THESIS APPROVAL

GRADUATE SCHOOL, KASETSART UNIVERSITY

Master of Science (Forest Biological Science)

DEGREE

Forest Biological Science — **FIELD**

Forest Biology — **DEPARTMENT**

TITLE: Home Range and Habitat Utilization of Kha Nyou (*Laonastes aenigmamus* Jenkins, Kilpatrick, Robinson & Timmins, 2005) in Phou Hin Poun National Biodiversity Conservation Area, Central Lao PDR

NAME: Mr. Thananh Khotpathoom

THIS THESIS HAS BEEN ACCEPTED BY

THESIS ADVISOR

(Associate Professor Naris Bhumpakphan, Ph.D.)

THESIS CO-ADVISOR

(Assistant Professor Ronglarp Sukmasuang Ph.D.)

THESIS CO-ADVISOR

(Assistant Professor Sara Bumrungsri, Ph.D.)

DEPARTMENT HEAD

(Assistant Professor Vijak Chimchome, Ph.D.)

APPROVED BY THE GRADUATE SCHOOL ON .....

DEAN

(Associate Professor Gunjana Theeragool, D.Agr.)

THESIS

HOME RANGE AND HABITAT UTILIZATION OF KHA NYOU (*Laonastes aenigmamus* Jenkins, Kilpatrick, Robinson & Timmins, 2005) IN PHOU HIN POUN NATIONAL BIODIVERSITY CONSERVATION AREA, CENTRAL LAO PDR

THANANH KHOTPATHOOM

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Science (Forest Biological Science)
Graduate School, Kasetsart University
2011

Thananh Khopathoom 2011: Home Range and Habitat Utilization of Kha Nyou (*Laonastes aenigmamus* Jenkins, Kilpatrick, Robinson & Timmins, 2005) in Phou Hin Poun National Biodiversity Conservation Area, Central Lao PDR. Master of Science (Forest Biological Science), Major Field: Forest Biological Science, Department of Forest Biology. Thesis Advisor: Associate Professor Naris Bhumpakphan, Ph.D. 100 pages.

The study on the home range and habitat utilization of the Lao endemic Kha nyou (*Laonastes aenigmamus*) was carried out from September, 2009 to January, 2011. Four Kha nyou were live-trapped, weighted, measured and equipped with radio collars to study their home range size and habitat use in different seasons. The average home ranges size were 1.69 ± 0.53 (n=4) and 1.49 ± 0.45 ha (n=3) for the dry season and the wet season respectively. No different was found (t=-0.54, df=5, p=0.61). Home range was high overlapped between all individuals in both the dry and the wet seasons. The home range overlapped ranged from 30.21 to 75.89% and 45.25 to 58.62% for the dry season and for the wet season respectively.

Average distance of daily movement among sexes: 2 males and 1 female in the dry season were respectively 1,687.88 ± 261.56 and 1,431.00 ± 105.42 m (t=2.41, df=10, p=0.03), while in the wet season were respectly 1,589.63 ± 183.36 and 1,528.33 ± 370.40 m (t=0.37, df=7, p=0.72). The habitats of Kha nyou were limestone boulder, sinkhole where appeared complex crevice system and covered above mainly with deciduous and evergreen trees. The proportions of habitat used were 75.84% LDF and 24.16% SEF for the dry season and 71.09% LDF and 28.91% SEF for the wet season. Kha nyou shared habitat with sympatric terrestrial rodents such as limestone rat *Saxatilomys paulinae* and long-tailed giant rat *Leopoldamys sabanus*. Kha nyou fed on a variety of plant species. The main threat to Kha nyou was from illegal hunting. The knowledge gained from this research is helpful for informing future conservation and management plans for the Kha nyou.

_____ _____ ____/____/____

Student's signature Thesis Advisor's signature

ACKNOWLEDGEMENTS

These research activities would not be possible without generous support from the Thailand International Development Cooperation Agency (TICA). I would like to express my sincere thanks to the Department of Forest Biology, Faculty of Forestry, Kasetsart University (Thailand) that not only provide facility for study, but also support some financial for field assistance and procurement of important field equipment for this research. Thanks are also extended to the Faculty of Forestry (FoF), National University of Laos (NUoL) for giving me the opportunity to study and provide me some of facilities on field study both smoothly formal official letter and field assistants.

I would like to express thanks and appreciation of all of my committee members, Assoc. Prof. Dr. Naris Bhumpakphan, Assist. Prof. Dr. Ronglarp Sukmasuang and Assist. Prof. Dr. Sara Bumrungsri for their brotherly encouragement, advice and invaluable suggestions.

Many people have assisted me during the realization of this research in the field and my sincere thanks are due to them all. Especially the officials of PHP NBCA unit, they assisted me on official document procuring. I also would like to thank all of my friends in Thakek who facilitated me on transportation and accommodation during this research was carrying out in the field. Two students from the FoF, NUoL are thanked for their active assisting and working for my data collection in the field. The friendship and support of local assistances at Mouang-doy village will always remain special to me. In addition, I particularly appreciate and thank my brother Mr. Thanonglit Khotpathoum for his assisted on field working. Finally, I am especially thankful to my wife, Bounmy Khotpathoom, my daughter Nathavanh Khotpathoom and also my son Khantivong Khotpathoom for the stimulation and encouragement which enabled me to complete this challenge study.

Thananh Khotpathoom

June 2011

TABLE OF CONTENTS

Page

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF FIGURES (Continued)

LIST OF ABBREVIATIONS

ANOVA	=	analysis of variance
CAM	=	composition analysis method
CITES	=	Convention on International Trade in Endangered Species of Wild Fauna and Flora
cm	=	centimeter
°C	=	Celsius
D	=	density
Do	=	dominance
DOF	=	Department of Forest
DS	=	dry season
EN	=	Endangered
F	=	frequency
FoF	=	Faculty of Forestry
g	=	gram
GPS	=	Global Positioning System
ha	=	hectare
IUCN	=	International Union for Conservation Nature
IVI	=	Important Value Index
K	=	Kha nyou
km	=	kilometer
Ko 1	=	the first of observant Kha nyou
Ko 2	=	the second observant Kha nyou
Lao PDR	=	Lao People' Democratic Republic
LDF	=	limestone dry forest
MAF	=	Ministry of Agricultural and Forestry
MANOVA	=	Multivariate analysis of variance
MCP	=	Minimum Convex Polygon
MDF	=	mixed deciduous forest
mm	=	millimeter
m	=	meter

LIST OF ABBREVIATIONS (Continued)

m asl	=	meter at sea level
NBCA	=	National Biodiversity Conservation Area
NUoL	=	National University of Laos
n	=	number
PAFO	=	Provincial Agricultural and Forest office
PHP	=	Phou Hin Poun
PHP NBCA	=	Phou Hin Poun National Biodiversity Conservation Area
RD	=	relative density
RDo	=	relative dominance
RF	=	relative frequency
SD	=	standard deviation
SEL	=	semi-evergreen forest
sq.m	=	square meter

HOME RANGE AND HABITAT UTILIZATION OF KHA NYOU (*Laonastes aenigmamus* Jenkins, Kilpatrick, Robinson & Timmins, 2005) IN PHOU HIN POUN NATIONAL BIODIVERSITY CONSERVATION AREA, CENTRAL LAO PDR

INTRODUCTION

The habitat implies the place where an organism lives that described by its geographic, physical, edaphic and biotic components. The structure and characteristic of the habitat, especial vegetations, which is a source of welfare factors, are important variable affecting animal diversity (Alan, 1993). Habitat is very significant for all animals. McComb (2008) defined that the habitat is the set of resource necessary to support a population over space and through time, whereas habitat use was defined as the way an animal use the physical and biological resource in a habitat (Hall *et al*., 1997). Within a habitat, the area traversed by the individual in its normal activities of food gathering, mating and caring for young is “home range” (Burt, 1943).

Relationship between wildlife and habitat or its interaction among them is very significant at an ecosystem level. Bolen and Robinson (1999) stated that wildlife is known as consumer in an ecosystem and it’s divided to herbivores, carnivores, and omnivores. The herbivores play an essential role in an ecosystem as plant consumers. Wildlife also plays a role in the nutrient cycling and energy flowing (Bhumpakphan, 2000). Energy from plants is transferred through a series of animal (Patton, 1992). Several species of plants in process of pollination and disposal is looked-for animal. Even the rodents, which known as major pest species of crop, but some of them play a significant role in pollination of crop and other plant species (Ken *et al*., 2003). Some wildlife is being as source of food for predators and all wildlife when dies, the minerals are returned back to the soil (Dasmann, 1964).

Kha nyou (*Laonastes aenigmamus*) is a rodent. This animal is now classified to Diatomyidae and its composition at an ecosystem is primarily vegetarian

(herbivory). It's a new small mammal species that accidental discovery in a local market of Thakhek district, Khammouane Province, Central Lao's People Democratic Republic (Lao PDR) by Robert Timmin in 1996 and then named in 2005 (Jenkins *et al.*, 2005). After discovery, Kha nyou was known as living fossil of Diatomyidae, while another member have been extinct more than 11 million years ago (Flynn, 2007). It distribution restricted to limestone karst with cover by both deciduous and evergreen trees. Kha nyou are distributed in 5 districts around Limestone Mountain, such as Thakhek, Mahaxay, Hinboun, Nhomalat and Bualapha (Vongsa, 2010). However, due to few researches have been conducted in recently year leaded to still lacks of information in both ecology and habitat use of this strange rodent.

Recently a few researches have been limited to taxonomy (Jenkins *et al*., 2005; Dawson *et al*., 2006; Huchon *et al*., 2007; Douangboupha *et al*., 2009; Hautier and Saksiri, 2009) and distribution and natural history (Vongsa, 2010). Furthermore, Kha nyou has been known as an endangered species (appendix I of Lao wildlife and aquatic red list) since 2008 (Department of Forestry [DOF], 2008) and an endangered species which belong to EN category of IUCN Red List (Aplin and Lunde, 2008). Thus, this research was carried out in order to enhance and fulfill information on its home range, daily movement and habitat use. In addition, it is expected that all knowledge and information gains from this research would provide helpful fundamental appreciation for future conservation and management planning of this new species and endemic species of Lao PDR.

OBJECTIVES

1. To determine the home range size and home range overlap of Kha nyou in the dry season and the wet season using radio tracking

2. To determine daily movement of Kha nyou in both the dry season and the wet season

3. To study habitat utiliztion of Kha nyou between the dry season and the wet season

LITERATURE REVIEW

1. Taxonomy

Kha nyou or Laotian rock rat (*Laonastes aenigmamus*) has just discovered in 1996 by Robert Timmin in Khammuoan Province, central Lao PDR. Nine years later, Jenkins *et al*. (2005) named Kha nyou as a new species which belong to new family Laonastidae. However, Dawson *et al.* (2006) re-evaluated the phylogenetic position of *Laonastes* based on comparing its morphology to fossil taxa and they indicated that *Laonastes* is actually sciurognathous and that it belongs to the described family Diatomyidae. Bhumpakphan (2006) also compared the skull of Kha nyou with fossil skull of *Diatomys shantungensis* and agreed that Kha nyou is not new family Laonastidae but should be belong to Diatomyidae. This view was supported by the result of multiple molecular analyses (Huchon *et al*., 2007).

Figure 1 An adult Kha nyou inside the crevice.

Currently, Diatomyidae contains 9 species of 5 genera including *Fallomus* (*Fallowmus rezae, F. ladakhensis, F. ginshurgi and F. guraishyi*), *Diatomys* (*Diatmys shantungensis and D. liensis*), *Willmus* (*Willmus maximus*), *Marymus* (*Marymus*

dalanae) and *Laonastes* (*Laonastes aenigmamus*) (Huchon *et al*., 2007). However, most of them are extinct except Kha nyou (Flynn, 2007). According to the above information, the taxonomy of this animal can be considered as following:

Kingdom: Animalia
Phylum: Chordata
Class: Mammalia
Order: Rodentia
Family: Diatomyidae
Genus: *Laonastes*
Species: *Laonastes aenigmamus*

2. Distribution

As mention previously, most of Diatomyidae was known only from fossil except Kha nyou. Most of these fossils just discovered in Asia such as Pakistan, India, Thailand, China and Japan (Dawson *et al*., 2006) (Figure 2). Kha nyou presumed to be found only in Limestone Mountain. According to recent report they were only found in Limestone Mountain in Khammouane province, central Lao PDR (Jenkins *et al*., 2005; Vongsa, 2010).

Distribution of Kha nhou was studied in 2009 throughout the country by Vongsa, (2010), he found that it distribute in Limestone Mountain. That study reported that Kha nyou appareled only in 5 districts of Khammouane province such as Thakhek, Mahaxay, Hinboun, Nhomalat and Bualapha (Figure 5), especially Phou Hin Poun National Biodiversity Conservation Area (PHP NBCA) formerly called Khammouane Limestone NBCA, while in two nearest limestone NBCA like Nam Kading NBCA next to the north and Hin Namno NBCA next to the east have no reported on apparent of them. In 1990s, a preliminary wildlife and habitat survey of Nam Kading NBCA (Walston and Vinton, 1998) and Hin Namno NBCA (Timmins and Khounbolin, 1996) also hasn't been reported concerning the apparent of this rodent.

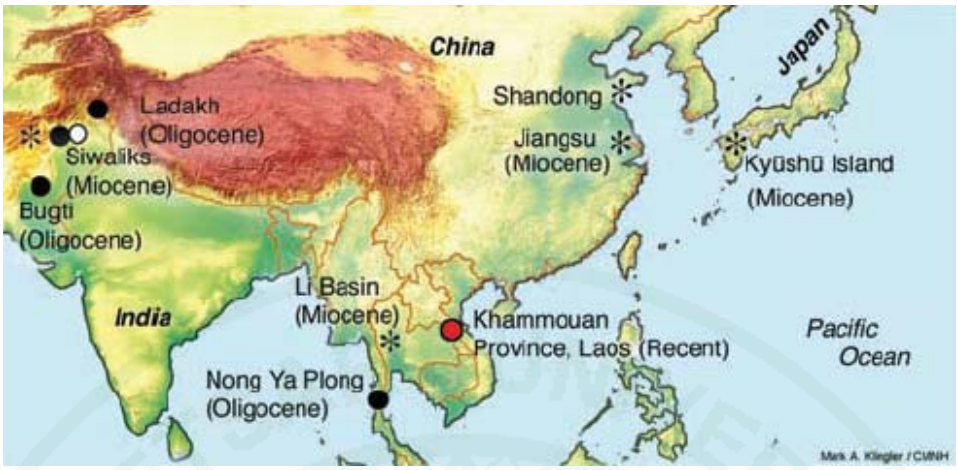


Figure 2 Geographical distribution of Diatomyidae based on information from fossil record (except *Laonastes*). Black cycles are *Fallomus*, asterisks are *Diatomys*, white cycle is *Willmus* and red cycle is *Laonastes*.

Source: Dawson *et al*. (2006)

3. Description

3.1 Body and coloration

Kha nyou is a rodent species that looks generally like rats; with thick, furred tails which similar to a squirrel. The head is large with very long whiskers. Their fur is dark slate grey, but for the tail is dark (Jenkins *et al*., 2005). Kha nyou is the small mammal. They are around 21-28 cm of head body length with 13-16 cm of tail and weigh around 330-455 g (Jenkins *et al*., 2005; Douangboupha *et al*., 2009; Vongsa, 2010) (Table 1).

3.2 skull

The skulls of Kha nyou have some distinctive morphological characters and were leaded to set it apart from other rodents. The combination of the skull with an enlarged infraorbital foramen, lower jaw lacking a coronoid process and having the

mandibular angle offset laterally, one premolar and three molars in each jaw, a transversely bilophodont pattern of the cheek teeth and four roots on the lower molar teeth (Jenkins *et al*., 2005).

Figure 3 The skull of Kha nyou from left to right: right lateral view of skull and mandible; dorsal view of skull; ventral view of skull; mandible on far right, ventral view above and dorsal view below.

Table 1 Weight and body sizes of Kha nyou in previous studies

Researcher	Sex	N	Weight (g)	Head Body (cm)	Tail (cm)	Hind Foot (cm)	Ear (cm)
Jenkins *et al.*, 2005	-	11	334-414	21.30-28.50	12.30-16.10	3.70-4.40	2.10-2.50
Douangboupha *et al*., 2009	-	55	365	24.70	13.70	-	-
Vongsa, 2010	Male	2	357	24.73	15.00	4.10	2.20
	Female	6	454	24.40	16.20	4.30	2.60

Note: (-) data not available

4. Ecology

4.1 Habitat

In Lao PDR, the specific research on habitat of species have only been limited to some important species such as Irrawady dolphins (*Orcaella brevirostris*) (Baird and Mounspupham, 1997), black crested gibbon (*Nomascus concolor*) (Johnson *et al*., 2005), tiger (*Panthera tigris*) (Lao Wildlife Conservation Society, 2005; Johnson *et al*., 2006) and langurs (*Trachypithecus* spp.) (Nadler, 2009). Howerver, several researches have been carried out on wildlife and habitat throutout Lao country, but almost concentrated on NBCA (Duckworth *et al*., 1993; Robichaud and Sounthala, 1995; Evans *et al*., 1996; Timmins and Khounboline, 1996; Timmins and Vongkhamheng, 1996a, 1996b; Timmins, 1997; Tizard *et al*., 1997; Steinmetz, 1998b; Showler *et al*., 1998; Walson and Vinton, 1998; Robinson and Webber, 2000; Fuchs *et al*., 2007; Timmins and Duckworth, 2008).

Kha nyou is the new species and lack of information on habitat. A few researches have been brief described on habitat of this animal (Jenkins *et al*., 2005; Vongsa, 2010). This animal was only restricted in Limestone Mountain area of Khammouane Province, central of Lao PDR, especially inside and surrounding the PHP NBCA.The habitats of PHP NBCA is consists of semi-evergreen forest, vine-bamboo forest, dry deciduous forest, mixed deciduous forest and wetlands (Steinmetz, 1998a, 1998b). In addition, Jenkins *et al*. (2005) reported that the limestone karst formations covered with both evergreen trees and deciduous trees with little ground vegetation were the places where Kha nyou was existed and captured.

4.2 Dietary

Kha nyou are presumed to be herbivorous. Vongsa (2010) reported that at least 25 species of plant are feed by Kha nyou such as *Caryota* sp1., *Caryota* sp2., *Costus speciosus*, *Rhapis* sp., *Anenga* sp., *Dendrobium* sp., *Liparis* sp., *Cereus* sp.,

Rhaphidophora peepla, Aglaonema simplex, Scindapsus annamucus, Ziziphus sp., *Streblus taxoides, Amorphophallus sp., Symplocos cochichinensis, Shorea hypochra, Pandanus* sp., *Didynocarpus* sp., *Elatostema* sp., *Sauropus* sp., *Dracaena elliptic, Pomentia pinnata, Dioscorea* sp., *Psycotria malayana* and *Paederia tometosa*.

Jenkins *et al*. (2005) reported that in the stomach contents consisted mainly of very fine particulate matter, mostly plant remains plus a few fragments of insect remains. Morphological features of the hypsodont molars, capacious stomach, large caecum and appendix combined with evidence of plant remains in the stomach, suggests that Kha nyou is primarily vegetarian in its diet.

5. Conservation status

Kha nyou is new to science and so little is known of the species ecology. They still not yet assess the species status under the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). However, Kha nyou were conserved by International Union for Conservation Nature (IUCN). They were an endangered species and belonged to Endangered (EN) category of IUCN Red List Verson 2010.2 (Aplin and Lunde, 2008).

Figure 4 The neck snare trap (died bamboo trap) called “Luong” in Lao. It’s a hand-made tool for rodent trapping of local people.

Recently years, Kha nyou were serious hunted for both subsistence and local trade leaded to rapid reducing of their population. Local hunter use native neck snare trap (Figure 4) maded from bamboo to trap this rodent. Vongsa (2010) reported that the main of threats are local hunter and the second are habitat loss by illegal logging. Lao government was realized in these situations by puting Kha nyou into appendix I of Lao Wildlife and Aquatic Red List since 2008 (DOF, 2008). In addition, the Lao government also puts Kha nyou as a provincial reserve species by setting up a special regulation at provincial level in order to stop poaching both for subsistence and local trade (Provincial Agriculture and Forest Office [PAFO], 2008).

6. Related research on home range, habitat use and movement

Recently years, the specific research of Lao wildlife and wildlife habitat not many. Duckworth *et al*. (1999) reported that those researches were limited to large mammal, birth or specific endangered species. As mentioned, Kha nyou also very a few researches have been done. Moreover, there have not been researched on home range, habitat use and movement by using radio tracking yet in Lao PDR. Thus, in this literature review were concentrated to another rodent or animal in foreign countries instead. The literature review was deliberated and concise described only the methodology and result of those researches.

6.1 Home range

The term of home range has been described as the area traversed by the individual in its normal activities of food gathering, mating and caring for young. Occasional sallies outside this area should not be considered as in part of the home range area (Burt, 1943) and home range need not cover the same area during the life-of the individual. Home range size of each animal is deferent up to the species because of its inherited behavior. Large animal almost use large home range than small one (Bhumpakphan, 2000). Home ranges are varies in size with their body mass of the species. Species with a larger body mass need more energy to support that mass. Herbivores tend to have smaller home ranges than those carnivores of the same

size, because energy available to herbivores is more abundant, and with each increase in trophic level there is a decrease in energy availability (McComb, 2008).

Home range study has been conducted for long time. Several studies on home ranges were carried out by using radio telemetry (Murphy and Dowding, 1995; Wolfe and hayden, 1996; Jennifer, 1997; Clint *et al*., 2001; Charles and Christopher, 2002; Bertolino *et al*., 2003; Taulman and Smith, 2004; Moraes Junior and Chiarello, 2005; Jennifer, 2005; Devillard *et al*., 2007; Simcharoen, 2008) and using Minimum Convex Polygon (MCP) (Mizutani and Jewell, 1998) of estimation method. MCP method is completely enclosing all data points by connecting the outer locations in such a way as to create a convex polygon. Jennifer (1997) and Osborn (2004) reported that this method was a simple procedure and was used widely in different animals.

