# DIET AND HABITAT USE OF VIVERRID GROUP AT SAKAERAT ENVIRONMENTAL RESEARCH STATION, NAKHON RATCHASIMA

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**A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of Master of Science in Environmental Biology**

**Suranaree University of Technology**

**Academic Year 2008**

# อาหารและการใช้พื้นที่อาศัยของสัตว์กลุ่มวิเวอร์ริดที่สถานีวิจัย
# สิ่งแวดล้อมสะแกราช นครราชสีมา

**นายศราวี อรุณ**

**วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรมหาบัณฑิต**
**สาขาวิชาชีววิทยาสิ่งแวดล้อม**
**มหาวิทยาลัยเทคโนโลยีสุรนารี**
**ปีการศึกษา 2551**

**DIET AND HABITAT USE OF VIVERRID GROUP AT SAKAERAT ENVIRONMENTAL RESEARCH STATION, NAKHON RATCHASIMA**

Suranaree University of Technology has approved this thesis submitted in partial fulfillment of the requirements for a Master's Degree.

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ศราวี อรุณ : อาหารและการใช้พื้นที่อาศัยของสัตว์กลุ่มวิเวอร์ริดที่สถานีวิจัยสิ่งแวดล้อมสะแกราช นครราชสีมา (DIET AND HABITAT USE OF VIVERRID GROUP AT SAKAERAT ENVIRONMENTAL RESEARCH STATION, NAKHON RATCHASIMA) อาจารย์ที่ปรึกษา : ผู้ช่วยศาสตราจารย์ ดร. ณัฐวุฒิ ธานี, 64 หน้า.

การศึกษานี้มีวัตถุประสงค์เพื่อศึกษาอาหารและการใช้พื้นที่อาศัยของสัตว์กลุ่มวิเวอร์ริด ที่สถานีวิจัยสิ่งแวดล้อมสะแกราช จังหวัดนครราชสีมา ข้อมูลของวิเวอร์ริดถูกเก็บโดยการวางกับดัก สำรวจร่องรอยสัตว์ ติดตั้งกล้องดักถ่ายภาพ และเก็บมูลสัตว์ ตามแนวถนนและแนวกันไฟ ตั้งแต่เดือนมกราคมถึงเดือนธันวาคม 2551 อีเห็นธรรมดา (*Paradoxurus hermaphroditus*) ชะมดแผงสันหางปล้อง (*Viverra zibetha*) และ ชะมดเช็ด (*Viverricula indica*) ถูกสำรวจพบในการศึกษานี้ ข้อมูลจากการสำรวจร่องรอยจะถูกนำมาศึกษาหาการเลือกใช้พื้นที่อาศัยของสัตว์ มูลของสัตว์จะถูกนำไปวิเคราะห์หาชนิดของอาหารและคำนวณการเปลี่ยนแปลงของอาหารในแต่ละฤดู ผลการศึกษาพบว่าสัตว์กลุ่มวิเวอร์ริดมีการใช้พื้นที่เขตป่าดิบแล้ง สุ่มใช้พื้นที่เขตป่าเต็งรัง และหลีกเลี่ยงเขตป่าปลูกทดแทน และเขตป่าไผ่ อาหารหลักของสัตว์กลุ่มวิเวอร์ริดคือสัตว์เลี้ยงลูกด้วยนมขนาดเล็กและผลไม้ โดยเฉพาะอย่างยิ่งหนูฟานเหลือง (*Maxomys surifer*) อาหารของสัตว์กลุ่มวิเวอร์ริดจะผันแปรไปตามฤดู ขึ้นอยู่กับความอุดมสมบูรณ์ของอาหาร และการหาอาหารของสัตว์

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| สาขาวิชาชีววิทยา | ลายมือชื่อนักศึกษา ______________________ |
| ปีการศึกษา 2551 | ลายมือชื่ออาจารย์ที่ปรึกษา ______________________ |
| | ลายมือชื่ออาจารย์ที่ปรึกษาร่วม______________________ |
| | ลายมือชื่ออาจารย์ที่ปรึกษาร่วม______________________ |

SARAWEE AROON : DIET AND HABITAT USE OF VIVERRID GROUP AT SAKAERAT ENVIRONMENTAL RESEARCH STATION, NAKHON RATCHASIMA. THESIS ADVISOR : ASST. PROF. NATHAWUT THANEE, Ph.D. 64 PP.

DIET/HABITAT USE/VIVERRID/SAKAERAT ENVIRONMENTAL RESEARCH STATION

The purposes of this study were to investigate the diet and habitat use of viverrids at Sakaerat Environmental Research Station, Nakhon Ratchasima province. Data on viverrids were obtained by live trapping, sign observations, camera trapping and scat collection along the roads and fire breaks from January to December 2008. Common palm civet (*Paradoxurus hermaphroditus*), large Indian civet (*Viverra zibetha*) and small Indian civet (*Viverricula indica*) were encountered during study. Data from sign surveys were used to interpret habitat use. Scat was analyzed for food items and used to calculate seasonal diet. Viverrids used dry evergreen forest, random use in dry dipterocarp forest and avoidanced plantation and bamboo forest. Small mammals and fruits were the major diet of viverrids, especially yellow rajah rat (*Maxomys surifer*). The diets of viverrids varied among seasons, depended on abundance and availability of food items.

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| Academic Year 2008 | Advisor's Signature____________________ |
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# ACKNOWLEDGEMENTS

I sincerely thank my thesis advisor, Asst. Prof. Dr. Nathawut Thanee, for his invaluable help and constant encouragement throughout the course of this research. I also thank my committee member: Asst. Prof. Dr. Griangsak Eumkeb for sharing his great knowledge and inspiration.

I thank my co-advisor, Mr. Taksin Artchawakom, Director of Sakaerat Environmental Research Station (SERS) for an excellent experience and for his assistance during my first research experience. Many thanks to Mr. Samai Sewakhonburee, Mr. Jumlong Placsanoi, Mr. Narin Suprapatpokar and the other staff of SERS for their help throughout this research.

Dr. Jaques G. Hill, my first foreign teacher and co-advisor made me excited with my first research project and helped me editing this thesis and provided many suggestions.

In addition, I am grateful for the staff of the school of Biology: Asst. Prof. Dr. Waree Widjaja, Asst. Prof. Dr. Sajeera Kupittayanant, Asst. Prof. Dr. Panee Wannitikul, Assoc. Prof. Dr. Sompong Thammathaworn, Dr. Pongthep Suwanwaree, and other persons for their suggestions and help. I also gained friendship and willpower from my seniors such as Mr. Seksan Sansorrapisoot, Mr. Sitthisak Pinmongkholgul, and Miss Anisong Chitnarin.

Special thanks also to Suranaree University of Technology and the National Research Council for my scholarship and financial support for this study. Special thanks is due to the Thailand Institute of Scientific and Technological Research (TISTR) for the permission to use the study site at the SERS.

Finally, I most gratefully acknowledge my parents and my friends for all their support throughout the period of this research.

Sarawee Aroon

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# CHAPTER I

# INTRODUCTION

## 1.1 Introduction

All organisms have a unique role or function in an ecosystem, commonly called "ecological niche" (Grinnell, 1917; Hutchinson, 1957). The ecological niche is the position or role of an organism in its environment, defined by such factors as foods, predators, habitat, and temperature requirements (Brooker *et al*., 2008). Each species occupies an ecological niche which is the set of resources it requires as well as its influence on the environment and other species. Niche parameters of different species may overlap and organisms may compete with other species for the resources they have in common. If two species are very similar, their niches will overlap resulting in competition (Wessells and Hopson, 1998). Species may reduced competition between each other by reduced the resource partitioning, behaviorial change, activity time changes, and morphological adaptations. Good examples of these phenomena can be found in carnivore communities (de Almeida Jácomo *et al*., 2004).

Carnivore communities often exhibit niche overlap because of the scarcity of major prey species, thus many carnivore families such as Ursidae (bears), Mephitidae (skunks), Herpestidae (mongooses), and Viverridae (civets, binturong, linsangs, and genets) are adapted for feeding on a variety of foods (Lekagul and McNeely, 1977). Carnivores generally eat other animals, although not all carnivores eat meat only; many are omnivores (Vaughan *et al*., 2000). Many carnivore species avoid niche overlap with other species by changing their food preference from animals to plants (Lekagul and McNeely, 1977).

Viverrids are small to medium size (0.6-20 kg) carnivores with short legs and a long tail. They comprise 19 genera and 39 species, mostly of the family Viverridae (Vaughan *et al*., 2000). Most species have well developed scent glands (except *Prionodon* and male *Arctogalidia*) which are used to mark their territories and attract the opposite sex during the breeding season (Lekagul and McNeely, 1977). The substances from these glands are used as raw materials to produce some of perfumes (Dannenfeldt, 1985).

Viverrids live in forest, brush, and grassland habitats and sometimes can be found near human habitations. Most are nocturnal and solitary animals. They sleep during the day and become active at night (Mudappa, 2006). They exhibit a variety of lifestyles and adaptations. For example, some species are excellent climbers which forage in trees, while many species live and forage on the ground (Vaughan *et al*., 2000).

Viverrids are primary carnivores in food webs (Lekagul and McNeely, 1977) and play important roles in tropical rain forest ecosystems, as predators, prey, and seed dispersers (Rabinowitz, 1991). They eat various foods such as birds, snakes, rats, frogs, fishes, and insects (Schreiber *et al*., 1989). They also eat some fruits and plants such as coffee berries. Coffee beans that have passed through their digestive systems are called Kopi Luwak and well-known for being a very expensive coffee with a unique taste and aroma in Indonesia (Marcone, 2004).

One step in understanding community organization of carnivores is to measure the niche overlap of carnivore species in a community. The most common resource use to calculate niche overlap are food and habitat. Moreover understanding the niche of a species within a community requires information about feeding relationships, habitat use, and reproductive biology (Marti *et al*., 1993). The objective of this study is to investigate the diet and habitat use of viverrids at Sakaerat Environmental Research Station, Nakhon Ratchasima province. The data from this study will provide a better understanding of the ecology of the sympatric viverrids in Thailand.

## 1.2 Research objectives

1.2.1 To investigate the seasonal diet composition and food niche breadth of the viverrids at Sakaerat Environmental Research Station.

1.2.2 To compare the food niche overlap of the viverrids between seasons.

1.2.3 To determine habitat use and distribution of the viverrids at SERS

## 1.3 Scope and limitations of the study

1.3.1 Scats were collected in the study area, once a month and during 12 months period from January to December 2008.

1.3.2 The diet composition was classified into 6 categories i.e., small mammals, arthropods, herpetofaunas, birds, fruits, and other.

1.3.3 Habitat use of viverrids at the SERS was classified into 4 types i.e., dry evergreen forest, dry dipterocarp forest, bamboo forest, and plantation forest.

## 1.4 Expected results

This study will provide some information about 1) the species of viverrids occur at SERS, 2) the food niche and diet composition of the viverrid group, 3) the relationship between environmental factors and diets of the viverrids, and 4) the habitat use and distribution of the viverrids which can be applied for ecological conservation and management at Sakaerat Environmental Research Station in the future.

# CHAPTER II

# LITERATURE REVIEWS

## 2.1 The concept of ecological niche

Ecological niche is a term for the position of a species within an ecosystem, describing both the range of conditions necessary for persistence of the species, and its ecological role in the ecosystem (Grinnell, 1917; Hutchinson, 1957). Each species occupies an ecological niche which is a set of habitat resources for a species requires as well as its influence on the environment and other species (Wessells and Hopson, 1998; Brooker *et al*., 2008). An organism's niche is determined both by physical factors such as light, temperature, pH, and by biological factors such as food, diseases, and predators. The segregation of these niche dimensions may permit the partitioning of resources and thus the ecological coexistence of species (de Almeida Jácomo *et al*., 2004). If two organisms are very similar, their niches will overlap which results in competition. Competitors vie for the same limited resources (Wessells and Hopson, 1998).

Ecologists distinguish two types of niche. The range which a species could occupy in the absence of interference from other species is its “fundamental niche”. The range to which it is confined by competitors or predators is its “realized niche” (Hutchison, 1957). Under serve competition, a species may only use a very narrow part of a resource spectrum and has a small realized niche (Beeby and Brennan, 1997).

