb was powered by a generator that provide light to the trap. Beetles that attracted to the light were caught at the net. The beetles were collected by hand and stored in killing jar which contain ethyl acetate (Abdullah et al., 2008a).

b) Yellow Pan Trap

For yellow pan trap, a common yellow picnic bowl or any bowl that is painted with yellow color were placed on the ground (Joshua & Hanula, 2007). One or two drop of detergent were added into the pan to reduce water tension (Joshua & Hanula, 2007). After the collecting period, the samples were filtered and the contents has been transfer to pinning board for a long term storage preservative (Joshua & Hanula, 2007).

c) Pitfall Trap

For pitfall trap, the trap has been partially filled with a form of preservative fluid (chloroform), and then the trap had been sink into the ground. Beetles and any other invertebrates that are active on the ground would fall into the trap, killed and preserved by the fluid. A roof made from any big leaves or any things that can cover the pitfall trap has been placed over the trap to protect the trap from rain or debris. The pitfalls trap also has been baited with brown sugar yeast bait and turpentine to attract invertebrates especially dung beetles and wood boring beetles (Cedric & Jean, 2014). Figure 3.2 shows the illustration of pitfall trap set up.

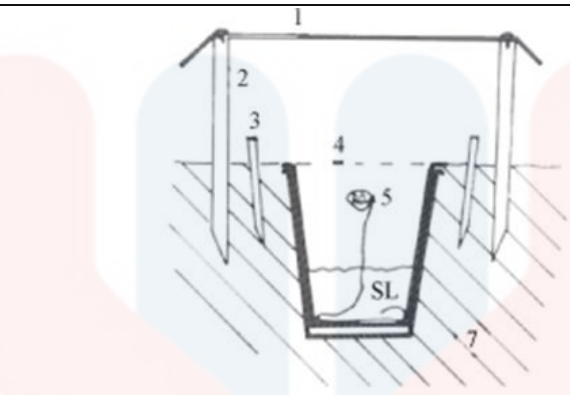

Fig 1 Pitfall traps used for collection of soil ants. 1: plastic roof, 2: support for roof, 3: anchor for the metallic grid, 4: metallic grid, 5: attractant bait, 6: soil, SL: solution of 1% formaldehyde in water.

Figure 3.2 Pitfall Trap

(Source: Skvarla et al., 2014)

3.2.3 Sorting and Preservation

The beetles were sorted and preserved in alcohol and put in a closed jar for easy transportation to laboratory for further analysis. After preserve the insects with alcohol, the beetles were taken out and have to relax before setting process.

3.2.4 Relaxing the Beetle before Setting

If the beetles are hardened before the setting processes, the beetles need to be softened or relaxing. Relaxing processes of beetles has been done by wetting the cotton or tissues with hot water in a suitable container. Beetles were placed on the tissues or cottons that has been dampened with hot water and the container were closed immediately, so that the water vapor in the container can soften the beetles.

3.2.5 Setting the Beetles

Setting is the procedure where the beetle are set up for pinning processes. Beetles can be set up if they are soft and relaxed. The beetle were pinned using entomological pins at the top part of the right elytra. A proper entomological pinned is used depend on the size of beetle. Size 3 pin is for small and moderate size beetle, size 5 is for large beetle (Abdullah et al., 2008a).

To pinning the beetle, grasp it underside down by the thumb and forefinger of left hand, and insert the pin perpendicular through the right elytra. Pinning may damage small specimens and the best for small specimen is mounted with glue on a small card. When the beetle was set in the preferred position, leave it to dry in a room with room temperature for 36 to 48 hours (Abdullah et al., 2008a).

3.2.6 Identification of Beetles

After the setting process, the specimen were identified using identification book for beetles that listed in the Table 3.1. After identification, the beetle were labelled using locality label and taxonomic label.

Table 3.1: List of Sources for Identification of Beetles

Title of Book	Author
Beetles of the World	Lawrence (1999)
An Ordinate Fondness for Beetles	Arthur & Charles (1996)
The book of Beetles	Patrice (2014)

3.2.7 Data Analysis

The data were analyzed using Shannon-Wiener Diversity index, Margalef Richness index, Pielou's Evenness index and species accumulation curve. Shannon-Wiener Diversity index is used to calculate the diversity of beetles, Margalef Richness index is used to estimate the species richness and Pielou's Evenness index is used to calculate the species evenness of Coleoptera at Gunung Reng.

