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BURROW CHARACTERISTICS AMONG THREE DIFFERENT SPECIES OF PORCUPINE IN BINTULU-MIRI AREA

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BURROW CHARACTERISTICS AMONG THREE DIFFERENT SPECIES OF PORCUPINE IN BINTULU-MIRI AREA

By

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ABSTRACT

This study was conducted to compare the burrow characteristics between three different species of porcupine and to determine factors that effect the habitat preference by porcupine to build their burrows. Four locations in Bintulu-Miri area were selected which are Kampung Sepaduk and Kampung Wawasan Jaya at Bintulu, Ulu Kelulit at Bekenu and Hutan Nirwana in UPMKB. Characteristics of burrow such as type of burrow, bearing, entrance direction, hole dimension, soil pH, soil temperature and habitat variables such as tree species, canopy cover, ground cover land and tree density were determined. Burrow of *Hystrix brachyura* were constructed by mixture of rock and soil 2.00 m in height and 2.43 m in width. Soil pH was 5.15 and 24.85 °C in soil temperature. Its burrow constructed under 84.00% of canopy cover, 49.50% cover with shrubs and 70.00% in tree density. For *Thecurus crassispinis* they built their burrow from earth and was 0.70 m in length and 0.79 m in width and soil pH was recorded as 4.94 and 25.51 °C. This porcupine species built their burrow in area with 19.00% cover with canopy, 75.00 % cover with shrubs and 22.00% dense with tree. While for *Trichys fasciculata,* they built their burrow by mixture of rock and soil was recorded with had 1.75 m in length and 1.10 m in width. The soil pH was 5.38 and the temperature of the soil was 25.50 °C. This porcupine species built their burrow in area with cover of 77.50% of canopy, 54.00% cover with shrubs and 58.50% dense with tree. The factors that contributed to their habitat selection to build burrows were the abundance of food resources and low risk from becoming preys.

ABSTRAK

Kajian ini dijalankan untuk membandingkan ciri-ciri busut bagi tiga spesies landak yang berbeza untuk menentukan faktor yang mempengaruhi pemilihan habitat. Empat lokasi di sepanjang kawasan Bintulu-Miri telah dipilih iaitu Kampung Sepaduk dan Kampung Wawasan Jaya di Bintulu, Ulu Kelulit di Bekenu dan Hutan Nirwana di UPMKB. Ciri-ciri busut landak seperti jenis busut, bering, arah pintu masuk, dimensi busut, pH tanah dan suhu tanah. Manakala kepelbagaian habitat spesies tumbuhan, litupan kanopi, litupan tumbuhan renek dan kepadatan tumbuhan dikenalpasti. Busut bagi *Hystrix brachyura*, dibina daripada campuran batu dan tanah, dengan ketinggian 2.00 m dan seluas 2.43 m. Tanah di busut ini mempunyai pH 5.15 dan mencatat suhu 24.85 °C. Busut landak ini dibina di kawasan yang mempunyai litupan kanopi sebanyak 84.00%, 49.50% litupan tumbuhan renek dan 70.00% kepadatan tumbuhan. Bagi *Thecurus crassispinis*, spesis ini membina busutnya daripada tanah, dengan ketinggian 0.70 m dan kelebaran 0.79 m. Tanah menunjukan pH 4.94 dan suhu direkodkan adalah 25.51 °C. Landak ini membina busutnya di kawasan yang dilitupi kanopi sebanyak 19.00%, 75.00 % litupan tumbuhan renek dan 22.00% kepadatan tumbuhan. Manakala bagi *Trichys fasciculata*, busut dibina daripada campuran batu dan tanah, mempunyai ketinggian 1.75 m dan kelebaran 1.10 m. Tanah menunjukan pH 5.38 dan suhu 25.50 °C. Kawasan busut mempunyai 77.50% litupan kanopi, 54.00% litupan tumbuhan renek dan 58.50% kepadatan tumbuhan. Kemungkinan faktor yang mempengaruhi pemilihan habitat untuk membina busut adalah terdapatnya sumber makanan yang tinggi dan kurang risiko pemangsa.

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I certify that this research project report entitled "Burrow Characteristic Among Three Different Species of Porcupine in Bintulu-Miri Area" has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus.

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LIST OF ABBREVIATIONS

Abbreviation	Definition
° C	Degree Celsius
et al.	And all
pH	Power of Hydrogen
m	meter
%	Percentage
º	Degree
‘	Minutes

CHAPTER 1

INTRODUCTION

1.1 Background

There are four species of porcupine in Malaysia which are Malayan porcupine or *Hystrix brachyura*, Thick-spine porcupine or *Thecurus crassispinis*, Brush-tailed porcupine or *Atherurus macrourus* and Long-tailed porcupine or *Trichys fasciculata* (Junaidi and Charles, 1998). Porcupines live in several different habitats and are predominantly terrestrial, preferring to live in burrows, caves, and fissures in or around fallen trees. These rodents forage nocturnally and spending most of the day in a burrow. Porcupines are highly adaptable, being found in all types of forest, plantations, rocky area, mountain and deserts. Habitat selection may occur when they build their burrows. Habitat selection is habitat chosen by animals for spend most of times for daily activities in their life (Litvaitis *et al.*, 1994). Burrows play an important role in the life of rodents especially porcupines. Burrow is a system with numerous nest chambers and associated interconnecting tunnels with a number of entrances (Jackson, 2000). These underground refuges consist of a single nest chamber that may be access by one or two tunnels leading to the surface. Usually, burrows have several entrances which are used for several years. It is used for nesting and food storage and provides the porcupine with shelter from predators during surface activity (Kucheruk, 1983). These systems provide porcupines with easy access to the surface and also as underground refuges, with their relatively stable microclimate, which provide protection to the porcupines from extreme temperature on the surface. Variety functions of burrows are associated with their complex structure represented by a number of functionally different chambers

connected by a system of tunnels. Burrow of porcupines have their own characteristics from other burrows. Factors such as food source availability and safety environment were effected them to build their burrows in chosen habitat. This research is important to undergoes two objectives, which are :

1.2 Objectives:

1. To compare the characteristics of burrow among three different species of porcupine.
2. To determine factors effecting habitat preference for porcupine to build their burrows.

CHAPTER 2

LITERATURE REVIEW

2.1 Porcupines in the World

According to Nowak (1999); Medway (1978) and Lekagul (1977), porcupine which is classified under Order of Rodentia, consists of two families with seven genera and 21 species distributed all over the world. Families of porcupine are Hystricidae (Old World porcupine) and Erethizondae (New World porcupine). Hystricidae Family includes of three genera and eleven species and distributed in the regions of Asia, Europe and Africa. While, family of Erethizontidae consists of four genera with ten species. They can be found in North America to northern Mexico and the Appalachian Mountain, and from southern Mexico to Ecuardor and Argentina. Distribution of porcupines in the world is shown in Table 2.1.

2.2 Porcupines in Malaysia

There are four species of porcupine distributed all over the country (Nowak, 1999; Lekagul and Mc Neely, 1977) Long-tailed porcupine (*Trichys fasciculata*), Brush-tailed porcupine (*Atherurus macrourus*), Malayan porcupine (*Hystrix brachyura*) and Borneo porcupine (*Thecurus crassispinis*). These species can be found in all types of forest in Peninsular Malaysia accept the Borneo porcupine which is endemic on Borneo Island (Medway, 1978; Freye, 1975).

Table 2.1: Porcupines in the world (Nowak, 1999)

Family	Genus	Sub-genus	Species	Distribution
Hystricidae	Hystrix	Thecurus	*Hystrix pumila*	Pahlawan, Busuanga and Bababac Island
			Hystrix sumatrae	Sumatrae
			Hystrix crassispinis	Borneo
		Acanthion	*Hystrix brachyura*	Nepal, Peninsular Malaysia, Hainan, Sumatrae, Borneo
			Hystrix javanica	Island of Java to Flores
		Hystrix	*Hystrix indica*	Asia, Arab Peninsular, Central Asia, India, Sri Lanka
			Hystrix cristata	Italy, Sicily, Mediterranean, coast of Africa to northern Zaire and Tanzania
			Hystrix africaeaustralis	Southern Africa
	Atherurus		*Atherurus macrourus*	South China, Assam, Burma, Thailand, Indochina, Peninsular Malaysia, Hainan
			Atherurus africanus	Gambia, Kenya, southern Zaire
	Trichys		*Trichys fasciculata*	Peninsular Malaysia, Sumatra and Borneo
	Echinoprocta		*Echinoprocta rufescens*	Colombia
Erethizontidae	Coendou		*Coendou bicolor*	Panama, Bolivia
			Coendou prehensilis	Venenzuela, Guianas, Brazil, Bolovia, Trinided
	Sphiggurus		*Sphiggurus mexicanus*	Mexico to Panama
			Sphiggurus pallidus	West Iddies
			Sphiggurus insidious	Surinam, Brazil
			Sphiggurus spinosus	Brazil
			Sphiggurus vestisus	Colombia, Venezuela
			Sphiggurus villosus	Brazil
	Erethizon		*Erethizon dorsatum*	North America

2.2.1 Malayan porcupine *(Hystrix brachyura)*

Malayan porcupine locally known as "Landak Raya", are the larger porcupine species in Malaysia. They are generally black in color, have long spines with white and black band towards the tip. The head, neck, shoulders, limb and underside of the body are covered with coarse, dark brown or black bristles (Lekagul and Mc Neely, 1977). The head and body length is between 60 to 93 cm, tail length between 8 to 17 cm and it weight is around 10 to 30 kg (Nowak, 1999). It feeds mainly on roots, tuber and fallen fruits.

Figure 2.1: Malayan porcupine (*Hystrix brachyura*)

2.2.2 Brush-tailed porcupine (*Atherurus macrourus*)

Nowak (1999) and Lekagul and Mc Neely (1977) have reported that Brush-tailed porcupine or "Landak Nibung" have body length between 26.5 to 57 cm and tail length between 10.2 to 26 cm. Their body weight is between 1.5 to 4.0 kg. It has grayish to blackish brown colour and have softer spine on the head, leg and under parts.

Figure 2.2: Brush-tailed porcupine

(*Atherurus macrourus*)

2.2.3 Long-tailed porcupine (*Thrichys fasciculata*)

Long-tailed porcupine or "Landak Padi" distribution is bordered to the North by the Malay Peninsula (Medway, 1978). Their body length is between 35 to 48 cm and tail length is between 17.5 to 23 cm. It weighs 1.75 to 2.25 kg (Nowak, 1999). It has brownish color. Long-tailed porcupines are the smallest members of the family Hystricidae, resembling spiny rats.