The study of resource overlap is important for understanding niche relationships, competitive processes, predations, and the influences that mammals exert on natural and cultivated ecosystem (Kauhara *et al*., 1998). There is evidence of strong competition among the species in carnivore communities. (Hesteinsson and Macdonald, 1992; Palomares *et al*., 1996). Differences between sympatric carnivore species in the use of trophic, temporal, and spatial niches have been frequently used to describe and explain community structure (Rabinowiz and Walker, 1991). Most evidence for this was based on preliminary studies on patterns of resource overlap. Thus, the study of resource overlap between sympatric carnivore species may be a useful way to deepen the knowledge of interactions and potential current competition of different carnivore species (Barrientos and Virgós, 2006).

## 2.2 Family Viverridae

The family Viverridae is the basal stock of the Feloidae. Viverridae is divided into 7 subfamilies, 19 genera, and 39 species, including all of the genets, the binturong, most of the civets, and the four linsangs. The taxonomy of this family is still uncertain due to a lack of clearly derived features defining it (Vaughan *et al*., 2000). The viverrids are to a diverse family of small and medium carnivores (Gaubert *et al*., 2002). They occupy various habitats in open biotopes (grassland, savanna), rain forests, logged forest, and sometimes they can be found near human habitations (Colón, 2002). They have diversified into a variety of biological roles such as predators, prey, and seed dispersers (Rabinowitz, 1991).

## 2.3 Classification and diversity of viverrids

The exact number of viverrid species, or even subspecies, is not yet known, and the systematic arrangement of the seven main viverrid groups differ in recent publications (Schreiber *et al*., 1989).

**Subfamily Viverrinae**

The subfamily Viverrinae includes some medium-sized ground living species such as civets (genus *Viverra*), but also genera adapted to an arboreal life (especially the linsangs of the genus *Poiana*). *Osbornictis* is a monotypic aquatic genus.

**Genus *Viverra***

Large Indian civet (*Viverra zibetha*) (Linnaeus, 1758)

Malayan civet (*Viverra tangalunga*) (Gray, 1832)

Malabar civet (*Viverra civettina*) (Blyth, 1862)

Large-spotted civet (*Viverra megaspila*) (Blyth, 1862)

**Genus *Civettictis***

African civet (*Civettictis civetta*) (Schreber, 1776)

**Genus *Viverricula***

Small Indian civet (*Viverricula indica*) (Desmarest, 1817)

**Genus *Genetta***

Haussa genet or Thierry's genet (*Genetta thierryi*) (Matschie, 1902)

Abyssinian genet or Ethiopian genet (*Genetta abyssinica*) (Rüppell, 1836)

Johnston’s genet (*Genetta johnstoni*) (Pocock, 1907)

Angolan genet (*Genetta angolensis*) (Bocage, 1882)

Small-spotted genet or common genet (*Genetta genetta*) (Linnaeus, 1758)

Panther genet or rusty-spotted genet (*Genetta maculata*) (Gray, 1830)

Cape genet or large-spotted genet (*Genetta tigrina*) (Schreber, 1776)

Servaline genet (*Genetta servakna*) (Pucheran, 1855)

Giant genet (*Genetta victoriae*) (Thomas, 1901)

Bourlon's genet (*Genetta bourloni*) (Gaubert, 2003)

Crested servaline genet or crested genet (*Genetta cristata*) (Hayman, 1940)

Pardine genet (*Genetta pardina*) (I. Geoffroy Saint-Hilaire, 1832)

King genet (*Genetta poensis*) (Waterhouse, 1838)

**Genus *Osbornictis***

Aquatic genet (*Osbornictis piscivora*) (J. A. Allen, 1919)

**Genus *Poiana***

African linsang (*Poiana richardsoni*) (Thomson, 1842)

Leighton's linsang (*Poiana leightoni*) (Pocock, 1908)

**Subfamily Prionodontinae**

The subfamily Prionodontinae includes 2 species of linsang. Both linsangs formerly were placed in the subfamily Viverrinae, but recent research suggests that their actual relationships may be somewhat different. The linsangs are remarkable for their morphological resemblance to cats, family Felidae, which is greater than in the other viverrids. However, DNA analysis indicates that while the linsangs are true viverrids closely related to the genets, they are not and may instead be the closest living relatives of the Felidae family.

**Genus *Prionodon***

Spotted linsang (*Prionodon pardicolor*) (Hodgson, 1842)

Banded linsang (*Prionodon Zinsang*) (Hardwicke, 1821)

**Subfamily Paradoxurinae**

The palm civets and their allies form a subfamily which is, with the exception of the Afrotropical genus *Nandinia* (African palm civet), confined to the rain forests of tropical Asia. Most species are arboreal and largely frugivorous.

**Genus *Arctictis***

Binturong (*Arctictis binturong*) (Raffles, 1821)

**Genus *Arctogalidia***

Small-toothed palm civet (*Arctogalidia trivirgata*) (Gray, 1832)

**Genus *Paradoxurus***

Common palm civet (*Paradoxurus hermaphroditus*) (Pallas, 1777)

Brown palm civet or Jerdon's palm civet (*Paradoxurus jerdoni*) (Blanford, 1885)

Golden palm civet (*Paradoxurus zeylonensis*) (Pallas, 1777)

Mentawai palm civet (*Paradoxurus Zignicolor*) (Miller, 1903)

**Genus *Paguma***

Masked palm civet (*Paguma Zarvata*) (Hamilton-Smith, 1827)

**Genus *Macrogalidia***

Sulawesi palm civet (*Macrogalidia musschenbroekii*) (Schlegel, 1877)

**Subfamily Hemigalinae**

The four genera classified as Hemigalinae contain some of the most elusive viverrids. All are inhabitants of Southeast Asian rain forests. The otter civets dwell near rivers and are to a large extent aquatic.

**Genus *Hemigalus***

Banded palm civet (*Hemigalus derbyanus*) (Gray, 1837)

**Genus *Chrotogale***

Owston’s palm civet (*Chrotogale owstoni*) (Thomas, 1912)

**Genus *Diplogale***

Hose's palm civet (*Diplogale hosei*) (Thomas, 1892)

**Genus *Cynogule***

Otter civet or sunda otter civet (*Cynogale bennettii*) (Gray, 1837)

**Subfamily Fossinae**

The subfamily Fossinae is confined to Madagascar. Its only species exhibits several phylogenetically primitive characteristics and may show some affinities to the Hemigalinae. Sometimes, the fanalouc (subfamily Euplerinae) is also included in the Fossinae.

**Genus *Fossa***

Malagasy civet (*Fossa fossana*) (P. L. S. Müller, 1776)

**Subfamily Euplerinae**

The fanalouc has a specialized way of life, feeding predominantly on earthworms.

**Genus *Eupleres***

Fanalouc (*Eupleres goudotii*) (Doyère, 1835)

**Subfamily Cryptoproctinae**

The fossa is the largest predator in Madagascar. Some aspects of its morphology are reminiscent of a cat species, a phenomenon which has elicited much debate among taxonomists.

**Genus *Cryptoprocta***

Fossa (*Cryptoprocta ferox*) (Bennett, 1833)

**Notes** from Lekagul and McNeely (1977); Schreiber *et al*. (1989); IUCN (2008).

## 2.4 Viverrids in Thailand

The viverrids in Thailand can be classified into 3 subfamilies, 9 genera, and 11 species (Lekagul and McNeely, 1977).

**Table 1** Viverrids in Thailand (Lekagul and McNeely, 1977).

| **Subfamily** | **Scientific name** | **Common name** |
|---|---|---|
| 1. Paradoxurinae | *Arctictis binturong* | Binturong |
| | *Paradoxurus hermaphroditus* | Asian palm civet |
| | *Paguma lavata* | Masked palm civet |
| | *Arctogalidia trivirgata* | Small-toothed palm civet |
| 2. Viverrinae | *Priondon linsang* | Banded linsang |
| | *Priondon pardiccolor* | Spotted linsang |
| | *Vivera megaspila* | Large-spotted civet |
| | *Viverra zibetha* | Large Indian civet |
| | *Viverricular indica* | Small Indian civet |
| 3. Hemigalinae | *Cynogale bennettii* | Otter civet |
| | *Hemigalus derbyanus* | Banded palm civet |

## 2.5 Some ecological aspects of viverrids

### Morphology

The family Viverridae is extraordinarily diverse families of mammals, and include species adapted to terrestrial, aquatic, fossorial, and arboreal life. They are small to medium size (0.6-20 kg) carnivores with short legs, slender bodies, and a long tail. The fur is short. The snout is pointed and the ears are erect. Most have five toes on each paw, though some may be lacking the hallux or pollex or both. The claws are less developed than in the Felidae, and may be retractile, non retractile, or partially retractile, with claw sheaths or without (Lekagul and McNeely, 1977).

The skull has a moderately long rostrum. The premolars are large and the carnassials are usually trenchant. The upper molars are tritubercular and are wider than they are long, the lower molars have well developed talonids. The dental formula is generally 3/3, 1/1, 3-4/3-4, 2/2 = 36-40 (Vaughan *et al*., 2000).

Viverrids are the only carnivores with scent glands (perfume glands between the anus and the genital organs) that produce a strong-smelling substance used for defense, territory marking, and sexual communication. These glands are most developed in civets and genets (except *Prionodon* and male *Arctogalidia*) (Lekagul and McNeely, 1977).

**Behavior**

Viverrids are generally solitary, although some may live in pairs or small groups. Most are nocturnal animals. They sleep during the day and become active at night (Mudappa, 2006). They exhibit a variety of lifestyles and adaptations for example; the common palm civet is almost exclusively arboreal. The otter civet and the aquatic genet live near rivers and streams (Vaughan *et al*., 2000).

Most viverrids mark territories and tree branches with scent secretions. They also deposit feces on rocks, topping them with scent secretions to advertise ownership. Some species can produce sounds, including hisses, screams, and coughs. Some breed throughout the year. Others breed during certain seasons. Some may give birth two or three times a year. The average litter size is two to three kittens. Kittens are born with a full coat. Males do not share in parenting (Lekagul and McNeely, 1977; Vaughan *et al*., 2000).

**Habitat and distribution**

Viverrids occupy tropical rain forests that provide canopies. They also inhabit tall grasses and thick brush for cover. Some prefer wetlands, while others live near rivers and streams. Although these animals are a forest dweller, some have come to favor living near areas of human habitation (Colón, 2002).

Viverrids are confined to the Old World, but the center of their distribution is in tropical and southern temperate areas, as well as from New Guinea and Australia. They do not occur, even as fossils, in the New World (Vaughan *et al*., 2000).

**Diet**

Viverrids are primary carnivores in food webs. They eat a variety of foods such as rodents, insects, reptiles, frogs, birds, crabs, eggs, and carrion (dead and decaying flesh). They tend to be generalist feeders exploiting a wide variety of resources and sometimes switching between prey types in order to buffer fluctuations in abundance that inevitably occur (Hanski *et al*., 1991). They may also eat some fruits and plants, such as coffee, berries, fruits, and nuts (Marcone, 2004). Palm civets are predominantly frugivores, eating pulpy fruits and berries.

## 2.6 Viverrids and people

Viverrid meat is consumed by some people. Some species are kept as pets to control rodents. Humans sometimes kill those that attack poultry and lambs. Oil from the civet is valued by perfume makers for enhancing the quality of fragrances (Dannenfeldt, 1985).

In 2002, an outbreak of severe acute respiratory syndrome (SARS) in southern China was linked to the consumption of masked palm civet. SARS is an infectious, potentially deadly disease. When the World Health Organization announced the end of the SARS outbreak in July 2003, more than 8,000 cases had been reported in 27 countries, with 774 deaths. In January 2004, when SARS resurfaced in China, authorities ordered the killing of all palm civets raised on farms. Other animals, including the raccoon dog and the Chinese ferret badger, also carry SARS virus. These are not eaten by humans and have not been destroyed (Saif, 2004; Wang and Eaton, 2007; Shi and Hu, 2008).