The accumulation curves is the collectors curve. This curve plotted the cumulative number of species that were recorded at Gunung Reng as a function of the number of samples. The formula of Shannon index, Margalef Richness index and Pielou's Evenness Index are stated below.

a) The Margalef's Richness Index

$$D_{mg} = \frac{(S-1)}{\ln N} \quad \text{…….. Equation 3.1}$$

Where,

S = Number of species

N = Total number of species in community

b) The Shannon Diversity Index (H')

$$H' = -\sum_{i=1}^{S}(P_i ln P_i) \quad \text{……. Equation 3.2}$$

Where,

S = Number of species

P_i = Total number of individuals in i^{th} species/ number of individual for all species

ln = Natural logarithm

c) Pielou's Evenness Index (J')

$$J' = \frac{H'}{Hmax} \quad \text{……. Equation 3.3}$$

Where,

H_{max} = ln S

H' = Shannon Diversity Index

CHAPTER 4

RESULT AND DISCUSSION

4.1 Beetle Species Assemblage

The study was carried out at Gunung Reng, Jeli, Kelantan. As has been shown and discussed in method section, Gunung Reng is surrounded by the lowland forest. The study area also surrounded by the playground and villager's houses. It also was near to the river. The study was carried out from August 2016 until September 2016 resulted in the variety of the beetle species. A total of 51 individuals were recorded at Gunung Reng, Jeli, Kelantan representing 12 species from 8 families.

There were 51 individuals of beetles were identified. Since there is no previous study of Coleoptera have been recorded in Gunung Reng, Jeli, Kelantan, all the beetles species collected now are considered a new data. Coleoptera in family Buprestidae, Carabidae, Cerambycidae, Chrysomelidae, Dytiscidae, Lycidae, Meloidae and Scarabidae are recorded in this study.

From the data gathered on beetle species, the species accumulation curve was plotted (Figure 4.1). Species accumulation curve is used to generate a sample curve and to determine when a sufficient sampling had been done. When the curve levels is off or flatten, there is no need to sample further. Based on the Figure 4.1, the curve has reach their asymptotes. It is means that 17 days of the study period is enough in this study. Thus, further research is necessary because more species await to be collected and identified, with a further sampling effort.