There are some researches on home range of rodent were studied by using radio-tracking. Beck-King *et al*. (1999) carried out to study on home range and population of rodent (*Agouti paca*) in Costa Rica. Ribble *et al*. (2002) conducted to study on home range of rodent (*Peromyscus*) during the summer of 1993 through 1998 in northern New Mexico. During 2001-2002, Bertolino *et al*. (2003) studied on home range and habitat use of garden dormouse (*Eliomys quercinus*) in Italy. In Kuantan Pahang, Malaysia during April to June 2008, Mariana *et al*. (2010) carried out to study on home range of common tree shrew (*Tupaia glis*). In addition, home range and habitat use of rodent also was studies by using marked recapture method (Hill and Grossman, 1987; Soontornpitakkool, 1996; Radic *et al*., 2006; Nakagawa *et al*., 2007). This method is lower cost and easy to practise than radio telemetry method.

6.2 Habitat use and selection

Dasmann (1964) states that habitat is very significant for wildlife. To manage wildlife we must first manage habitat. The term of habitat use was defined as the way an animal use the physical and biological source in a habitat (Hall *et al*., 1997), whereas habitat selection is the set of complex behaviors that a species has developed among individuals in a population to ensure fitness (McComb, 2008). In all

habitats can support a limit number of animal and that limitation were known as the carrying capacity of habitat (Dasmann, 1964; Bhumpakphan, 2000). Recently, several researches were carried out to study on habitat use and habitat selection by radio tracking (Jone and Morton, 1992; Sukmasuang, 2001; Graham, 2001; Borkowski and Pudelko, 2007; Bocca *et al*., 2007; Buenestado *et al*., 2008; Simcharoen *et al*., 2008; Sager-Fradkin *et al*., 2008).

For the statistical analysis, the Composition Analysis Method (CAM) was used widely and was helpful in term of habitat utilization. For instance, Graham (2001) conducted to study habitat selection on keel-billed toucan (*Ramphastos salfuratus*) in southeasternVeracruz, Mexico (1998) and CAM was used to compare habitat use among individuals. Borkowski and Pudelko (2007) conducted to study on habitat use of deer (*Dama dama*) in southern Poland and used CAM for data analysis and used multivariate analysis of variance (MANOVA) to analyze the influence of a season and part of a day on habitat selection. Simcharoen *et al*. (2008) also carried out to study on habitat selection of the leopards (*Panthera pardus*) in Huai Kha Khaeng Wildlife Sanctuary, Thailand and used CAM to determine habitat selection.

In recent years, habitat use and selection of rodent was also conducted to study by using radio tracking (Tattersall *et al*., 2001; Bertolino *et al*., 2003; Cox *et al*., 2000). Some researches were carried out using maked recapture method (Lemen and Freeman, 1986; Soontornpitakkool, 1996; Lambert and Adler, 2000; Harper *et al*., 2005; Bias and Morrison, 2006; Prevedello *et al*., 2010; Traba *et al*., 2010). The trap station was set on different types of habitat. The animals were captured; recorded, marked, and then released them to the wild at the place of capture.

6.3 Movement and activity

Wildlife movement study by radio tracking has been done for 6 decades. Wendell (1967) stated that this method was stated in 1950s and then widely used in 1960s (Tester *et al*., 1964; Mech *et al.*, 1966; Balding, 1967). Radio-telemetry was accepted as an essential tool in modern studied of movement, migrant and disposal of

most vertebrate (Garton *et al*., 2001). Since 1990s, several studies were studied on movement or activity using radio-telemetry (Grigg *et al*., 1995; Alterio and Morller, 1997; Ibrahim, 2002; Rowe, 2003; Moraes Junior, 2004; McCarthy *et al*., 2005; Whisson *et al*., 2007; Graham *et al*., 2009; McLoughlin *et al*., 2010).

Alterio and Morller (1997) conducted to study on daily activity of stoats (*Mustela erminea*) and feral house cats (*Felis catus*) by using radio-tracking. Animal was scored as active when radio-transmitter produced highly erratic signals and was scored as inactive when the signals were constant. The variation in the signal will occur when collared animal moving or shifting (Valenzuela and Ceballos, 2000; Moraes Junior, 2004). This technique was also used to estimate the activity pattern of leopards (*Panthera pardus*) in Royal Bardia National Park, Nepal (Odden and Wegge, 2010).

A few researches were studied on movement of rodent using radio collar. For instance, in Southern Arizona, Gottesman *et al*. (2004) carried out to research on movement and home range of brush mice (*Peromyscus boylii*). They used t-tests method to quantify differences in movement between sexes, whereas, in different season they used analysis of variance (ANOVA). In northern Borneo, Malaysia, Welle *et al*. (2008) also conducted research on movement and range patterns of tropical rat (*Leopoldamys sabanus*) and used a Student's t-test to test for diference between forest types and sexes.

Cutrera *et al*. (2006) conducted to study on activity patterns of South American subterranean rodent (*Ctenomys talarum*) in Atlantic Coast of Buenos Aires Province, Argentina in 2005. For the statistical on rhythmic patterns of activity, they used autocorrelation analysis method. In San Juan Province, Argentina 2006, Ebensperger *et al*. (2008) also studied on activity and range area of viscacha rats (*Octomys mimax*). They compared the rate of day and night activity between male and female by using separate Wilcoxon-matched pairs tests.

7. Study site

The largest areas of limestone in Lao PDR are in Kammouane Province. There are two limestone areas were established to be NBCA such as PHP NBCA in the West and Hin Namno NBCA in the East (Figure 5). PHP NBCA was chosen for study area and Mouang-doy village, Thakhek district was target study site. This target village is known to be the first study area of Kha nyou (Jenkins *et al*., 2005) located approximately 21 km from Thakhack to the north (Figure 5 and Figure 6). This area is accessible by unpaved road in both the dry season and the wet season. Public transportation is not routine, but Took-took or Mini buss service always available for visitors.

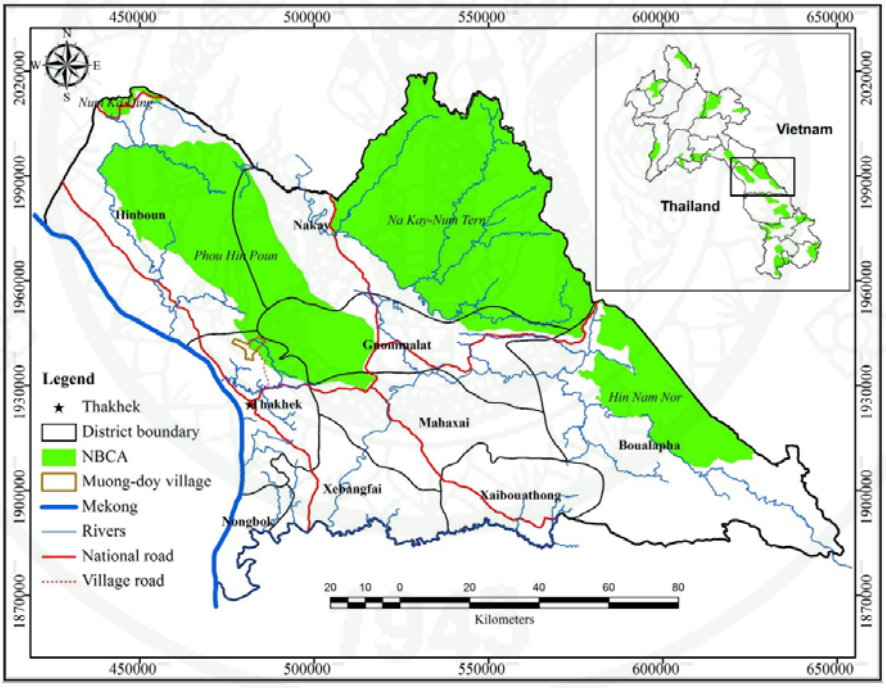


Figure 5 Map of NBCA and study site Mouang-doy village, Thakhek district.

7.1 Geography

Phou Hin Poun NBCA is located in central Lao PDR, Khammouane Province far from Vientiane around 330 km to the south. It lies between 17°26' and

18°05' north latitude; and between 104°25' and 105°10' east longitude. The whole area covers 1,620 km^2 of limestone karst with sparsely-vegetated karst and pockets of tall forest in depressions in the rock (Timmins, 1997).

The topography in PHP NBCA is a limestone karst type and extends from 180 to 1500 m above sea level. There are contiguous karsts in the area and separated from each other by settled and cultivated lowland with only intermittent karst outcrops. There are 4 main river systems in the PHP NBCA. The biggest river is Nam Hin Boun which flows from the north to the west, while the other smaller rivers such as Nam Pakan, Nam Don and Nam Pa Den flow from the south to the west (Southammakot and Iain, 2001). Due to this NBCA is quite large area, so it extended over 4 political districts such as Hin boun district to the north, Mahaxay to the south, Nhommalat to the east and Thakhek to the west (Figure 5).

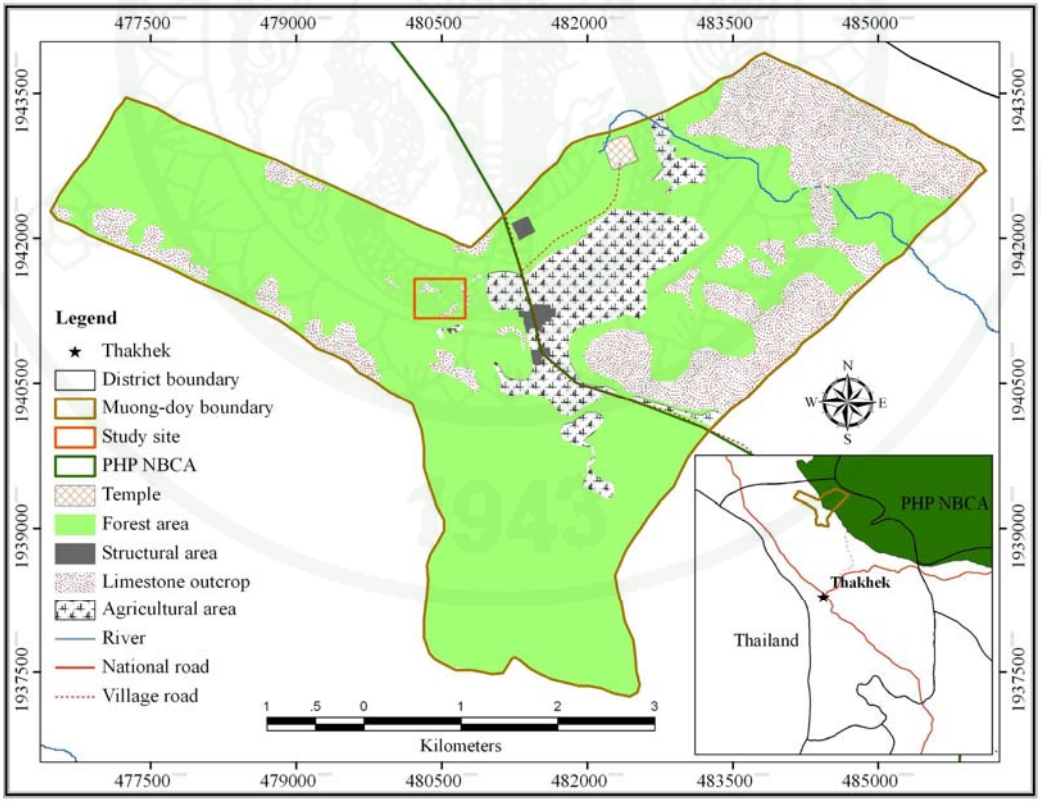


Figure 6 Map of Mouang-doy village and study site, Thakhek district.

7.2 Climate

The climate of PHP NBCA is tropical climate and dominated by the monsoons. This type of climate can be separated two different seasons, rainy season (the wet season) and the dry season. According to the climate statistic for ten years between 2000 and 2009 from Thakhek meteorological station (the nearest meteorological station of study area) found that the wet season is six months, begin from April to September and the dry season also six months, which start from October to March. The average annual rainfall of Thakhek district was 2,509.86 mm. The average monthly rainfall is highest in August (614.97 mm) and lowest in January and December (1.40 and 2.54 mm respectively).

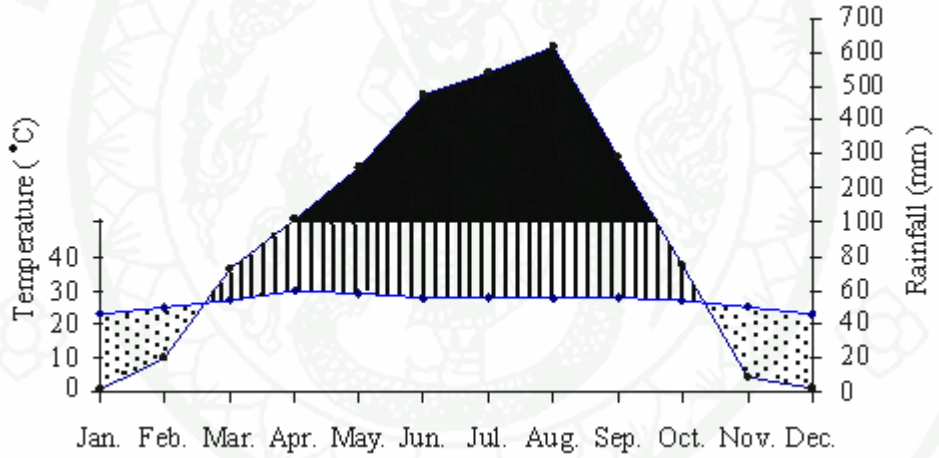


Figure 7 Monthly rainfall and temperature diagram in 10 years from 2000-2009.

Source: Thakhek Meteorological Station (2010)

The averages of air temperatures ranged from 22.58-29.50°c. The average of air temperature is highest in April (29.50°c) and lowest in January and December (22.58 and 23.10°c respectively). Whereas, the average monthly of relative humidity (2000-2009) ranged between 61.91-78.00% (Figure 8).The average is highest in July and August (76.80 and 78.00% respectively) and lowest in February and March (61.91 and 62.94% respectively).

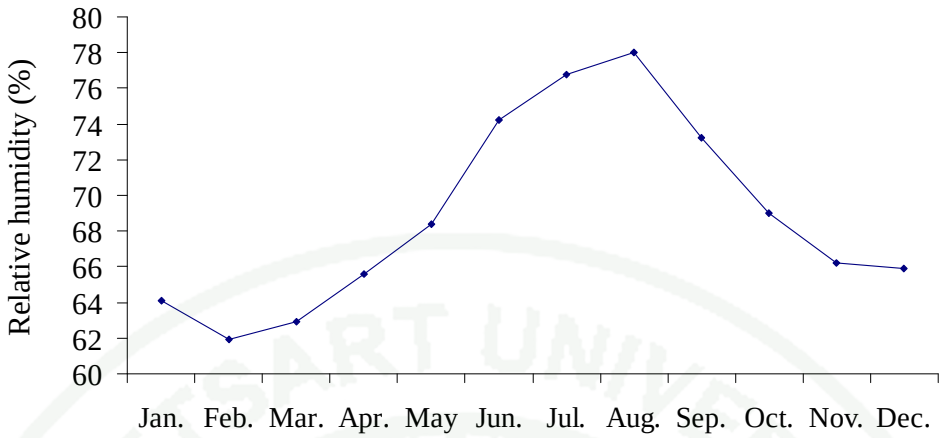


Figure 8 Average relative humidity in 10 years from 2000-2009.

Source: Thakhek Meteorological Station (2010)

7.3 Vegetation

Most of the PHP NBCA is steep limestone karst whose cliffs and slops support a sparse vegetation community in which cycads and a deciduous tree provisionally identified as *Sterculia* sp. are common. The prominent vegetation community consists of semi-evergreen forest (SEF), mixed deciduous forest (MDF) and dry forest (Steinmetz, 1998b).The vegetative covers within the PHP NBCA are SEF (31.10%) covers from middle to top of the karst, which has more soil cover and deeper soil, MDF (14.90%) covers on the slopes leading into the central forest area (at about 300 m asl), other (dry forest and cultivation area (2.30%) and the rest of this NBCA covered by rock (51.70%) (Steinmetz, 1998a; Southammakot and Iain, 2001).

7.4 Wildlife

Wildlife and habitats of PHP NBCA have been preliminary conducted to survey. However, those researches were limited to large mammal important birds (Steinmetz, 1998a, 1998b). Large important mammal is Asian elephant (*Elephas maximus*), gaur (*Bos gaurus*), sambar (*Cervus unicolor*), giant muntjac (*Megamuntiacus vuquangensis*), Asiatic black bear (*Ursus thibetanus*), Malayan sun

bear (*Ursus malayanus*), tiger (*Panthera tigris*) and eeopard (*Panthera pardus*). Whereas, some important bird are red-collared woodpecker (*Picus ranieri*), wreathed hornbill (*Aceros undulatus*), barn owl (*Tyto alba*), green pea-fowl (*Pavo munticus*) and gray peacock pheasant (*Polyplectron bicalcaratum*) (Steinmetz, 1998a; Southammakot and Iain 2001). Two species of bird are restricted to limestone area such as sooty babbler (*Stachyris herberti*) and wren babbler (*Gypsophila crispifrons*) (Duckworth *et al*., 1998). In addition, there are 41 species of bat have been recorded in this NBCA (Robinson and Webber, 2000), while the another wildlife, Southammakot and Iain (2001) reported that there are 81 species of reptiles, 47 species of amphibians and more than 145 species of fresh water fish.

Robichaud *et al*. (2001) reported that rodent in Lao PDR just started to sporadic study commence 1994. There are 37 species of rodent have been recorded (Francis, 1999). Inside this, there are 13 species of murid rodent were recorded in PHP NBCA such as *Mus cookie, M. cervicolor, M. caroli, M. Shortridgei, Rattus rattus, R. losea, R. argentiventer, R. nitidus, Bandicota india, Chiropodomys gliroides, Chiromyscus chiropus, leopoldamys sabanus* and *Berylmys berdmorei* (Smith *et al*., 2004) and there are 5 species of diurnal squirrels (*Ratufa bicolor, Callosciurus erythraeus, C. finlaysonii, Tamiops mcclellandii* and *Dremomys rufigenis*) (Timmins and Duckworth, 2008).

In addition to rodents, Orlov *et al*. (2009a) reported that there area at least 4 species of rat (*Laonastes aenigmamus, Leopoldamys sabanus, Rattus* cf. *argentiventer* and *Saxatilomys paulinae*), 2 species of mice (*Mus* cf. *musculus* and *Chiropodomys gliroides*) and 2 species of insectivores (*Crocidura* sp. and *Tupaia belangeri*). Two of them are new species such as *Laonastes aenigmamus* (Jankins *et al*., 2005) and *Saxatilomys paulinae* (Musser *et al*., 2005). The large rodents were recorded in Lao PDR, such as black giant squirrel (*Ratufa bicolor*), red-cheeked flying squirrel (*Hylopetes spadiseus*), hairy-footed flying squirrel (*Hylopetes spodiceus*) and Phayre's flying squirrel (*Hylopetes phyrei*) and marayan himalayan porcupine (*Hystrix brachyura*) (Southammakot and Iain, 2001) were recorded in PHP NBCA.

MATERIALS AND METHODS

Materials

- Topographic maps of study area, 1:100,000 scales
- Sets of radio tracking materials including transmitters, receiver, telex headphone and handheld two-elements Yagi antenna
- Radio collars
- Time watching sets
- Liquid-filled precision handheld compass
- Handheld GPS receiver
- Waterproof making pens
- Tape (Diameter tape, 23 and 50 – meter tapes)
- Binoculars
- Camera
- Single door live traps
- Cloth bags
- Torch
- Cutters
- Scissors
- Weight balance (1 kg)
- Tent
- Sleeping back
- Computer and necessary software

Methods

The study on habitat use, home range and daily movement by radio tracking of Kha nyou in PHP NBCA for this during period of times were very significant, for the reason that deficient in this information. Hence, the research was mainly focused on field data collection, while literature review was less.

1. Data collection

1.1 Capture procedure and radio collar equipment

Kha nyou were captured using single door live trap 30x10x10 cm baited with uncooked glutinous rice (Figure 9) or some time used mixed baits (rice with husked or rice with fired nuts of *Irvingia malayana*). The traps were set at night among boulders inside the crevice (Figure 10) throughout study area with approximately 250 trap-nights during three study periods. The first period started in July 2009, the second was between December 2009 and January 2010 and the last was between December 2010 and January 2011. All traps were inspected each day in the morning and put the bait for next day.

Figure 9 Single door live traps and a trap with uncooked glutinous rice as bait.

Seven Kha nyou (4 males and 3 females) and fifteen other rodents (Appendix table 4 and Appendix table 5 respectively) were captured during these study periods. Captured Kha nyou were weighted, sexed and measured (head body length, tail length, hind foot length and ears length) before insure proper fitting of the radio collar. The age class was determined using scrotal sac and mamae technique, while gender using genital papilla technique (Aplin *et al*., 2003). To avoid the stress, the handing and collaring time was limited in a minimum (Douglass *et al*., 2006).

The radio collars weighed 11g (Holohil Systems Ltd., Ontario, Canada) with a battery life of 12 months were chosen for this study. Especially, those radio

collars were specific designed for this animal. The suitable radio collars for animal would not over 5% of the adult body weight to avoid a disturbance of its natural behavior (Zwicker, 1989; Moraes Junior and Chiarello, 2005). The collared animal will be risked and increased normality while carrying a heavy radio collar due to reduced vigilance and impedance while moving (Pouliquen *et al.*, 1990; Haughland *et al*., 2008). The radio collars should as small as possible for small mammal (Withey *et al*., 2001). In this study, five Kha nyou was fitted with radio collars (Table 2) and all of them carried radio collar weighed <4% of their body weight. Radio-collared Kha nyou was released at the area of capture. After releasing, all traps surrounding study areas were closed in order to avoid influencing behavior and movement of individuals being monitored (Moraes Junior and Chiarello, 2005).