## 2.7 Conservation status

The International Union for Conservation of Nature (IUCN) lists eight species as threatened. The Malabar civet is classified as Critically Endangered, facing an extremely high risk of extinction, due to habitat loss, predation, and hunting by humans. The otter civet and the crested genet are listed as Endangered, facing a very high risk of extinction, because of habitat loss, predation, and hunting by humans. Five species are listed as Vulnerable, facing a high risk of extinction, mostly because of habitat loss and hunting by humans. These are Owston's palm civet, Hose's palm civet, the Malagasy civet, the Sulawesi palm civet, and Jerdon's palm civet (IUCN, 2008).

# CHAPTER III

# METHODOLOGY

## 3.1 Study site description

**Location**

The study was conducted at the Sakaerat Environmental Research Station (SERS) in Wang Nam Khieo and Pak Thong Chai districts, Nakhon Ratchasima province, Northeast Thailand. SERS covers 81 $km^2$ and is situated approximately at 14° 30′ N, 101° 55′ E, about 300 km northeast of Bangkok (Fig. 1) (Suriyapong, 2003).

**History**

SERS is one of the five UNESCO designated biosphere reserves of Thailand. It was first established in September, 1967, by the Applied Scientific Research Corporation of Thailand to use as a national forest reserve for scientific propose by the Royal Forest Department, Ministry of Agriculture and Cooperatives. In 1976, SERS was delegated by the UNESCO to be a World Biosphere Reserve of Thailand (Hanboonsong, 2000).

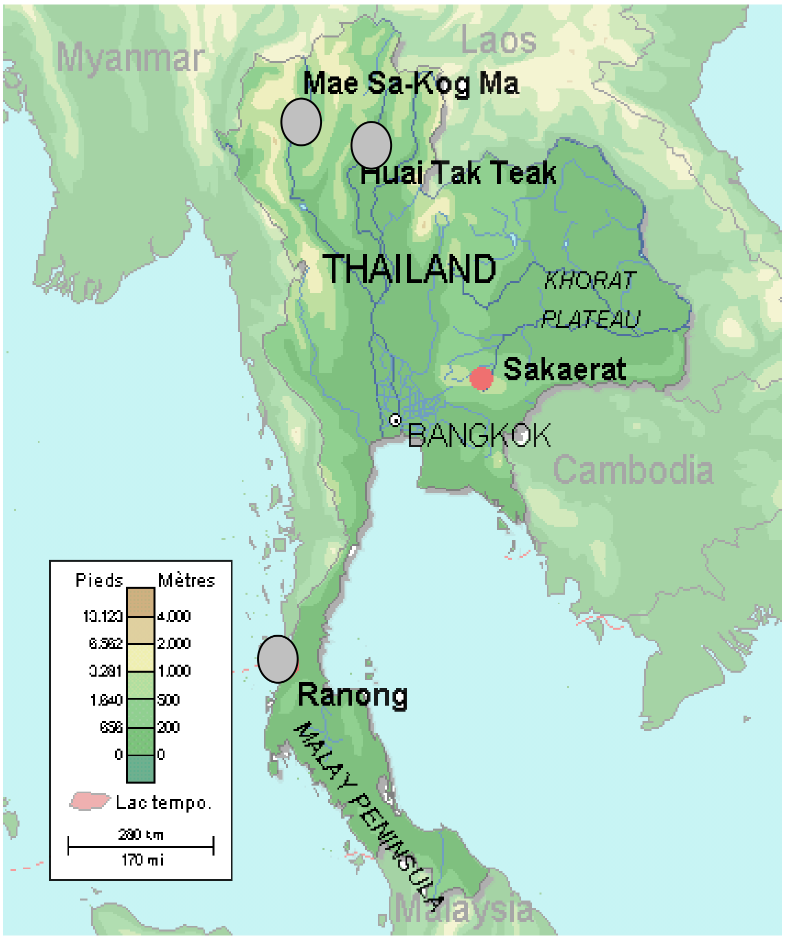


**Figure 1** Location of Sakaerat Environmental Research Station (SERS) (Modified from UNESCO-MAB, Online, 2006).

**Climate**

Meteorological summary data for the years 2008 were available from the Sakaerat 1 meteorological station at SERS (14° 30' 65" N; 101° 56' 03" E; altitude: 394 m), which was situated about 50 m southwest of the station office.

During the study period (January-December 2008) monthly precipitation ranged between a minimum of 5.1 mm (January 2008) and a maximum of 270.5 mm (September 2008). Monthly mean temperatures ranged between 15.5°C (December 2008) and 35.4°C (April 2008). Annual precipitation is about 1131.9 mm. Mean annual temperature is 25.7°C and mean annual relative humidity is 90% (http://www.tistr.or.th /sakaerat/Meteorlogical/Mont/2008-mont.htm).

SERS has a tropical climate and three distinct seasons, summer (March-May), rainy season (June-October), and winter (November-February) (Sampanpanish, 2005).

**Topography**

SERS was mainly dominated by dry evergreen and dry dipterocarp forest. The majority of vegetation is dense dry evergreen forest, except for the north and northeast sections of the area where an open dry dipterocarp forest occurs. The elevation ranges between 280 to 762 m. above sea level (Suriyapong, 2003).

**Wildlife diversity**

Approximately 380 wildlife species of both mammals and birds were described at SERS. Among those 70 species are small mammal species such as barking deer and wild pig and 200 species are birds. Several species of wild life in SERS are rare species and some, like the wild deer, the tiger, and the wild peacock are close to become extinct (Hanboonsong, 2000). The Viverrid assemblage in this area included five species (*Viverra zibetha*, *Viverricula indica, Paradoxurus hermaphroditus, Paguma larvata, Arctictis binturong*) (Pakarnseree *et al*., 2003).

## 3.2 Habitat classification

A digital land cover map was used to determine habitat availability and habitat use. This map was developed from satellite images with the support of data from field surveys. Satellite images of the study area came from the summer of 2003.

ArcView 3.2a (ESRI, California, USA) was used to analyze the habitat characteristics and calculate the habitat availability. The map was divided to 1 km$^2$ cell grids to match the Universal Transverse Mercator (UTM) format (Fig. 2). Habitat availability was calculated using polygons on the digital land cover map.

Habitats were classified into four different habitat classes: dry evergreen forest, dry dipterocarp forest, bamboo forest, and plantation forest.

## 3.3 Sign surveys

Preliminary surveys were conducted in December 2007. All main roads, fire breaks, and forest trails were surveyed for viverrid signs such as tracks, scrapes, and scats. The viverrid signs were recorded and removed from transects.

Field observations were started from January until December 2008, with a one week per month. Ten transects, where animals signs found, were established for survey in this study (Fig. 3). Ten line transects were surveyed by a vehicle driving at 10-20 km/h or walked along transects. At each line transect, tracks, scats, and viverrid species detected were recorded. Animal tracks were identified using a key book (Kanjanavanit, 2004). Site locations, dates, and habitat descriptions were also recorded.

Camera trap and spotlight surveys were also conducted in this study. Two camera traps were placed at optimal locations, based on the presence of viverrid signs. Each camera trap station was baited with chicken, banana or sea fish. Cameras were not set during inclement weather.

Spotlight surveys were conducted on the sign survey transects by driving a vehicle at 10-15 km/h, two or more observers used spotlight to scan both sides of transect. Surveys were completed between 8 pm and 12 pm and were not undertaken on nights of inclement weather.

The locations from sign surveys, camera traps, and spotlight surveys were determined by GPS (Garmin GPSMAP 76CSx) and recorded in UTM format. Locations were not recorded into the GPS until the estimated accuracy was <10 m. Species presence/absence locations were imported into ArcView 3.2a (ESRI, California, USA) to examine habitat use (Woolf *et al*., 2001).

## 3.4 Trapping procedure

Six line transects were distributed across the various habitat types including dry evergreen forest, dry dipterocarp forest, bamboo forest, and plantation forest (Fig. 3). Ten traps were set at 100 m intervals along the main road and fire breaks, where animal signs were detected. 10 steel mesh cages (100 x 40 x 50 cm) baited with chicken, banana or sea fish (Perkin, 2004; Jennings *et al.*, 2006; Martinoli *et al*., 2006). Traps were placed on dry ground and near large trees, covered by leaves with the trap floor covered with soil and leaf litter. Traps were set at dusk and checked once per day in the morning (Colón, 2002; Jennings *et al.*, 2006). The traps were sampled over five consecutive nights for each month from February 2008 to December 2008.

Captured animals were returned to the field laboratory at Station, anesthetized with an intramuscular injection of Zoletil® (Vibrac Laboratories, Carros, France) at 5 mg/kg., weighted, measured, and photographed. Animals were classified into subfamily, genus, and species by the key book from Lekagul and McNeely (1977). Sex and age were recorded. Age was classified as juvenile, sub adult, adult or old according to body size, reproductive condition, and tooth wear. Ectoparasites were collected by combing the animal's fur or examining the skin and removing parasites with tweezers. Blood samples were collected from marginal ear veins for examined blood parasites. After processing, animals were marked by ear notching and released at the captured location.

## 3.5 Scat collection and analysis

Scats were collected along the road in the study area every month for one year (January-December 2008). Scats were identified by presence of tracks and morphological characteristics (see Appendix C for detailed description of viverrid's tracks). Scats were collected in plastic bag and labeled for transect, scat description, and date. Incomplete scats were excluded from the analysis.

Analysis of scats was carried out following the standard method of washing, sifting, and drying (Kruuk and Parish, 1981; Reynolds and Aefbischer, 1991). Scats were washed in a fine meshed sieve and dried in the sun. Undigested remains in the scat were classified into bone fragments, reptile scales, mammalian hairs, feathers, invertebrate remains, grasses, and seeds. They were identified by comparison with specimens collected inside the study area (Martinoli *et al*., 2006) and by using a key book from Lekagul and McNeely (1977).

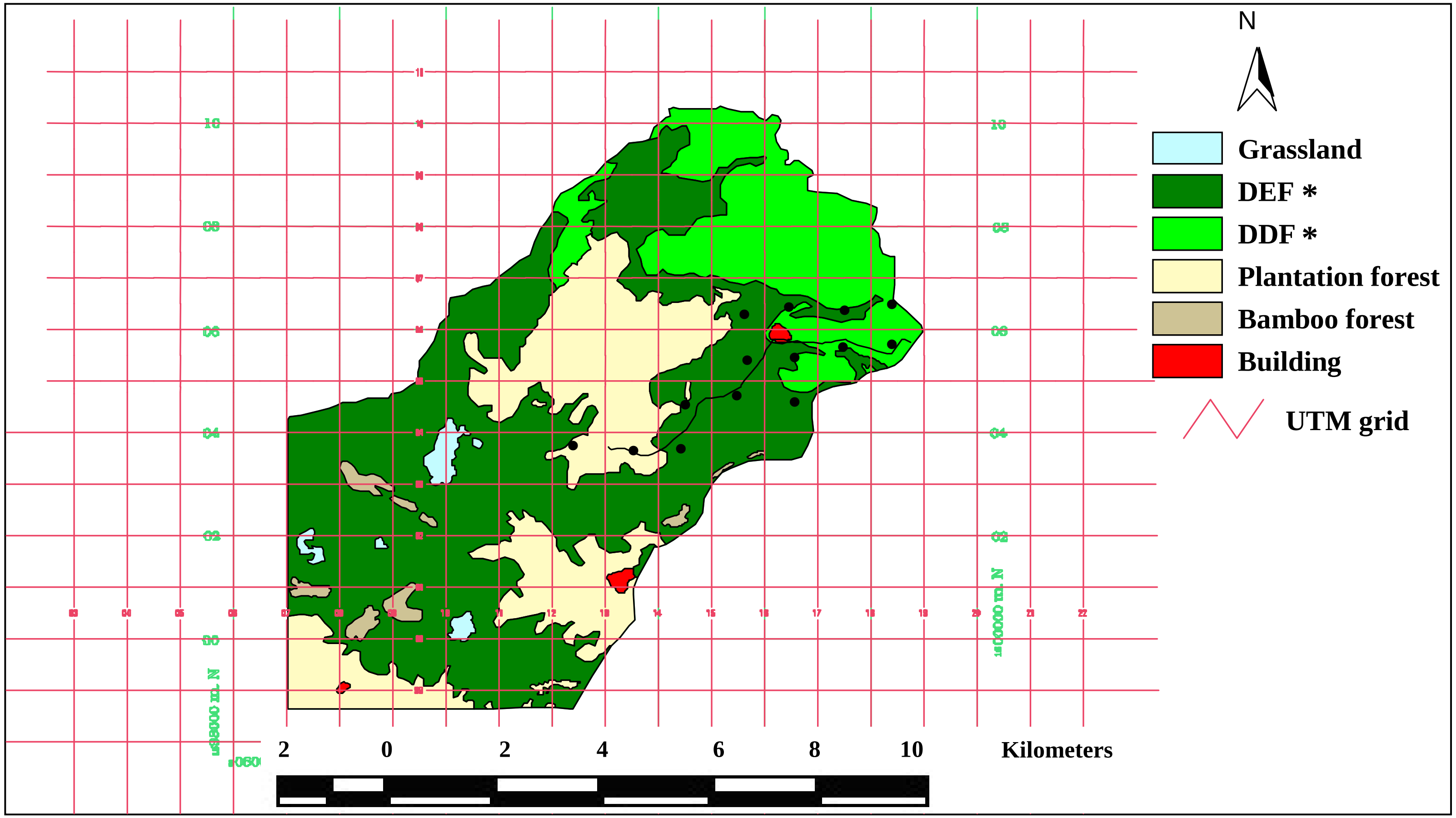


**Figure 2** Digital land cover map with 1 km$^2$ cell grids of SERS. (•) Area surveyed for viverrids using sign surveys and live trapping in 2008. (*) DEF = dry evergreen forest, DDF = dry dipterocarp forest (Modified from map of SERS).