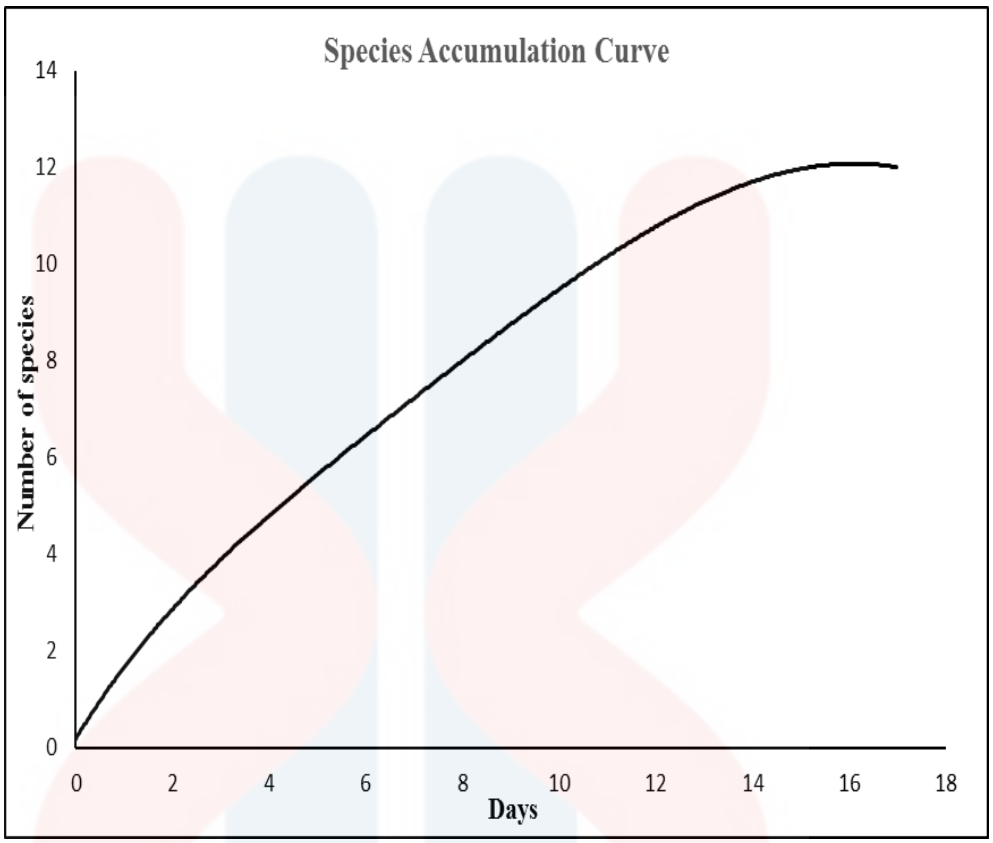

Figure 4.1 Species Accumulation Curve

Four species which is *Epicauta hirticornis*- Blister Beetle, *Chrysolina herbacea*– Mint Beetle, *Oryctes rhinoceros*– Asiatic Rhinocheros Beetle and *Cicindela aurulenta*– Golden- spotted Tiger Beetle (Appendix A) were the most common beetle species at Gunung Reng, Jeli, Kelantan.

Table 4.1 Beetle species with abundance in Gunung Reng, Jeli, Kelantan

Family	**Scientific Name**	**No. of Individual**
Buprestidae	*Steraspis squamosal*	1
Carabidae	*Cicindela aurulenta*	6
	Ptrerostichus melanarius	1
Cerambycidae	*Pterolophia melanura*	1
	Xystrocera festiva	1
Chrysomelidae	*Cassida circumdata*	1
	Unknown	1
Dytiscidae	Unknown	1
Lycidae	*Metriorrynchus rhipidius*	1
Meloidae	*Epicauta hirticornis*	14
Scarabidae	*Chrysolina herbacea*	16
	Oryctes rhinoceros	7
Total		**51**

A total of 12 species were recorded at Gunung Reng, Jeli, Kelantan. The highest number of species recorded was – Blister beetle and Mint Beetle with the 14 individuals. This is because blister beetle feed on flower and foliage of a wide variety of crops at Gunung Reng. Mint Beetle also high in number because they also feed on leaf and plants, which is the main reason for their highest frequency as Gunung Reng is surrounded by many types of plant.

Besides that, the Asiatic Rhinoceros Beetle species had been identified with the seven individuals recorded in the study area. Most of the individual recorded were from the shrub area and plant cultivation at Gunung Reng, Jeli, Kelantan. Adult rhinoceros beetle feed on nectar, plant sap and fruit, while the larvae eat on the rotting wood or the compost where they live (National Wildlife Federation, 2016). In spite for their fierce appearance with horns, they are totally harmless. They cannot bite or sting human with their horns because the horns is only used for protection (National Wildlife Federation, 2016).

Furthermore, the third highest species recorded was Golden-spotted Tiger Beetle with six individuals. Tiger Beetle is one of the species that display unusual form of pursuit in which they alternatively sprint quickly toward their prey (Cassola & Pearson, 2001). They have aggressive predatory habits and known for their running speed. Tiger beetle is one species that have richest diversity, and the genus *Cicindela* has a cosmopolitan distribution (Cassola & Pearson, 2001). Next species recorded is longhorn beetle, which are *Xystrocera festiva* and *Pterolophia melanura* under the family Cerambycidae.

Longhorn beetle are cosmopolitan family of beetles that have long antennae, which are often as long as or longer than the beetles body (Deborah, 2005). Longhorn beetle bore into wood, and can cause extensive damage to either untreated lumber or living trees (Deborah, 2005). Figure 4.2 shows the image of a longhorn beetle.