Table 2 Radio frequencies, body weight, fixed location and date of captured and radio collars fitted

Collared Kha nyou	Age class	Sex	Collar Frequency (MHz)	Weight (g)	Date of Capture and Radio Fitting	Date of Last Location	Fixed Location	
							DS	WS
K 61	Adult	Male	142.61	374	12.12.2009	26.06.2010	460	233
K 55	Adult	Male	142.55	360	01.01.2010	08.08.2010	418	511
K 65	Adult	Female	142.65	505	04.01.2010	08.08.2010	373	527
K 39	Adult	Female	142.39	290	03.01.2011	05.01.2011	14	-
K 47	Adult	Male	142.47	355	02.01.2011	09.01.2011	109	-

Note: DS = dry season, WS = wet season and (-) = data not available

1.2 Radio tracking and data record

Collared Kha nyou were tracked using 142/146 MHz receivers with a handheld two-element Yagi antenna (Telonics, Inc, USA) and a handheld compass from at least two receiver stations. During study period six receiver stations were established in study site. Kenward (2001) stated that radio wave was reflected quite

strongly by cliffs, hillsides, woods, trees and rocks. Thus, the receiver stations were set on highest point in order to avoid these reflections.

Figure 10 A characteristic of crevices (limestone cavity) where live-trapped K 65.

In this study, two main receiver stations were chosen on middle of mountain (limestone mountain) in stead of the top because on the top mostly was rocky tower. Four additional receiver stations were established on the highest or the top of mountain and used them when undetected signal from the main receiver stations. The location and spatial coordinates of receiver stations were defined using a Global Positioning System (GPS) and the GPSMAP 60CSx (Garmin Ltd. USA) was used. Triangulation technique was used to determine the fixed locations of collared animal (for the first three collared Kha nyou, Table 2), which has been used widely in previous researches (Sukmasuang, 2001; Koen, 2005; Borkowski and Pudelko, 2007; Eiris and Barreto, 2009).

The triangulation technique will give some errors in animal location estimation, therefore, in this study the radio telemetry errors were tested by placing radio collars in a variety of habitats condition (cliff, boulder, and stand) of study area (Garton *et al*., 2001) and then calculated the different among real location and

estimation location from trangulation technique. The result of test showed the average of telemetry errors were 21.24±9.87 (n=25) and 35.54±12.93 m (n=13) for the staying and moving subject respectively.

First three radio-collared Kha nyou were K 61, K 55 and K 65 (Table 2). Most of them were tracked at least 8 consecutive months from December 2009 to August 2010 (excape K 61 due to it missed with no clue during June to July 2010). Radio tracking (Radio telemetry) was mostly detected from receiver stations. The radio tracking error was minimized using homing in technique (Withey *et al*., 2001). Sankar *et al*. (2010) applied this technique in monitoring of reintroduced tigers in Sariska Tiger Reverve, India. Coleman and Downs (2010) also used this technique to study home range of black-tailed tree rat (*Thallomys nigricauad*) in Weenen Game Reserve, South Africa. However, in this research all first radio-collared Kha nyou were some time carried out this technique in order to minimize disturbance. They were tracked every hour per day with 30 Minutes for time interval.

Radio-collared animals were tracked at least 5 consecutive days per month for home range estimation. The longest tracking was carried out in January 2010 (11 consecutive days) and between July and August 2010 (8 consecutive days) for estimation of cumulative home range area. Distance of daily movement estimation was tracked only first three collared Kha nyou (K 61, K 55 and K 65) at least two consecutive days (24 hours) with 30 Minutes for time interval (n=4 days for the dry season and n=6 days for the wet season).

Last two radio-collared Kha nyou, K 47 and K 39 were live-trapped and fitted with radio collar at the end of research period (Table 2). Homing in technique was used for their home range estimation. The fixed locations ware defined using GPS.Only K 47 was homed in and got reach asymptote of cumulative home range size after seven days tracking, while K 39 was not because it dead after two days releasing (the cable tail of radio collar stuck into its skin neck and cut led to serious injury and dead) led to only 14 locations had been recorded.

1.3 Additional activity study

In this study, two live-trapped Kha nyou (1 male and 1 female) were caught into semi-natural habitat bar (5x5 m) fenced with nylon net in study site (Figure 11). A male (Ko 1) was caught and observed in 30th December 2010, whereas a female (Ko 2) was carried out in 3rd January 2011. Ko 1 has a short time observed (approximately 20 cumulative minutes) before it escaped, but Ko 2 has at least 2 cumulative hours before it escaped. The information from this observation was only qualitative data due to a short time and limit of sample size. However, the aim of this method was focused to discovery a sign of diurnal and nocturnal.

Figure 11 An adult female Kha nyou (Ko 2) was relaxing after long minutes eating inside nylon bar (semi-natural habitat bar).

1.4 Vegetation sampling

Vegetation studies in this study were focused on physiognomy and general structure, especially dominant life forms and dominant species. Vegetation

communities (LDF and SEF) within home range size of collared Kha nyou in different elevation were sampled with the quadrats sampling plots. Mueller-Dombois and Ellenberg (1974) affirmed that quadrat sampling plots are standard procedure for vegetation studies and in each different layer were used with different sizes of plot sampling. In this study, all trees over 3 m height were measured for its diameter and total height in the 10x10 m plots, while all tree undergrowth smaller than 3 m height were measured in the 4x4 m plots and seedling or herb were counted in the 1x1 m plots (Mueller-Dombois and Ellenberg, 1974).

1.5 Habitat and cover or shelter study

The term cover described in different senses. One there is cover essential for the survival of an animal in an area in the absence of its natural enemies and another one cover needed if the animal is to escape its predators (Dasmann, 1964). In addition to cover, Bolen and Robinson (1999) defined as cover prevents the wastage of energy by protecting animals from adverse weather (shelter) or from predators and other enemies (concealment). Habitat and cover study were mainly used observing method. The boulders and crevices where used to capture Kha nyou in both inside and outside study area were noted and described. The boulders and crevices where could not captured also were observed and noted for comparison. In addition, local hunter interview was conducted. Visiting capture locations of local people was also carried out both inside and outside study area.

1.6 Wildlife and threat factor study

Wildlife inside and surrounding of study area was preliminary surveyed using field survey combined with local people interview. These techniques were used widely in a preliminary wildlife and wildlife habitat survey in the proposed protected area (Duckworth *et al*., 1993; Tizard, 1996) and NBCA in Lao PDR (Evans *et al*., 1996; Timmins, 1997; Steinmetz, 1998b; Showler *et al*., 1998;). Wildlife was divided in to different interaction group with Kha nyou included predators, competitions and other group. The threats factors of Kha nyou were also carried out to study using

combination method (direct observation on field, visit local market and local interview).

2. Data analysis

2.1 Home range size and home range overlap

Home range sizes were calculated for each separate seasons using Home Range software extension for Arc View (Rodgers and Carr, 1998) which has been widely used (Aliaga-Rossel, 2004; Beasley, 2005; Vaughan *et al*., 2006; Beasley *et al*., 2007; Coleman and Downs, 2010). Arc View ® GIS 3.2 software (ESRI, Redlands, California, USA) was used. This software is license of Faculty of Forestry, National University of Laos (FoF, NUoL). The minimum convex polygon (MCP) method (Mizutani and Jewell, 1998) with 95% MCP was used to calculate home range size which has been widely used (Green *et al*., 2001; Menzel *et al*., 2006; Holloway and Malcolm, 2007; Schrecengost *et al*., 2009; Ebensperger *et al*., 2008; Quirici *et al*., 2010) and 50% MCP were used to estimate core area (Broomhall *et al*., 2003; Beaudoin *et al*., 2004; Sharpe and Goldingay, 2007; Houser *et al*., 2009).

Comparison of home ranges between seasons and sexes were tested using independent t-test and estimating significant differences at the $P < 0.05$, which has been widely used to compare a different of home range between seasons or sexes of animal (Dowding and Murphy, 1994; Dickson and Beier, 2002; Gottesman *et al*., 2004; Cooper and Randall, 2007).

Home range overlap among individuals was estimated for both the dry season and the wet season. The home range overlap was calculated using a technique which used to estimate home range overlap of leopard (*Panthera pardus*) in Huai Kha Khaeng Wildlife Sanctuary, Thailand (Simcharoen *et al*., 2008). The home range overlap was estimated for all individual (K 61, K 55, K 65 and K 47). The formula of home range overlaps calculation as follow:

Home range overlap (%) = {[(Oh*100)/ Hk1] + [(Oh*100)/ Hk2]}/2

Where: Oh is the overlap home range between two home ranges, and Hk1 and Hk2 are the sizes of respective individual Kha nyou' home ranges.

2.2 Daily movement and activity

Daily movement was calculated using the total of hourly-detected point throughout the day (24 hours) with 30 minutes for time interval. The straight-line between two points (sequential daily locations) was calculated for index of daily distance (Sukmasuang, 2001; Aliaga-Rossel, 2004; Simcharoen, 2008).

From this, the mean of individual distance of daily movement were monitored separately for each sex and season. Quantify difference in distance of daily movement between seasons and calculate differences in distance of daily movement between sexes were used independent t-test method. For the activity, becase the collars were not equipped with an activity and inactivity pulse function, thus, in this study was used the combination method between visual ovservation of Kha nyou in semi-natural habitat bar and interview local people who have had experience on feeding this animal as pet.

2.3 Habitat use

Habitat use was determined by comparison among availability of habitat types within the combined home range area of collared Kha nyou and the appearance of fixed location of collared Kha nyou in each habitat types. This method was described by Johnson (1980). The habitat type was categorized into 6 categories based on forest stand and elevation. Limestone deciduous forest (LDF) was categorized into 3 categories besed on elevation (LDF 250m asl, LDF 300m asl and LDF 350m asl) and also 3 categories for semi-evergreen forest (SEF) (SEF 250m asl, SEF 300m asl and SEF 350m asl).

2.4 Vegetation analysis

The dominant trees of LDF and SEF inside of home range were calculated their importance value indices (IVI). The IVI was determined by adding the relative density (RD), relative dominance (RDo) and relative frequency (RF) (Mueller-Dombois and Ellenberg, 1974). The RD, RDo and RF were calculated from the density (D), dominance (Do) and frequency (F) of individual species. All of them were calculated using as below formula:

$$D_A = \frac{\text{Number of species A has been found in sampling plots}}{\text{All of sampling plot areas}}$$

$$Do_A = \frac{\text{Basal area of species A in sampling plots}}{\text{All of sampling plot areas}}$$

$$F_A = \frac{\text{Number of plots which species A has been found}}{\text{Number of sampling plots}}$$

$$RD_A = \frac{\text{Density of species A}}{\text{Density of all species in sampling plots}} \times 100$$

$$RDo_A = \frac{\text{Dominance of species A}}{\text{Dominance of all species in sampling plots}} \times 100$$

$$RF_A = \frac{\text{Frequency of species A}}{\text{Frequency of all species in sampling plots}} \times 100$$

RESULTS AND DISSCUSSIONS

Results

1. Capture procedure

In this study, Kha nyou capturing was attempted in three periods. The first period was live-trapped in July 2009 (rainy season) using single door live trap (approximate 40 trap-nights). Capture was carried out based on experiences of two field local assistances. However, the first attempt was unsuccessful and no Kha nyou have been caught. In fact, local people (local hunter) in Khammouane usually trap this animal with their neck snare bamboo trap (Figure 4) during the dry season (November to March). They mentioned that the animal rejects to enter any traps outside this period. The higher food availability in the wet season might be lead to trapping failure.

The second period was conducted in the dry season during November, 2009 and January, 2010 using 20 single door live traps (approximate 160 trap-nights). Two adult males and one adult female Kha nyou were captured. The trap success rate was one individual per 53.33 trap-nights. All live-trapped Kha nyou was weighted, sexed and the essential information was mearured (Table 2) before radio collar was fit to the animal. They were released at the place of capture (Figure 12 and 13). Kha nyou was showed some signs of stress during holding. Other twelve individuals of two rodent species were captured during this period such as five males and four females of Lao limestone rat *Saxatilomys paulinae* (1 individual/17.78 trap-nights) and three males of long-tailed giant rat *Leopoldamys sabanus* (1 individual/53.33 trap-nights). All of them were weighted, measured and evaluated with regard to sex and age class (appendix table 3) before releasing at the place of capture.

Last trapping period, Kha nyou were live-trapped between December 2010 and January 2011 (approximate 50 trap-nights). Four Kha nyou were trapped (2 males

and 2 females). At this period the trap success rate was one individual per 12.5 trap-nights. Two of them were equipped with radio collar (1 male: K 47, and 1 female: K 39) and two other (1 male: Ko 1 and 1 female: Ko 2) were used for activity observation. In addition, three individuals of sympatric rodents were also captured such as two males of limestone rat *Saxatilomys paulinae* (1 individual/25 trap-nights) and a male of variable squirrel *Callosciurus finlaysonii* (1 individual/50 trap-nights).

Figure 12 The collared K 61 was released at the area of capture (12.12.2009)

Figure 13 The collared K 47 tooke a rest inside the crevice after minutes of releasing (02.01.2011)

2. Morphological study

In this study, morphological measurements were taken from seven live-trapped Kha nyou (appendix table 2) and eightteen remains Kha nyou from local people (appendix table 1). After recording, all Kha nyou remains were returned to owners (Figure 14).

Table 3 Weight (g) and the morphological measurements (cm) of adult and young Kha nyou

Parameter	Adult Male			Adult Female			Young Male		
	n	Mean	SD	n	Mean	SD	n	Mean	SD
Weight	12	414.92	56.90	11	431.27	86.05	2	155.00	21.21
Head Body Length	12	25.53	1.96	11	25.50	1.51	2	20.00	2.12
Tail Length	11	14.58	0.92	11	14.53	1.65	2	11.85	0.49
Hind Foot Length	12	4.40	0.25	11	4.38	0.13	2	3.75	0.07
Ears Length	12	2.34	0.14	11	2.31	0.13	2	1.90	0.14

Note: An adult male (K 47) was stumptailed

Figure 14 An adult female Kha nyou remain (showed dorsal and ventral view).

The weights of adult Kha nyou in this study were ranged from 355-518 g and 290-525 g for males and females respectively. The average weights were 414.92 g (SD=56.90) and 431.27 g (SD=86.05) for males and females respectively (Table 3). The biggest male weighted 518 g with 28.50 cm of head body length and 16.20 cm of tail length, while the biggest female weighted 525 g with 28.00 cm of head body length and 16.00 cm of tail lenght (appendix table 1). Comparison of weight between sexes (excluded 2 young males) found that it was not significant difference (t=0.53, df=17, p=0.60). The sex ratio was 1:0.8. This result might be due to the aggressiveness of males toward the trap, which was also found in wild house mice (*Mus domesticus*) (Drickamer *et al*., 1995), lesser bandicoot rat (*Bandicot savilei*) (Soontornpitakkool, 1996), yellow-necked mouse (*Apodemus flavicollis*) and striped field mouse (*Apodemus agrarius*) (Vukicevic-Radic *et al*., 2006).

3. Home range and core area

3.1 Home range

In this study, the home range area was estimated separately for each season using incremental area technique. The home range area was obtained from fixed location of two techniques (triangulation and homing in technique). The incremental home range area from triangulation showed that at least 8-9 days and approximately 240 fixed locations were required for home range estimate in the dry season (Figure 15), while in the wet season were required at least 5-6 days and 180 fixed locations (Figure 16). The incremental home range from homing in technique showed that at least 5-6 days and 100 fixed locations were required for home range estimation in the dry season (Figure 17).

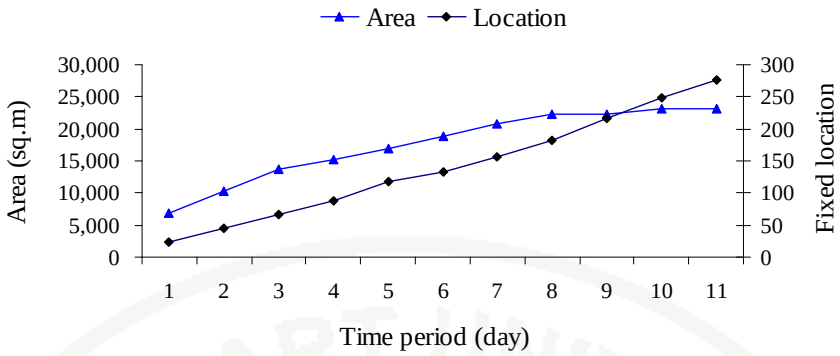


Figure 15 Cumulative home range area (100% MCP) with successive number of fixed locations and days in the dry season (average from K 61 and K 65).

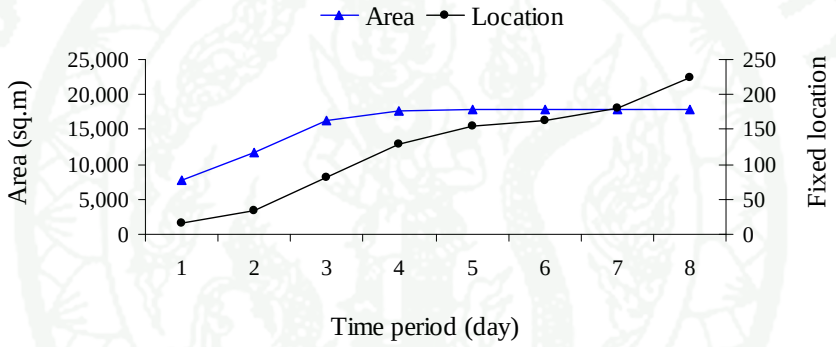


Figure 16 Cumulative home range area (100% MCP) with successive number of fixed locations and days in the wet season (average from K 55 and K 65).

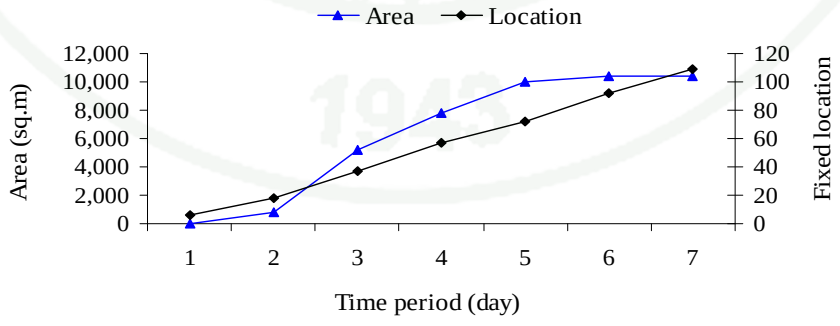


Figure 17 Cumulative home range area (100% MCP) with successive number of fixed locations and days in the dry season using homing in technique (only K 47).

Table 4 Home range (95% MCP) and core area (50% MCP) in hectares (ha) in different seasons and combined all seasons

Radio collared Kha nyou	Sex	Tracking Date		Dry Season (n)		Wet Season (n)		All Season Combined (n)	
		Start	Stop	Home Range	Core Area	Home Range	Core Area	Home Range	Core Area
K 61	Male	12.12.2009	26.06.2010	2.22 (437)	0.41 (230)	1.04 (222)	0.27 (117)	1.99 (659)	0.39 (347)
K 55	Male	01.01.2010	08.08.2010	1.99 (398)	0.48 (209)	1.95 (486)	0.61 (256)	2.34 (883)	0.63 (465)
K 47*	Male	02.01.2011	08.01.2011	1.04 (109)	0.34 (55)	-	-	-	-
K 65	Female	04.01.2010	08.08.2010	1.50 (355)	0.51 (187)	1.47 (501)	0.34 (264)	1.84 (855)	0.46 (450)
Average Male				1.75 (3)	0.41 (3)	1.50 (2)	0.44 (2)	2.16 (2)	0.51 (2)
SD				0.63	0.07	0.64	0.24	0.25	0.17
Average Female				1.50 (1)	0.51 (1)	1.47 (1)	0.34 (1)	1.84 (1)	0.46 (1)
Both Sexes				1.69 (4)	0.43 (4)	1.49 (3)	0.41 (3)	2.06 (3)	0.49 (3)
SD				0.53	0.07	0.45	0.18	0.25	0.13

Note: In K 47* all fixed locations obtained from homing in technique in January 2011 and 100% MCP was used. With low fixed locations, K 39 was omitted in home range and core area analysis

(-) data not available

3.2 Home range size

The home ranges of all radio-collared Kha nyou were determined for each separate season and combined all seasons. The results showed that the home range of radio-collared Kha nyou was slightly shift between seasons for K 55 and K 65 (Figure 19 and 20), the home range of K 61 did not (Figure 18). In the dry season, individual male home range ranged from 1.04-2.22 ha, whereas in the wet season ranged from 1.04-1.95 ha. In this study, in fact two females were fitted with radio collar (K 65 and K 39), but only K 65 was tracked and was determined the home range because K 39 died two days after release (14 fixed locations) and thus omit from home range estimation (Table 4). The home range of K 65 was 1.50 and 1.47 ha for the dry season and the wet season respectively. The combined home ranges of male were slightly greater than that of female in both seasons.

The home ranges were averaged among individuals for each separate season. In the dry season it was 1.69 (SD=0.53), while in the wet season it was 1.49 (SD=0.46) ha. Average home ranges in the dry season was slightly greater than that in the wet season, but was not significantly different (t=-0.54, df=5, p=0.61). In addition, the average home ranges among individuals for all seasons were 2.06 (SD=0.25) ha (Table 4).

3.3 Core area

The core areas were also estimated for each separate season. The everage core area of males were 0.41 (SD=0.07) and 0.44 (SD=0.24) ha for the dry season and the wet season respectively (Table 4).

The everage core areas among individuals were also calculated for each separate season. In the dry season it was 0.43 (SD=0.07), while in the wet season it was 0.41 (SD=0.18). The average core areas were not significantly different between seasons (t=0.25, df=3, p=0.81). In addition, the combined average core areas for all seasons were 0.49 (SD=0.13).