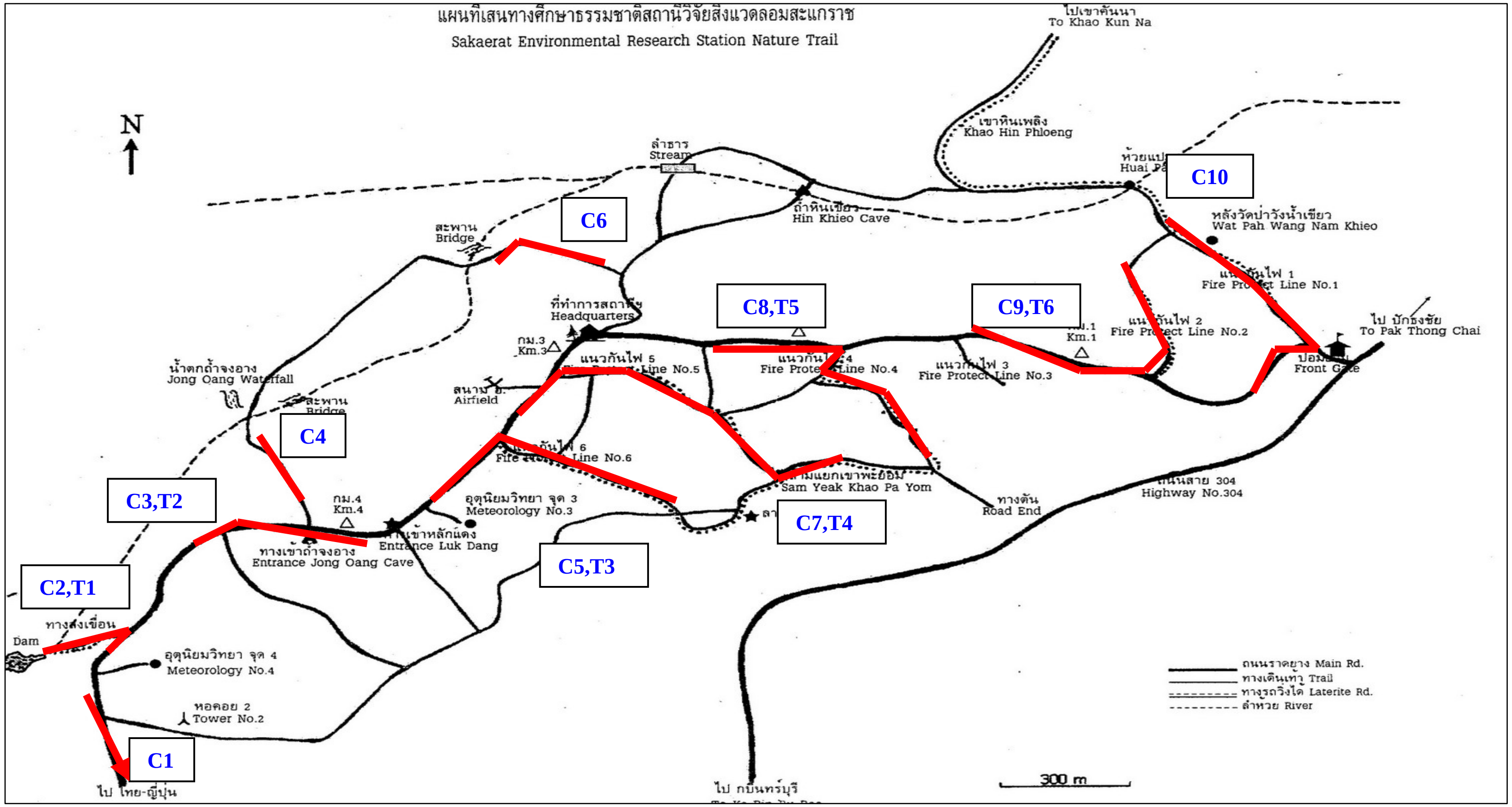


**Figure 3** Location of the ten line transect surveys (C) and six trapping lines (T) at SERS in 2008 (Modified from map of SERS).

## 3.6 Data analysis

### 3.6.1 Habitat analysis

**Trapping success**

Trapping success was calculated using the formula as follows:

$$\% \text{ trapping success} = \frac{\text{Number of captures}}{\text{Number of trap nights}} \text{X } 100$$

**Distribution pattern**

Distribution pattern was calculated using the standardized Morisita index ($I_p$) (Morisita, 1962; Krebs, 1998).

$$I_d = n\left[\frac{\sum x^2 - \sum x}{(\sum x)^2 - \sum x}\right]$$

where $I_d$ = Morisita's index of dispersion

$n$ = sample size

$\Sigma x$ = sum of the quadrat counts

$\Sigma x^2$ = sum of the quadrat counts squared

then calculated two critical values for the Morisita index from the following formulas:

$$\text{Uniform index} = M_u = \frac{x^2_{.975} - n + \sum x_i}{\left(\sum x_i - 1\right)}$$

where $x^2_{.975}$ = value of chi-squared from table with ($n$-1) degree of freedom

$x_i$ = number of samples in quadrat

$n$ = number of quadrat

$$\text{Clumped index} = M_c = \frac{x^2_{.025} - n + \sum x_i}{\left(\sum x_i - 1\right)}$$

where $x^2_{.025}$ = value of chi-squared from table with ($n$-1) degree of freedom

$x_i$ = number of samples in quadrat

$n$ = number of quadrat

then calculated the standardized Morisita index by one of the following four formulas:

when $I_d \geq M_c > 1.0$; $\quad I_p = 0.5 + 0.5\left(\frac{I_d - M_c}{n - M_c}\right)$

when $M_c > I_d \geq 1.0$; $\quad I_p = 0.5\left(\frac{I_d - 1}{M_u - 1}\right)$

when $1.0 > I_d > M_u$; $\quad I_p = -0.5\left(\frac{I_d - 1}{M_u - 1}\right)$

when $1.0 > M_u > I_d$; $\quad I_p = -0.5 + 0.5\left(\frac{I_d - M_u}{M_u}\right)$

**Habitat use**

Habitat use was calculated using the Ivlev’s electivity index (Ivlev, 1965; Jacobs, 1974).

$$E_i = \frac{(u_i - a_i)}{(u_i + a_i)}$$

where $E_i$ = the Ivlev's index for habitat *i*

$u_i$ = the proportion of observations in habitat *i*

$a_i$ = the proportion of habitat *i* available in the study area

**3.6.2 Dietary analysis**

**Dietary diversity**

Diversity of diet was calculated using the Shannon-Wiener index (Krebs, 1998).

$$H' = \sum_{i=1}^{S} P_i \log_e P_i$$

where $H'$ = species diversity index

$P_i$ = the proportion of individuals in the i species

$S$ = total number of diet species

**Frequency of occurrence (%FO)**

Percentage frequency of occurrence of food items in scats is a measure of how often an animal feeds on a certain type of food (Zabala and Zuberogoitia, 2003). It was calculated using the formula as follows:

$$\%FO = \frac{\text{Number of scats containing a particular items}}{\text{Total number of scats}} \times 100$$

**Volume of food items (%V)**

Percentage of volume of food items in scats is a measure of major and minor food of animals (Zabala and Zuberogoitia, 2003). It was estimated by eye (Kruuk and Parish, 1981) and scored on a nine point scale: 0, 1 (<1%), 2 (1–5%), 3 (6–10%) 4 (11–25%), 5 (26–50%), 6 (51–75%), 7 (76–98%), and 8 (>98%). For arthropods, scores were converted to the midpoint of each percent interval 0, 1 (0.5%), 2 (3%), 3 (8%), 4 (18%), 5 (38%), 6 (63%), 7 (87%), and 8 (99%) (Ray and Sunquist, 2001). Then, sum of bulk-scores containing item *a* divided by the total number of scats

**Minimum number of individuals (MNI)**

Minimum number of individuals is a measure of number of prey in food. MNI for mammals was estimated by counting jaw or jaw fragments, and for herpetofauna and fish by counting vertebrate. When only hair or scales was contained in a scat, the MNI was assumed to equal 1 (Ray and Sunquist, 2001).

### 3.6.3 Dietary niche analysis

**Dietary niche breadth ($B_A$)**

Niche breadth was calculated using the Levins's standardized niche breadth (Krebs, 1998).

$$B_A = \frac{B-1}{n-1}$$

where $B_A$ = Levins's standardized niche breadth

$B$ = Levins's measure of niche breadth

$N$ = number of possible resource states

$$B = \frac{1}{\sum p^2 j}$$

$B$ = Levins's measure of niche breadth

$p_j$ = Fraction of items in the diet that are of food category j

**Dietary niche overlap ($O_{jk}$)**

Niche overlap was calculated for seasonal dietary overlap by using the Pianka's index (Pianka, 1974).

$$o_{jk} = \frac{\sum_{i}^{n} p_{ij} p_{ik}}{\sqrt{\sum_{i}^{n} p_{ij}^2 p_{ik}^2}}$$

where $O_{jk}$ = Pianka's measure of niche overlap between season $j$ and season $k$

$p_{ij}$ = proportion resource $i$ is of the total resources used in season $j$

$p_{ik}$ = proportion resource $i$ is of the total resources used in season $k$

$n$ = total number of resource states

**3.6.4 Seasonal diet**

Seasonal diet differences in the percentage volume (%V) and the frequency of occurrence (FO) of each prey group in the scats were examined using the $X^2$ test. The Shannon-Wiener diversity index ($H'$) of diet was compared between seasons using the t-test (Zar, 1999). SPSS 13.0 (SPSS, Illinois, USA) was used for all statistical analyses.

# CHAPTER IV

# RESULTS AND DISCUSSION

## 4.1 Sign surveys and live trapping

A total of 238 records of three viverrid species were collected; including 213 scats, 15 captures, 6 tracks, 2 observations, and 2 camera captures. Common palm civet (*Paradoxurus hermaphroditus*, 15 captures, 2 camera captures, 2 tracks, and 1 observation), large Indian civet (*Viverra zibetha*, 4 tracks) and small Indian civet (*Viverricula indica*, 1 observation) were encountered during study. Scats were not identified for species in this study. The most common species of viverrid at SERS was common palm civet. They occured on all survey methods.