Figure 4.2 *Pterolophia melanura* - Longhorn beetle

Another unique species is *Cassida circumdata*, under subfamily Cassidinae. The Cassidinae are a subfamily of leaf beetle. Cassidinae are often colourful and metallic, with the ability to the colour which is present in the living tissue below the translucent cuticle (Abdullah et al., 2008b). The cassidines have a rounded outline with the edges of the protonum and elytra spreading out to cover the legs and head (Abdullah et al., 2008b). They have the mouthparts reduced into a cavity in the head capsule, the legs have four segmented tarsi (Abdullah et al., 2008b). Although these shields are thought to provide defense, no evidence exists for such a role.

4.2 Beetle Diversity Index

All of the data collected for beetle species were analyzed by using Shannon-Wiener Index (H'), Margalef's Richness Index and Pielou's Evenness index to calculate the species evenness of Coleoptera at Gunung Reng. Table 4.2 shows the diversity index of beetle at Gunung Reng.

Table 4.2 Shannon-Wiener Index (H'), Margalef's Richness Index (DMg).

Site	DMg	H'	H'max
Gunung Reng, Jeli, Kelantan	2.80	1.88	2.48

Based on Table 4.2, the Shannon-Wiener Index value was 1.88. The results showed that Gunung Reng has low variations communities between the species. The results showed that Gunung Reng, Jeli, Kelantan has quite low diversity between the beetle species.

Margalef's Diversity Index also were used to estimate the species richness and abundance of beetles at study site. The value of DMg was obtained as shown in Table 4.3. The value of DMg is 2.80. The value has proved that the species of beetle collected at Gunung Reng, Jeli, Kelantan was moderately abundance.

4.3 Evenness

Pielou's Evenness Index (J') was used to calculate the species evenness of beetle at Gunung Reng, Jeli, Kelantan. The result was shown in the Table 4.3.

Table 4.3 Pielou's Evenness Index

Site	J'
Gunung Reng, Jeli, Kelantan	0.76

Based on Table 4.3, the value of J' is 0.76. The result showed that Gunung Reng, Jeli, Kelantan, has high variation communities between the beetle species. So, it can be said that beetle species in Gunung Reng, Jeli, Kelantan are well distributed.

The biodiversity (diversity index, species richness and evenness) of beetle at Gunung Reng is mainly due to the rich of vegetation in Gunung Reng area as vegetation plays an important role for the existence of insect fauna such as beetle in a community. This is because the vegetation is the main source of food for insects (Aslam, 2009).

The total number of individuals caught in a trap is an indication of biomass although more care has to be taken in its interpretation than for the diversity. This is due to the size of a light trap catch that influenced significantly by the setting of the trap, lunar cycles and also the interference from other lights (Aslam, 2009).

4.4 Abundance

Results of this study shows that Gunung Reng has low species richness and abundance of beetles. This disturbed habitat explained the moderate diversity of beetle in Gunung Reng. Gunung Reng is disturbed being a park for people doing activities which explained the low diversity there.

Human alteration of landscape in Gunung Reng is likely to negatively impact the abundance and diversity of beetles. From this study, 51 specimens were caught and beetles from family Scarabidae have the highest abundance, followed by beetles from family Meloidae. Beetles from another six families have low abundance, probably due to high level of human disturbance towards their habitat.

Based on Figure 4.3, the result of monitoring of beetle species conducted in Gunung Reng, Jeli, Kelantan from August to September 2016 shows the highest number of individuals from family Scarabidae, followed by family Meloidae, and then Carabidae, Cerambicydae, Chrysomelidae, Buprestidae, Dytistidae, Lycidae respectively. All together two different species of Scarabid beetle have been recorded, two species from family Carabidae, Cerambycidae and Carabidae while the other four family recorded one species for each family.