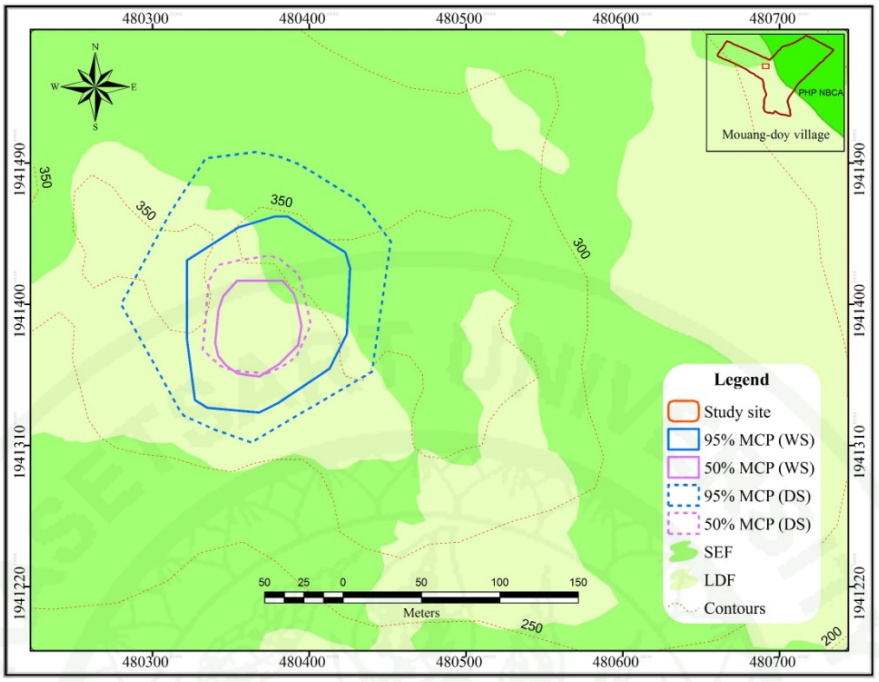


Figure 18 The home range (95% MCP) and core area (50% MCP) of K 61 in both the dry season and the wet season (WS: Wet season and DS: Dry season).

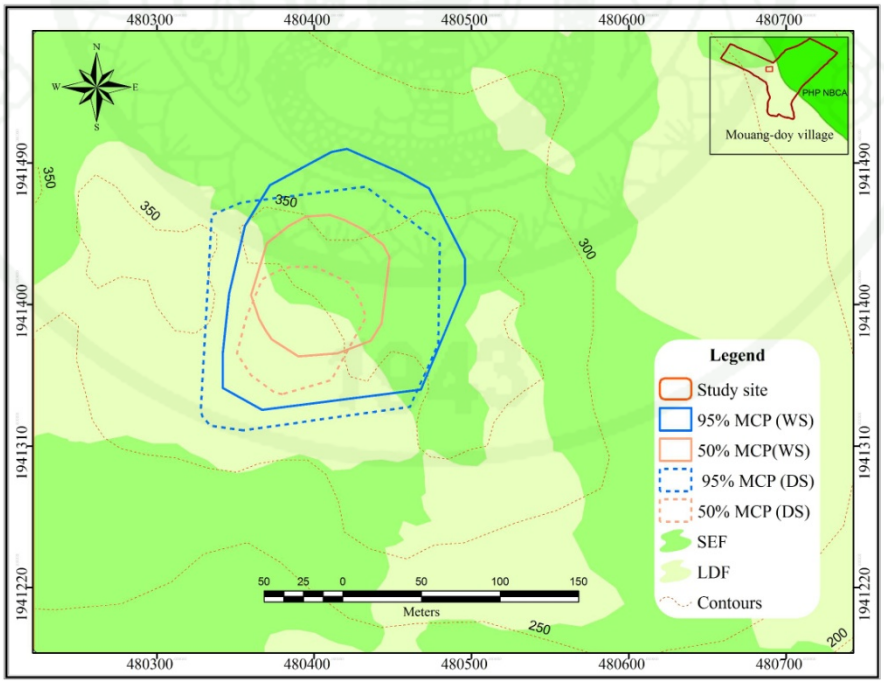


Figure 19 The home range (95% MCP) and core area (50% MCP) of K 55 in both the dry season and the wet season.

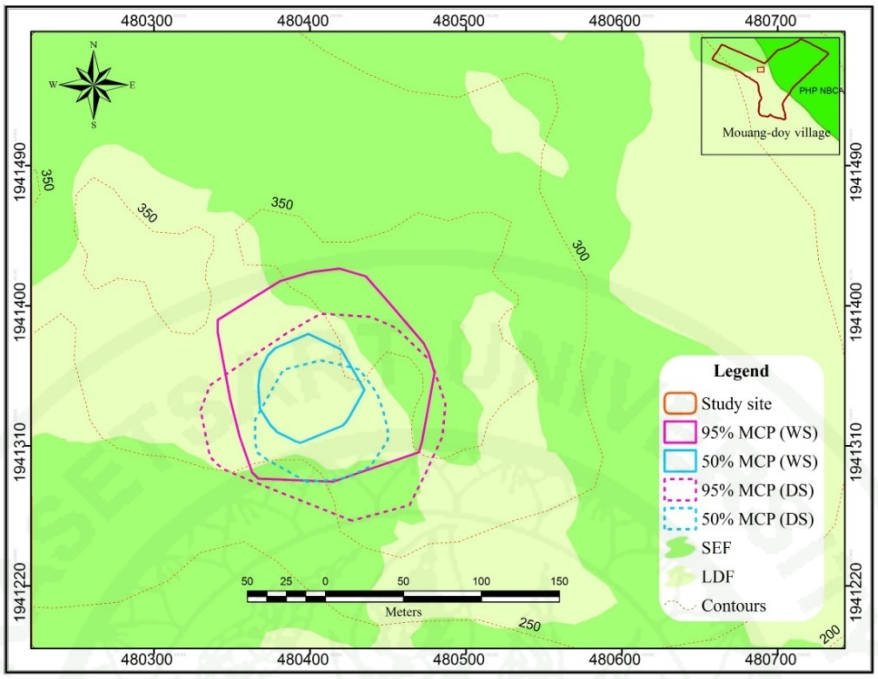


Figure 20 The home range (95% MCP) and core area (50% MCP) of K 65 in both the dry season and the wet season.

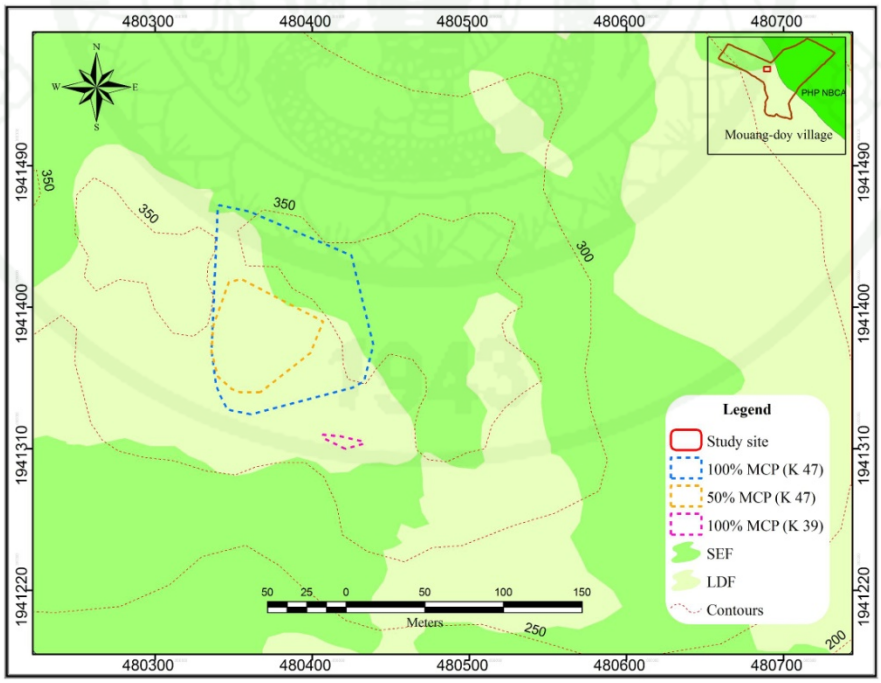


Figure 21 The home range (100% MCP) and core area (50% MCP) of K 47 and home range (100% MCP) of K 39 in January 2011 (dry season).

4. Home range overlap

Home ranges overlaps among individuals of four radio-collared animals were calculated for each separat season. In addition, the core areas were also calculated for both the dry season and the wet season. In the dry season, all home range of individuals were overlapped. The highest overlapped was 75.89% (between males K 55 and K 47), while the lowest overlapped was 30.21% (between female K 65 and male K 61) (Figure 22). In this season, the core area was also overlapped among individuals (except K 65). The highest overlapped core area was 77.39% (between males K 61 and K 47), while the lowest was 29.77% (between males K 55 and K 47).

Table 5 Percentages (%) of home range and core area overlap in the dry season

Radio-collared Kha nyou	K 61	K 55	K 65	K 47
Home range overlap (95% MCP)				
K 61	-	61.29	30.21	73.36
K 55	61.29	-	31.91	75.89
K 65	30.21	31.91	-	31.08
K 47*	73.36	75.89	31.08	-
Core area overlap (50% MCP)				
K 61	-	39.40	-	77.39
K 55	39.40	-	-	29.77
K 65	-	-	-	-
K 47	77.39	29.77	-	-

Note: Home range of K 47 obtained from 100% of fixed location (100% MCP)

In the wet season, the home ranges and core areas overlap were calculated for only first three radio-collared Kha nyou (K 61, K 55 and K 65). In this season, the highest overlapped home range was 58.62% among K 61 and K 55, while the lowest overlapped home range was 45.25% (between male K 55 and female K 65). The core

areas were also overlapped for all three individuals, but slightly lower compared with the dry seasion (Table 6).

Table 6 Percentages (%) of home range and core area overlap in the wet season

Radio-collared Kha nyou	K 61	K 55	K 65
Home range overlap (95% MCP)			
K 61	-	58.62	45.25
K 55	58.62	-	53.59
K 65	45.25	53.59	-
Core area overlap (50% MCP)			
K 61	-	39.41	8.18
K 55	39.41	-	15.02
K 65	8.18	15.02	-

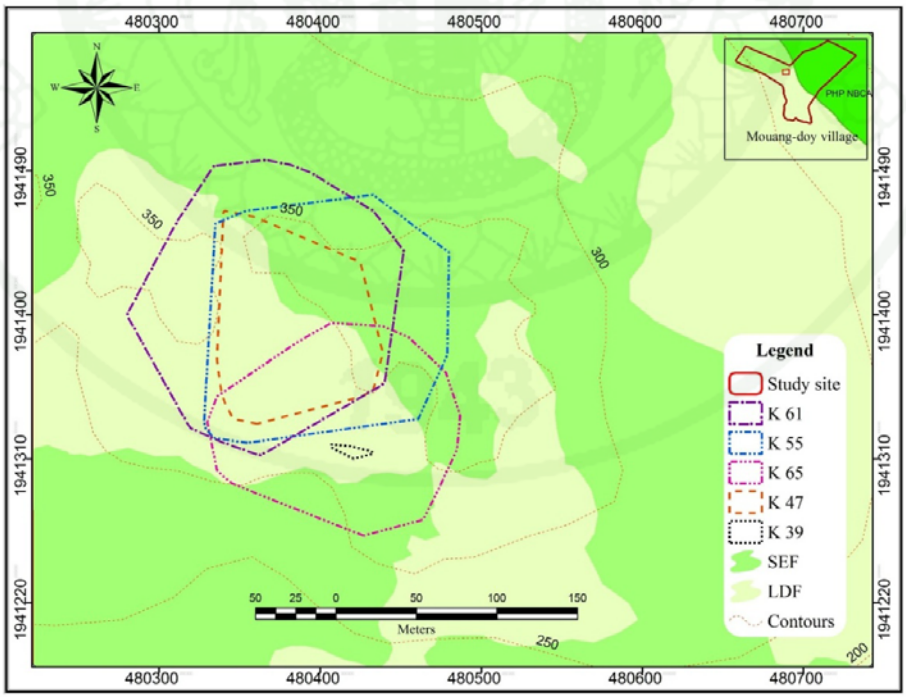


Figure 22 Home range (95% MCP) overlap among individuals in the dry season.

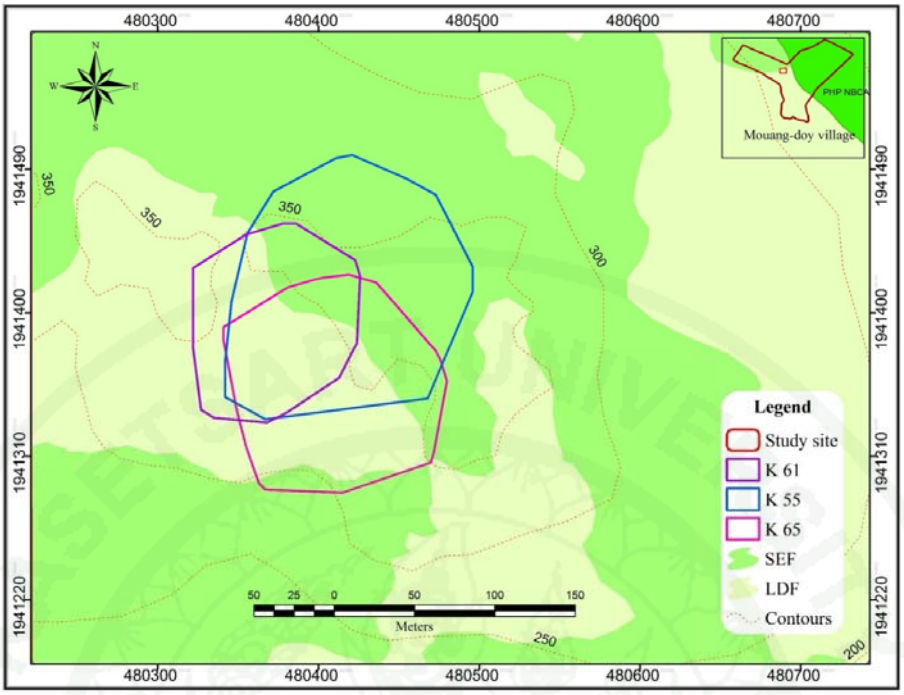


Figure 23 Home range (95% MCP) overlap among individuals in the wet season.

5. Daily movement distance

The mean daily movement distance was obtained from two consecutive tracking days of the first three radio-collared Kha nyou (K 61, K 55 and K 65). Total tracking day was 4 (2 times) with a total of 96 hours in the dry season and 6 (3 times) with a total of 144 hours in the wet season (except K 61). K 61 was tracked only one time (2 days) in the wet season due to the missing of signal during June to July 2010. The everage daily movement distance among individuals was 1,602.25 m (SD=250.13) (66.76 m/hour, n=3 individuals) and 1,563.36 m (SD=268.07) (65.14 m/hour, n= 3 individuals) for the dry season and the wet season respectively (Table 7). The everage daily movement distance showed no significant difference between seasons (t=0.38, df=24, p=0.71).

The mean distance of daily movements in the dry season of male and female were 1,687.88 m (SD=261.56) and 1,431.00 (SD=105.42) respectively (t=2.41, df=10, p=0.03), while in the wet season was 1,589.63 (SD=183.36) and 1,528.33 m

(SD=370.40) for male and female respectively (t=0.37,df=7,p=0.72). In this study, distances of daily movement was estimated for both daytime and nighttime. Daily movement distance in the dry season were 778.92 m (SD=86.44) (64 m/hour) and 823.33 m (SD=76.61) (68 m/hour) for daytime and nighttime respectively, while in the wet season were 731.28 m (SD=41.17) (65 m/hour) and 847.33 m (SD=61.81) (71 m/hour) for daytime and nighttime respectively. No significant difference was found between distance of daily movement of daytime and nighttime in both the dry season and the wet seasons (t=0.66, df=4, p=0.54 for the dry season and t=2.70, df=3, p=0.07 for the wet season).

Table 7 Distance of daily distance movement of radio-collared Kha nyou in different seasons

Collared Kha nyou	Dry Season (m)				Wet Season (m)			
	No. of Day	Total Distance	Mean/day	SD	No. of Day	Total Distance	Mean/day	SD
K 61	4	6,840.00	1,710.00	258.10	2	3,264.00	1,632.00	217.79
K 55	4	6,663.00	1,666.75	302.83	6	9,524.00	1,575.50	191.38
K 65	4	5,724.00	1,431.00	105.42	6	9,485.00	1,528.33	370.40
Total	12	19,227.00	1,602.25	250.13	14	21,887.00	1,563.36	268.07

6. Habitat use

The areas of 20 ha covered with LDF (9 ha) and SEF (11 ha) were used as the main study area. The combined home ranges of radio-collared Kha nyou covered 3.39 and 2.72 ha for the dry season and the wet season respectively. The proportions between LDF and SEF within the combined home range in the dry season was 54.27 and 45.73% respectively, while in the wet season was 51.02 and 48.98% respectively.

In the dry season, Kha nyou used LDF (75.84%) more than those SEF (24.16%), especially LDF at 300m asl (71.98±4.47%) (n=4) (Figure 24). In the wet

season, these animals used LDF (71.09%) than those SEF (28.91%). In this season, they also used LDF at 300m asl (67.10±19.51%) (n=3) more than others (Figure 25).

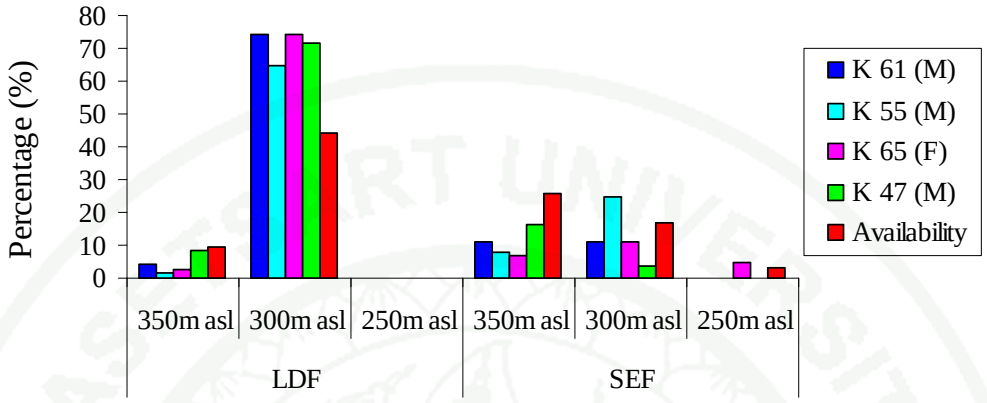


Figure 24 The percentages of availability of habitat components and fixed locations of four radio-collared Kha nyou in the dry season for each forest types.

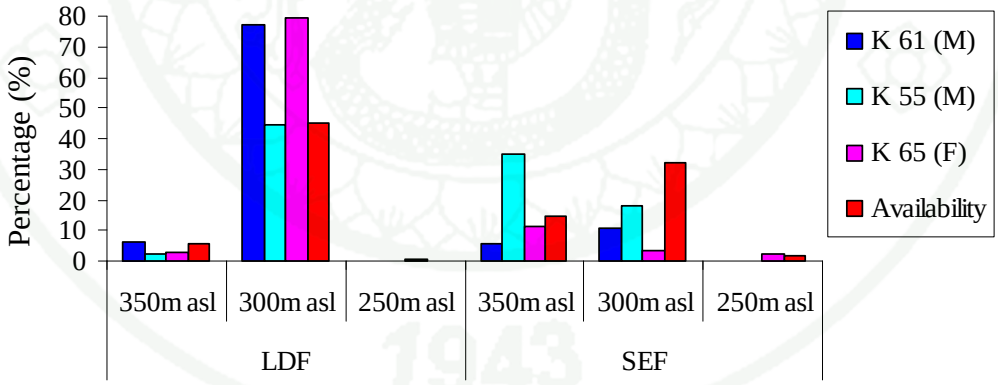


Figure 25 The percentages of availability of habitat components and fixed location of three radio-collared Kha nyou in the wet season.

7. Vegetation study

Two main forests communities were found in the study area between 160-400 m of elevation. Limestone deciduse forest covered on steep slope, limestone karst and

outcrop areas, while semi-evergreen forest was found in valleys and sinkhole where the soil is accumulated.

Figure 26 The limestone deciduou forest at 300m asl (dry season) inside core area of K 61 and K 55. The trees mostly grow from limestone grikes or cracks with some soil.

7.1 Limestone deciduou forest (LDF)

This community was very common in the study site and surrounding areas. It presented from 200 to 400m asl. The community was mostly covered with deciduous trees. Bamboo was also found. Most trees were grown from limestone grikes or cracks with some soil. In the dry season, their leaves are withered and droped due to limit of water (Figure 26). Scatters of sinkhole covered with both evegreen and deciduous trees were also present. Twenty two tree species with density of 1,260 trees/ha were found in sampling plots. The dominant trees of the top layer were *Sterculia* sp.1 (IVI=81.65), *Spondias pinnata* (L.F) Kurz (IVI=26.28), *Shorea siamensis* Miquel (IVI=19.74) and *Bombax ceiba* L. (IVI=12.66). Whereas, the dominant trees of the second layer were *Canarium* sp. (IVI=22.97), *Azadirachta* sp. (IVI=17.23) and *Wrightia* sp. (IVI=10.82) (appendix table 9). The common species of understory layer were *Aglaonema* sp., *Pandanus* sp., *Cycas revoluta* Thunb. and *Amorphophallus* sp.

Figure 27 Semi-evergreen forest (SEF) in sinkhole where soil depth at the 350m asl inside home range of K 55.

7.2 Semi-evergreen forest (SEF)

In this study area, this community was found between 160-350 m above sea level. This community is the major forest type of the PHP NBCA. The community was covered with both evergreen and deciduous tree. The sampling plots were laid inside the combined home range of all radio-collared Kha nyou and surrounding area where this animal was found. Sampling plots in SEF community was covered with 43 tree species with 2,060 trees/ha. At the valley and the base of mountain was covered with big and tall tree (closed-crown forest). At the top layer, the dominant trees were *Hopea ferrea* Pierre (IVI=51.70) and *Lagerstroemia calyculata* King (IVI=12.18). The second layer were *Diospyros curraniopsis* Bakh. (IVI=22.41) and *Hydnocarpus ilicifolius* King (IVI=14.39), while the third layer were dominated by *Memecylon ovatum* Sm. (IVI=18.65), *Streblus asper* (Re.) Loureiro (IVI=18.15) and *Alphonsea boniana Finet & Gagnep* (IVI=17.17) (appendix table 8).