Figure 2.3: Long-tailed porcupine (*Thrichys fasciculata*)

2.24 Thick-spined porcupine (*Thecurus crassispinis*)

Thick-spined porcupine is also known as Borneo porcupine and is endemic on Borneo Island (Medway, 1978; Freye, 1975). Generally, they have dark brown spines with white tip with base and lengths of between 50-60 cm. They feed on fallen fruits and other vegetable materials.

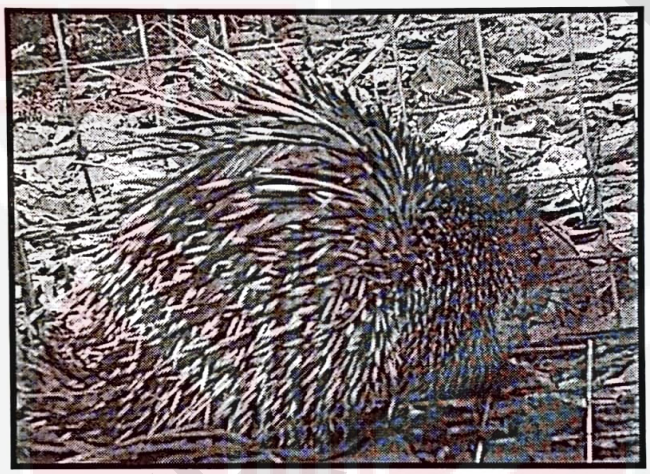

Figure 2.4: Thick-spined porcupine (*Thecurus crassispinis*)

2.3 Behavior

Porcupines are nocturnal animals which are active at night and primarily ground dwelling animals. They rest during the day in their burrows and live in family clans that usually are in the range of four to eight members and they share common runs, trails, excrement depositories, feeding places, refuges and territories. Usually porcupines excavated the soil to build their burrows (Nowak, 1999).

2.4 Feeding

Porcupines are mainly herbivorous and usually feed on vegetation, agriculture crops and natural sources which they seek during the night. Their diet includes roots, bark, fruit and tubers (Lekagul and Mc Neely, 1988 and Medway, 1978). Malayan Porcupine in the wild mainly feed on barks, roots, tubers, rhizomes, bulbs, fallen fruits and cultivated crops. In Central Italy, *Hystrix cristata* mainly feeds on roots, bulbs, fruits and cultivated plants (sunflowers, cereals and others) both on hypogeal and epigeal parts (Bozzi and Lovari, 1999; Bruno and Riccardi, 1995; Santini, 1980). Other example, *Hystrix africaeaustralis* consume a variety of subterranean and above-ground plant parts, including geophytes (parennial plants which resprout from underground storage organs), rootstocks and stem tissue of trees (Skinner and Smithers, 1990).

2.5 Habitat

Preferred habitat is the habitat choosen by the animals for most of the time they are in for daily activities such as searching food, resting, sleeping, and other social activities. Porcupines are adaptable to a variety of habitats and can be found in all types of forests, plantations, rocky areas, deserts and mountains. For example, according to Nowak (1999), *Hystrix brachyura* can be found in all types of forest, plantation and rocky areas. They often use abandoned deep burrows of other animals, caves, rock crevices, decaying logs, hollow trees, and holes dug by other animals, or deep burrows that they have excavated themselves. Habitat selection may occur when they want to built new burrows. It can be defined as a process by which an

animal chooses from among alternative habitat resources to find the most suitable (Litvaitis *et al.*, 1994).

2.5.1 Habitat variables

For small mammals, patterns of habitat selection reflect a variation in the availability of resources in space and time scales (Viera *et al.*, 2005). Patterns of habitat use by mammals are important for understanding the mechanisms involved in their distribution and abundance. According to Henriques and Alho (1991), habitat selection by rodent is positively associated with herbaceous plant, tree and shrub cover of the area. For example, burrow system of two species of whistling rats, *Parotomys brantsii* and *P. littledalei. P. brantsii* burrows are situated in open locations with only limited plant cover while *P. littledalei* are restricted to areas of good plant cover (Jackson, 2000).

Porcupines are mainly herbivorous which utilize agricultural crops and natural plants as source of food. For example, the main food source for Indian porcupine is vegetables material including fruits, grains and roots. According to Vieira *et al.* (2005), fruit availability also influenced the porcupine to make their burrows.

Canopy also influenced the porcupine's habitat selection. The area that offered big crown and close canopy provided with good shade for the burrow. Close canopy showed that the habitat had higher density of trees (Vieira *et al.*, 2005) and it

provided with additional protection from predators and provided food sources. As reported by Viera *et al.* (2005), *Oryzomys scotti* (rodent) generalist inhabits in close canopy habitat in Cerradao.

The distribution of species particularly rodent family were heavily influenced by vegetations and substrates (Schmidly, 1977). High cover of shrubs can provide protections from predator and food sources (Thompson, 1982). For example, burrow system of two species of whistling rats, *Paratomys brantsii* burrow's are situated in open locations with only limited plant cover while *Paratomys littledalei* are restricted in good plant cover (Jackson, 2000). Meserve *et al.* (1984), Lagos *et al.* (1995) and Vasquez *et al.* (2002) reported that shrub habitat provide lower predation risk than exposed area.

2.6 Burrow

According to Jackson (2000), burrow is a system with numerous nest chambers and associated interconnecting tunnels with a number of entrances. Porcupines usually used cave, rock crevices, dead tree burrow and burrow they dig by themselves (Nowak, 1999). Other rodent species, dassie rat, *Petromys typicus* and Namaqua rock mouse, *Aethomys namaquensis* constructed their burrows under rocks (Skinner & Smithers, 1990). Kangaroo bush rat, *Otomys unisulcatus* and desert woodrat, *Neotama lepida* constructed their burrows under complex stick (Plessis and Kerley, 1990; Cameron and Rainey, 1972).

Burrows were used for nesting and food storage and provides rodents with shelter from predators during rodent surface activity (Kucheruk, 1983). Burrows also provide shelter from harsh weather and predators (Fernandez and Palomares, 2000) a place to raise young and store food stuffs. These refuge system also acta as buffer against environmental extremes of temperature and humidity (Jackson, 2000). Variety of functions of burrows are associated with their structure represented by a number of chambers connected by a system of tunnels (Shenbrot *et al.*, 2002).

2.6.1 Burrow structure

Xu (1994) pointed out that burrow construction (including location, direction, depth and breath) varies according to species, topography of the area and presence of seasons. Burrow's construction is relatively simple with majority of single tunnel entrance, but there are some with two or four saparate entrances. These underground refuges consist of a single nest chamber that may be accessed by one or two tunnels leading to the surface.

2.6.2 Burrow holes direction

Normally porcupines build their burrows based on direction towards a food sources (Litvaitis *et al.*, 1994). Porcupines might select south exposures ti synchronize with sunset. Porcupines also avoid to build their burrows at muddy ground especially in winter (Tinelli and Tinelli, 1988).

2.6.3 Soil

Different soil textures provide different burrowing conditions and the level of burrow complexity of the rodent species depends on soil properties. Usually, the most complex burrows occur in hard (clay and silt) soils and the simplest burrows in sandy soils (Dubyansky, 1962; Laundre and Reynolds, 1993).

CHAPTER 3

METHODOLOGY

3.1 Study area

This study was conducted in Bintulu-Miri area in Sarawak. After initial survey, six locations of porcupine burrow were selected in Kampung Ulu Kelulit, (03°57' N, 113°46'E), in Bekenu area in Miri while in Bintulu, Kampung Sepaduk (03°9'N, 113°9'E), Kampung Wawasan Jaya (03°22'N, 113°27'E) and Hutan Nirwana UPM (03°27'N, 113°23'E) were selected as study areas. Burrows were position with GPS Handheld (Appendix G2). Study sites in Bekenu and Hutan Nirwana UPM are secondary forest while in Kampung Sepaduk and Kampung Wawasan Jaya are agriculture areas.

3.2 Burrow Identification and Positioning

Surveys on porcupine burrows were conducted along Bintulu-Miri area. Burrows were identified based on the information about porcupine burrow and their activities as pest in plantation crop as reported by Ahmad *et al.* (1987) and Brooks *et al.* (1988). Which species of porcupine inhabit the burrow can be distinguished with setting camera trapping for three until five nights at the burrow to record which animal belonged to each burrow. Other methods to identify the porcupine's burrow are by presence of characteristics of spines and specific footprint found near the burrow.

Plastic tags (Appendix D4) was used to mark the burrows and the coordinate of the burrow was recorded using Global Positioning System (Garmin GPS 12XL). The activeness of burrows was indicated by presence of activity in the burrows. The burrow was indicated as active if any food, fresh tracks, digging activities or spines and footprint were found near the burrow.

3.3 Burrow Classification

Fieldwork was conducted to examine differences of burrow system of each species of porcupine. Type of burrow was indicated by either of A (rock), B (earth) or C (mixture between rock and earth) as reported by Bragg *et al.* (2005). The number of entrances was recorded. The dimension of the hole as indicated by length and width of each burrow was measured using a measuring tape or meter distance (see appendix D6). Bearing and back bearing was determined using Sunto clinometer (see appendix D3). Back bearing was used to determined entrance direction of each burrow. Burrow was classified as exposed to North (from 316-45°), East (from 46-135°), South (from 136-225 °) and West (from 226-315°). Reference points for burrow holes were determined after choose the active burrow in each location.

Sample of soil was taken using Auger (Appendix D7) one meter from burrow entrances. Color of soil was determined using MUNSEL soil chart and pH of soil was determined by laboratory analysis method (see detailed description in Appendix F).

3.4 Habitat Variable Determination

Habitat variable was determined to investigate habitat preference to select their habitat among different species of porcupine. A plot in 10 meter radius from burrow entrance was set up. Center of the plot was determined by choose the active burrow (main burrow).