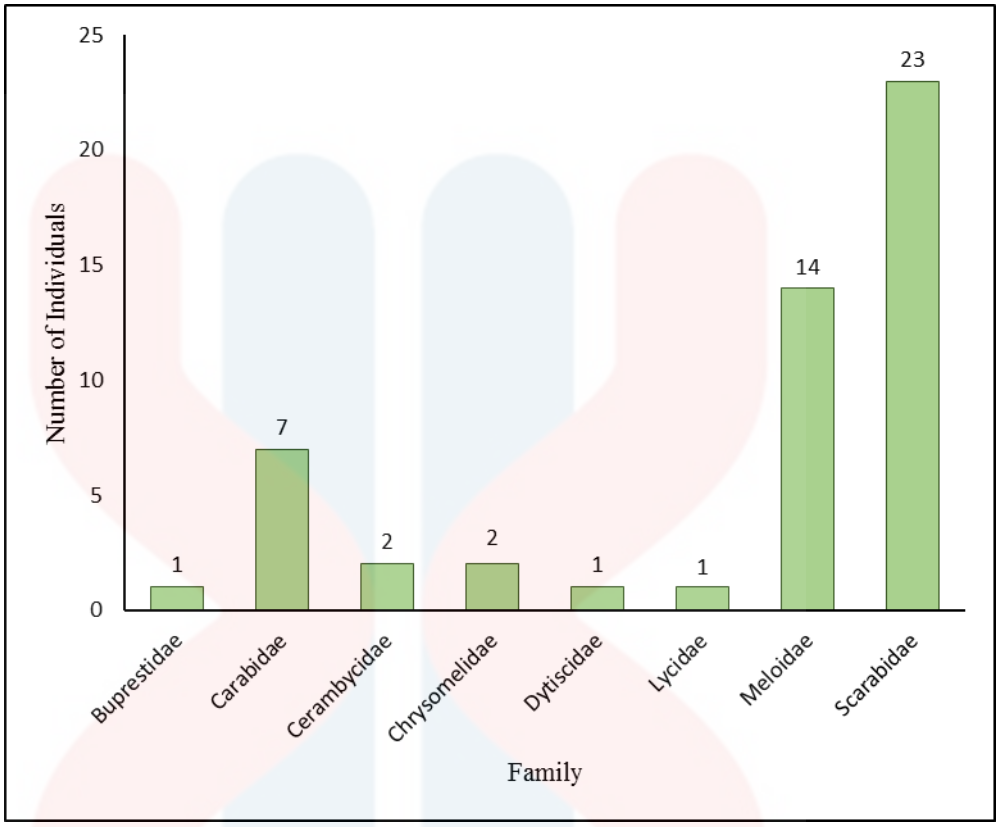

Figure 4.3 Number of individuals of each family of the beetles recorded at Gunung Reng, Jeli, Kelantan

This study showed that population of Scarabid beetles was always highest during monitoring period which was followed by Meloidae family and Carabidae. The number of beetles collected at weekly interval from August to September 2016 through light trap, yellow pan trap and pitfall trap in Gunung Reng, Jeli, Kelantan.

Analysis of the data for monitoring beetles species indicated that 23 individuals of Scarabid beetles were represented in the 51 specimens collected over the one month period. Among those 51 specimens, 41.2% were Scarabidae, 27.5% were Meloidae, 13.7% were Carabidae, 4% were Cerambycidae, 4% were Chrysomelidae, 2% were Buprestidae, 2% were Dytiscidae and 2% were Lycidae.

The species of scarab beetles vary in different site depending upon cropping pattern, temperature, soil type, host crop and other factors (Maharjan & Khanal, 2016). Emergence of adult beetles also takes place after the first rain in the month and infests the field till heavy monsoon (Maharjan & Khanal, 2016). Temperature and rainfall also may determine survival of adult beetles. This is due to positive impact of rain to break hard cover of pupae. Due to negative impact of heavy rainfall for adult flight, the catches of beetle by light trap showed a decreasing order after the heavy monsoon start (Maharjan & Khanal, 2016).

4.5 Comparison of Beetle with Previous Study

The data collected in Gunung Reng, Jeli, Kelantan for beetle's species is compared to the data of beetle in Taman Negeri Diraja Belum. The study of beetle's diversity in Gunung Reng, Jeli, Kelantan is compared to the sampling in Taman Negeri Diraja Belum because the location of Gunung Reng, Jeli, Kelantan is near with Taman Negeri Diraja Belum. Table 4.4 shows the comparison between beetle species collected in Gunung Reng, Jeli, Kelantan with the data for beetle in Taman Negeri Diraja Belum.

Based on Table 4.4, the total number of species recorded in Gunung Reng, Jeli, Kelantan are 12 species, while the total number of beetle's species recorded in Taman Negeri Diraja Belum are 49 species (Abdullah, et al., 2011). Taman Negeri Diraja Belum data showed no record of beetle's species from family Meloidae. The natural characteristics and the habitat characteristics of the beetles from family Meloidae may contribute to absence of family Meloidae in Taman Negeri Diraja Belum (Abdullah et al., 2011).