The understory of this community was covered with seedling of *Hopea ferrea* Pierre, *Streblus asper* (Re.) Loureiro, *Streblus ilicifolius* (S. Vidal) Corner, Palm (*Caryota* sp, *Rhapis* sp. and *Arenga* sp.) and Zingiber (*Curcuma* sp. and *Globba* sp.) also were commonly found in this layer at the base of mountain and the valley.

8. Wildlife communities

In this research, wildlife survey was also conducted using local interview combined with field survey both night and day time. The results showed that, this area are the habitat of some endemic wildlife species. At least 42 species of mammals were recorded. The largest mammals were sambar deer (*Rusa unicolor*) and serow (*Capricornis sumatraensis*), but their population was small. The new endemic species was *Saxatilomys paulinae* and *Laonastes aenigmamus*. The *Saxatilomys paulinae* was very common in the study site and surrounding area. *Neofelis nebulosa, Prionailurus bengaolensis* and *Viverricula indica* were known as the largest carnivore. They were not commonly found during the study period due to hunting pressure and habitat fragmentation (appendix table 4). At least 44 species of birds were found. The common birds in this area were *Pycnonotus*, *Dicrurus* and *Stachyris herberti*. The new species of bird *Pycnonotus hualon* (Woxvold *et al*., 2009) was also found. The birds of prey were *Tyto alba, Accipiter badius* and *Cirus spilonotus*, which were relatively common (appendix table 5).

There were at least 42 species of reptiles were found in this study area. The reptile was separated into 3 groups such as lizards (15 species), snake (23 species) and turtle (4 species) (appendix table 6). The biggest small lizard was *Varanus bengalensis* and *Physignathus cocincinus*, but their population was small. The biggest reptile was *Pytohon molurus* and *P. curtus*. Both of them were also rare. In the last five years, local reported that they caught a big python with approximately 4 m of total length in Khuan noi (large valley covered with SEF). This area was also included in field wildlife survey, which is 2 km from study site to the west.

Thirdteen species of amphibians were found (appendix table 7). This was mainly from interview and literature review. One of them was recorded as the new species *Rhacophorus spelaeus* (Orlov *et al*., 2009b).

Discussions

1. Morphology measurement

The weights and lengths of Kha nyou in this study were heavier and longer than those previous studies (Table 1). In this study, the mean weights were 422.74 g (SD=71.10) and the mean head body lengths were 25.51 cm (SD=1.72). Females were slightly heavier than those males in average of weight, but was not significantly different (t=0.53, df=17, p=0.60). The largest Kha nyou was female (525 g of weight and 28 cm of head body lenght). Similarly, Vongsa (2010) reported that females (454.50 g (SD=55.44)) bigger than those males (357.00 g (SD=28.28)) respectively.

The first record of Kha nyou' body size ranged from 334-414 g (Jenkins *et al*., 2005). The research conducted in the same area of this research (Mouang-doy village). Douangboupha *et al.* (2009) also conducted a research in this area and reported that the average weights of Kha nyou were 365 g. However, no researcher has compared the body mass between sexes (Table 1).

Previous researchers also showed no significant sexual difference in body mass of rodents. For in stance, the mean body mass of garden dormouse (*Eliomys quercinus*) in Scots pine woodland, Italy were 75.00 g (SD=10.61) and 80.33 g (SD=6.83) for males and females respectively (Bertolino *et al*., 2003), while the average body mass of black-tailed tree rat (*Thallomys nigricauda*) in South Africa were 71.47 g (SD=4.46) and 63.41 g (SD=4.41) for males and females respectively (Coleman and Downs, 2010). Similarly, Mariana *et al*. (2010) reported the everage body mass of common tree shrew (*Tupaia glis*) in Kuantan Pahang, Malaysia were 179.00 g (SD=13.53) and 176.50 g (SD=17.68) for males and females respectively.

2. Home range size

In this study, the average home range of Kha nyou for all seasons was varied from 1.84 to 2.34 ha. Home range of this rat was bigger compared with home range of

long-tailed giant rat (*Leopoldamys sabamus*) (0.21 to 0.98 ha) in Borneo, Malasia (Wells *et al*., 2008), which quite similar size with its (401.67±7.64 g for Kha nyou and 368.00±64.00 g for long-tailed giant rat) (Wells *et al*., 2006). On the other hand, home range of Kha nyou was slightly similar compared with grey-bellied squirrel (*Callosciurus canicep*) (1.18 to 2.35 ha) in a lowland dipterocarp forest in Malasia (Saiful *et al*., 2001). However, this squirrel was slightly smaller of masss (347.10±24.60 g for male and 328.70±26.30 g for female) compared with Kha nyou.

Home range in the dry season was slightly greater than those in the wet season but was not significantly different (t=-0.54, df=5, p=0.61). In fact, limestone karst in the dry season was very dry and flesh leaves are rare. The slightly larger home range in this season could be explained by security of food (Sommer, 1996). Several previous studies conducted on rodents in arid habitat concluded that food availability drive the spatial behavior of them (Eccard *et al*., 2004; Schradin, 2005; Cooper and Randall, 2007). In addition, near the Pacific cost in Costa Rica, Beck-King *et al*. (1999) observed that the female *Agouti paca* shifted its home range and increased home range size when food was insufficient in August. Similar to Harris and Leitner (2004) who reported that the home range size of female Mohave ground squirrels (*Spermophilus mohavensis*) in the west Mojave Desert of California in years of no reproduction appears to vary in response to food availability.

However, the smaller home ranges of Kha nyou in the wet season could not only be explained by security of food, but also by the appearant of predators. Sommer (1996) found that the home range of Malagasy giant jumping rat (*Hypogeomys antimena*) in Madagascar reduce after the arrival of predators. In this study, during the wet season, the predators like civet and barn owl existing in study area; therefore it might influenc Kha nyou's home range size. In addition, Kha nyou was reported to give a birth in the dry season (Jenkins et al., 2005; Vongsa, 2010), hence, it might be affected their home range size. Orteca (1990) reported that the home range of males of rock squirrel (*Spermophilus variegatus*) in southeastern Arizona was largest during the breeding season (May and June). Similarly, Priotto *et al*. (2002) observed both males and females of Cordoba vesper mouse (*Calomys venustus*) increased their home

range during breeding period and when population density was low on a railway bank in southern Cordoba Pronice, Argentian.

Comparison of sexual home range variation in this study was limited due to the limit sample size for female. However, the results showed that average home range of male slightly larger than that female in both the dry season and wet season (Table 4). Similarly, previous studies on other rodents reported home range of males were greater than those females (Beck-king *et al*., 1999; Tattersall *et al*., 2001; Ribble *et al*., 2002; Schmidt *et al*., 2002; Bertolino *et al*., 2003; Van der Ree and Bennett, 3003; Cutrera *et al*., 2006; Whisson *et al*., 2007).

However, Dowding and Murphy (1994) found home range size between sexes of roof rat (*Rattus rattus*) was not different. Similarly, the home range size between sexes of brush mice (*Peromyscus boylii*) (Gottesman *et al*., 2004), yellow-necked mouse (*Apodemus flavicollis*) and striped field mouse (*Apodemus agrarius*) (Vukicevic-Radic *et al*., 2006) and kangaroo rat (*Dipodomys ingens*) (Cooper and Randall, 2007) were also not different. In contrast, Saiful *et al*. (2001) found that home range of female plantain squirrels (*Callosciurus notatus*) were significant greater than those males and similar to Mariana *et al*. (2010) reported home range of female common tree shrews (*Tupaia glis*) are being 20.8% larger than those of males.

Results of this study, home ranges for individuals in the dry season varied from 1.04 to 2.22 ha. The time period and fixed location influence home range area. Home range size of K 61 in the wet season was smaller than that K 55 and K 65 might be due to the time period and number of fixed location of it less than K 55 and K 65 (Table 4). Menzel *et al*. (2006) reported numbers of sampling locations and the time period were affected to the home range estimate using MCP method. The greater number of locations of radio telemetry may possibly lead to larger home range sizes (Ribble *et al*., 2002).

3. Home range overlap

Home range of four radio-collared Kha nyou in this study were overlapped, even the core areas were also overlapped in both the dry season and the wet season (except core area of K 65 was not overlap in the dry season). Highly overlapping home ranges of this animal might be in response to available of suitable habitat such as limestone boulders, cavities and complex crevices system. In addition, they may live in group as was found in the striped mouse (*Rhabdomys pumili*) (Schradin, 2005). Local people stated that they used to trap two or three Kha nyou in the same place (cavities or crevices) in one night or several consecutive days. They also stated that this animal lives in group and share a high quality habitat and safe crevices. Similar to the result of camera trapping in the dry season 2010, at least two individuals were photographed in the same night at the core area of K 61 (one with radio collar and another one un-collared). The evidence of lavatory (appendix figure 14, 15 and 16) suggests that Kha nyou live and share that crevice with other individuals.

The results from this research showed that male K 61 did not shift their home range and core area between seasons (Figure 18), while male K 55 and female K 65 showed slightly shifted their home range and core area in the wet season. K 65 shifted her home range and core area up to K 61 and K 55 lead to increasing overlapped among them. Futhermore, the core area among them was not overlaped in the dry season, but was overlapped in this season (Table 6).

Home range of K 65 in the south was so humid in the wet season, especially the crevices due to this part is a large sinkhole area which covered with closed crown of SEF. These might be a main reason of home range shifting. Local hunters mentioned that most Kha nyou were trapped in the dry crevices coverd with opened crown forest. This was the habitat character in the center of combined home ranges and core areas.

Home range overlaps among sexes of rodent have been described in previous studies. Bertolino *et al*., (2003) found the males of garden dormouse (*Eliomys*

quercinus) increased their home range overlap with females (mean 33.6%), while in females not found. Schmidt *et al*. (2002) observed that home range of male lemming showed considerable overlap, whereas female home range was almost completely discrete. In addition, the home range overlap among sexes of roof rats (*Rattus rattus*) was also high (Whisson *et al*., 2007).

Home range of Kha nyou did not only overlapped among radio-collared Kha nyou, but also overlapped with un-collared Kha nyou and other terrestrial rodents. Results from camera trap in core area of K 61 showed, there were 3 pictures of Kha nyou with radio collar, 5 pictures of Kha nyou with no radio collar and 3 pictures of *Saxatilomys paulinae.* Similarly, results from live trap, 15 individuals of other terrestrial rodent were live-trapped (3 species, appendix table 4) such as *Saxatilomys paulinae, Leopoldamys sabanus* and *Callosciurus finlaysonii.* The evidence that home range of Kha nyou overlapped other Kha nyou and other terrestrial rodents, suggests that they may not actively defend territories.

4. Daily distance movement and activity

In the dry season males moved significant greater than that of female (Table 7) (t=2.41, df=10, p=0.03), while in the wet season male also moved slightly greater than that of female, but was not significantly different (t=0.37,df=7,p=0.72). Similarly, Wells *et al*. (2008) found insignificantly different of daily distances movement among sexes of long-tailed giant rat or tropical rat (*Leopoldamys sabanus*). In addition, the mean daily distance movements of this rat (1,443±991 m) slightly similar with Kha nyou in this study (1,602±250.13 m for the dry season and 1,563±268.07 for the wet season).

Distances of movement of males were greater than those females. It is such the common characteristic of many mammalian species (Nass, 1977). Similarly, Schmidt *et al*. (2002) observed males lemming (*Dicrostonyx groenlandicus*) moving larger distances than those females. In contrast, Menzel *et al*. (2006) reported females of common tree shrew (*Tupaia glis*) move greater distance when comparing to males

(366.29±23.05 m/day for females and 305.30±57.80 m/day for males). The results of daily distances movement of Kha nyou, which found in the dry season slightly greater than those in the wet season was consistent with the home ranges of them that in the dry season slightly larger than those in the wet season. In addition, males move longer than those females were consistent with male's home ranges larger than those females.

Jenkins *et al*. (2005) presumed that Kha you are nocturnal rodent due to lack of diurnal sighting during their research. In contrast, in this research the diurnal sightings were found. Daily distance movement between daytime and nighttime showed slightly similar in both the dry and the wet season. In addition, the variation (erratic, constant) of radio signal was found during tracking radio-collared Kha nyou in both daytime and nighttime. Furthermore, result from direct observation in semi-natural habitat bar found that Kha nyou spend their times in eating and walking to find the way out and taking a rest some time. In contrast, no drowsy or asleep were found in daytime. These evidences suggest that Kha nyou were both nocturnal and diurnal.

5. Habitat use

Result of this research found that specific habitats of Kha nyou were limestone karst where bounders, cavities, and crevices were covered with both LDF and SEF. Mostly SEF where Kha nyou was found was open crown forests. Comparison of usage among LDF and SEF found that they used LDF than that SEF in both the dry season and the wet season. Similarly, local people stated they mostly trapped this animal inside crevices and cracks near sinkhole covered with both deciduous and evergreen tree. Vongsa (2010) stated that Kha nyou distributed only in limestone karst and restricted to crevice among rocks of limestone karst. Similarly, Jenkins *et al*., (2005) reported Kha nyou only trapped among limestone boulders covered with both evergreen and deciduous trees on steep slope surounding karst formations.

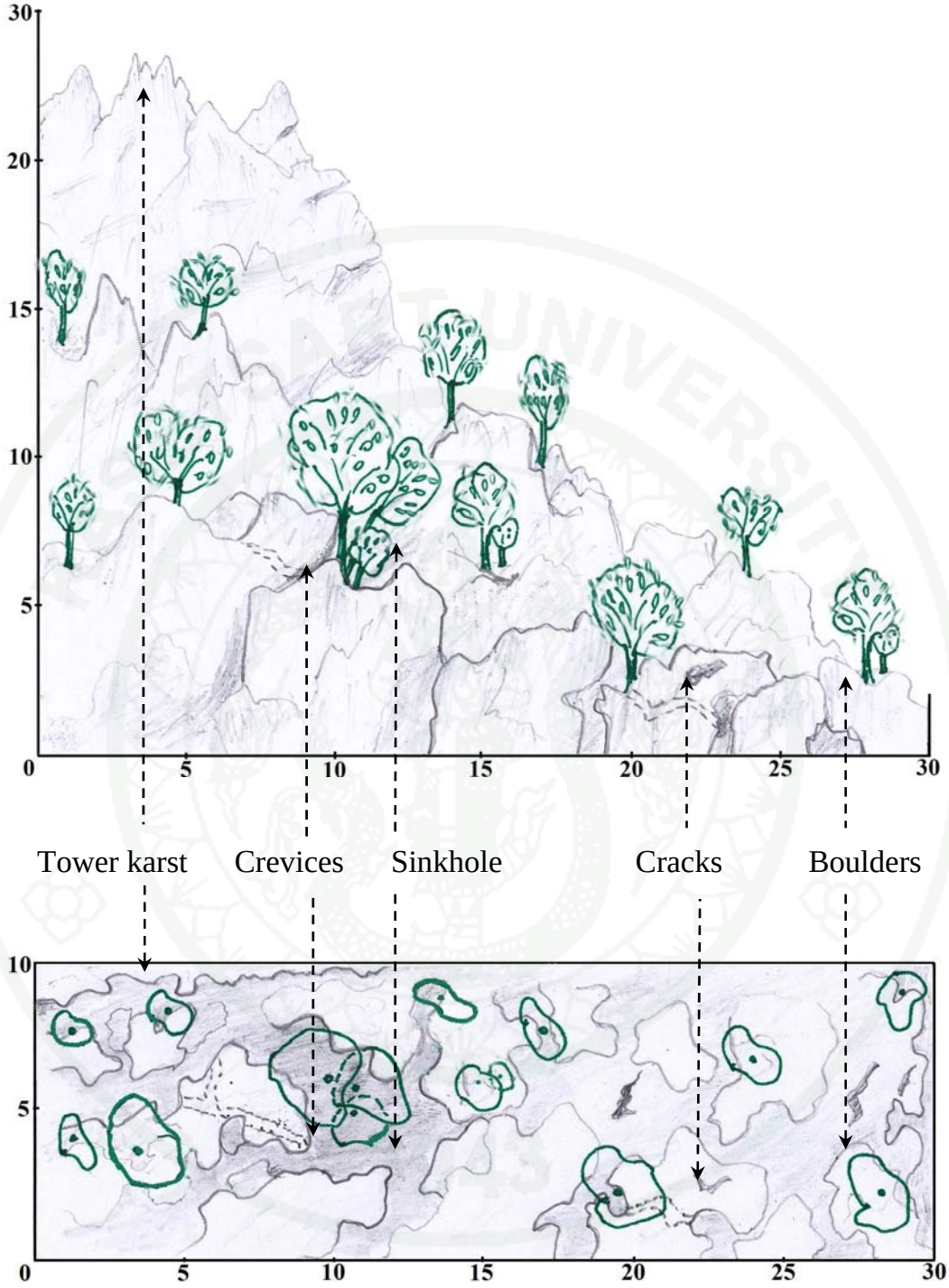


Figure 28 Limestone karst and tree diagram (m) of combined core area within LDF.

Kha nyou use and restrict to limestone karst with complex cavities and crevices might be because they are slothful animal, thus, need more complex shelters to avoid predators. Similarly, hairy-tailed bolo mice (*Necromys lasiurus*) forage in

area with more shelters (Vieira *et al*., 2005) and viscacha rat (*Octomys mimax*) limits its foraging range to rocky environment (Traba *et al*., 2010) in order to avoid predators.

The evidence of Kha nyou appeared and mostly used limestone karst, crevice and sinkhole covered both deciduous and evergreen tree, suggests that these characteristics are the unique habitat of Kha nyou. The unique habitats of each rodent species are different and in response to place, time, food and cover availability. In Khao Yai National Park, Thailand, Soontornpitakkool (1996) reported that roof rat (*Rattus rattus*) use only grassland, while in New South Wales, Australia this rat found in a deep cover of leaf litter and dense understory with numerous vertical stems (Cox *et al*., 2000). Rice field rat (*Rattus argentiventer*) use burrows when tillering rice low, but they use rice fields when rice is ripening (Brown *et al*., 2005).

Kha nyou was appeared from 250-350m asl in both the dry season and the wet season and especially at 300-350m asl. However, in this study the sample sizes were quite limited led to insufficient data to confirm that habitat use of this animal relate with elevation. Based on evidences from local people' trap success showed that Kha nyou found from 200-450m asl (the top of mountain) depend on bounders and crevices presence. In addition, result from homing-in tracking of K 47 found that he used LDF at 300m asl (more than 70%) where the boulders, crevices and small sinkhole covered both deciduous and evergreen tree. The result suggests that Kha nyou uses mainly limestone karst with lots of boulders, crevices or cracks and covered with both deciduous and evergreen trees.

6. Some behavior, population and biological information

Kha nyou spend most of its activities in burrow among the boulders, cracks and crevices. They continuously forage and move among boulders and take rest inside safety crevices, therefore lead to be rarely seen. Kha nyou are known to be docile animal, but they quite adroitly on using their habitat when faced an unsafe situation. During study period, one un-collared Kha nyou was seen in their natural environment

(inside crevice) at 4 am (5th January 2011) within overlap core area between K 61 and K 65, but it vanished into deep crevice in a second.

Local people have mentioned about the interesting behavior of this animal was 'sunbath'. This, also not often takes place in a cool day in the morning around 7:00-8:00 am (December and January). Kha nyou comes out from their crevices and sit in sun on the boulders adjacent to the crevices. The animal performs this behavior in undisturbed area. In December 2010, a local people reported that he found two times (in different site) at his trap site 4 km from Mouang-doy village to the North (3 individuals at first time and 2 individuals at the second time).

Kha nyou have a particular place for stools within their crevices (lavatory). In this study site, a lavatory was found within K 65 home range (appendix figure 14). Other lavatory (appendix figure 16) was found 4 km to the North (at local hunter trap site). This lavatory is large and mixed together between old and new pellets. This may suggest that this lavatory have been used for long time. It also suggests that this animal may share a lavatory or live in group. A local hunter mentioned that at least 15 individual was captured in this crevice (lavatory) in December 2011. This result consistent with the radio tracking that Kha nyou shares the unique habitat and has an overlap home range.

Kha nyou have a typical eating behavior. They skillfully control their food (leave) by using forefoot and after finishing the pieces of food they usually clean their lip with internal dorsal of forefoot. This evidence resulted in lacking of fur (bare) on their internal dorsal forefoot.

The population in disturbed habitat is lower than undisturbed habitat. In disturbed area located 2 km from this study site to the south (approximately 15 ha), local people reported that in this year at least 27 Kha nyou were trapped (using neck snare trap, Figure 4) in 6 consecutive days capture (approximately 390 trap-nights, 1 individual/14.44 trap-nights), thus the estimated population of this animal is 1.80/ha. Vongsa (2010) reported in disturbed area in Mahaxay district the density is 2.66/ha (4

consecutive days of capture and approximately 400 trap-nights). Local reported that the population is now decreasing compared with the last 10 years; however, it is still high in the area where undisturb.

The breeding season of Kha nyou is still unclear; however, most pregnancy was found during dry season (December to Febuary) (Jenkins *et al*., 2005; Vongsa, 2010). In contrast, Kha nyou have been found to be pregnant and to give birth in the wet season. A local people reported that he accidently trapped a pregnant Kha nyou with young in July last year 2010. Local people usually set the trap in the wet season on ground within the valley for ground animall after harvesting thire rice field. From this study suggests that this animal might give birth in all year round.

7. Threats

Several wild animals have been hunted for food and trade by Lao local people (Ministry for Agriculture and Forestry [MAF], 2003). In the early 2000s, Kha nyou were also seriously hunted for both subsistence and trade. Vongsa (2010) also reported the main threat of this animal is hunting for subsistence and trade of local people. Similarly, Jenkins *et al*. (2005); Aplin and Lunde (2008) reported hunting and habitat disturbance from logging and firewood collection was the major threats to this animal population.

In this study area, local people reported in 1990s, they could easily capture Kha nyou even near the village. In one night with 10-20 neck snare traps (dead bamboo trap or Luang in Lao), they captured at least 3-5 Kha nyou, while now they have to use 40-50 traps to get 3-5 Kha nyou and have to go further more from village. In addition, at that duration Kha nyou have wide hunted not only for subsistence but also for trade due to this animal is known as it has the best taste. Hence, this main hunting pressure quickly decreased on its population at last decade in this study area.