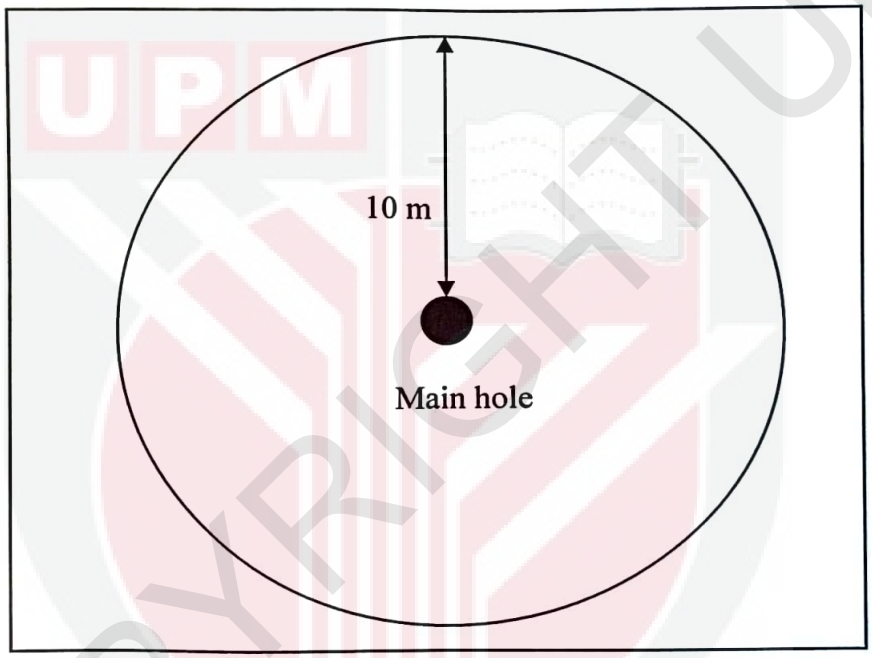

Figure 3.1: Plot in 10 meters radius

Plants species in the plot was identified using botanical information. From the identification, fruit tree which potential function as food source to porcupines was determined. In vegetation density estimation, systematic sampling method was used. Every 5x5 meter quadrant, there was 2x2 meter sub quadrant. From quadrant established, density of ground cover land was estimated. Percentage of vegetation

density in sub quadrate was estimated (Vieira *et al.*, 2005). Vegetation density was estimated by counting the percentage of vegetation present in sub quadrant in plot established.

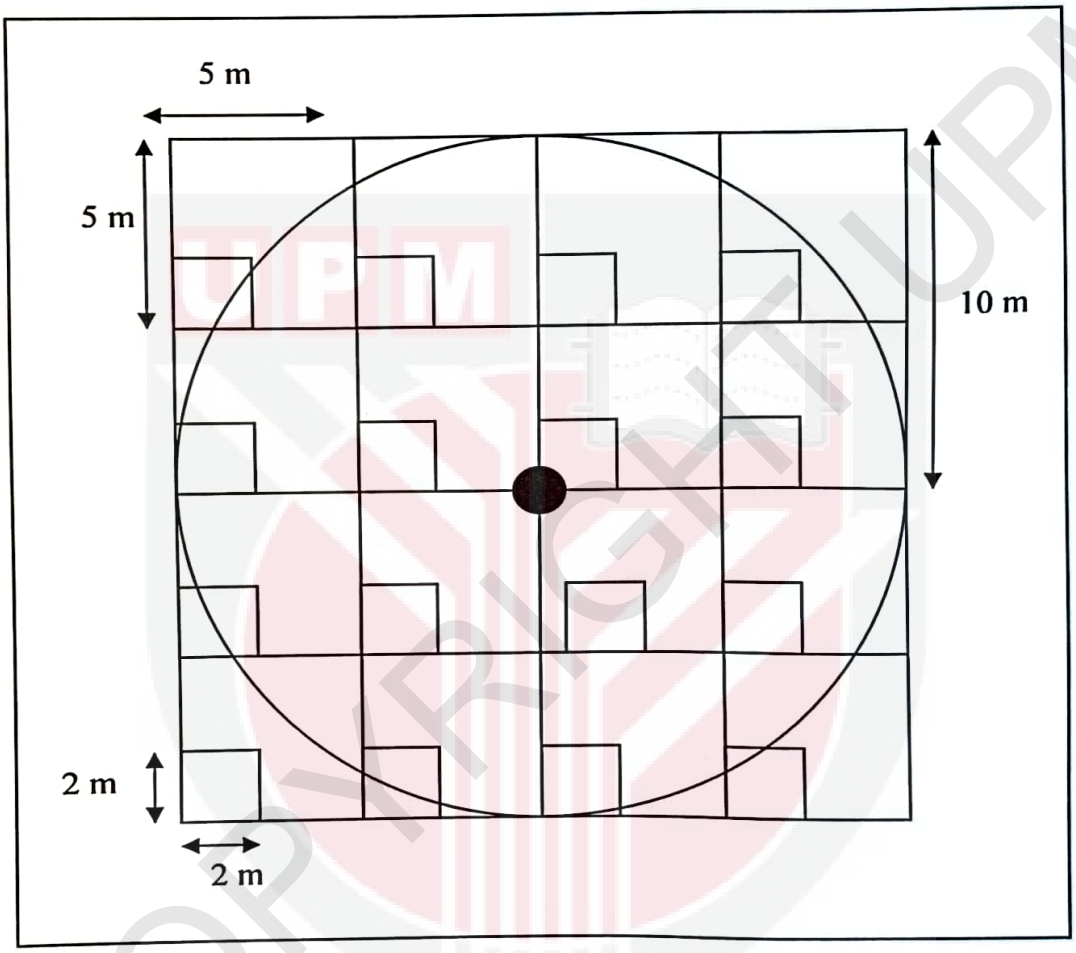

Figure 3.2: Quadrant established in systematic sampling method

Percentage of canopy cover in the plot was measured manually by measured the diameter of crown for tree. Density of tree over 6.5 DBH in the plot also determined.

3.5 Data Analysis

Statistical analysis was carried out using SPSS VERSION 14, 2006 software. Data was analyzed using ANOVA, Duncan and Tukey's test. The data on GPS was analyzed using Geographical Information System with Arc View 3.2 ESRI for windows software.

CHAPTER 4

RESULT

4.1 Burrow's Parameters

Parameters of burrow of porcupine species namely, *H. brachyura*, *T. crassispinis* and *T. fasciculata* were determined and the results on parameters such as type of burrows, bearing, entrances direction, hole dimension and soil properties were recorded.

4.1.1 Type of Burrow Holes

In this study, it was observed that all of the *H. brachyura* and *T. fasciculata* burrows were actived. Incase if *T. crassispinis* species, two of their holes were non active (Figure 4.1-4.4). Burrows of *H. brachyura* were constructed from A and C type while *T. fasciculata* from B and C type. For *T. crassispinis*, majority of their holes were B type and only two of them were C type and one was A type.