Pakarnseree *et al*. (2003) recorded common palm civet (*Paradoxurus hermaphroditus*), large Indian civet (*Viverra zibetha*), small Indian civet (*Viverricula indica*), masked palm civet (*Paguma larvata*), and binturong (*Arctictis binturong*) at SERS. But masked palm civet and binturong were not detected during this study period. Both masked palm civet and binturong difficult to encounter the transect surveys and traps because they mostly living and foraging in the tree (Lekagul and McNeely, 1977).

The viverrid signs were found in all seasons; including 45 scats and 1 track in summer, 105 scats and 2 tracks in rainy season, and 63 scats and 3 tracks in winter. The mean number of viverrid signs were not different among three different seasons (Kruskal-Wallis H = 0.967, d.f. = 2, $P$ = 0.616). These data differ from Ray and Sunquist 2001) who found that the seasonal effect was highly significant on the number of African rainforest carnivore scats (*Herpestes naso*, *Bdeogale nigripes*, *Atilax paludinosus*, *Genetta servalina*, *Civettictis civetta*, *Nandinia binotata*, *Profelis aurata*, and *Panthera pardus*), with a mean of 65.5 scats recovered per dry season month versus 30.1 per month in the early wet and 33.9 in the late wet season. Rosalino and Santos-Reis (2002) found that the number of genet scats in summer, spring, and winter were higher than autumn in central Portugal. Those scats have high decay rate because high average rainfall (1,457 mm.) in African rainforest and coastal condition in central Portugal. It can be concluded that the ecological factors among seasons at SERS have few effects on the decay rate of viverrid's signs.

A total of 15 common palm civets were captured in 606 trap nights; seven civets were recaptured and one civet was captured but escaped prior to processing. Thus, seven individual civets were captured in this study; consisting of three juvenile males, three adult males, and one adult female. The body measurements of trapped animals are presented in Table 2. The body measurements recorded showed that the common palm civets caught in this study were closer to the previous recorded in Thailand (Lekagul and McNeely, 1977). Four nontarget species were captured; included seven variable squirrel (*Callosciurus finlaysoni*), three common treeshrew (*Tupaia glis*), one Indochinese ground squirrel (*Menetes berdmorei*), and nine yellow rajah rat (*Maxomys surifer*).

Trapping success was 1.7% in juveniles (ten captured in 606 trap nights, seven recaptured) and 0.7% in adults (four captured in 606 trap nights, none recaptured). Total trapping success was 2.3%. Viverrids are notoriously difficult to capture because of their suspicion when encountering traps. For example, Jennings *et al*. (2006) showed a success rate of 3.1% in trapping Malay civets in Indonesia. Colón (2002) showed a success rate of only 2.2% in trapping Malay civets in Malaysia. These data are confirming the trap shyness of this carnivore group.

**Table 2** Body measurements of captured common palm civets (*Paradoxurus hermaphroditus*) at SERS, 2008.

| Civet | Sex | Age | Weight* | Head-body Length** | Tail length | Neck circumference | Height at shoulder | Right hind foot length | Right ear length | Upper right canine length |
|---|---|---|---|---|---|---|---|---|---|---|
| C1 | M | Adult | 2.0 | 46.5 | 46.5 | 16.0 | 24.0 | 8.0 | 5.0 | 0.7 (broken) |
| C2 | F | Adult | 3.2 | 40.0 | 54.0 | 20.0 | 26.0 | 5.0 | 5.5 | 1.0 |
| C3 | M | Juvenile | 1.2 | 34.0 | 43.0 | 13.0 | 17.0 | 7.5 | 4.2 | 0.5 |
| C4 | M | Juvenile | 1.3 | 37.0 | 39.0 | 12.0 | 17.0 | 7.0 | 5.0 | 0.7 |
| C5 | M | Juvenile | 1.2 | 32.0 | 43.0 | 11.5 | 12.5 | 6.0 | 4.3 | 0.6 |
| C6 | M | Adult | 3.5 | 50.0 | 54.0 | 17.5 | 20.0 | 7.5 | 5.0 | 1.1 |
| C7 | M | Adult | 4.0 | 58.0 | 53.0 | 19.5 | 23.0 | 7.0 | 4.5 | 1.2 |

* Weight in kg.
** All measurements in cm.

## 4.2 Distribution and habitat use

The survey area was covered about 12.27 $km^2$ and dominated by dry evergreen forest (6.97 $km^2$, 56.81%), followed by dry dipterocarp forest (3.93 $km^2$, 27.63%), plantation forest (1.89 $km^2$, 15.40%), and bamboo forest (0.02 $km^2$, 0.16%).

In total of 238 location records of viverrids, 165 locations were found in dry evergreen forest, 66 locations in dry dipterocarp forest, and 7 locations in plantation forest. No viverrid's signs were found in bamboo forest (Fig. 4). The viverrids at SERS showed the use of habitat in dry evergreen forest, random use in dry dipterocarp forest, and avoidance in plantation forest and bamboo forest (Fig. 5). The presence of these animals was generally associated with dry evergreen forest, probably because the better cover of this habitat type was useful for den sites and favored foraging areas (Mudappa, 2006). Dry dipterocarp forest, plantation forest, and bamboo forest were less cover compared with dry evergreen forest.

The viverrids showed uniform distribution pattern in study area (standardized Morisita index = - 0.304, $P$ = 0.05) (Fig. 4). Uniformly distributed populations occurred when resources were spread thinly and evenly or when individuals were antagonistic to one another. This pattern mostly occurred with predator or territorial animals such as bears, coyotes, and hawks (Wessells and Hopson, 1998).

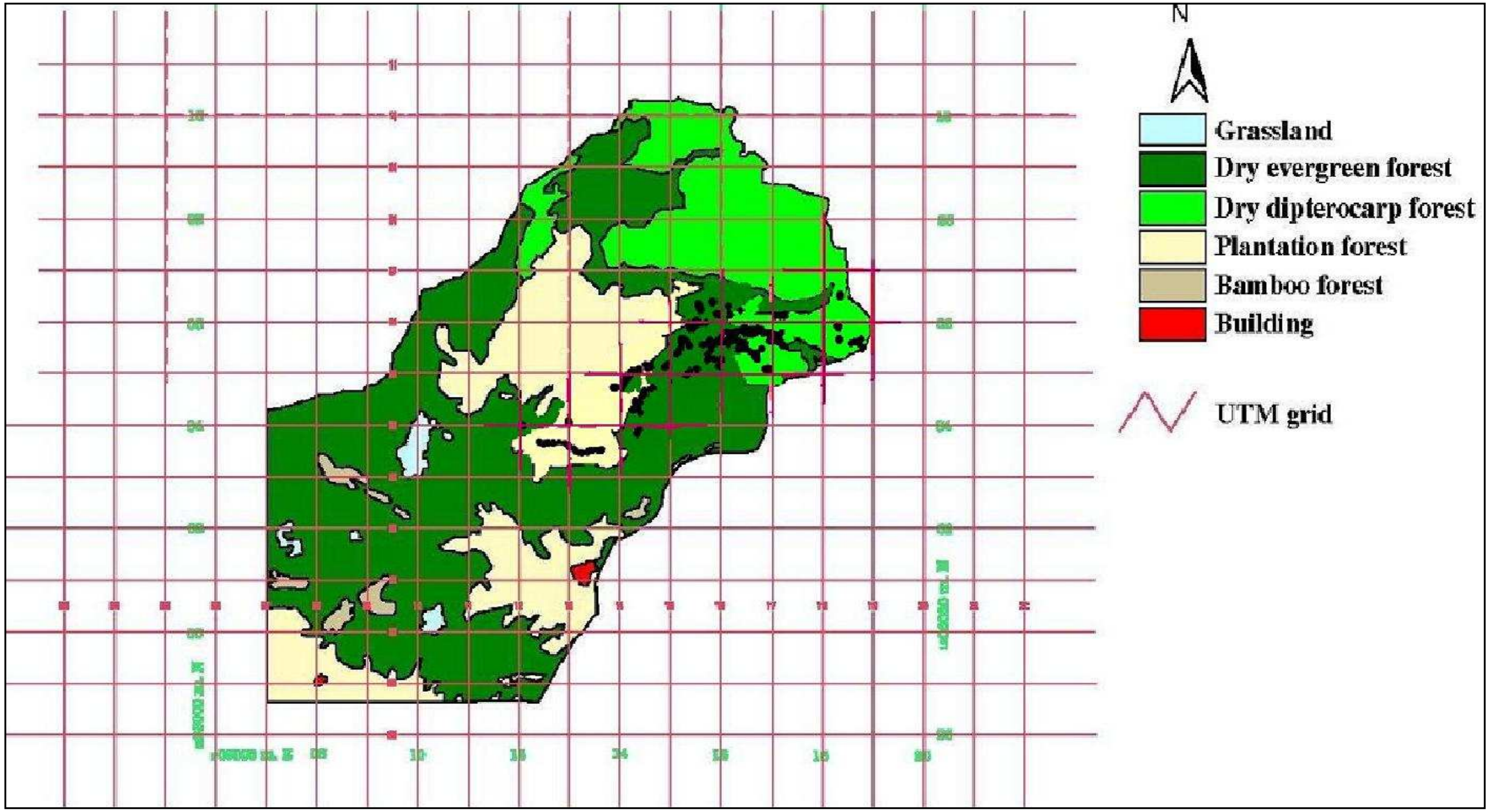


**Figure 4** Distribution of viverrids in different habitat types at SRES, 2008 (Modified from map of SERS).

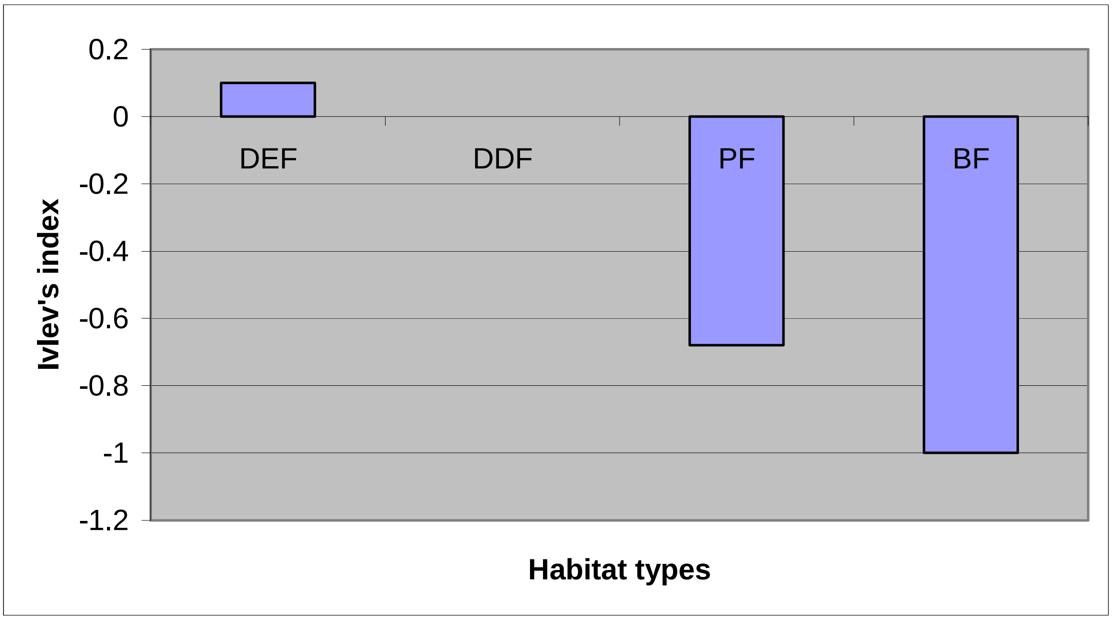


**Figure 5** Ivlev's electivity index indicating habitat selection (positive value) or avoidance (negative value) for viverrids at SERS, 2008 (DEF = dry evergreen forest, DDF = dry dipterocarp forest, PF = plantation forest, BF = bamboo forest).

## 4.3 Diet of viverrids

A total of 162 scats, out of a total of 213 encountered scats, were collected and examined for diet of viverrids. Of these, 35 scat samples were collected in summer, 81 in rainy season, and 46 in winter. Another 51 incomplete scats could not be identified, because they were destroyed by many factors such as climate, animals or human activities.