In addition, the natural predators are also important factors. In the study area, based on result from direct observation and local people interview, predator that presumed to be preyed on Kha nyou include some species of both nocturnal and

diurnal animal. In this area, some species of mammals such as *Prionailurus bengalensis, Viverricula indica, Prionodon pardicolor* and *Paradoxurus hermaphroditus* were found. *Prionailurus bengalensis* were commonly found in this area and they could have a negative effect on hunting and control Kha nyou population.

Barn owl (*Tyto alba*) which reported that they preferently prey on rodents than other preys (Vassallo *et al*., 1994; Hafidzi and Saayon, 2001; Moreno and Espinosa, 2009) were also commonly found in this area in the wet season. Jenkins *et al*, (2005) reported remains of Kha nyou in owl pellets. In addition, the other predators such as some birds (*Circus spilonotus, Spilornis cheela*) and reptiles (*Pytohon molurus, Pytonon curtus, Ptyas fuscus*) also some time appeared. They may also prey on Kha nyou too.

In general, the threats of wildlife in Laos as well as Kha nyou are recognized in wildlife and aquatics law (National congress, 2008). Status of Kha nyou is endangered species and putted into appendix I in Lao wildlife and aquatic red list (DOF, 2008) and specific regulation was set in provincial level to preserve them (PAFO, 2008). People who hunt or sale this animal will be charged and fined with 500,000 Lao kip (around 60 US dollars). However, illegal hunting of this animal has still occured. During this research, Kha nyou is now intensively hunt for both subsitance and commercial, therefore an urgent approach is needed to protect the remains population. More participatory of more stakeholders both government and non-government organization including local people who are slaughter this marvelous animal.

8. Dietary

The examination of three stomachs collected found that it contain mostly plant remains (leaves, stems, seeds) plus a few fragments of ants remains, but could not identify to taxa. The plant remain from rodent stomach is very hard to indentify (Miller and Miller, 1995). Identification of the vegetal items from stomach vegetarian

is needed the samples from study area (Talamoni *et al*., 2007). This technique was applied by Lorkhamheaung and Manisy (2010). The result showed only one species of plant which expected to be food of Kha nyou was identified as *Paederia tometosa*. In fact, they collected and made 12 samples (plant leaves) from their study site (Dang village in Mahaxay district, Khammouane province), but they can not identify most of them.

In this study, stomach contents analysis was also carried out, but it failed to do so because time is limited. However, from this pilot study, it found that most of them were plants remains plus a few of ant, which similar to previous study conducted by Jenkins *et al*. (2005). Inside this, the leaves were commonly found based on stomata apparent (appendix figure 22) which restricted to the lower leaf surface (Mantovani and Pereira, 2005; Kotrnon *et al*., 2007). In addition, this result found at least a species of fern (Polypodiaceae) and an ant (appendix figure 21). Results from this examination suggest that food of Kha nyou is mostly plants, while insects (ant) were probably eaten with their food. Scopin *et al*. (2011) stated that Kha nyou is hervivor rodent and it is a smallest folivorous mammal.

In addition to the diet of Kha nyou, Vongsa (2010) reported that at least 25 species of plant expected to be fed by Kha nyou, such as *Costus speciosus, Dendrobium* sp., *Aglaonema simplex, Pandanus* sp., *Caryota* sp. *Cereus* sp. (detail see appendix table 10). He compiled them from local interview based on feeding sign identification. Most of the feeding signs were identified from leaves and a few from stem and root. In addition, results from local people who used to feed this animal at house showed they are able to feed on plants such as *Musa acuminate, Leucaena leucocephala*, *Paederia tometosa* and *Bauhinia* sp. In addition, at the semi-natural habitat, it found that this animal feeded mostly on dry leaves. The evidences from this research, suggestats that diet of Kha nyou were composed of various species of plants and the leaves might be the most important part of plants.

CONCLUSION AND RECOMMENDATIONS

Conclusion

The study on home range and habitat utilization of Kha nyou (*Laonastes aenigmamus*) was conducted at Mouang-doy village, PHP NBCA in Khammouane, central Lao PDR using radio tracking within 20 ha. Five Kha nyou (3 males and 2 females) were live-trapped and equipped with radio collars between December 2009 and January 2011. Two males and one female were live-trapped, equipped with radio collars and tracked mainly from receiver stations between December 2009 and July 2010 (triangulation technique), while two addited were live-trapped, equipped with radio collars and tracked using homing in technique in January 2011. However, only four Kha nyou (3 males and 1 female) were used to estimate their home range due to 1 female (K 39) dead after two days releasing.

The average weights of adult Kha nyou were respectively 414.92 ± 56.90 and 431.27 ± 86.05 g for males (n=12 individuals) and females (n=11 individuals). The average weights between adult males and females do not show significantly different (t=0.53, df=17, p=0.60). The average head-body lengths of adult males and females were 25.53 ± 1.96 and 25.50 ± 1.51 cm respectively and do not show significantly different (t=-0.03, df=20, p=0.97). The average weights and head-body lengths from two young males was 155.00 ± 21.12 g and 20.00 ± 2.12 cm respectively.

The average home ranges size of Kha nyou in the dry season were respectively 1.75 ± 0.63 ha for males (n=3 individuals) and 1.50 ha for female (n=1 individual), while in the wet season were respectively 1.50 ± 0.64 and 1.47 ha for males (n=2 individuals) and female (n=1 individual). In this study, average home range of adult males slightly greater than that female. Howerver, statistical test can not be done due to insufficient sample size of female. The average home ranges of Kha nyou in the dry season and in the wet season were 1.69 ± 0.53 (n=4 individuals) and 1.49 ± 0.45 ha (n=3 individauls) respectively and no different was found (t=-0.54, df=5, p=0.61).

The home ranges of radio-collared Kha nyou overlapped among individuals in both the dry and the wet seasons. In the dry season, average overlapped home ranges among them were ranged from 30.21 to 75.89%, while in the wet season were 45.25 to 58.62%. The highest overlapped home range was 75.89% between K 55 and K 47 in the dry season, while the highest overlapped home range in the wet season was 58.62% between K 61 and K 55. Moreover, not only home ranges, but the core areas were also overlapped between individuals both the dry season and the wet season (except K 65 in the dry season, Table 5).

The mean daily distance movement in the dry season were 1,687.88 ± 261.56 and 1,431.00 ± 105.42 m for males and female respectively (t=2.41, df=10, p=0.03), while in the wet season were 1,589.63 ± 183.36 and 1,528.33 ± 370.40 m for males and female respectively (t=0.37,df=7,p=0.72). The average combined distance of daily movement for all individuals was 1,602.25 ± 250.13 (66.76 m/hour, n=96) and 1,563.36 ± 268.07 m (65.14 m/hour, n=144) for the dry season and the wet season respectively. No significant difference was found (t=0.38, df=24, p=0.71).

The combined cumulative home ranges of all radio-collared Kha nyou covered 3.39 (LDF 54.27% and SEF 45.73%) and 2.72 ha (LDF 51.02% and SEF 48.98%) for the dry season and the wet season respectively. The propotion of used of Kha nyou in the dry season were 75.84 and 24.16% for the LDF and SEF respectively, while in the wet season was 71.09 and 28.91% for the LDF and SEF respectively. The habitat of Kha nyou was restricted to limestone karst where boulder, small sinkhole and complex system crevices were presence. The habitat was mainly covered with LDF and some of SEF (edge of SEF which next to LDF).

Kha nyou is both nocturnal and diurnal. It is active in both nighttime and daytime among the boulders, crevices and sinkholes which covered with deciduous and evergreen trees. The other common terrestrial rodents, which sharing habitat with Kha nyou consisted of those sympatric species *i.e.* Lao limestone rat (*Saxatilomys paulinae*), long-tailed giant rat (*Leopoldamys sabanus*) and variable squirrel

(*Callosciurus finlaysonii*). The main factors threaten to their population consisted of illegal hunting and human disturbance in their habitat.

Recommendations

In this study, the sample size was small due to its elusive behavior and used of live trapping experience of researcher. Thus, further study should be considered and resolved this limitation with different live trap such as sharman live or specific design trap. In this study, activity study at the field could not carry out in their natural habitat due to the limestone bounders, crevices and cavities too complexes and this animal quite sensitive with disturbance lead to limit visualization. For this reason, future study should be considered observation of animal in semi-natural habitat and captive animal.

In the future, the use of Shermen live trap (or specific design for karst formation environment) to study on population and elevation relationship of Kha nyou will be interesting research. The result will be provided a better understanding on density of population and comparison of habitat utilization with this study. In addition, more extensive studies are necessary to better understand the specific microhabitats use and niches of this animal.

Knowledge gains from this study should be helpful for making decision and planning such as designing a working plan and creating the conservation zone for protecting Kha nyou population. Area zoning for Kha nyou can be established inside or outside the NBCA where boulders, crevies and sinkholes covered with both LDF and SEF is presence. It should be considered for long-term conservation for this Lao endemic rodent. The conservation zone also needs effective of law enforcement and specific regulation in order to resolve or reduce the main threats-illegal hunting and disturbance in their habitat. On the other hand, local awereness, making of multiple values of wildlife biodiversity and natural resources should be more consideration for implementation.

LITERATURE CITED

Alan, R. 1993. **Wildlife Field Research and Conservation Training Manual**. Paul-Art Press Inc., New York City.

Aliaga-Rossel, E.R. 2004. **Landscape Ues, Ecology and Home Range of the Agout (*Dasyprocta punctata*)**. M.S. Thesis, State University of New York.

Alterio, N. and H. Moller. 1997. Daily activity of stoats (*Mustela erminea*), feral ferrets (*Felis catus*) in Coastal grassland, Otago Peninsula, New Zealand. **New Zealand Journal of Ecology** 21 (1): 89-95.

Aplin, K and D. Lunde. 2008. *Laonastes aenigmamus*. **The IUCN Red List of Threatened Species, Verson 2010.2**. Available Source: http://www.iucnredlist.org/apps/redlist/details/136474/0, August 28, 2010.

Aplin, K.P., P.R. Brown, J. Jacob, C. J. Krebs and G.R. Singleton. 2003. **Field Methods for Rodent Studies in Asia and the Indo-Pacific**. BPA Print Group, Melbourne.

Baird, I.G. and B. Mounsoupham. 1997. Distrubution, mortality, diet and conservation of irrawady dolphins (*Orcaella brevirostris*) in Lao PDR. **Asian Marine Biology** 14:41-48.

Balding, T.A. 1967. Radio-tracking a White-Tailed Deer. **The Ohio Journal of Science** 67 (6): 382-384.

Beasley, J.C. 2005. **Home Range Attributes and Multi-Scale Habitat Selection of Raccoons (Procyon lotor) in Northern Indiana.** M.S. Thesis, Pudue University.

Beasley, J.C., T.L. Doevault, M.I. Retamosa and O.E. Rhodes JR. 2007. A hierarchical analysis of habitat selection by raccoons in northern Indiana. **Journal of Wildlife Management** 71 (4): 1125-1133.

Beaudoin, C., M. Crete, J. Huot, P. Etcheverry and S.D. Cote. 2004. Does predation risk affect habitat use in snowshoe hares? **Ecoscience** 11 (4): 370-378.

Beck-King, H., O.V. Helversen and R. Beck-King. 1999. Home range, population density, and food resources of *Agouti paca* (Rodentia: Agoutidae) in Costa Rica: A study using Alternative Methods. **Biotropica** 31 (4): 675-685.

Bertolino, S., N. Cordero and I. Currado. 2003. Home rang and habitat use of garden dormouse (*Eliomys quersinus*) in mountain habitat in summer. **Acta Zoologica Academiae Scientiarum Hungaricae** 49 (1): 11-18.

Bhumpakphan, N. 2000. **Wildlife Management**. Faculty of Forestry, Kasetsart University. (in Thai).

_____. 2006. **Kha-nyou the new rodent and the fossil forms - Shantung and Li rodents.** Kasetsart University. (in Thai) (Unpublished manuscript).

Bias, M.A. and M.L. Morrison. 2006. Habitat selection of the salt marsh harvest mouse and sympatric rodent species. **Journal of Wildlife Management** 70 (2): 732-742.

Bocca, M., L. Carisio and A. Rolando. 2007. Habitat use, home ranges and census techniques in the Black Woodpecker (*Dryocopus martius*) in the Alps. **Ardea** 95 (1): 17-29.

Bolen, E.G and W.L Robinson. 1999. **Wildlife Ecology and Management**. 4th ed. Prentice-Hall, Inc. New Jersey.

Borkowski, J. and M. Pudelko. 2007. Forest habitat use and home-range size in radio-collared fallow Deer. **Annales Zoologici Fennici** 44: 107-114.

Broomhall, L.S., M.G.L. Mills and J.T. du Toit. 2003. Home range and habitat use by Cheetahs (*Acinonyx jubatus*) in the Kruger National Park. **Journal of Zoology** 261: 119-128.

Brown, P.R., T. Nguey Phu and P.B. Banks. 2005. Movements, habitat use and response of ricefield rats to removal in an intensive cropping system in Vietnam. **Belgian Journal of Zoology** 135: 145-152.

Buenestado, F.F., P. Ferreras, M. Delibes-Mateos, F.S. Tortosa, J.A. Blanco-Aguiar and R. Villafuerte. 2008. Habitat selection and home range size of red-legged partridges in Spain. **Agriculture, Ecosystems and Environment** Vol. 126 (2008): 158-162.

Burt, W.H. 1943. Territoriality and home range concepts as applied to mammals. **Journal of Mammalogy** 24 (3): 346-352.

Charles, R.F. and V. Christopher. 2002. Home range, habitat use, and activity of Baird's Tapir in Costa Rica. **Biotropica** 34 (3): 423-437.

Clint, W.B., E.A David and L.K. Patricia. 2001. **Home Range and Habitat Use of Northern Goshawks (*Accipiter gentilis*) in Minnesota.** (Unpublished manuscript).

Coleman, J.C. and C.T. Downs. 2010. Does home range of the black-tailed tree rat (*Thallomys nigricauad*) change with season along an aridity gradient? **African Zoology** 45 (2): 177-188.

Cooper, L.D. and F.A. Randall. 2007. Seasonal changes in home range of the Giant Kangaroo Rat (Ripodomys ingens): A study of flexible social structure. **Journal of Mammalogy** 88 (4): 1000-1008.

Cox, M.P.G., C.R. Dickman and W.G.Cox. 2000. Use of habitat by the black rat (Rattus rattus) and North Head, New South Wales: an observational and experimental study. **Austral Ecology** 25: 375-385.

Cutrera, A.P., C.D. Antinuchi, M.S. Mora and A.I. Vassallo. 2006. Home range and activity patterns of the South American subterranean rodent (*Ctenomys talarum*). **Journal of Mammalogy** 87 (6): 1183-1191.

Dasmann, R.F. 1964. **Wildlife Biology**. John Wiley & Sons. Inc., California.

Dawson, M.D., L. Marivaux, C.K Li, K.C Beard and G. Metais. 2006. Laonastes and the ‘‘Lazarus Effect’’ in recent Mammals. **Science** 311: 1456-1458.

Department of Forestry. 2008. **Lao wildlife and Aquatic Red List**. DOF, Vientiane (in Lao).

Devillard, S., J. Aubineau, F. Berger, Y. Leonard, A. Roobrouck and S. Marchandeau. 2007. Home range of the European rabbit (Oryctolagus cuniculus) in three contrasting French populations. **Mammalian Biology** 73 (2): 128-137.

Dickson, B.G and P. Beier. 2002. Home-rang and habitat selection by adult cougars in Southern California. **Journal of Wildlife Management** 66 (40): 1235-1245.

Douangboupha, B., K. Khamphoukeo, V. Herbreteau, R. Cornette, J.P. Hugot and S. Morand. 2009. New pieces of information about the Kha-nyou, the recently discovered enigmatic rodent from the Lao PDR. **The Lao Jurnal of Agrecultyre and Forestry** (20): 48-54.

Douglass, R.J., W.J. William, J. Semmens, S.J. Matlock-Cooley and A.J. Kuenzi. 2006. Deer mouse movement in Peridomestic and Sylvan Settings in relation to Sin Nombre Virus antibody prevalence. **Journal of Wildlife Diseases** 42 (4): 813-818.

Dowding, J.E. and E.C. Murphy. 1994. Ecology of ship rats (*Rattus rattus*) in a Kauri (Agathis australis) forest in Northland, **New Zealand. New Zealand Journal of Ecology** 18 (1): 19-27.

Drickamer, L.C., S. Lenington, M. Erhart and A.S. Bobinson. 1995. Trappability of wild house mice (Mus domesticus) in large outdoor pens: implication for dodels of t-complex gene frequency. **The American Midland Naturalist Journal** 133: 283-289.

Duckworth, J.W., R.J. Timmins and K. Cozza. 1993. **A Wildlife and Habitat Survey of Phou Xang He Propose protected Area, Savannakhet, Laos.** Rept.

_____, R.E. Salter and W.G. Robinchaud. 1999. Introduction, pp. 1-41. *In* J.W. Duckworth, R.E. Salter and K. Khounboline, comps. **Wildlife in Lao PDR**. IUCN, Vientiane.

_____, R.J Tizard, R.J. Timmins, R.M. Thewlis, W.G. Robichaud and T.D. Evans. 1998. Bird records from Laos, October 1994-August 1995. **Forktail** Vol. 13 (1998): 33-68.

Ebensperger, L.A., R. Sobrero, V. Campos and S.M. Giannoni. 2008. Activity, range areas, and nesting patterns in the Viscacha rat (*Octomys mimax*). **Journal of Arid Environments** 72: 1174-1183.

Eccard, J.A., J. Meyer and J. Sundell. 2004. Space use, circadian activity pattern, and mating system of the Nocturnal tree rat Thaillomys nigricauda. **Journal of Mammalogy** 85 (3): 440-445.

Eiris, G.C and G.R. Barreto. 2009. Home range of Marsh rats, Holochilus sciureus, a rodent pest in rice fields of Venezuela. **Journal of Science and Technology of the Americas** 34: 400-405.

Evans, T.D., A.T. Stones, R.C.M Thewlis and H.C. Towll. 1996. **A Wildlife and Habitat Survey of Phou Xiang Thong National Biodiversity Conservation Area, Champasak and Salavan Province, Lao PDR.** Rept.

Flynn, L.F. 2007. Origin and evolution of the Diatomyidae, with clues to Paleoecology from the fossil record. **Bulletin of Carnegie Museum of Natural History** 39 (1): 173-181.

Francis, C.M. 1999. Order Rodentia, family Muridae, pp. 237-252. *In* J.W. Duckworth, R.E. Salter and K. Khounboline, comps. **Wildlife in Lao PDR**. IUCN, Vientiane.

Fuchs, J., A. Cibois, J.W. Duckorth, R. Eve, W.G. Robichaud, T. Tizard and D.V. Gansberghe. 2007. Birds of Phongsaly province and the Nam Ou river, Laos. **Forktail** Vol. 23 (2007): 22-86.

Garton, E.O., M.J. Wisdom, F.A. Leban and B.K. Johnson. 2001. Experimental design for radio telemetry studies, pp. 15-42. *In* J.J. Millspaugh and J.M. Marzluff, eds. **Radio Tracking and Animal Populations**. Academic Press, Califo

Gottesman, A.B., P.R. Krausman, M.L. Morrison and Y. Petryszyn. 2004. Movements and home range of Brush Mice. **The Southwestern Naturalist** 49 (2): 289-294.

Graham, C. 2001. Habitat selection and activity budgets of Keel-Billed toucans at the Landscape level. **The Condor** 103: 776-784.

Graham, M.D., I. Douglas-Habmilton, W.M. Adams and P.C. Lee. 2009. The movement of African elephants in Human-dominated land-use mosaic. **Animal Conservation** 12: 445-455.

Green, M.C., L.A. Harveson and L.E. Loomis. 2001. Habitat selection by Collared peccaries in Trans-Pecos Texas. **The Southwestern Naturalist** 46 (2): 246-251.

Grigg, G.C., A.R. Pople and L.A. Reard. 1995. Movements of feral camels in central Australia determined by satellite telemetry. **Journal of Arid Environments** 31: 459-469.

Hafidzi, M.N and M.K. Saayon. 2001. Status of rat infestation and recent control strategies in oil palm plantations in Peninsular Malaysia. **Pertanika Journal of Tropical Agricultural Science** 24 (2): 109-114.

Hall, L.S., P.R. Krausman and M.L. Morrison. 1997. The habitat concept and a plea for standard terminology. **Wildlife Society Bulletin** 25:173-182.

Harper, G.A., K. J.M. Dickson and P.J. Seddon. 2005. Habitat use by three rat species (*Rattus* spp.) on Stewart Island/Ratiura, New Zealand. **New Zealand Journal of Ecology** 29 (2): 251-260.

Harris, J.H. and P. Leitner. 2004. Home range size and use of space by adult Mohave ground squirrels, *Spermophilus mohavensis*. **Journal of Mammalogy** 85 (3): 517-523.

Haughland, D.L., K.W. Larsen and M. Wheatley. 2008. The important of radio-telemetry in arboreal squirrel research. **Current Science** 95 (7): 912-917.

Hautier, L. and S. Saksiri. 2009. Masticatory muscle architecture in the Laotian rock rat Laonastes aenigmamus (Mammalia, Rodentia): new insights into the evolution of hystricognathy. **Journal of Anatomy** 315: 401-410.

Hill, J. and G.D. Grossman. 1987. Home range estimates for three North American stream fishes. **Copeia** 2: 376-380.

Holloway, G.L. and J.R. Malcolm. 2007. Northern and southern flying squirrel use of space within home ranges in central Ontario. **Forest Ecology and Management** 242: 747-755.

Houser, A.M., M.J. Somers and L.K. Boast. 2009. Home range use of free-ranging Cheetah on farm and conservation land in Botswana. **South African Journal of Wildlife Research** 39 (1): 11-22.

Huchon, D., P. Chevret, U. Jordan, C. W. Kilpatric, V. Ranwez, P. D. Jenkins, J. Bosius and J. Schitz. 2007. Multiple molecular evidences for a living Mammalian Fossil. **Proceeding of the National Academy of Sciences of the United States of Anerica** 104 (18): 7495-7499.