Table 4.4 Comparison between the beetle species in Gunung Reng, Jeli, Kelantan and data for Taman Negeri Diraja Belum

Family	Number of species in each family	
	Gunung Reng, Jeli, Kelantan	Taman Negeri Diraja Belum
Buprestidae	1	1
Carabidae	2	9
Cerambycidae	2	3
Chrysomelidae	2	16
Dytiscidae	1	1
Lycidae	1	3
Meloidae	1	0
Scarabidae	2	16
Total	12	49

The diversity of beetle species in Taman Negeri Diraja Belum is higher compared to Gunung Reng, Jeli, Kelantan. Taman Negeri Diraja Belum has high diversity of beetle species whereas Gunung Reng has moderately lower diversity of beetle species. Table 4.5 shows the diversity index for Gunung Reng, Jeli, Kelantan and Taman Negeri Diraja Belum.

Table 4.5 Diversity Index for Gunung Reng, Jeli, Kelantan and Taman Negeri Diraja Belum

Site	H'	J'	DMg
Gunung Reng, Jeli, Kelantan	1.88	0.76	2.80
Taman Negeri Diraja Belum	3.12	0.92	20.22

Taman Negeri Diraja Belum have high diversity of beetle species (Abdullah et al., 2011). This could due to high suitable habitat and many crop and vegetation for beetle as it is a reserve forest (Abdullah et al., 2011). Gunung Reng, Jeli, Kelantan obtained low diversity of beetle's species because there is human disturbance on the habitat of beetles and also due to the different of temperature of this two site.

CHAPTER 5

CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Gunung Reng, Jeli, Kelantan had a various species of Coleoptera. There were eight family had been recorded namely Meloidae, Cerambycidae, Scarabidae, Lycidae, Buprestidae, Carabidae, Chrysomelidae and Dytiscidae. The composition of Coleoptera showed that Scarabidae was the common family found with a total of 21 individuals, followed by Meloidae with 14 individuals, Carabidae (7 individuals), Chrysomelidae (4 inviduals), Cerambycidae (2 individuals), Lycidae (1 individual), Buprestidae (1 individual), and lastly Dytiscidae (1 individual).

Besides, the value of Shannon-Wiener Index was 1.88. The value of Shannon-Wiener Index shows that the diversity of beetle at Gunung Reng is low. The evenness value is 0.76, which is relatively close to one. It is considered that the species of beetle in Gunung Reng, Jeli, Kelantan is well distributed because the evenness value is close to one, as one is the maximum value for evenness.

Furthermore, pitfall traps and yellow pans traps were not very effective in this sampling. Only Scarabidae attracted to pitfall trap and Buprestidae are the only one that attracted to yellow pan trap. This site is surrounding by water bodies like river and surrounded by forest garden and plant cultivation. The physical characteristic of the study area could be the factors contributing to the variety of the beetle species.

5.2 Recommendations

It is recommended to do future research in this study area because there might be more beetle species would be collected and identified in the study area, with a further sampling effort. This study also could bring positive input towards ecotourism activity if this area is well protected.

Therefore, it is suggested that suitable management approaches be designed and adopted against the beetle as they might play a crucial role in the local biodiversity. Their biological study could explain what roles they play in the local ecology. So, the development of conservation and management strategies for beetles in Kelantan can be done using the information presented in this study.

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APPENDIX A

Chrysolina herbacea

Oryctes rhinoceros

Epicauta hirticornis

Cicindela aurulenta

Steraspis squamosa

Unknown

APPENDIX B

Table 4.2 Shannon-Wiener Diversity Index

N_i	P_i	lnP_i	$-(P_i*lnP_i)$
1	0.02	-3.91	0.080
6	0.12	-2.12	0.254
14	0.27	-1.31	0.354
1	0.02	-3.91	0.080
14	0.27	-1.31	0.354
7	0.14	-1.97	0.276
1	0.02	-3.91	0.080
1	0.02	-3.91	0.080
1	0.02	-3.91	0.080
1	0.02	-3.91	0.080
1	0.02	-3.91	0.080
1	0.02	-3.91	0.080
			H'= 1.88