A total of 192 food items was detected in scats; each scat containing approximately one component on average (mean = 1.1, SD = 0.1). Small mammals were the most important diet of viverrids, both in frequency of occurrence and volume (%FO = 53.70, %V = 51.84). Four species of mammals were found in diet. Yellow rajah rat (*Maxomys surifer*) was the most important individual prey in the diet. They were the major portion in diet and frequently consumed by viverrids (%FO = 50.00, %V = 48.75, MNI = 81).

Fruits were the second important diet of viverrids (%FO = 37.65, %V = 34.75). Ten species of wild fruits were found in diet of viverrids. *Antidesma acidum* was the most important fruits in diet (%FO = 8.02, %V = 7.78). Other fruits were also important supplemented in diet: *Dialium cochinchinense* (%FO = 6.79, %V = 6.78), *Diplocyclos palmatus* (%FO = 6.17, %V = 5.86), and *Memecylon ovatum* (%FO = 5.56, %V = 4.72).

Arthropods were the third important diet of viverrids (%FO = 14.82, %V = 10.57). The most important arthropod was millipedes (%FO = 8.64, %V = 7.06), corresponding to almost 66.79% of the total volume in arthropods ingested.

Herpetofauna, bird, and grass were relatively low importance in diet. They were consumed in low volume of all food items. Overall 87 mammals, 1 lizard, and 1 snake were consumed by viverrids in this study. The summary of frequency of occurrence, minimum number of individuals, and volume of food items of viverrids are presented in Table 3.

These results showed that viverrids at SERS consumed a wide variety of food items, which is similar to other tropical rainforest predator community (Ray and Sunquist, 2001). The tropical rain forest has the highest diversity, abundance, and species richness of biological community, conservatively 3 million kinds of plants, animals and microorganisms (Wessells and Hopson, 1998). Thus, the carnivores in tropical rain forest have more food choice than other terrestrial habitats.

Kanchanasaka (2000) showed that the bulk percentages of large Indian civet's diet were not differed between animals and plants in rubber plantation, Surat Thani province. But the bulk percentage were differed between animals and plants in this study ($X^2$ = 7.364, df = 1, $P < 0.01$). Suggest that the SERS has more abundance of animal prey than in rubber plantation. Thus, viverrids were consumed animals more than plants in this area. The abundance of small mammals at SERS is shown in Appendix B (Pinmongkholgul, 2008).

However, plants are important diet for viverrids. Ten species of wild fruits were found in the viverrid's diet in this study (%FO = 37.65, %V = 34.75). These results are similar to those of Rabinowitz (1991) who found that viverrids fed on at least 18 fruit species in Huai Kha Khaeng Wildlife Sanctuary, Thailand. Corlett (1996) found that 15 fruit species in viverrid scats in Hong Kong. Viverrids exhibited high degree of frugivory in this study. Both animals and plants are important diet of viverrids, especially small mammals and fruits.

**Table 3** Frequency of occurrence (FO), volume of food items (%V), and minimum number of individuals (MNI) in the diet of viverrids at SERS, 2008.

| Prey items | n | %FO | %V | MNI |
|---|---|---|---|---|
| **Small mammals** | **87** | **53.70** | **51.84** | **87** |
| *Maxomys surifer* | 81 | 50.00 | 48.75 | 81 |
| *Leopoldamys sabanus* | 2 | 1.23 | 1.23 | 2 |
| *Rattus rattus* | 1 | 0.62 | 0.57 | 1 |
| *Callosciurus finlaysoni* | 1 | 0.62 | 0.62 | 1 |
| unidentified | 2 | 1.23 | 0.67 | 2 |
| **Arthropods** | **24** | **14.82** | **10.57** | **-** |
| Scorpion | 1 | 0.62 | 0.61 | - |
| Isopterans | 2 | 1.23 | 1.15 | - |
| Millipedes | 14 | 8.64 | 7.06 | - |
| Centipedes | 1 | 0.62 | 0.61 | - |
| Orthopterans | 1 | 0.62 | 0.05 | - |
| Coleopterans | 1 | 0.62 | 0.02 | - |
| unidentified | 4 | 2.47 | 1.07 | - |
| **Herpetofaunas** | **2** | **1.24** | **0.42** | **2** |
| Lizard | 1 | 0.62 | 0.11 | 1 |
| Snake | 1 | 0.62 | 0.31 | 1 |
| **Birds** | **1** | **0.62** | **0.62** | **-** |
| unidentified | 1 | 0.62 | 0.62 | - |
| **Fruits** | **61** | **37.65** | **34.75** | **-** |
| *Dialium cochinchinense* | 11 | 6.79 | 6.78 | - |
| *Uvaria dac* | 1 | 0.62 | 0.62 | - |
| *Diplocyclos palmatus* | 10 | 6.17 | 5.86 | - |
| *Microcos tomentosa* | 2 | 1.23 | 0.93 | - |
| *Memecylon ovatum* | 9 | 5.56 | 4.72 | - |
| *Willughbeia edulis* | 1 | 0.62 | 0.03 | - |
| *Morinda coreia* | 1 | 0.62 | 0.62 | - |
| *Syzygium cumini* | 6 | 3.70 | 3.70 | - |
| *Musa acuminata* | 1 | 0.62 | 0.01 | - |
| *Antidesma acidum* | 13 | 8.02 | 7.78 | - |
| unidentified | 6 | 3.70 | 3.70 | - |
| **Other** | **17** | **10.49** | **3.10** | **-** |
| Grass | 17 | 10.49 | 3.10 | - |

## 4.4 Seasonal diet of viverrids

The diversity of food consumed by the viverrids were highest in rainy season ($H'$ = 2.017) followed by summer ($H'$ = 1.844) and winter ($H'$ = 1.100), respectively. But they were not differed among seasons (summer/rainy season: $t$ = 0.233, df = 6, $P$ = 0.824, summer/winter; $t$ = 2.394, df = 4.417, $P$ = 0.069, rainy season/winter: $t$ = 2.346, df = 4.105, $P$ = 0.077). Overall the Shannon-Wiener diversity index was 2.294. Viverrids consumed diversified food throughout the year. Indicate that the SRES has high species richness and diversity of prey species.

There were no difference in the frequency of arthropods ($X^2$ = 3.130, df = 1, $P$ = 0.077), herpetofaunas ($X^2$ = 0.333, df = 1, $P$ = 0.564), and grass ($X^2$ = 0.600, df = 2, $P$ = 0.741) in diet among season. Arthropods were not found in winter and herpetofaunas were not found in summer, while bird was found only in rainy season (Fig. 6).

The volume of arthropods ($X^2$ = 2.000, df = 1, $P$ = 0.157) and grass ($X^2$ = 0.200, df = 2, $P$ = 0.905) in diet were not differed among season. The volume of bird and herpetofaunas in diet were insufficient for statistical calculation.

Consumption of small mammals varied significantly among seasons. The frequencies of occurrence were significant difference between summer and winter ($X^2$ = 9.151, df = 1, $P$ < 0.01) and between rainy season and winter ($X^2$ = 7.377, df = 1, $P$ < 0.01). The volumes of diet were also significant difference between summer and winter ($X^2$ = 9.143, df = 1, $P$ < 0.01) and between rainy season and winter ($X^2$ = 6.759, df = 1, $P$ < 0.01). But, there were no difference between summer and rainy season in the frequency of occurrence ($X^2$ = 0.101, df = 1, $P$ = 0.750) and the volume of diet ($X^2$ = 0.190, df = 1, $P$ = 0.663). Viverrids consumed mammals more often in winter than summer and rainy season (Fig. 6). They also consumed mammals more proportion in winter than summer and rainy season (Fig. 7).

For fruits, the frequencies of occurrence were significant difference between rainy season and winter ($X^2$ = 6.914, df = 1, $P$ < 0.01). The volumes of diet were differed between rainy season and winter ($X^2$ = 5.730, df = 1, $P$ < 0.05). The frequencies of occurrence were not different between summer and rainy season ($X^2$ = 0.976, df = 1, $P$ = 0.323) and between summer and winter ($X^2$ = 2.770, df = 1, $P$ = 0.096). The volume of diet were not different between summer and rainy season ($X^2$ = 0.205, df = 1, $P$ = 0.652) and between summer and winter ($X^2$ = 3.814, df = 1, $P$ = 0.051).

Small mammals and fruits were the major diet of viverrids. They were found in the diet throughout the year. The frequency and proportion of scats with fruits were highest in rainy season and lowest in winter (Fig. 6, Fig. 7), which corresponded with ripe fruit abundance. Ripe fruits were highest diversity and abundance in rainy season in tropical forest in Thailand (Rabinowitz, 1991; Kitamura *et al*., 2002). It can be concluded that seasonal differences in the ripe fruits probably reflect variations in the abundance of mammalian preys (see Appendix B for detailed description of abundance of small mammals among season at SERS). Viverrids were consumed more mammals in winter, when the ripe fruits were decreased.

Viverrids were consumed arthropods, herpetofaunas, and bird occasionally. For example, arthropods, and herpetofaunas in the scats were often found in rainy season (Fig. 6), which corresponded with the abundance of these animals. Arthropods were highest abundance in rainy season in Thailand (Wiwatwitaya and Takeda, 2005).

Similarly, herpetofaunas were highest abundance in rainy season in Thailand (Sretarugsa *et al*., 2001).

These data show the seasonal diet of viverrids. The diets of vivrrids were variable among seasons, but viverrids were not switched the major food in this study (Fig. 6, Fig. 7). The results differ from those of Zhou *et al*. (2008.) who found that dietary switched of masked palm civets in Central China. They change the major food from small mammals to fruits in fruiting season and change back in the end fruiting season. Viverrids were not switched the food in this study because the ripe fruits were available throughout the year in tropical forests in Thailand (Rabinowitz, 1991; Kitamura *et al*., 2002) (see Appendix B for detailed description of fruiting season at SERS).