Ibrahim, A.A. 2002. Activity area, movement patterns, and habitat use of the desert monitor, *Varanus griseus*, in the Zaranik Protected Area, North Sinai, Egypt. **African Journal of Herpetology** 51 (1): 35-45.

Jenkins, P.D., C.M. Kilpatrick, M.F. Robinson and R.J. Timmins. 2005. Morphological and molecular investigations of a new family, genus and species of rodent (Mammalia: Rodentia: Hystricognatha) from Lao PDR. **Systematic and Biodiversity** 2 (4): 419-454.

Jennifer, C.H. 1997. **Survival, Home Range and Spatial Relationships of Virginia's Exploited Black Bear Population.** M.S. Thesis, Virginia Polytechnic Institute and State University.

Jennifer, P.A. 2005. **Home Range and Behavior of the Timber Rattlesnake (*Crotalus horridus*).** M.S. Thesis, Marshall University.

Johnson, A., C. Vongkhamheng, Venevongphet, T. Saithongdam and M. Hedemark. 2006. Status of tiger, prey and human-tiger conflict in the Nam Et-Phou Louey national protected Area, Lao PDR, pp. 231-235. *In* McNeely, J.A., T.M. McCarthy, A. Smith, L. Olsvig-Whittaker and E.D. Wikramanayake, eds. **Conservation Biology in Asia**. Conservation Biology Asia Section and Resources Himalaya, Kathmandu, Nepal.

Johnson, A., S. Singh, M. Duangdala and M. Hedemark. 2005. The western black crested gibbon *Nomascus concolor* in Laos: new records and conservation status. **Oryx** 39 (3): 311-317.

Johnson, D.H. 1980. The comparison of usage and availability measurements for evaluating resource preference. **Ecology** 61 (1): 65-71.

Jone, G. and M. Morton. 1992. Radio-tracking study on habitat use by greater horseshoe bats (*Rhinolophus ferrumequinum*), pp. 521-538. *In* I.G. Priede and S.M. Swift, eds. **Wildlife Telemetry Remote Monitoring and Tracking of Animals**. ELLIS HORWOOD LIMITED, Chichester, UK.

Ken, P.A., R.B. Peter, J. Jens, J.K. Charles and R.S. Grand. 2003. **Field Methods for Rodent Studies in Asia and the Indo-Pacific**. BPA Print Group, Melbourne.

Kenward, R.E. 2001. **A Manual for Wildlife Radio Tagging**. Academic Press, London.

Koen, E.L. 2005. **Home Range, Population Density, Habitat Preference, and Survival of Fishers (*Martes pennanti*) in Eastern Ontario**. M.S. Thesis, University of Ottawa, Canada.

Kotrnon, K., A. Thammathaworn and P. Chantaranothai. 2007. Comparative anatomy of the genus Pyrrosia Mirbel (Polydiaceae) in Thailand. **The Natural History Journal of Chulalongkorn University** 7 (1): 75-85.

Lambert, T.D. and G.H. Adler. 2000. Microhabitat use by a tropical forest rodent, Proechimys semispinosus, in central Panama. **Journal of Mammalogy** 81 (1): 70-76.

Lao Wildlife Convervation Society. 2005. **Survey, Assessment, and Conservation of the Indochinese Tiger (*Panthera tigris corbetti*) in Lao PDR-Year 2**. Rept.

Lemen, C.A. and P.W. Freeman. 1986. Habitat selection and movement patterns in Sandhills rodents. **Prairie Naturalist** 18 (3): 129-141.

Lorkhamheaung, P. and S. Manisy 2010. **Study of Leaves Epidermis Expected to be Food of *Laonastes aenigmamus* in Phou Hin Poun NBCA, Laos**. B.S. Thesis, National University of Laos. (In Lao).

Mantovani, A. and T.E. Pereira. 2005. Comparative anatomy of leaf and spathe of nine species of *Anthurium* (section *Urospaix*; subsection *Flavescentiviridia*) (Araceas) and their diagnostic potential fore taxonomy. **Rodriguesia** 56 (88): 145-160.

Mariana, A., M.N. Shukor, N.H. Muhd, N.B. Intan and T.M. Ho. 2010. Movements and home range of a common species of tree-shrew, *Tupaia glis*, surrounding houses of otoacariasis cases in Kuantan, Pahang, Malaysia. **Asian Pacific Journal of Tropical Medicine** (2010): 427-434.

McCarthy, T.M., T.K. Fuller and B. Munkhtsog. 2005. Movement and activities of snow leopards in southwest Mongolia. **Biological Conservation** 124: 1174-1183.

McComb, B.C. 2008. **Wildlife Habitat Management: Concepts and Applications in Forestry**. CRC Press. Taylor & Francis Group, London.

McLoughlin, D., C. Benson, B. William and D. Cotton. 2010. The movement patterns of two populations of Twites *Carduelis flavirostris* in Ireland. **Ringing & Migration** 25: 15-21.

Mech, L.D., K.L. Heezen and D.B. Siniff. 1966. Onset and cessation of activity in cottontail Rabbits and snowshoe Hares in relation to sunset and sunrise. **Animal Behaviour** 14: 410-413

Menzel, J.M., W.M. Ford, J.W. Edwards and T.M. Terry. 2006. Home range and habitat use of the Vulnerable Virginia northern flying squirrel *Glaucomys sabrinus fuscus* in the Central Appalachian Mountains, USA. **Oryx** 40 (2): 204-210.

Miller, C.J. and T.K. Miller. 1995. Population dynamics and diet of rodents on Rangitoto island, New Zealand, including the effect of a 1080 poison operation. **New Zealand Journal of Ecology** 19 (1): 19-27.

Ministry of Agriculture and Forestry. 2003. **Biodiversity Country Report**. Ministry of Agriculture and Forestry, Vientiane

Mizutani, F. and P.A. Jewell. 1998. Home-range and movements of leopards (*Panthera pardus*) on a livestock ranch in Kenya. **Journal of Zoology** 244: 269-286. *Cited* C.O. Mohr. 1947. Table of equivalent populations of North American small mammals. **American Midland Naturalist** 37: 223-249.

Moraes Junior, E.A. 2004. Radio tracking of one *Metachirus nudicaudatus* (Desmarest, 1817) individual in Atlantic Forest of Southeastern Brazil. **Boletim Museu Biologia Mello Leitão** 17: 57-64.

Moraes Junior, E.A. and A.G. Chiarello. 2005. A radio tracking study of home range and movement of the Marsupial (*Micoureus demerarae*) (Mammalia, Didelphidae) in the Atlantic forest of Sounth-eastern Brazil. **Revista Brasileira de Zoologia** 22 (1): 85-91.

Moreno, A.S and A.M.A. Espinosa. 2009. Mammalian prey of Barn owl (*Tyto alba*) in Southeastern Oaxaca, Mexico. **Acta Zoologica Mexicana** 25 (1): 143-149.

Mueller-Dombois, D. and H. Ellenberg. 1974. **Aims and Methods of Vegetation Ecology**. John Wiley & Sons, New York.

Murphy, E.C. and J.E. Dowding. 1995. Ecology of the stoat in Nothofagus forest: home range, habitat use and diet at different stages of the beech mast cycle. **New Zealand Journal of Ecology** 19 (2): 97-109.

Musser, G.G., A.L Smith, M.F. Robinson and D.P. Lunde. 2005. **Description of a new genus and species of Rodent (Murinae, Muridae, Rodentia) from the Khammouan Limestone National Biodiversity Conservation Area in Lao PDR**. American Museum Novitates. Available source: http://digitallibrary.amnh.org/dspace/handle/2246/5666, February 15, 2009.

Nakagawa, M., H. Miguchi, K. Sato and T. Nakashizuka. 2007. Apreliminary study of two sympatric Maxomys rats in Sarawak, Malaysia: specing patterns and population dynamucs. **The Raffles Bulletin of Zoology** 55 (2): 381-387.

Nass, R.D. 1977. Movements and home ranges of Polynesian rat in Havaiian Sugarcane. **Pacific Science** 31 (2): 135-142.

Nadler, T. 2009. Observations of Lao langur (*Trachypithecus* [*laotum*] *laotum* and black langurs (*Trachypithecus* [*laotum*] *hatinhensis* morph *ebenus*) in Khammouane Province, Lao and remarks to their systematic positing. **Vietnames Journal of Primatology** 3: 9-15.

National congress. 2008. **Aquatic and Wild Animal Law**. Forest Department, Ministry of Agriculture and Forestry, Vientiane Capital City. (in Lao).

Odden M. and P. Wegge. 2010. Spacing and activity of leopards Panthera pardus inRoyal Bardia National Park, Nepal. **Wildlife Biology** 11 (2): 145-152.

Orlov, N.L., A.N. Tikonov and A.V. Abramov. 2009a. **Results of Field Survey in Thakhek District, Khammouane Province, Lao PDR**. Rept. (Unpublished manuscript)

_____, S. Ghophanxay, T. Phimminith and K. Phomphoumy. 2009b. A new species of Rhacophorus GENUS (AMPHIBIA: ANURA: RHACOPHORIDAE: RHACOPHORINAE) from Khammouan Province, Lao PDR. **Russian Journal of Herpetology** 16 (4): 295-303.

Orteca, J.C. 1990. Home-range size of adult rock squirrel (*Spermophilus variegates*) in southeastern Arizona. **Journal of Mammalogy** 71 (2): 171-176.

Osborn, F.V. 2004. The concept of home range in relationship of Elephants in Africa. **Pachyderm** 37: 37- 44.

Patton, D.R. 1992. **Wildlife Habitat Relationships in Forested Ecosystems**. Timber Press, Inc. Portland, Oregon.

Pouliquen, O., M. Leishman and T.O. Redhead. 1990. Effects of radio collars on wild mice *Mus domesticus.* **Canadian Journal of Zoology** 68 (7): 1607-1609.

Prevedello, J.A., R.G. Rodrigues and E.L.A. Monteiro-Filho. 2010. Habitat selection by two species of small mammals in the Atlantic Forest, Brazil: Comparing results from live trapping and spool-and-line tracking. **Mammalian Biology** 75 (2): 106-114.

Priotto, B.J., A. Steinmann and J. Polop. 2002. Factors affecting home range size and overlap in *Calomys venustus* (Murdae: Sigmonontinae) in Argentine agro-ecosystems. **Mammalian Biology** 67 (2): 97-104.

Provincial Agriculture and Forest Office. 2008. **Regulation on Conservation of Kha Nhou**. PAFO. Khammouane. Lao PDR.. (in Lao).

Quirici, V., R.A. Castro, L. Ortiz-Tolhuysen, A.S. Chesh, J.R. Burger, E. Miranda, A. Cortes, L.D. Hayes and L.A. Ebensperger. 2010. Seasonal variation in the range areas of the diurnal rodent *Octodon degus*. **Journal of Mammalogy** 91 (2): 458-466.

Radic, V.O., R. Matic, D. Kataranovski and S. Stamenkovic. 2006. Spatial organization and home range of *Apodemus flavicollis* and *A. agrarius* on MT. Avala, Serbia. **Acta Zoologica Academiae Scientiarum Hungaricae** 52 (1): 81-96.

Ribble, D.O., A.E. Wurtz, E.K. McConnell, J.J. Buegge and K.C. Welch. 2002. A comparison of home ranges of two species of Peromyscus using trapping and radio-telemetry data. **Journal of Mammalogy** 83 (1): 260-266.

Robichaud, W and B. Sounthala. 1995. **A Preliminary Wildlife and Habitat Survey of Phou Dendin National Biodiversity Conservation Area, Phongsali,** Rept.

_____, C.W. Marsh, S. Southammakoth and S. Khounthikoummane. 2001. **Review of the National Protected Area System of Lao PDR.** Lao-Swedish Programme, Vientiane.

Robinson, M.F and M. Webber. 2000. Survey of bats (Mammalia: Chiroptera) in the Khammouan Limestone National Biodiversity Conservation Area, Lao P.D.R. **Nat. Hist. Bull. Siam. Soc**. 48: 21-45.

Rodgers, A.R. and A.P. Carr. 1998. **HRE: The Home Range Extension to ArcView. User's Manual**. Centre for Northern Forest Ecosystem Resarch, Ontario Ministry of Natural Resources, Available source: http://flash.lakeheadu.ca/~arodgers/hre/, March 7, 2011.

Rowe, J.W. 2003. Activity and movements of Midland Painted Turtles (*Chrysemys picta marginata*) living in a small marsh system on Beaver Island, Michigan. **Journal of Herpetology** 37 (2): 342-353.

Sager-Fradkin, K.A., K.J. Jenkins, P.J. Happe, J.J. Beecham, R. Gerald Wright and R.A. Hoffman. 2008. Space and habitat use by Black Bears in the Elwha Valley Prior to dam removal. **Northwest Science** Vol. 82 (2008): 164-178.

Saiful, A.A., A.H. Idris, Y.N. Rashid, N. Tamuran and F. Hayashi. 2001. Home range size of sympatric squirrel species inhabiting a lowland Dipterocarp Forest in Malaysia. **The Journal of Tropical Biology and Conservation** 33 (2): 346-351.

Sankar, K., Q. Qurenshi, P. Nigam, P. Nigam, P.K. Malik, P.R. Sinha, R.N. Mehrotra, R. Gopal, S. Bhattacharjee, K. Mondal and S. Gupta. 2010. Monitoring of reintroduced tigers in Sariska Tiger Reserve, Western India: preliminary findings on home range, prey selection and food habits. **Tropical Conservation Science** 3 (3): 301-318.

Schmidt, N.M., T.B. Berg and T.S. Jensen. 2002. The influence of body mass on daily movement patterns and home ranges of the collared lemming (*Dicrostonyx groenlandicus*). **Canadian Joural of Zoology** 80: 64-69.

Schradin, C. 2005. Whole-day follows of striped mice (*Rhabdomys pumilio*), a diurnal murid rodent. **Japan Ethological Society and Springer-Verlag Tokyo** 24: 37-43.

Schradin, C. and N. Pillay. 2006. Female striped mice (Rhabdomys pumilio) change their home range in response to seasonal variation in food availability. **Behavioral Ecology** 17 (3): 452-458.

Schrecengost, J.D., J.C. Kilgo, H. Scott Ray and K.V. Miller. 2009. Home range, Habitat use and survival of Coyotes in Western South Carolina. **American Midland Naturalist** 162: 346-355.

Scopin, A.E., A.P. Saveljev, N.A. Suntsova, S. Gnophanxay, A.N. Tikhonov and A.V. Abramov. 2011. Digestive system of the Laotian rock rat Laonates aenigmamus (Rodentia: Diatomyidae) from the evolutionary viewpoint. **Proceedings of the Zoological Institute RAS** 315 (1): 3-18.

Sharpe, D. and R.L. Goldingay. 2007. Home range of the Australian squirrel gliger, *Petaurus norfolcensis* (Diprotodontia). **Journal of Mammalogy** 88 (6): 1515-1522.

Showler, D.A., P. Davidson, C. Vongkhamheng and K. Salivong. 1998. **A Wildlife and Habitat Survey of the Southern Border of Xe Sap National Biodiversity Conservation Area and the Dakchung Pateau, Xe Kong Province, Lao PDR.** Rept.

Simcharoen, S. 2008**. Ecology of the Leopard (*Pantera pardus* Linn.) in Huai Kha Khaeng Wildlife Sanctuary**. PhD. Thesis, Kasetsart University.

_____, A.C.D. Barlow, A. Simcharoen and L.D. Smith. 2008. Home range and daytime habitat selection of Leopards in Huai Kha Khaeng Wildlife Sanctuary. **Biological Conservation** 141: 2242-2250.

Smith, A.L., M.F. Robinson and M. Webber. 2004. Muridae (Rodentia) from the Khammouan limestone and Xe Piane National Biodiversity Conservation Areas, Lao PDR. **Mammalia** 68 (2-3): 167-173.

Sommer, S. 1996. Ecology and social structure of Hypogeomys antimena, an endemic rodent of the dry deciduous forest in Western Managascar. **Biogeographie de Madagascar** 1996: 295-302.

Soontornpitakkool, S. 1996. **Population Characteristics of Rat and Mice in Evergreen Forest and Grassland at Khao Yai Nation Park**. M.S. Thesis, Kasetsart University.

Southammakot, S. and C. Iain. 2001. **National Biodiversity of Laos's information**. Department of Forestry, Ministry of Agricultural and Forestry. Vientiane. (in Lao).

Steinmetz, R. 1998a. **A participatory Biodiversity Assessment of Khammouan Limestone National Biodiversity Conservation Area, Khammouan Province, Lao PDR.** Rept.

_____. 1998b. **A Survey of Habitat and Mammals in and Around Khammouan Limestone National Biodiversity Conservation Area.** Rept.

Sukmasuang, R. 2001. **Ecology of Barking Deer (*Muntiacus* spp.) in Huai Kha Khaeng Wildlife Sanctuary**. Ph.D. Thesis, Kasetsart University.

Talamoni, S.A., D. Couto, D.A. Cordeiro Junior and F.M. Diniz. 2007. Diet of some species of Neotropical small mammals. **Mammalian Biology** 73: 337-341.

Tattersall, F.H., D.W. Macdonald, B.J. Hart, W.J. Manley and R.E. Feber. 2001. Habitat use by wood mice (*Apodemus sylvaticu*s) in a changeable arable landscape. **Journal of Zoology** 255: 487-494.

Taulman, J.F. and K.G. Smith. 2004. Home range and habitat selection of southern flying squirrels in fragmented forests. **Mammalian Biology** 69 (1): 11-27.

Tester, J.R., D.W. Warner and W.W. Cochran. 1964. A radio-tracking system for studying movements of deer. **Journal of Wildlife Management** 28 (1): 42-45.

Timmins, R.J. 1997. **Note on Wildlife and Habitats in Khammouan Limestone National Biodiversity Conservation Area, Khammouan Province, Lao PDR.** Rept.

_____, and C. Vongkhamheng. 1996a. **A Preliminary Wildlife and Habitat Survey of Xe Sap National Biodiversity conservation Area and Mountains to the South, Salavan Province, Lao PDR.** Rept.

_____, and _____. 1996b. **A Preliminary Wildlife and Habitat Survey of the Dong Khanthung Area, Champasak Province, Lao PDR.** Rept.

_____, and J.W. Duckworth. 2008. Diurnal squirrels (Mammalia Rodentia Sciuridae) in Lao PDR: distribution, status and conservation. **Tropical Zoology** 21: 11-56.

_____, and K. Khounboline. 1996. **A Preliminary Wildlife and Habitat Survey of Hin Namno National Biodiversity Conservation Area, Khammoune Province, Lao PDR.** Rept.

Tizard, R.J. 1996. **A Prelininary Wildlife and Habitat Survey of the Proposed Northern Extension to the Nakai-Nam Theun National Biodiversity Conservation Area and the Adjacent Nam Ghouang Area, Bolikhamsai Province, Lao PDR.** Rept.

_____, R., P. Davidson, K. Khounboline and K. Salivong. 1997. **A Wildlife and Habitat Survey of Nam Ha and Nam Kong Protected Areas** Final Rep.

Traba, J., P. Acebes, V.E. Campos and S.M. Giannoni. 2010. Habitat selection by two sympatric rodent species in the Monte desert, Argentina. First data for *Eligmodontia moreni* and *Octomys mimax.* **Journal of Arid Environments** 75: 179-185.

Valenzuela, D. and G. Ceballos. 2000. Habitat selection, home range, and activity of the white-nosed coati (*Nasua narica*) in a Mexican tropical dry forest. **Journal of Mammalogy** 81 (3): 810-819.

Van der Ree, R. and A.F. Bennett. 2003. Home range of the squirrel glider (Petaurus norfolcensis) in a network of remnant linear habitats. **Journal of Zoology** 259: 327-336.

Vassallo, A.I., M.J. Kittlein and C. Busch. 1994. Owl predation on two sympatric species of Tuco-tucos (Rodentia: Octodontidae). **Journal of Mammalogy** 75 (3): 725-732.

Vaughan, C., O. Ramirez, G. Herrera and E. Fallas. 2006. Home range and habita use of Basiliscus plumifrons (Squamata: Corytophanidae) in an active Costa Rican cacao farm. **Appllied Herpetology** 4 (3): 217-226.

Vieira, E.M., G. Iob, D.C. Briani and A.R.T. Palma. 2005. Microhabitat selection and daily movements of two rodents (*Necromys lasiurus* and *oryzomys scotti*) in Brazilian Cerrado, as revealed by a spool-and-line device. **Mammalian Biology** 70 (6): 359-365.

Vongsa, U. 2010. **Distribution, Natural History and Threat of Kha Nyou (*Laonastes aenigmamus*)**. M.S. Thesis, National University of Laos. (In Lao).

Vukicevic-Radic, O., R. Matic, D. Kataranovski and S. Stamenkvic. 2006. Spatial organization and home range of Apodumus flavicollis and A. agrarius on MT. Avala, Serbia. **Acta Zoologica Academiae Scientiarum Hungaricae** 52 (1): 81-96.

Walston, J. and M. Vinton. 1998. A **Wildlife and Habitat Survey of Hin Namno National Biodiversity Conservation Area and Adjacent Areas.** Biodiversity Survey. Rept.

Wells, K., E.K.V. Kalko, M.B. Lakim and M. Pfeiffer. 2008. Movement and ranging patterns of a tropical rat (*Leopoldamys sabanus*) in logged and unlogged rain forest. **Journal of Mammalogy** 89 (3): 712-720.

_____, M.B. Lakim and M. Pfeiffer. 2006. Nest sites of rodents and treeshrews in Borneo. **Ecotropica** 12: 141-149.

Wendell, E.D. 1967. **Biotelemetry-its use in vertebrate control studies**. University of Nebraska - Lincoln. Available source: http://digitalcommons.unl.edu/vpc3/27, October 27, 2010.

Whisson, D.A., J.H. Quinn and K.C. Collins. 2007. Home range and movement of roof rats (*Rattus rattus*) in an old-growth riparian forest, Chlifornia. **Journal of Mammalogy** 88 (3): 589-594.