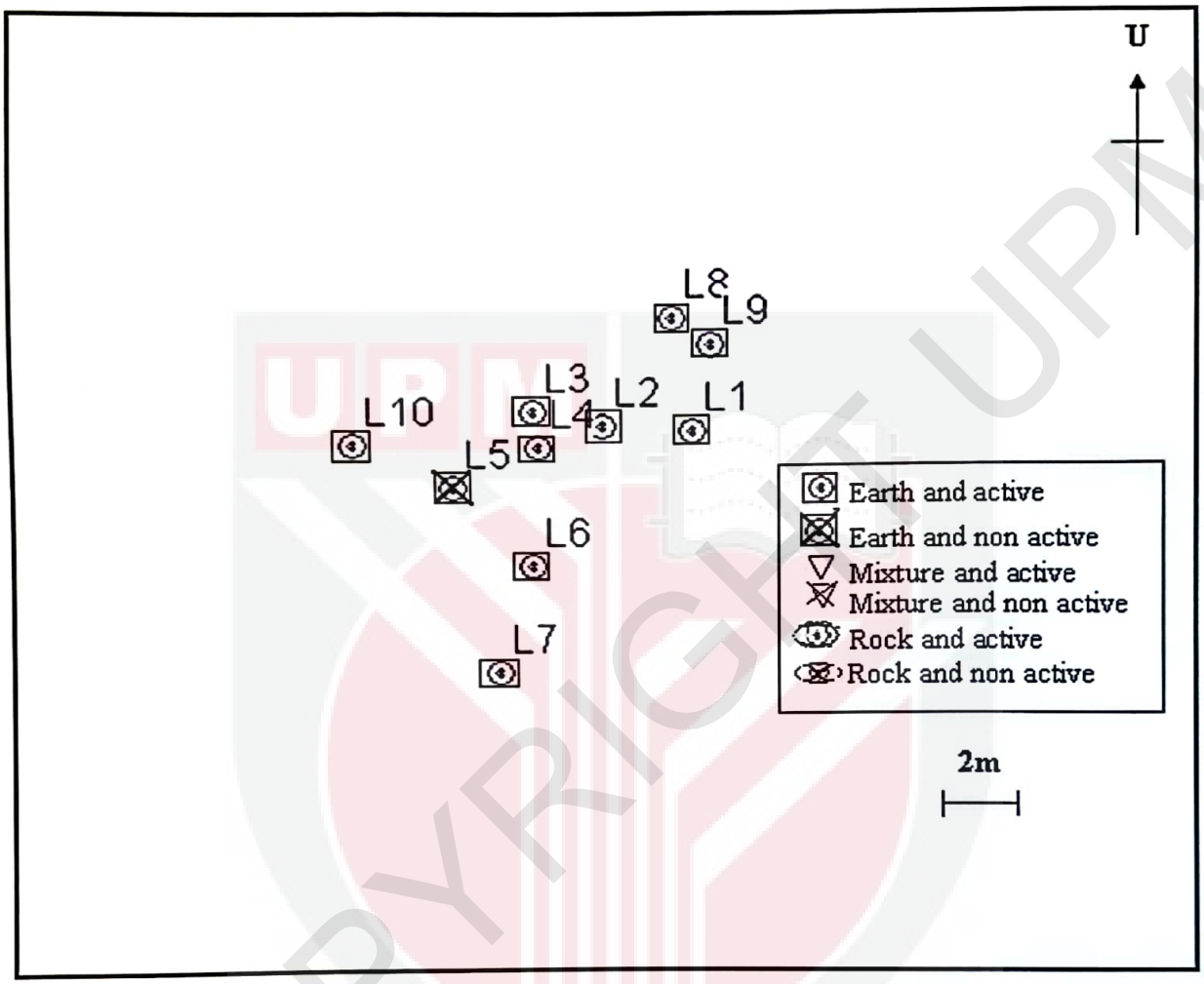

Figure 4.1: Type of burrow of *Thecurus crassispinis* in Kampung Sepaduk

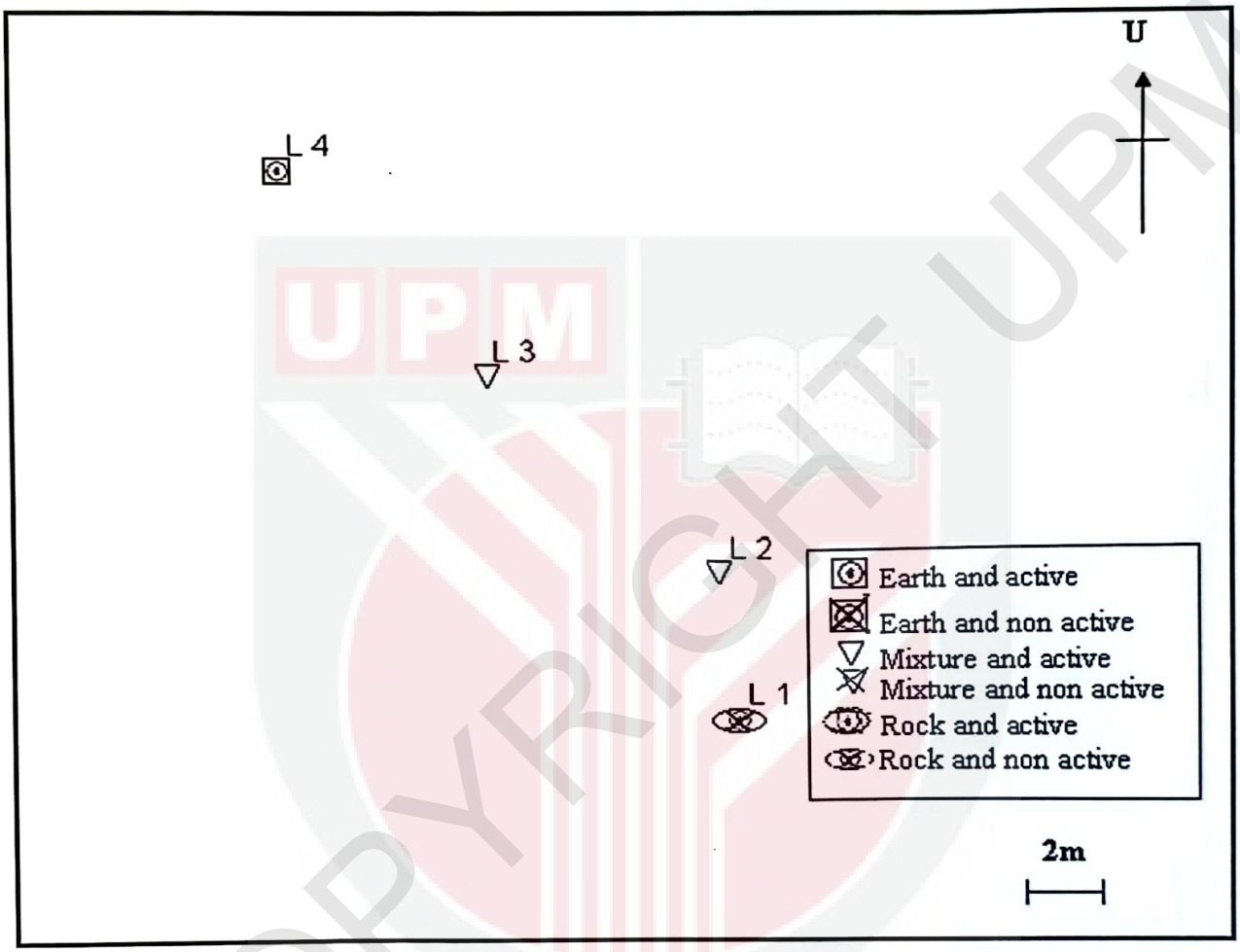

Figure 4.2: Type of burrow of *Thecurus crassispinis* in Kampung Wawasan Jaya

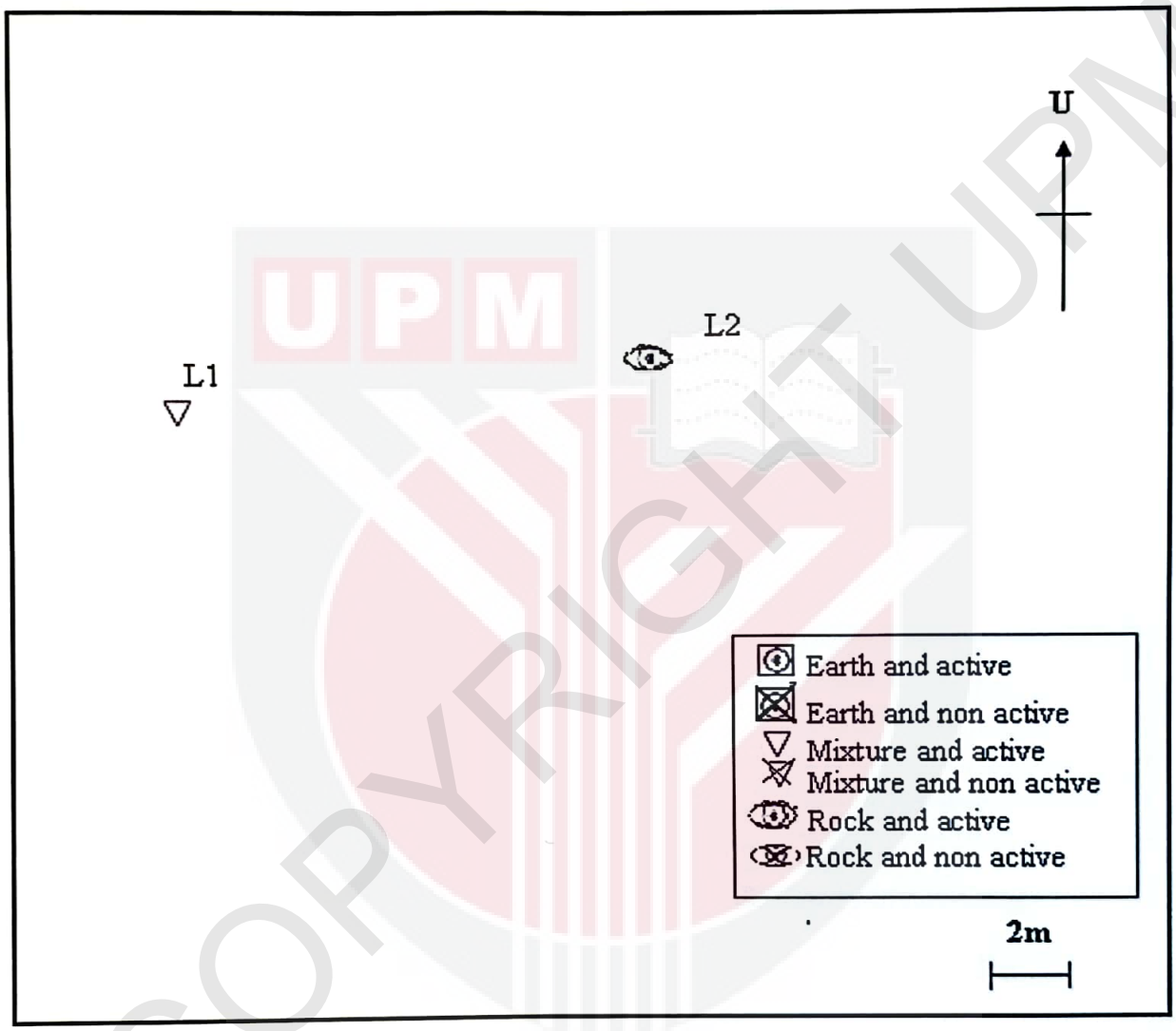

Figure 4.3: Type of burrow of *Hystrix brachyura* in Ulu Kelulit

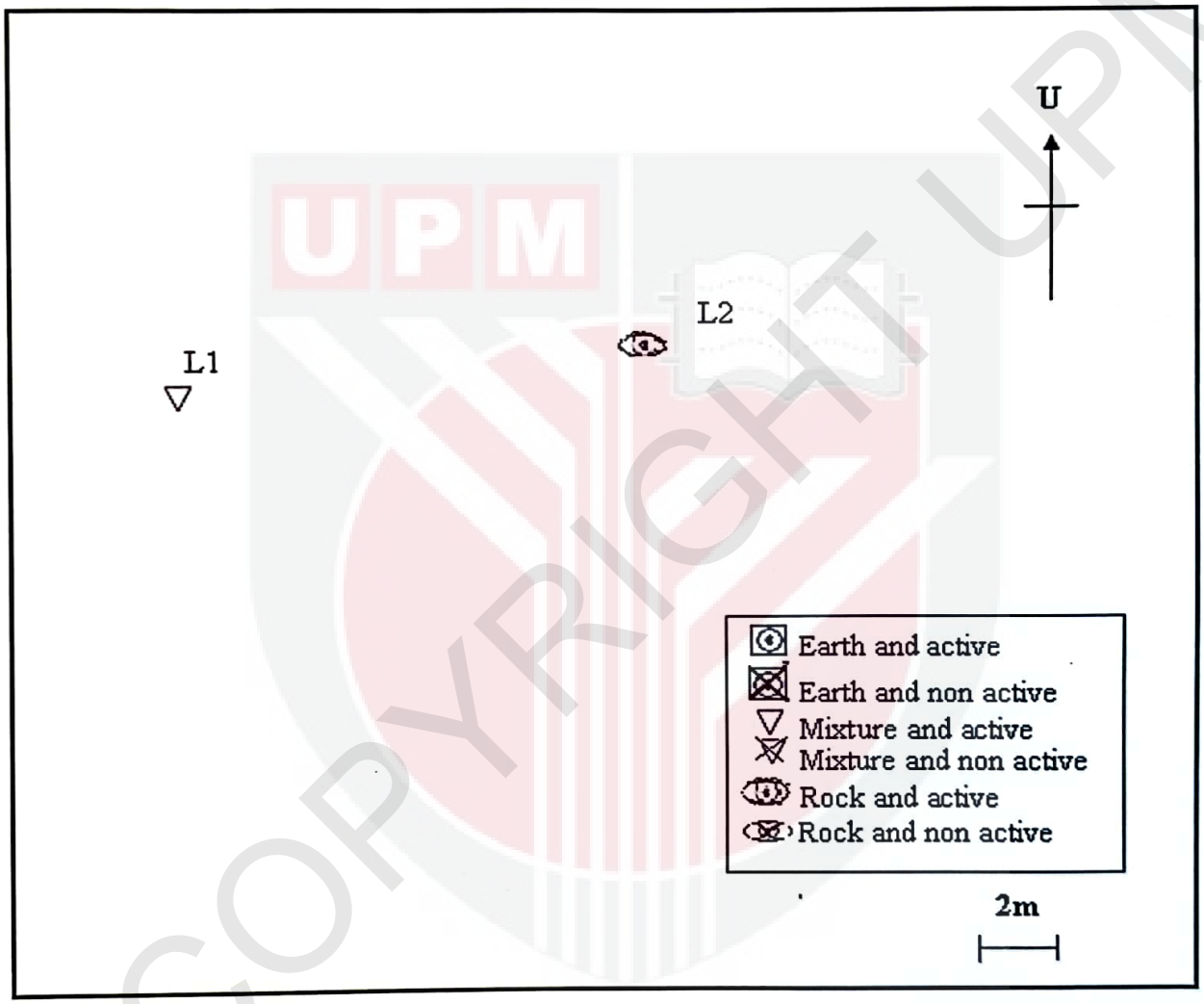

Figure 4.4: Type of burrow of *Trichys fasciculata* in Hutan Nirwana

4.1.2 Direction of Entrances

Bearing value for burrow holes showed that *H. brachyura* burrow had a range of 110° to 125° while *T. crassispinis* in ranged 40° to 350° and *T. fasciculata* between 5° to 20°. After determining direction of the entrance from back bearing, it showed that *H. brachyura* burrows in Ulu Kelulit, Bekenu, were directed to the West, *T. fasciculata* burrows in Hutan Nirwana, was exposed to the North and for *T. crassispinis* in Kampung Sepaduk, majority of their burrow holes were directed to the East and two of them were exposed to the South, while two burrows in Kampung Wawasan Jaya were exposed to the East and one was exposed to the North (Figure 4.5 to 4.8).