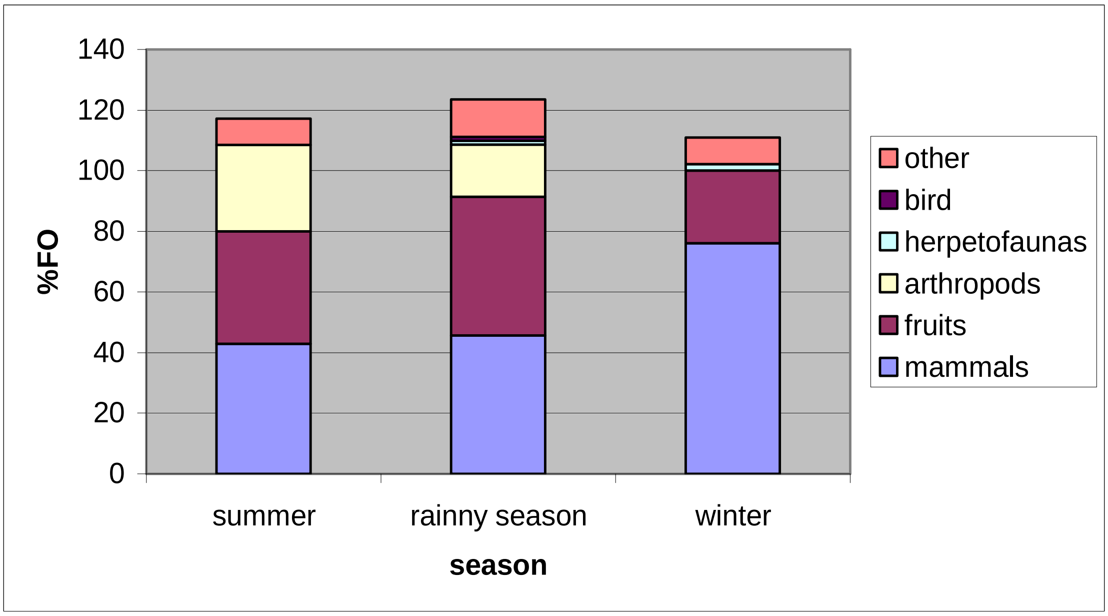


**Figure 6** Seasonal diet in frequency of occurrence (%FO) of viverrids at SERS, 2008.

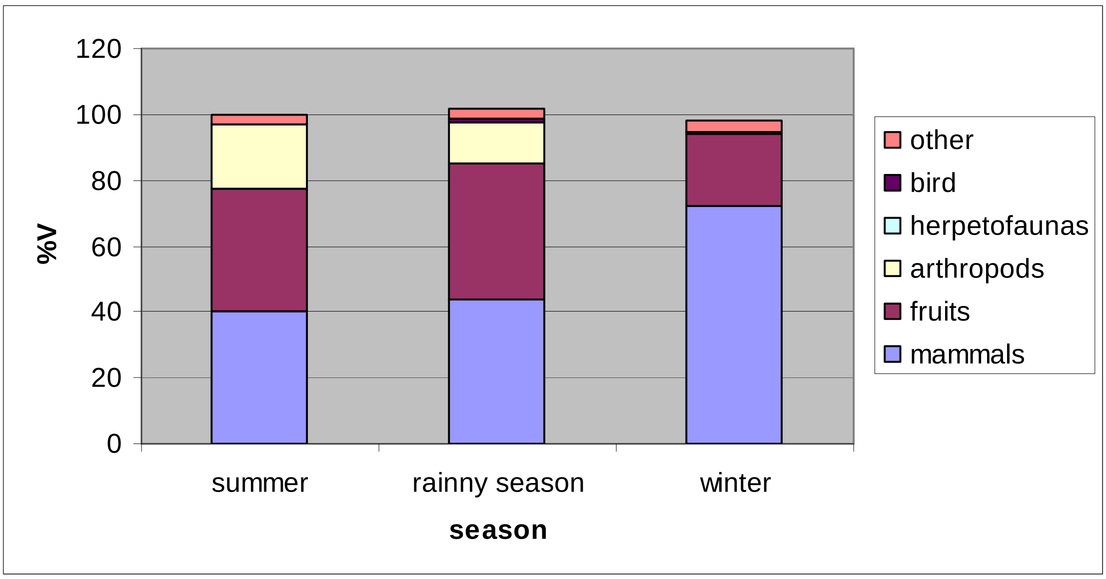


**Figure 7** Seasonal diet in volume of food items (%V) of viverrids at SERS, 2008.

## 4.5 Dietary niche of viverrids

Viverrids exhibited the widest dietary niche breadth in rainy season ($B_A$ = 0.169) followed by summer ($B_A$ = 0.148). The narrowest dietary niche breadth was showed in winter ($B_A$ = 0.090). Overall dietary niche breadth of viverrids was 0.412. Viverrids had the narrow dietary niche breadth throughout the year, especially in winter, when the ripe fruits were decreased.

Although viverrids exhibited the narrow dietary niche breadth, but the diversity index of prey was high in this study (Table 4). These data indicate that viverrids can select the favorite foods throughout the year, while the large number of food items available in this area.

Dietary niche of viverrids were high overlap among seasons (Table 5). This is probably because similar food items were consumed throughout the year. These data confirm the high species richness and diversity of viverrid's diet at SERS.

**Table 4** Shannon-Wiener diversity index ($H'$) and niche breadth ($B_A$) among seasons of viverrids at SERS, 2008.

| Season | Shannon-Wiener index ($H'$) | Food niche breadth ($B_A$) |
|---|---|---|
| Summer | 1.844 | 0.148 |
| Rainy season | 2.017 | 0.169 |
| Winter | 1.100 | 0.090 |
| Overall | 2.294 | 0.412 |

**Table 5** Pianka's index calculated for food niche overlap among seasons of viverrids at SERS, 2008.

| Season | Summer x Rain | Summer x Winter | Rain x Winter |
|---|---|---|---|
| Pianka's index | 0.781 | 0.899 | 0.803 |

# CHAPTER V

# CONCLUSION

This study confirms the generalist feeding behavior of viverrids. They regard as omnivores and consume variety of food items. The diets of viverrids varied among seasons, depended on abundance and availability of food items. Viverrids were not switched the major food among seasons because the major food were available throughout the year. Small mammals and fruits were the major foods of viverrids in this study, especially yellow rajah rat (*Maxomys surifer*).

Viverrids exhibited the narrow food niche breadth, but high diversity of prey species in this study. Indicate that viverrids can select the favorite foods, while the large number of food items available in this area. Dietary overlap was high among seasons because viverrids consume the similar food items throughout the year. Moreover, the data from diet of viverrids in this study indicate the high species richness, abundance, and diversity of organisms at SERS.

The viverrids at SERS showed the use of habitat in dry evergreen forest, random use in dry dipterocarp forest, and avoidance in plantation forest and bamboo forest, probably because the better cover of dry evergreen forest was useful for den sites and favored foraging areas (Mudappa, 2006). Uniformly distributed populations occurred with viverrids in this study. This distribution pattern was similar with other carnivore such as bear, coyotes, and hawks (Wessells and Hopson, 1998).

This study was emphasized on the survey method for viverrids. The other methods such as intensive capture program, camera trapping, radio transmitter or molecular methods, which help to improve the knowledge about these carnivores are needed. Moreover, the study on the other carnivores, which share the niche with these carnivores is needed.

This study provides important data on habitat use and seasonal dietary of viverrids which can be used in wildlife conservation and management of wild carnivore in Thailand.

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# APPENDICES

# APPENDIX A

# CLIMATIC DATA

**Table A** Monthly climatic data at the SERS, 2008 (http://www.tistr.or.th/sakaerat/Meteorlogical/Mont/2008-mont.htm).

| Month | Temperature (°C) | | | Humidity (%) | Precipitation (mm) |
|---|---|---|---|---|---|
| | Max. | Min. | Mean | | |
| January | 29.7 | 16.1 | 22.9 | 84.0 | 5.1 |
| February | 29.3 | 16.9 | 23.1 | 89.0 | 27.4 |
| March | 34.4 | 20.7 | 27.6 | 88.0 | 29.4 |
| April | 35.4 | 23.0 | 29.2 | 89.0 | 123.0 |
| May | 31.2 | 23.2 | 27.2 | 92.0 | 160.3 |
| June | 31.5 | 23.5 | 27.5 | 90.0 | 112.4 |
| July | 31.4 | 24.9 | 28.2 | 90.0 | 46.3 |
| August | 30.7 | 24.3 | 27.5 | 91.0 | 126.0 |
| September | 29.1 | 24.1 | 26.6 | 94.0 | 270.5 |
| October | 28.0 | 23.9 | 26.0 | 96.0 | 190.1 |
| November | 25.5 | 19.6 | 22.6 | 92.0 | 35.5 |
| December | 24.9 | 15.5 | 20.2 | 89.0 | 5.9 |
| Mean | 30.1 | 21.3 | 25.7 | 90.0 | 94.3 |

# APPENDIX B

# THE DIET OF VIVERRIDS AND THE ABUNDANCE OF FRUITS AND SMALL MAMMALS

**Table B-1** Frequency of occurrence (FO) and volume of food items (%V) in the diet of viverrids among seasons at SERS, 2008.

| Prey class | Summer | | Rainy season | | Winter | |
|---|---|---|---|---|---|---|
| | %FO | %V | %FO | %V | %FO | %V |
| Small mammals | 42.86 | 40.06 | 45.68 | 43.91 | 76.09 | 72.33 |
| Arthropods | 28.57 | 20.00 | 17.28 | 12.49 | 0.00 | 0.00 |
| Herpetofaunas | 0.00 | 0.00 | 1.23 | 0.06 | 2.17 | 0.39 |
| Birds | 0.00 | 0.00 | 1.23 | 1.23 | 0.00 | 0.00 |
| Fruits | 37.14 | 37.14 | 45.68 | 41.10 | 23.91 | 21.78 |
| Other | 8.57 | 3.74 | 12.35 | 3.01 | 8.70 | 3.52 |

**Table B-2** Location and fruiting seasons of fruit in viverrid's diet at SERS, 2008 (http://www.tistr.or.th/sakaerat/Plant%20in%20Sakaerat/plant.htm).

| Fruit species | Locations | fruiting seasons |
|---|---|---|
| *Dialium cochinchinense* | DDF, DEF, PF | rainy season-winter |
| *Uvaria dac* | DEF | rainy season |
| *Diplocyclos palmatus* | DDF | winter |
| *Microcos tomentosa* | DDF, DEF, PF | rainy season-winter |
| *Memecylon ovatum* | DEF, PF | rainy season |
| *Willughbeia edulis* | DEF | rainy season |
| *Morinda coreia* | DDF | summer-rainy season |
| *Syzygium cumini* | DDF | rainy season |
| *Musa acuminata* | DEF, PF | year-round |
| *Antidesma acidum* | DDF | rainy season |

*DEF = dry evergreen forest, DDF = dry dipterocarp forest, PF = plantation forest.

**Table B-3** Number of different individuals and number of capture (% of total capture) obtained for nine small mammal species in different habitat types at SERS, Thailand (Pinmongkolgul, 2008).

| **Species** | **Forest type** | | | **Total number of individuals** |
|---|---|---|---|---|
| | **DDF** | **ECO** | **DEF** | |
| **Trap-night** | | 3528 | | |
| **MURIDAE** | | | | |
| 1) *Maxomys surifer* | 53 (14.29%) | 78 (21.02%) | 113 (30.46%) | 244 (65.77%) |
| 2) *Rattus rattus* | 28 (7.55%) | 8 (2.16%) | 6 (1.62%) | 42 (11.32%) |
| 3) *Leopoldamys sabanus* | - | 8 (2.16%) | 6 (1.62%) | 14 (3.77%) |
| 4) *Mus cervicolor* | - | - | 1 (0.27%) | 1 (0.27%) |
| **TUPAIDAE** | | | | |
| 5) *Tupaia glis* | 20 (5.39%) | 23 (6.20%) | 7 (1.89%) | 50 (13.48%) |
| **SCIURIDAE** | | | | |
| 6) *Callosciurus finlaysoni* | - | 8 (2.06%) | 1 (0.27%) | 9 (2.43%) |
| 7) *Callosciurus caniceps* | 1 (0.27%) | 2 (0.54%) | 4 (1.08%) | 7 (1.89%) |
| **HERPESTIDAE** | | | | |
| 8) *Herpestes javanicus* | 3 (0.81%) | - | - | 3 (0.81%) |
| **LEPORIDAE** | | | | |
| 9) *Lepus peguensis* | 1 (0.27%) | - | - | 1 (0.27%) |
| **Total numbers (% of total captured)** | 106 (28.57%) | 127 (34.23%) | 138 (37.20%) | 371 |
| **Total captures including recaptured** | | 877 | | |

*DEF = dry evergreen forest, DDF = dry dipterocarp forest, ECO = ecotone.

**Table B-4** Number of different individuals and numbers of capture (% of total capture) obtained for six small mammal species in dry dipterocarp forest in the each season at SERS, Thailand (Pinmongkolgul, 2008).

| Species | DDF | | | | % of total captures (371) |
|---|---|---|---|---|---|
| | Season | | | | |
| | Early rainy | Late rainy | Winter | Summer | |
| **MURIDAE** | | | | | |
| *Maxomys surifer* | 19 (5.12%) | 9 (2.43%) | 12 (3.23%) | 13 (3.50%) | 53 (14.29%) |
| *Rattus rattus* | 7 (1.89%) | 12 (3.23%) | 5 (1.35%) | 4 (1.08%) | 28 (7.55%) |
| **SCIURIDAE** | | | | | |
| *Callosciurus caniceps* | - | - | - | 1 (0.27%) | 1 (0.27%) |
| **TUPAIIDAE** | | | | | |
| *Tupaia glis* | 2 (0.54%) | 11 (2.96%) | 5 (1.35%) | 2 (0.54%) | 20 (5.39%) |
| **LEPORIDAE** | | | | | |
| *Lepus peguensis* | - | - | - | 1 (0.27%) | 1 (0.27%) |
| **HERPESTIDAE** | | | | | |
| *Herpestes javanicus* | 1 (0.27%) | - | 1 (0.27%) | 1(0.27%) | 3 (0.81%) |
| Total numbers of individuals (%of total captures) | 29 (7.82%) | 32 (8.63%) | 23 (6.20%) | 22 (5.93%) | 106 (28.57%) |

*DEF = dry evergreen forest, DDF = dry dipterocarp forest, ECO = ecotone.