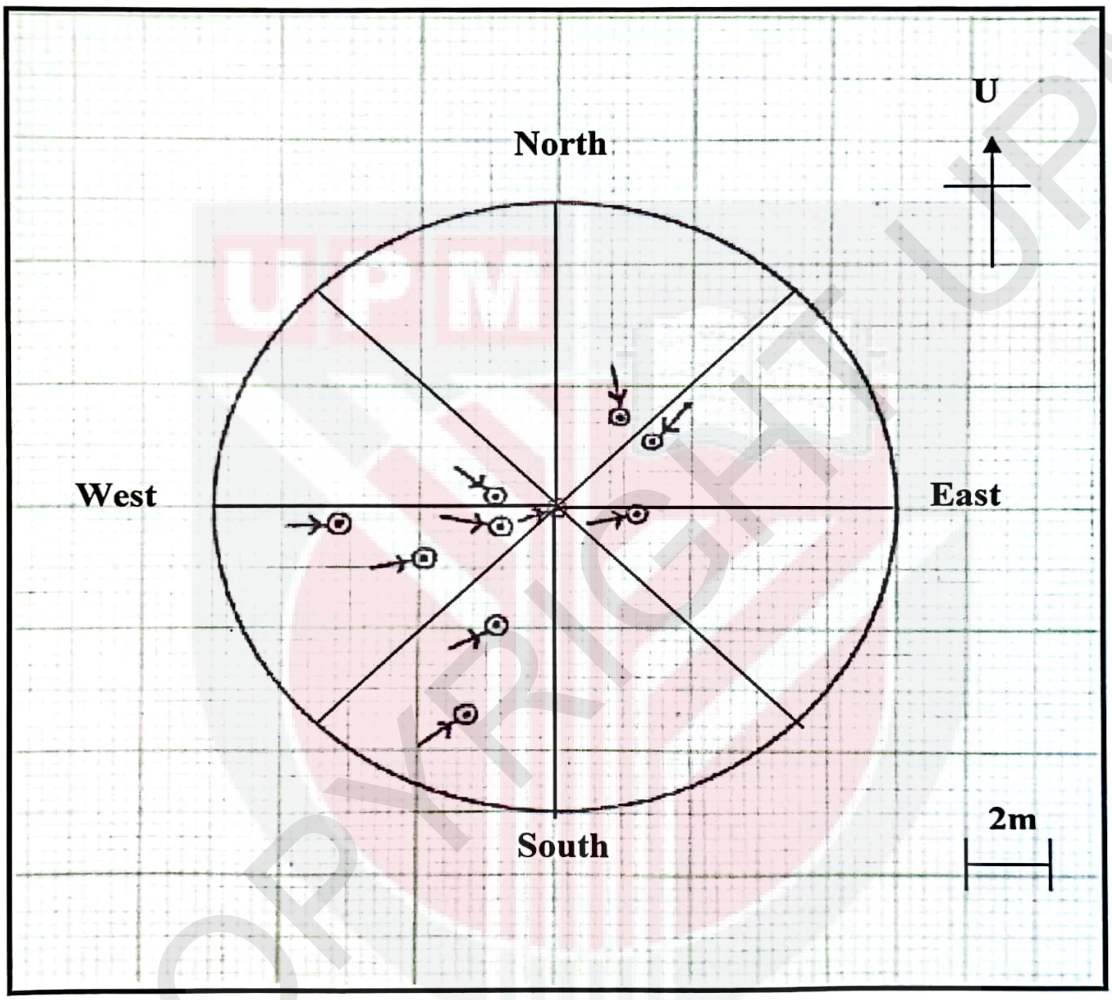

Figure 4.5: Direction of entrance for burrows of *Thecurus crassispinis* in Kampung Sepaduk

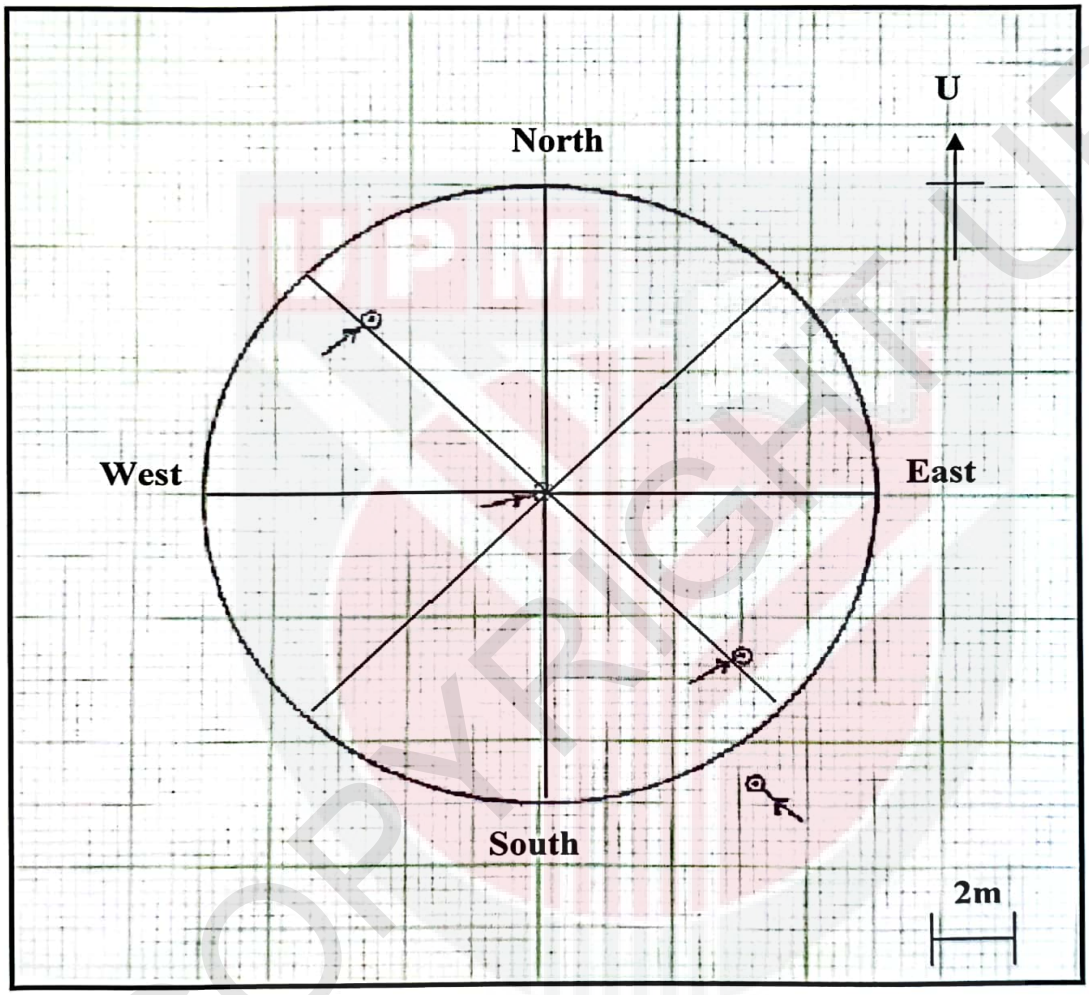

Figure 4.6: Direction of entrance for burrows of *Thecurus crassispinis* in Kampung Wawasan Jaya

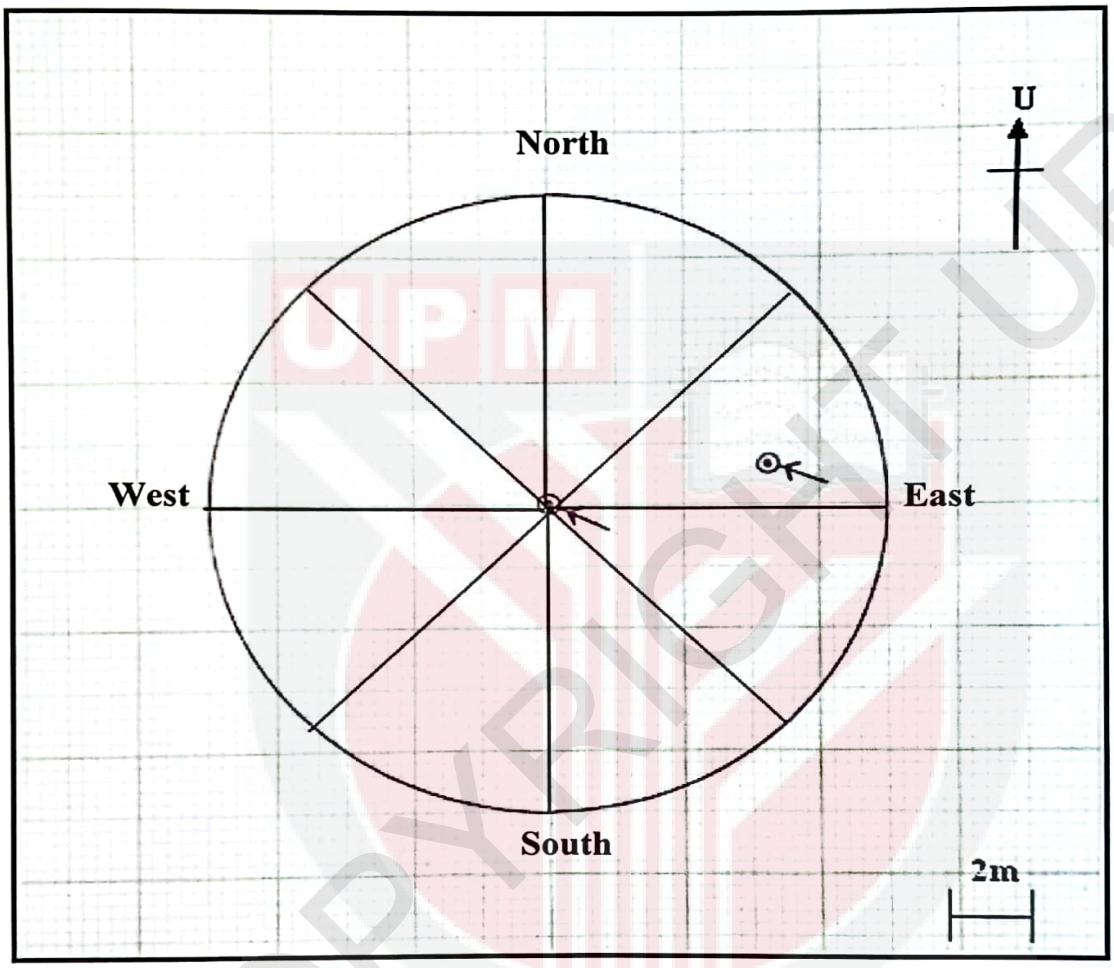

Figure 4.7: Direction of entrance for burrows of *Hystrix brachyura* in Ulu Kelulit