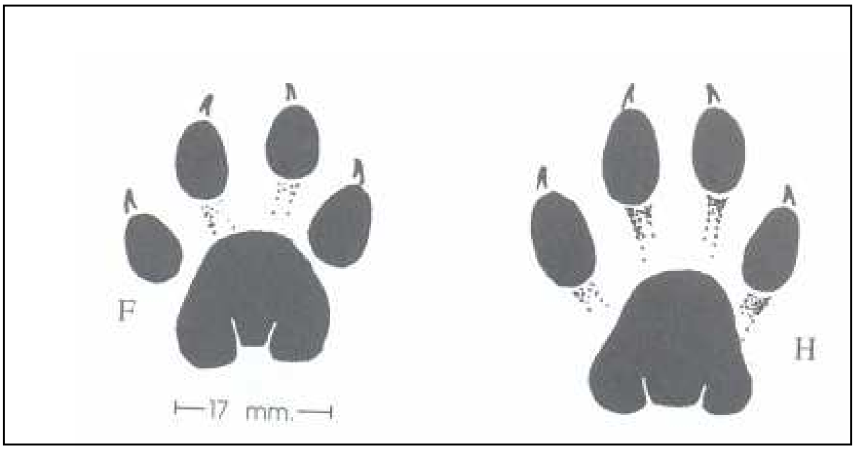
**Table B-5** Number of different individuals and numbers of capture (% of total capture) obtained for six small mammal species in dry evergreen forest in the each season at SERS, Thailand (Pinmongkolgul, 2008).

| Species | DEF | | | | % of total captures (371) |
|---|---|---|---|---|---|
| | Season | | | | |
| | Early rainy | Late rainy | Winter | Summer | |
| **MURIDAE** | | | | | |
| *Maxomys surifer* | 26 (7.01%) | 40 (10.78%) | 30 (8.09%) | 17 (4.58%) | 113 (30.46%) |
| *Rattus rattus* | 1 (0.27%) | 3 (0.81%) | 2 (0.54%) | - | 6 (1.62%) |
| *Leopoldamys sabanus* | 2 (0.54%) | 1 (0.27%) | - | 3 (0.81%) | 6 (1.62%) |
| *Mus cervicolor* | 1 (0.27) | - | - | - | 1 (0.27%) |
| **SCIURIDAE** | | | | | |
| *Callosciurus finlaysoni* | - | 1 (0.27%) | - | - | 1 (0.27%) |
| *Callosciurus caniceps* | 1 (0.27%) | - | 1 (0.27%) | 2 (0.54%) | 4 (1.08%) |
| **TUPAIIDAE** | | | | | |
| *Tupia glis* | 2 (0.54%) | 2 (0.54%) | 1 (0.27%) | 2 (0.54%) | 7 (1.89%) |
| Total numbers of individuals (%of total captures ) | 33 (8.89%) | 47 (12.67%) | 34 (9.16%) | 24 (6.47%) | 138 (37.20%) |

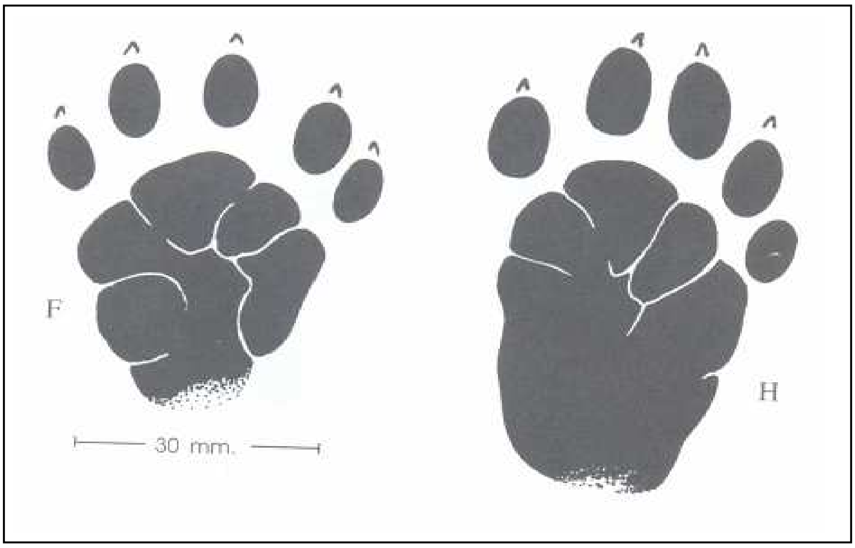
*DEF = dry evergreen forest, DDF = dry dipterocarp forest, ECO = ecotone.

## APPENDIX C

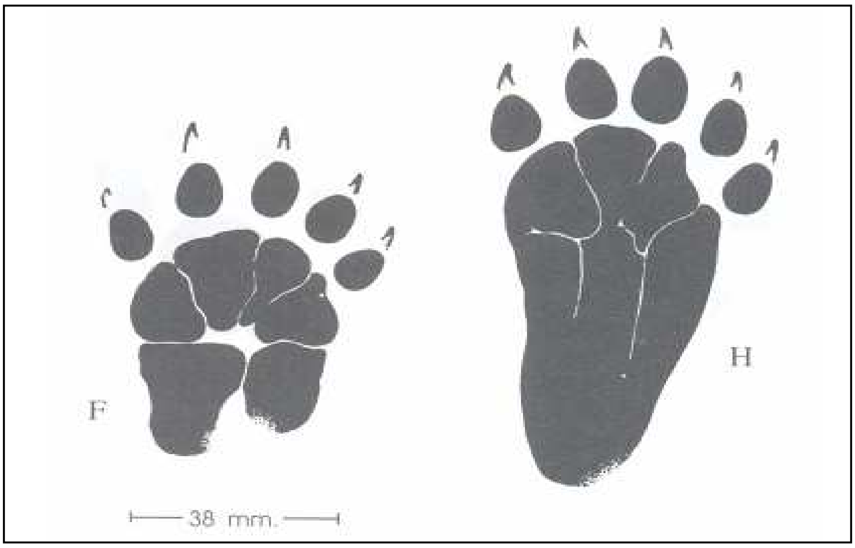
## THE KEY TO VIVERRID TRACKS



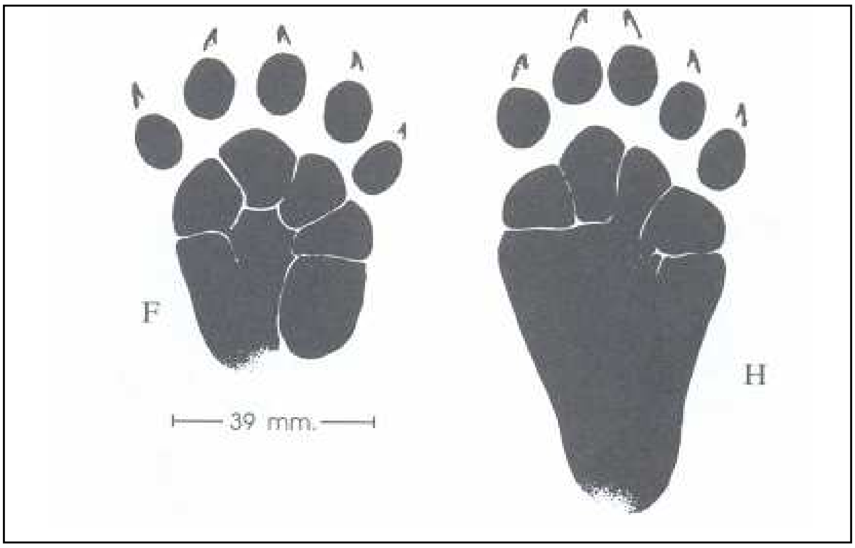

Small Indian civet (*Viverricula indica*)



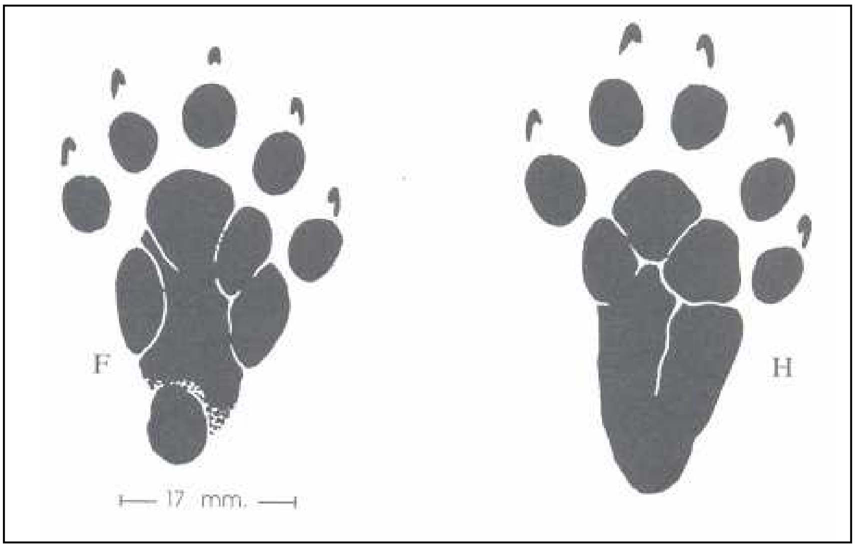

Common palm civet (*Paradoxurus hermaphroditus*)



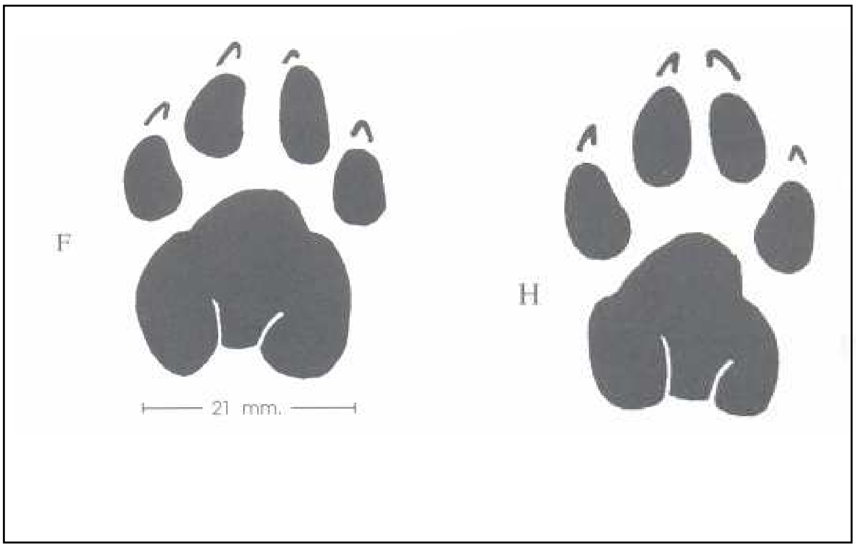

Masked palm civet (*Paguma larvata*)




Binturong (*Arctictis binturong*)




Otter civet (*Cynogale benetti*)




Large Indian civet (*Viverra zibetha*)

(Modified from Kanjanavanit, 2004)

# APPENDIX D

# PHOTOGRAPHS OF FIELD DATA COLLECTION

**Picture 1** Steel mesh cage for trapping viverrids in this study.

**Picture 2** Trap setting for capture viverrids in this study.

**Picture 3** Captured viverrid from line trapping in this study.

**Picture 4** Body measurement of viverrid after captured.

**Picture 5** Scat of viverrid in the study area.

**Picture 6** Track of viverrid in the study area.

# CURRICULUM VITAE

Mr. Sarawee Aroon was born on October 12, 1980 in Bangkok, Thailand. He finished high school from Satriwitthaya 2 School. He received his Bachelor Degree in Science (Animal Production Technology) form Suranaree University of Technology in 2003. After graduation, he has been worked in private company for 3 years. He has been interested more in the wildlife ecology. So, he has continued with his graduate studies in Environmental Biology Program, Institute of Science, Suranaree University of Technology since 2006.