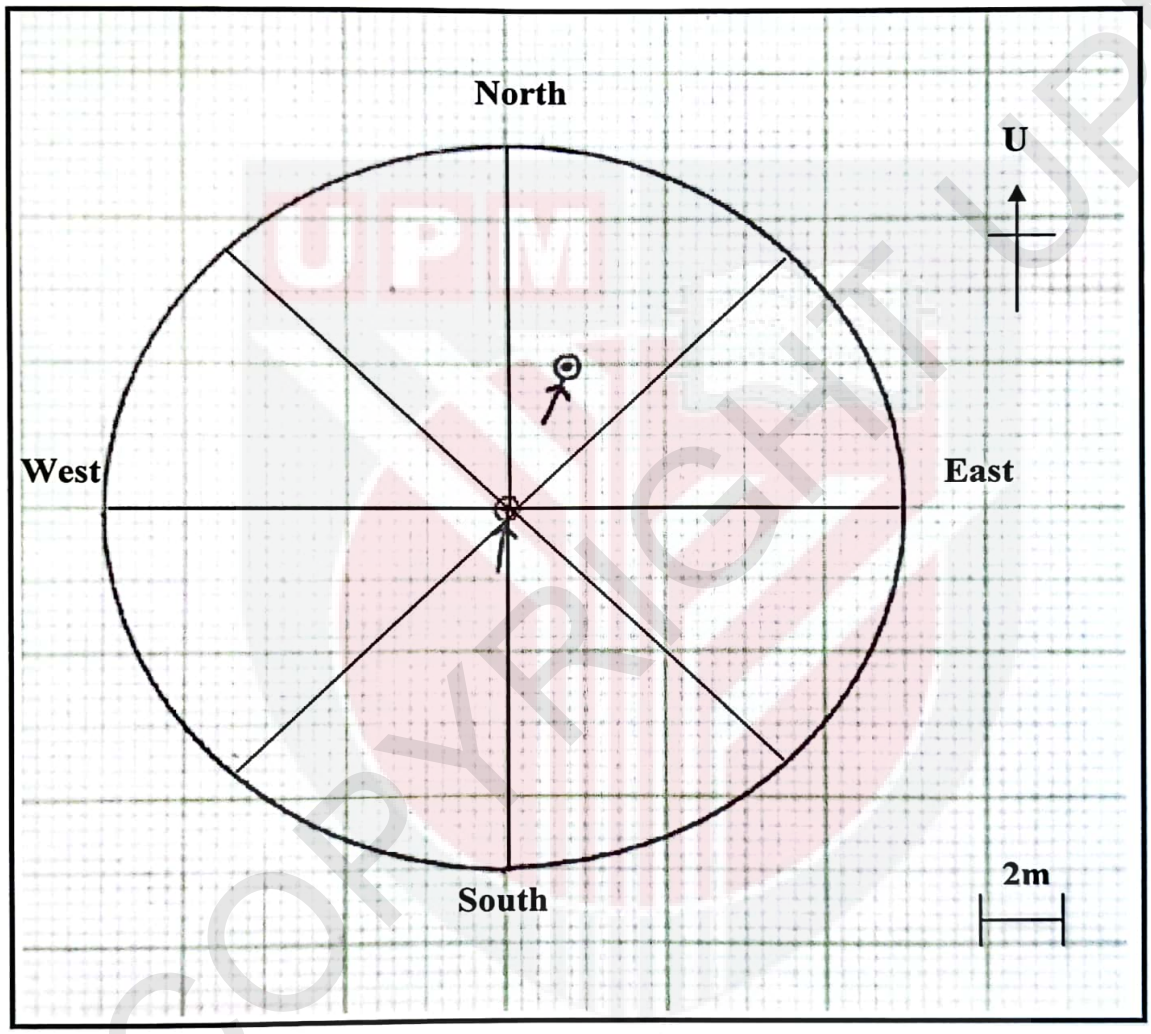

Figure 4.8: Direction of entrance for burrows of *Trichys fasciculata* in Hutan Nirwana

4.1.3 Entrances

T. crassispinis excavated burrow system with higher number of entrances than the other two species of porcupines, *H. brachyura* and *T. fasciculata*. *T. crassispinis* in Kampung Sepaduk excavated 10 entrances around 10 meter radius plot while at the other study area in Kampung Wawasan Jaya excavated 4 entrances. *H. brachyura* in Ulu Kelulit excavated two entrances. *T. fasciculata* in Hutan Nirwana also excavated two entrances.

4.1.4 Hole dimension

There was not significant different on one-way ANOVA, Tukey test, for hole dimension of burrows, height and width for three species of porcupine (Table 4.1). Burrow's hole dimension of *H. brachyura* had semi-circular openings with 2.000 ± 0.776 m in height and 2.430 ± 0.686 m in width. Meanwhilele *T. fasciculata* species had 1.750 ± 1.026 m in height and 1.100 ± 0.907 m in width while for *T. crassispinis* had slightly smaller opening with the measurement recorded at 0.704 ± 0.776 m in height and 0.786 ± 0.686 m in width.

Table 4.1: Hole dimension of burrow (mean ± S.E) for three species of porcupine

Species	n	Height (m)	Width (m)
Hystrix brachyura	2	2.000 ± 0.776 ^{NS}	2.430 ± 0.686 ^{NS}
Thecurus crassispinis	14	0.704 ± 0.776 ^{NS}	0.786 ± 0.686 ^{NS}
Trichys fasciculata	2	1.750 ± 1.026 ^{NS}	1.100 ± 0.907 ^{NS}

$p < 0.05$

^{NS}: Not significantly different

4.1.5 Soil properties

Results of the soil pH from the laboratory showed that the soil pH at all locations had an acidic pH and it ranged between 4.94 to 5.38 and the soil temperature for the burrow ranged from 24.85°C to 25.51°C. The average of soil pH and temperature are presented in Table 4.2. Colour of soil for all locations showed from yellowish brown to very dark brown. Soil in Kampung Sepaduk had a yellowish brown to dark yellowish colour, while Kampung Wawasan Jaya had dark yellowish brown to very dark brown. Colour of soil were recorded in Ulu kelulit had yellowish brown to dark yellowish brown colour, and in Hutan Nirwana it was dark brown in colour.

Table 4.2: Soil pH and soil temperature of burrows for three species of porcupine (average ± S.E)

Species	n	Soil pH	Soil Temperature
Hystrix brachyura	2	5.15 ± 0.281^{NS}	24.85 ± 0.349^{NS}
Thecurus crassispinis	14	4.94 ± 0.281^{NS}	25.51 ± 0.349^{NS}
Trichys fasciculata	2	5.38 ± 0.371^{NS}	25.50 ± 0.461^{NS}

$p < 0.05$

NS: Not significantly different

4.2 Habitat Variables

Habitat variables such as canopy cover, ground cover land, tree density and tree species in 10 m radius plot for each burrow in each location were determined by percentage. The canopy cover revealed significant differences between porcupine species while other variables like ground cover tree density did not show any significant different when using ANOVA, Tukey's test (Table 4.3).

Table 4.3: Habitat variables for three different species of porcupine in percentage (average ± S.E)

Species	Canopy Cover	Ground Cover	Tree Density
Hystrix brachyura	84.00 ± 11.292*	49.50 ± 21.311 ^{NS}	70.00 ± 18.207 ^{NS}
Thecurus crassispinis	19.00 ± 11.292*	75.00 ± 0.349 ^{NS}	22.00 ± 0.349 ^{NS}
Trichys fasciculata	77.50 ± 11.29*	54.00 ± 0.461 ^{NS}	58.50 ± 0.461 ^{NS}

* $p < 0.05$

NS: Not significantly different

4.2.1 Canopy cover

The canopy cover of *H. brachyura* burrows showed the highest percentage of 84.00 ± 11.292 while *T. crassispinis* scored the lowest percentage of 19.00 ± 11.292 and *Trichys fasciculaae* burrows showed 77.50 ± 11.29 percent of canopy cover (Table 4.3).

4.2.2 Ground cover

The ground cover land or shrub cover for burrows showed that *T. crassispinis* had the highest percentage than other species (75.00 ± 0.349), while *H. brachyura* burrow had the lowest percentage of ground cover (49.50 ± 21.311) and *T. fasciculata* burrow had with 54.00 ± 0.461 percent of ground cover.

4.2.3 Tree density

The tree density (%) around *H. brachyura* burrows was the highest compared to burrows of *T. crassispinis* and *T. fasciculata* with recorded value of 70.00 ± 18.207 percent. *Trichys fasciculata* burrows had 58.50 ± 0.461 and 22.00 ± 0.349 respectively. The differences might be due to the habitat selection of these species.

4.2.4 Plants species

During the study, plants species around each burrows were identified (Table 4.4 to 4.7). Tree species that were available as food source for *H. brachyura* in Ulu Kelulit were *Artocarpus elasticus* (terap), *Salacca affinis* (salak). Kampung Wawasan Jaya which was inhabited by *T. crassispinis* showed *Ficus aurata* (ara) and *Pithecellobium jiringa* (jering) as food source. Kampung Sepaduk had *Bambusa* sp (buluh) and *Pithecellobium jiringa* (jering) tree species as food source. For *Trichys fasciculata* at Hutan Nirwana, *Dryobalanops beccarii* (kapur) twigs were the trees that were used probably as food source.

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Table 4.4: Plants in Ulu Kelulit

Ulu Kelulit, Bekenu	Local name
1. Anisophyllea disticha	Pokok kancil
2. Ardisia elliptica	Pokok mata pelanduk
3. Artocarpus elasticus	Pokok terap
4.Caesalpinia sappan	Pokok sepang
5.Canarium sp.	Pokok mertama
6. Cinnamomum sp.	Pokok medang
7. Diospyros sp.	Pokok kayu malam
8. Havea brasiliensis	Pokok getah
9. Lygodium circinnatum	Pokok akar ru
10. Pandanus discastigma	Pandan liar
11. Pinanga sp.	Pokok pinang hutan
12. Salacca affinis	Pokok salak
13. Saraca sp.	Pokok daun gapis
14. Syzgium sp.	Pokok kelat
15. Xanthophyllum sp.	Pokok minyak beruk
16. Zingiber sp.	Halia liar

Table 4.5: Plants in Kampung Sepaduk

Kampung Sepaduk, Bintulu.	Local name
1. Anisophyllea disticha	Pokok kancil
2. Bambusa sp.	Buluh
3. *Barringtonia racemosa*	Pokok putat
4. *Caesalpinia sappan*	Pokok sepang
5. Calamus sp.	Rotan
6. Dillenia suffruticosa	Pokok simpuh
7. Endospermum diadenum	Pokok sesenduk
8. Macaranga triloba	Pokok mahang
9. Ficus sp.	Pokok ara
10. Havea brasiliensis	Pokok getah
11. Licuala sp.	Palma palas
12. Pometia pinnata	Pokok kasai
13. Pithecellobium jiringa	Pokok jering
14. Saraca sp.	Pokok daun gapis

Table 4.6: PlantsTree species in Kampung Wawasan Jaya

Kampung Wawasan Jaya	Local name
1. Alphitonia philippinesis	Pokok serap
2. Anisophyllea disticha	Pokok kancil
3. Asystasia intrusa	Resam
4. Bulmea balsamifera	Pokok bungor
5.Curculigo latifolia	Resam
6. Dicranoptris linearis	Pokok ranting
7. Ficus aurata	Pokok ara
8. Lygodium circinnatum	Pokok akar ru
9. Lygodium flexuosum	Pokok pakis
10. Linociera sp.	Pokok sapah hutan
11. Macaranga triloba	Pokok mahang
12. Melastoma malabathricum	Senduduk
13. Miscanthus floridus	Pokok berjuntai
14. Nephrolepis bisserata	Resam
15. Nomolanthus populneus	Pokok akar merawan
16. Passflora foetido	Pokok redang
17. Pithecellobium jiringa	Pokok jering
18. Vitex sp.	Pokok leban

Table 4.7: Plants in Hutan Nirwana

Hutan Nirwana	Local name
1. Ardisia elliptica	Pokok mata pelanduk
2. Caesalpinia sp.	Pokok sepang
3. Dillenia suffruticosa	Pokok simpuh
4. Dryobalanops beccarii	Pokok kapur
5. Macaraga triloba	Pokok mahang
6. Pandanus discastigma	Pandan liar
7. Shorea macroptera	Pokok meranti
8. Vitex pubescens	Pokok leban
9. Zingiber sp.	Halia liar

CHAPTER 5

DISCUSSION

5.1 Burrow Characteristics.

Majority of burrows for *T. crassispinis* were earth type while *H. brachyura* and *T. fasciculata* constructed their burrows from mixture of earth and rock condition. According to Shenbrot (2000), digging in soil condition is relatively easy and requires less energy for the porcupine. One of the factor that influence the porcupine to build their burrows is their body size. *H. brachyura* has larger body size and higher metabolism rate that give them more energy to build their burrow in rocky condition. On the other hand, *T. crassispinis* has small body size compared to *H. brachyura* which relates to the height and width of the burrow holes.

Not all of the burrow entrances were used equally from the observation on active or non active burrows. Porcupine usually dug several tunnels of their burrow but later on, apparently selected only a few (Pigozzi, 1984). Selection may be consequential from the interaction of several factors such as slope angle, predator avoidance and number of individuals in the burrow (Monetti *et al.*, 2004).

Variation in size of burrows closely related to body size (Damuth, 1981) and the burrow diameter increased with increase in body size (Vleck, 1981). Generally, *H. brachyura* had larger body size than other porcupine, thus they needed to excavate big burrows compared to the other two species. Although *T. fasciculata* had the

smaller size, but the results showed they excavated big burrows compared to *T. crassispinis,* which may be due their higher metabolic rate.

Porcupine burrows also showed a clear avoidance of Northern exposure (Santini, 1980). Porcupines might select South exposures to synchronize with sunset but this study showed that most of the entrances were directed to the East. This might be influenced by the rising sun. The rising sun in the East provide more sunlight to the plants and influence the growth of plants in the East direction. The resulting higher density of plants may also influence the porcupine to build their burrows facing exposed to the East.

According to Monetti *et al.* (2004) may also influence site selection. Porcupines select steep slopes to build their burrow possibly for a better rain drainage. The inward slope angle may facilitate the porcupine to enter and excavate the burrow while the outer slope angle provided their excavation activity.

5.2 Habitat Variables

This study showed that porcupine preferred to build burrows in areas covered with shrubs and moderately in tree density. The availability of shrub cover provide with protection and lower predation risk as compared to exposed area (Meserve *et al.*, 1984; Lagos *et al.*, 1995; Vasquez *et al.*, 2002). Vegetation cover may also provide protection from adverse climatic conditions and predation. Higher density of tree can

give additional protection (Vieira *et al.*, 2005). Porcupine cubs are defenceless and vulnerable especially in first week of birth and they are easy target by the predators. Lucherini *et al.* (1991) reported that some predation on young porcupines were mainly by the red fox. High canopy cover also was related with tree density and it meant that the close canopy cover has high density of trees. This statement was echoed by Vieira *et al.* (2005) who stated the high density of trees will provide protection and food sources to porcupine. The study on small mammals showed that the habitat selection is depends on the abundance of food resources whether its quality and quantity and also their responds to the availibility of resting sites (Corbalan, 2005). The study on small mammals showed that the habitat selection is depends on the abundance of food resources whether its quality and quantity and also their responds to the availibility of resting sites (Corbalan, 2005). Tree species and fresh pellets identification from the study that has been conductes, food resources for *Thecurus crassispinis* were fruits of *Pithecellobium jiringa* and *Ficus aurata* , bulb of bamboo tree and an oil palm trees like reported by Buckle *et al.* (1997). Porcupine were recognized as pest in plantation industries especially in oil palm plantation. *H. brachyura* which were inhabited in secondary forest feed on wild fruit such as *Salacca affinis* and tuber of *zingiber* sp., while *T. fasciculata* feeds on seeds of *Dryobalanops beccarii* and tuber of *zingiber* sp..

CHAPTER 6

CONCLUSION

The study on burrow characteristics showed that there are similar characteristics for this three different species of porcupine. Burrows of *H. brachyura* construct from mixture of soil and rock with big hole dimension while *T. crassispinis* burrows from earth with smaller hole dimension. These two species prefer to build their burrows in acidic soil with lower temperature than ambient air. *H. brachyura* build their burrows in higher percentage of canopy cover but it is different in the case for *T. crassispinis* as they prefer to build their burrows in the open areas. Ground cover land for *H. brachyura* were moderately covered while burrows of *T. crassispinis* had a lower cover land. Other than that, burrows of *H. brachyura* showed higher density of trees but different for *T. crassispinis* as they opted for lower density. The study also showed that *T. fasciculata* preferred to build their burrows in mixture condition with moderate hole dimension. Apart from that, they also build their burrow in acidic soil with lower soil temperature. Other characteristics also include burrow's selection in moderate cover of canopy, higher ground cover land and moderate density of trees. The factors that influenced their habitat selection such as the abundance of food resources and hiding away from predators.

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APPENDICES

Appendix A:

Burrow of Thick spine porcupine (*Thecurus crassispinis*)

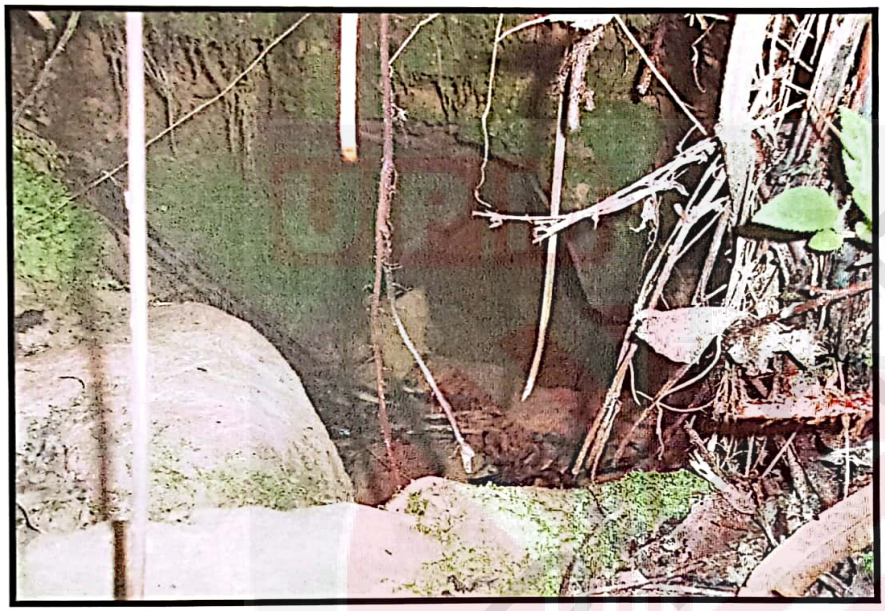

Figure A 1: Burrow 1 in Kampung Wawasan Jaya, Bintulu

Figure A 2: Burrow 2 in Kampung Wawasan Jaya, Bintulu

Figure A 3: Burrow 3 in Kampung Wawasan Jaya, Bintulu

Figure A 4: Burrow 4 in Kampung Wawasan Jaya, Bintulu

Figure A 5: Burrow 1 in Kampung Sepaduk, Bintulu

Figure A 6: Burrow 2 in Kampung Sepaduk, Bintulu

Figure A 7: Burrow 3 in Kampung Sepaduk, Bintulu

Figure A 8: Burrow 4 in Kampung Sepaduk, Bintulu

Figure A 9: Burrow 5 in Kampung Sepaduk, Bintulu

Figure A 10: Burrow 6 in Kampung Sepaduk, Bintulu

Figure A 11: Burrow 7 in Kampung Sepaduk, Bintulu

Figure A 12: Burrow 8 in Kampung Sepaduk, Bintulu

Figure A 13: Burrow 9 in Kampung Sepaduk, Bintulu

Figure A 14: Burrow 10 in Kampung Sepaduk, Bintulu

APPENDIX B

Burrow of Malayan porcupine (*Hystrix brachyura*)

Figure B 1: Burrow 1 in Ulu Kelulit, Bekenu

Figure B 1: Burrow 2 in Ulu Kelulit, Bekenu

APPENDIX C

Burrow of Long-tailed porcupine (*Thrichys fasciculata*)

Figure C 1: Burrow 1 in Hutan Nirwana, UPMKB

Figure C 1: Burrow 2 in Hutan Nirwana, UPMKB

APPENDIX D

Equipments

Figure D 1: GPS Handheld

Figure D 2: MUNSELL soil color chart book

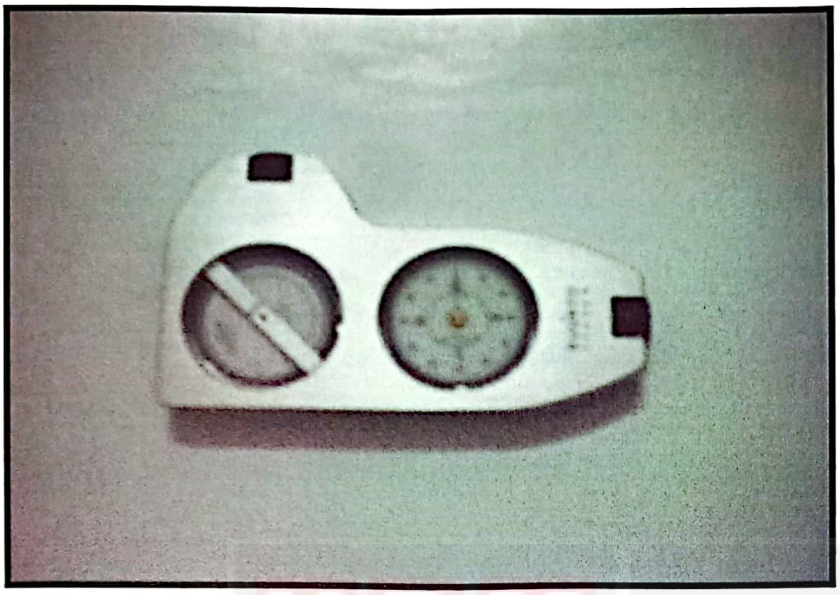

Figure D 3: Sunto clinometer

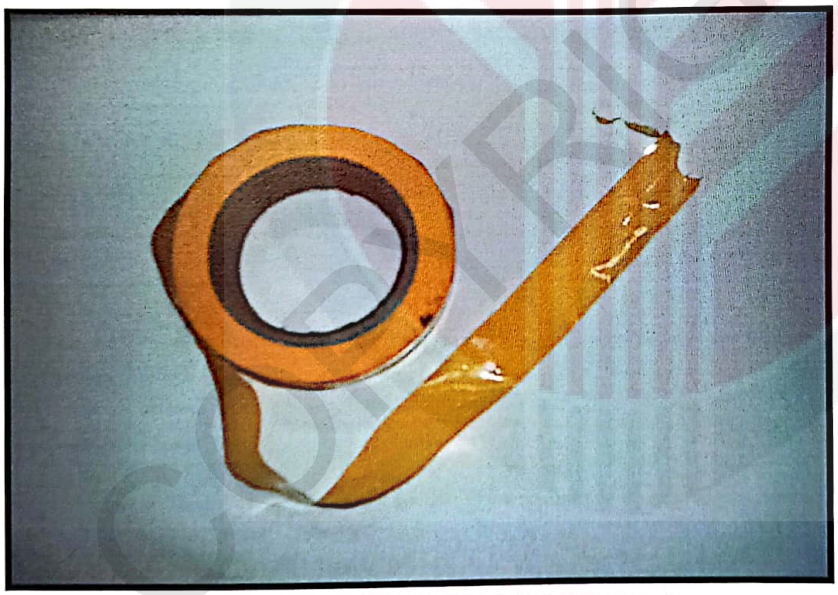

Figure D 4: Plastic tag

Figure D 5: Chektemp 4

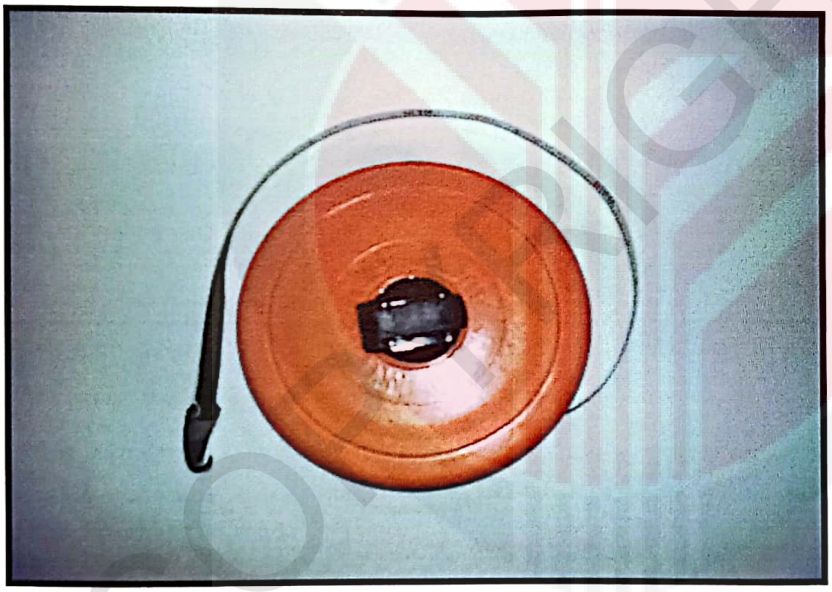

Figure D 6: Meter distance

Figure D7: Auger

APPENDIX E

Table E 1: Burrow Datasheet

Burrow:.....

Date		
Time		
Area		
Found[1]		
Active[2]		
Type[3]		
GPS Point		
Bearing	Bearing	
	Back bearing	
Entrance Direction[4]		
Hole Dimension	Height (m)	
	Width (m)	
Soil Temperature (°C)		
Light Density		
Soil pH		
Colour of Soil		

1-Method used to find the burrow: A = by following a porcupine or some porcupine track B = after finding a porcupine by telemetry.

2-Indicate if burrow is active: Yes = the burrow is used now and the porcupine is in, fresh pellets and fresh tracks. No = the burrow is not used now.

3-Type of burrow: A = Rock B = Mixed C = Earth

4-Classify as exposed to: A = North (316^{o}-45^{o}) B = East (46^{o}-135^{o}) C = South (136^{o}-225^{o}) D = West (226^{o}-315^{o})

APPENDIX F

pH Soil Determination

Determination of pH in $CaCl_2$:

a) 10 g of air dried soil were weighed and transferred into plastic vials.

b) 25 ml of 1 N $CaCl_2$ were added to plastic vials and shaken at 180 rpm for 15 minutes.

c) The pH meter was calibrated with two buffer solutions, namely pH 4.0 and pH 7.0. After adjusting the pH meter, the electrode of the pH meter was rinsed with distilled water and placed in the soil suspension above.

d) The data in the scale of the pH were recorded.

e) Electrode was rinsed with distilled water after measuring the pH and it was placed in the buffer solution of pH 7.0 or soaked in distilled water.

APPENDIX G

Result:

Table G 1: Burrows paramater for all location of study area

No	Location	Active	Types of burrow			Bearing	Back Bearing	References Point
			Rock	Earth	Mixed			
1	Ulu Kelulit (1)	Yes	✔			125 °	305 °	23 °
2	*Ulu Kelulit (2)	Yes			✔	110 °	290°	0 °
7	*Kg. Sepaduk (1)	Yes		✔		260 °	80°	0 °
8	Kg. Sepaduk (2)	Yes		✔		250 °	70°	50 °
9	Kg. Sepaduk (3)	Yes		✔		310 °	130°	132 °
10	Kg. Sepaduk (4)	Yes		✔		280 °	100°	100 °
11	Kg. Sepaduk (5)	Yes		✔		235 °	55°	50 °
12	Kg. Sepaduk (6)	Yes		✔		240 °	60°	60 °
13	Kg. Sepaduk (7)	No		✔		260 °	80°	85 °
14	Kg. Sepaduk (8)	Yes		✔		350 °	170°	120 °
15	Kg. Sepaduk (9)	Yes		✔		40 °	175°	175 °
16	Kg. Sepaduk (10)	Yes		✔		270 °	90°	90 °
17	Kg. Wawasan Jaya (1)	No	✔			140 °	320°	320 °
18	*Kg. Wawasan Jaya (2)	Yes			✔	240 °	60°	0 °
19	Kg. Wawasan Jaya (3)	Yes			✔	255 °	75°	80 °
20	Kg. Wawasan Jaya (4)	Yes		✔		230 °	50°	55 °
21	*Hutan Nirwana (1)	Yes			✔	185°	5 °	0 °
22	Hutan Nirwana (2)	Yes		✔		200 °	20 °	23 °

*- Reference point

Hole dimension		Soil temperature (°C)	Colour of Soil (Munsell)	Soil pH
Height (m)	Widht (m)			
2.80	2.76	24.8	10YR 5/8 Yellowish brown	4.88
1.20	2.10	24.9	10YR 4/4 Dark yellowish brown	5.42
0.20	0.23	26.5	10YR 5/8 Yellowish brown	4.76
0.12	0.23	25.8	10YR 5/8 Yellowish brown	4.63
0.23	0.26	25.3	10YR 5/8 Yellowish brown	5.00
0.18	0.36	25.3	10YR 5/8 Yellowish brown	4.86
0.25	0.36	25.2	10YR 5/8 Yellowish brown	5.19
0.18	0.25	25.2	10YR 4/6 Dark yellowish brown	4.57
0.10	0.25	26.2	10YR 5/8 Yellowish brown	4.65
0.15	0.20	25.6	10YR 5/8 Yellowish brown	4.74
0.20	0.35	26.2	10YR 3/6 Dark yellowish brown	4.44
0.15	0.34	25.2	10YR 4/6 Dark yellowish brown	4.62
2.90	2.70	25.4	10YR 3/6 Dark yellowish brown	5.41
2.53	2.30	25.1	10YR 2/2 Very dark brown	5.69
2.48	2.48	25.0	10YR 3/3 Dark brown	5.23
0.18	0.69	25.1	10YR 3/3 Dark brown	5.43
1.70	1.50	25.2	10YR 3/3 Dark brown	4.80
2.00	0.50	25.8	10YR 3/3 Dark brown	4.88

Table G 2: GPS reading for Kampung Sepaduk, Kampung Wawasan Jaya and Ulu Kelulit.

Location	Position
sepaduk 1	N3 09.316 E113 09.326
sepaduk2	N3 09.316 E113 09.322
sepaduk3	N3 09.317 E113 09.319
sepaduk4	N3 09.315 E113 09.319
sepaduk5	N3 09.313 E113 09.316
sepaduk6	N3 09.310 E113 09.319
sepaduk7	N3 09.305 E113 09.318
sepaduk8	N3 09.321 E113 09.325
sepaduk 9	N3 09.320 E113 09.327
sepaduk10	N3 09.315 E113 09.312
Ulu kelulit 1	N3 58.045 E113 47.091
Ulu kelulit 2	N3 57.241 E113 46.419
Wawasan jaya 1	N3 22.815 E113 27.761
wawasan jaya 2	N3 22.823 E113 27.760
wawasan jaya 3	N3 22.835 E113 27.747
wawasan jaya 4	N3 22.847 E113 27.736

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled "Burrow Characteristics among Three Different Species of Porcupine in Bintulu-Miri Area" by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus and published in the form approved by the Faculty.

MORLIANA BTE MOKHTAR

Date : 4th May 2007