Withey, J.C., T.D. Bloxton and J.M. Marzluff. 2001. Effects of tagging and location error in wildlife radiotelemetry studies, pp. 43-75. *In* J.J. Millspuagh and J.M. Marzluff, eds. **Radio Tracking and Animal Population**. Academic Press, California.

Wolfe, A. and T.J. Hayden. 1996. Home range sizes of Irish Mountain Hares on coastal grassland. **Biology and Environment: Proceedings of the Royal Irish Academy** 96b (3): 141-146.

Woxvold, I.A., J.W. Duckworth and R.J. Timmins. 2009. An unusual new bulbul (Passeriformes: Pycnonotidae) from the limestone karst of Lao PDR. **Foktail** 25: 1-12.

Zwicker, K. 1989. Home range and spatial organization of the Beach Vole, *Microtus breweri*. **Behavioral Ecology and Sociobiology** 25: 161-170.

APPENDIX

Appendix Table 1 Measurements information of remains Kha nyou

Sex	Weight (g)	Head Body Length (cm)	Tail length (cm)	Hind Foot Length (cm)	Ear Length (cm)	Collection Date
Adult Female	520	27.00	16.50	4.60	2.50	14.11.09
Adult Female	484	27.20	14.80	4.40	2.40	09.12.09
Adult Female	360	24.00	12.00	4.40	2.30	10.12.10
Adult Female	525	28.00	16.00	4.40	2.50	29.12.10
Adult Female	420	25.00	15.60	4.40	2.20	29.12.10
Adult Female	510	25.50	15.50	4.40	2.40	30.01.10
Adult Female	410	26.50	14.40	4.40	2.30	02.01.11
Adult Female	300	24.50	12.00	4.10	2.20	02.01.11
Young Male	170	18.50	11.50	3.70	1.80	14.11.09
Young Male	140	21.50	12.20	3.80	2.00	02.01.11
Adult Male	392	23.50	13.50	4.40	2.70	12.12.09
Adult Male	365	25.20	13.80	4.20	2.30	16.12.09
Adult Male	400	25.50	14.00	4.00	2.20	16.12.09
Adult Male	425	26.50	15.20	4.50	2.30	07.01.10
Adult Male	505	29.20	14.70	5.00	2.40	07.01.10
Adult Male	518	28.50	16.20	4.50	2.50	11.01.10
Adult Male	470	26.20	13.30	4.60	2.40	29.12.10
Adult Male	440	26.50	14.30	4.20	2.30	30.12.10

Appendix Table 2 Measurements information of live-trapped Kha nyou

Sex	Weight (g)	Head Body Length (cm)	Tail Length (cm)	Hind Foot Length (cm)	Ear Length (cm)	Collection Date
Male (K 61)	374	23.00	15.50	4.30	2.20	12.12.09
Male (K 55)	360	23.40	15.40	4.40	2.20	01.01.10
Male (K 47)	355	24.50	5.50	4.40	2.30	02.01.11
Male (Ko 1)	375	24.30	14.50	4.30	2.30	30.12.11
Female (K 65)	505	25.50	16.00	4.40	2.30	04.01.10
Female (K 39)	290	23.50	12.50	4.20	2.10	03.01.11
Female (Ko 2)	420	23.80	14.50	4.50	2.20	03.01.11

Appendix Table 3 Measurements information of other live-trapped rodent

Sex	Weight (g)	Head Body Length (cm)	Tail Length (cm)	Hind Foot Length (cm)	Ear Length (cm)	Collection Date
1. *Saxatilomys paulinae*						
Adult male	130	15.00	16.50	3.20	2.40	09.12.09
Adult male	135	14.60	16.40	3.30	2.20	11.12.09
Adult male	125	14.00	16.30	3.00	2.20	10.12.09
Adult male	120	14.30	15.20	3.20	2.30	03.01.11
Adult male	130	14.40	16.20	3.10	2.30	03.01.11
Adult male	140	16.20	17.00	3.40	2.40	12.12.09
Adult male	135	14.70	16.50	3.20	2.30	09.12.09
Adult female	130	15.50	16.80	3.30	2.50	01.01.10
Adult female	135	15.00	16.40	3.40	2.40	03.01.10
Adult female	125	14.30	16.00	3.20	2.30	03.01.10
Adult female	136	14.00	15.70	3.00	2.30	11.12.09
2. *Leopoldamys sabanus*						
Adult female	410	24.50	32.50	4.80	3.30	12.12.09
Adult female	395	24.00	33.00	4.30	3.20	01.01.10
Adult female	400	25.00	32.50	4.40	3.40	05.01.10
3. *Callosciurus finlaysonii*						
Adult male	195	21.30	22.50	4.50	2.10	03.01.11

Appendix Table 4 List of mammal species in the study area

No.	Family	Zoological Name	Source Information	
			Observation	Interview
1	Bovidae	*Capricornis sumatraensis*	X	x
2	Cercopithecidae	*Macaca assamensis*		x
3	Cercopithecidae	*M. mulatta*	X	x
4	Cercopithecidae	*M. leonine*		x
5	Cercopithecidae	*M. arctoides*		x
6	Cercopithecidae	*Semnopithecus francoisi*	X	x
7	Cervidae	*Muntiacus muntjak*	X	x
8	Cervidae	*Rusa unicolor*		x
9	Cervidae	*Tragulus kanchil*		x

Appendix Table 4 (Continued)

No.	Family	Zoological Name	Source Information	
			Observation	Interview
10	Diatomyidae	*Laonastes aenigmamus*	X	x
11	Erinaceidae	*Hylomus megalotis*	X	x
12	Felidae	*Neofelis nebulosa*	X	x
13	Felidae	*Prionailurus bengaolensis*	X	x
14	Herpestidae	*Herpestes javanicus*		x
15	Hylobatidae	*Hylobates leucogenys*		x
16	Hystricidae	*Hystrix brachyura*	X	x
17	Hystricidae	*Atherurus macrourus*	X	x
18	Leporidae	*Lepus pequensis*	X	x
19	Lorisidae	*Nycticebus coucang*		x
20	Lorisidae	*N. bengalensis*		x
21	Muridae	*Rattus tanezumi*		x
22	Muridae	*R. nitidus*		x
23	Muridae	*R. argentiventer*	X	x
24	Muridae	*Chiropodomys gliroides*	X	
25	Muridae	*Saxatilomys paulinae*	X	x
26	Muridae	*Leopoldamys sabanus*	X	x
27	Mustelidae	*Melogale personata*	X	x
28	Pteromyidae	*Hylopetes spadiceus*		x
29	Pteromyidae	*Menetes berdmorei*	X	x
30	Sciuridae	*Hylopetes phayrei*	X	x
31	Sciuridae	*Callosciurus finlaysonii*	X	x
32	Sciuridae	*Dremomys rufigenis*	X	x
33	Sciuridae	*Callosciurus erythraeus*	X	x
34	Sciuridae	*Tamiops maritimus*	X	x
35	Sciuridae	*Callosciurus inornatus*	X	
36	Sciuridae	*Ratufa bicolor*		x
37	Soricidae	*Crocidura* sp.		x
38	Suidae	*Sus scrofa*	X	x
39	Tupaiidae	*Tupaia belaugeri*		x
40	Tupaiidae	*T. glis*		x
41	Viverridae	*Paradoxurus hermaphroditus*	X	x
42	Viverridae	*Viverricula indica*		x

Appendix Table 5 List of birds species in the study area

No.	Family	Zoological name	Source information	
			Observation	Interview
1	Accipitridae	*Accipiter badius*	X	x
2	Accipitridae	*Circus spilonotus*	X	
3	Accipitridae	*Spilornis cheela*		x
4	Centropodidae	*Centropus sinensis*	X	x
5	Chloropseidae	*Chloropsis cochinchinensis*	X	
6	Columbidae	*Streptopelia chinensis*	X	x
7	Columbidae	*Treron sieboldii*	X	X
8	Columbidae	*T. vernans*	X	x
9	Coraciidae	*Eurystomus orientalis*	X	
10	Corvidae	*Corvus macrorhynchos*		x
11	Cuculidae	*Phaenicophaeus tristis*	X	
12	Dicruridae	*Dicrurus macrocercus*	X	
13	Dicruridae	*D. leucophaeus*	X	
14	Dicruridae	*D. paradiseus*	X	
15	Dicruridae	*D. hottentottus*	X	
16	Dicruridae	*D. aeneus*	X	
17	Dicruridae	*Oriolus chinensis*	X	x
18	Dicruridae	*Rhipidura albicollis*	X	
19	Dicaeidae	*Dicaeum agile*	X	
20	Eurostopodidae	*Eurostopodus macrotis*	X	
21	Hirundinidae	*Apus affinis*	X	
22	Hirundinidae	*Cypsiurus balasiensis*	X	
23	Laniidae	*Lanius cristatus*	X	
24	Megalaimidae	*Megalaima faiostricta*	X	x
25	Muscicapidea	*Copsychus saularis*	X	
26	Muscicapidea	*Monticola solitarius*	X	x
27	Nectariniidae	*Aethopyga siparaja*	X	
28	Phasianidae	*Gallus gallus*	X	x
29	Picidae	*Dinopium javanense*	X	
30	Picidae	*Dendrocopos canicapillus*	X	
31	Pycnonotidae	*Pycnonotus melanicterus*	X	x
32	Pycnonotidae	*P. Jocosus*	X	x

Appendix Table 5 (Continued)

No.	Family	Zoological name	Source information	
			Observation	Interview
33	Pycnonotidae	*P. blanfordi*	X	
34	Pycnonotidae	*P. hualon*	X	
35	Stenostiridae	*Culicicapa ceylonensis*	X	
36	Strigidae	*Otus bakkamoena*	X	x
37	Strigidae	*O. sunia*		x
38	Strigidae	*Glaucidium cuculoides*	X	x
39	Sturnidae	*Acridotheres fuscus*	X	
40	Sylviidae	*Garrulax leucolophus*	X	
41	Sylviidae	*Orthotomus atrogularis*	X	
42	Timatiidae	*Stachyris herberti*	X	
43	Turdinae	*Myophonus caeruleus*		x
44	Tytonidae	*Tyto alba*	X	x

Appendix Table 6 List of Reptile species in the study area

No.	Family	Zoological name	Source information	
			Observation	Interview
		Sauria (Lizards)		
1	Agamidae	*Calotes emma*	X	
2	Agamidae	*Acanthosaura lepidogaster*	X	
3	Agamidae	*Calotes versicolor*	X	x
4	Agamidae	*Physignathus cocincinus*		x
5	Agamidae	*Draco maculatus*		x
6	Gekkonidae	*Hemidactylus frenatus*	X	x
7	Gekkonidae	*Gekko gecko*	X	x
8	Gekkonidae	*G. russelltraini* sp.	X	
9	Gekkonidae	*Cyrtodactylus* sp.	X	
10	Lacertidae	*Takydromus sexlineatus*		x
11	Scincidae	*Mabuya multifasciata*	X	x
12	Scincidae	*M. longicaudata*	X	x
13	Scincidae	*Sphenomorphus* sp.	X	
14	Scincidae	*Mabuya macularia*	X	x
15	Varanidae	*Varanus bengalensis*	X	x

Appendix Table 6 (Continued)

No.	Family	Zoological name	Source information	
			Observation	Interview
		Ophidia (Snake)		
16	Colubridae	*Chrysopelea ornata*	X	
17	Colubridae	*Xenochrophis flavipunctatus*	X	x
18	Colubridae	*Enhydris plumbea*		x
19	Colubridae	*Psammodynastes pulverulentus*	X	
20	Colubridae	*Rhabdophis* sp.	X	x
21	Colubridae	*lycodon* sp.	X	
22	Colubridae	*Elaphe radiate*		x
23	Colubridae	*Ptyas korros*		x
24	Colubridae	*P. mucosa*		x
25	Colubridae	*Ahaetulla prasina*	X	
26	Colubridae	*Amphiesma modestum*	X	
27	Elapidae	*Bungarus candidus*		x
28	Elapidae	*B. fasciatus*		x
29	Elapidae	*Naja siamensis*		x
30	Elapidae	*Ophiophagus hannah*		x
31	Elapidae	*Sinomicrurus* sp.	X	
32	Pythonidae	*Pytohon molurus*		x
33	Pythonidae	*P. curtus*		x
34	Viperidae	*Cryptelytrops albolabris*		x
35	Viperidae	*Protobothrops mucrosquamatus*		x
36	Viperidae	*Triceratolepidophis sieversorum*		x
37	Viperidae	*Trimeresurus* sp.	X	x
38	Xenopeltidae	*Xenopeltis unicolor*		x
		Testudines (Turtles)		
39	Bataguridae	*Cuora amboinensis*	X	x
40	Bataguridae	*C. galbinifrons*		x
41	Bataguridae	*Pyxidea mouhotii*		x
42	Trionychidae	*Amyda cartilaginea*		x

Appendix Table 7 List of amphibian species in the study area

No.	Family	Zoological name	Source information	
			Observation	Interview
1	Bufonidae	*Bufo melanostictus*	X	x
2	Dicroglossidae	*Occidozyga lima*	X	x
3	Dicroglossidae	*O. martensi*	X	
4	Dicroglossidae	*Hoplobatrachus rugulosus*	X	x
5	Dicroglossidae	*Feiervaria limnocharis*	X	x
6	Microhylidae	*Microhyla pulchra*	X	x
7	Microhylidae	*Kaloula pulchra*	X	x
8	Microhylidae	*Microhyla ornata*	X	
9	Ranidae	*Hylarana nigrovittata*	X	
10	Ranidae	*H.* sp.	X	
11	Rhacophoridae	*Polypedates leucomystax*	X	x
12	Rhacophoridae	*Rhacophorus orlovi*		x
13	Rhacophoridae	*R. spelaeus*		x

Appendix Table 8 List of tree species and their IVI of semi-evergreen forest at study area from ten 10x10 plots

Family	Botanical name	D	F	Do	RD	RF	Rdo	IVI
Dipterocarpaceae	*Hopea ferrea*	0.12	0.80	16.50	5.83	6.96	38.92	51.70
Ebenaceae	*Diospyros curraniopsis*	0.14	0.60	4.41	6.80	5.22	10.40	22.41
Melastomataceae	*Memecylon ovatum*	0.17	0.80	1.46	8.25	6.96	3.44	18.65
Moraceae	*Streblus asper*	0.21	0.60	1.16	10.19	5.22	2.74	18.15
Annonaceae	*Alphonsea boniana*	0.17	0.80	0.83	8.25	6.96	1.96	17.17
Sapindaceae	*Dimocarpus* sp.	0.13	0.80	1.60	6.31	6.96	3.77	17.04
Sapindaceae	*Cossinia pinnata*	0.13	0.60	1.28	6.31	5.22	3.02	14.55
Ebenaceae	*Hydnocarpus ilicilolius*	0.10	0.40	2.57	4.85	3.48	6.06	14.39
Lythraceae	*Lagerstroemia calyculata*	0.09	0.60	1.10	4.37	5.22	2.59	12.18
Dipterocarpaceae	*Shorea siemensis*	0.02	0.20	2.39	0.97	1.74	5.64	8.35
Leguminosea-caesalpinioideae	*Afzelia* sp.	0.06	0.40	0.69	2.91	3.48	1.63	8.02
Leguminosea-caesalpinioideae	*Afzelia xylocarpa*	0.06	0.30	0.64	2.91	2.61	1.51	7.03
Apocynaceae	*Unidentify*	0.04	0.40	0.30	1.94	3.48	0.71	6.13

Appendix Table 8 (Continued)

Family	Botanical name	D	F	Do	RD	RF	Rdo	IVI
Oxalidaceae	*Averrhoa sp.*	0.07	0.20	0.36	3.40	1.74	0.85	5.99
Aceraceae	*Acer* sp.	0.05	0.30	0.39	2.43	2.61	0.92	5.96
Moraceae	*Ficus altissima*	0.03	0.20	1.13	1.46	1.74	2.67	5.86
Leguminosea-caesalpinioideae	Unidentify	0.05	0.30	0.11	2.43	2.61	0.26	5.30
Guttiferae	*Garcinia xanthochymus*	0.04	0.20	0.24	1.94	1.74	0.57	4.25
Apocynaceae	*Wrightia* sp.	0.04	0.20	0.11	1.94	1.74	0.26	3.94
Leguminosea-caesalpinioideae	*Erythrina* sp.	0.03	0.20	0.30	1.46	1.74	0.71	3.90
Rubiaceae	*Pavetta indica*	0.04	0.20	0.07	1.94	1.74	0.17	3.85
Burseraceae	*Canarium* sp.	0.01	0.10	0.96	0.49	0.87	2.26	3.62
Meliaceae	*Chukrasia tabularis*	0.01	0.10	0.96	0.49	0.87	2.26	3.62
Sterculiaceae	*Pterospermum* sp.	0.02	0.10	0.71	0.97	0.87	1.67	3.51
Moraceae	*Streblus ilicifolius*	0.03	0.20	0.10	1.46	1.74	0.24	3.43
Combretaceae	*Terminalia bellirica*	0.02	0.20	0.13	0.97	1.74	0.31	3.02
Leguminosae-palionoideae	*Uvaria* sp.	0.02	0.20	0.06	0.97	1.74	0.14	2.85
Leguminosea-caesalpinioideae	*Saraca declinata*	0.02	0.10	0.41	0.97	0.87	0.97	2.81
Labiatae	*Vitex* sp.	0.01	0.10	0.25	0.49	0.87	0.59	1.94
Sterculiaceae	*Sterculia* sp.2	0.01	0.10	0.18	0.49	0.87	0.42	1.78
	Unidentify	0.01	0.10	0.15	0.49	0.87	0.35	1.71
Datiscaceae	*Tetrameles nudiflora*	0.01	0.10	0.11	0.49	0.87	0.26	1.61
	Unidentify	0.01	0.10	0.11	0.49	0.87	0.26	1.61
	Unidentify	0.01	0.10	0.11	0.49	0.87	0.26	1.61
	Unidentify	0.01	0.10	0.09	0.49	0.87	0.21	1.57
	Unidentify	0.01	0.10	0.09	0.49	0.87	0.21	1.57
Ebenaceae	*Diospyros peregrina*	0.01	0.10	0.08	0.49	0.87	0.19	1.54
Dipterocarpaceae	*Hopea recopei*	0.01	0.10	0.08	0.49	0.87	0.19	1.54
	Unidentify	0.01	0.10	0.06	0.49	0.87	0.14	1.50
Bombacaceae	*Bombax ceiba*	0.01	0.10	0.05	0.49	0.87	0.12	1.47
Moraceae	*Ficus sp.*	0.01	0.10	0.05	0.49	0.87	0.12	1.47
Moraceae	*F. vasculosa*	0.01	0.10	0.02	0.49	0.87	0.05	1.40
	Total	2.06	11.50	42.40	100	100	100	300

Appendix Table 9 List of tree species and their IVI of Limestone deciduou forest at study area from ten 10x10 plots

Family	Scientific Name	D	F	Do	RD	RF	Rdo	IVI
Sterculiaceae	*Sterculia* sp.1	0.33	1.00	11.32	26.19	13.33	42.13	81.65
Anacardiaceae	*Spondias pinnata*	0.06	0.50	3.99	4.76	6.67	14.85	26.28
Burseraceae	*Canarium* sp.	0.10	0.60	1.89	7.94	8.00	7.03	22.97
Dipterocarpaceae	*Shorea siemensis*	0.03	0.30	3.59	2.38	4.00	13.36	19.74
Meliaceae	*Azadirachta* sp.	0.09	0.50	0.92	7.14	6.67	3.42	17.23
	Unidentify	0.07	0.70	0.56	5.56	9.33	2.08	16.97
Acanthaceae	*Marcrania* sp.	0.06	0.60	0.26	4.76	8.00	0.97	13.73
Bombacaceae	*Bombax ceiba*	0.06	0.40	0.69	4.76	5.33	2.57	12.66
Dracaceae	*Dracaena loureiri*	0.08	0.30	0.33	6.35	4.00	1.23	11.58
Apocynaceae	*Wrightia* sp.	0.07	0.30	0.34	5.56	4.00	1.27	10.82
	Unidentify	0.04	0.40	0.22	3.17	5.33	0.82	9.33
Legumninsae-papilionoideae	*Erythrina stricta*	0.04	0.20	0.54	3.17	2.67	2.01	7.85
	Unidentify	0.03	0.20	0.61	2.38	2.67	2.27	7.32
Araceae	*Cereus* sp.	0.03	0.30	0.13	2.38	4.00	0.48	6.86
Sterculiaceae	*Sterculia pexa*	0.03	0.20	0.23	2.38	2.67	0.86	5.90
Moraceae	*Ficus religiosa*	0.02	0.10	0.51	1.59	1.33	1.90	4.82
Labiatae	*Vitex* sp.	0.02	0.10	0.25	1.59	1.33	0.93	3.85
Combretaceae	*Terminalia bellirica*	0.02	0.10	0.13	1.59	1.33	0.48	3.40
Ebenaceae	*Disspyros* sp	0.02	0.10	0.10	1.57	1.33	0.37	3.28
Melastomataceae	*Memecylon* sp.	0.01	0.10	0.10	1.57	1.33	0.37	3.28
Moraceae	*Ficus* sp.	0.01	0.10	0.04	0.79	1.33	0.15	2.28
Moraceae	*Ficus vasculosa*	0.01	0.10	0.03	0.79	1.33	0.11	2.24
Sapindaceae	*Dimocarpus* sp.	0.01	0.10	0.03	0.79	1.33	0.11	2.23
Aceraceae	*Acer* sp.	0.01	0.10	0.03	0.79	1.33	0.11	2.24
Moraceae	*Ficus altissima*	0.01	0.10	0.03	0.79	1.33	0.11	2.24
Total		1.26	7.50	26.87	100	100	100	300

Appendix Table 10 List of tree species expected to be diet of Kha nyou and usage part from previous study

Family	Name		Usage Part		
	Local Name	Botanical Name	Leaves	Bark or Stem	Root
Palmae	ຕາວຫ້າງ	*Caryota* sp. *1*	X		
"	ຕາວຫ້າງ	*Caryota* sp. *2*	X		
"	ສານ	*Rhapis* sp.	X	x	
"	ຕາວຕາດ	*Anenga* sp.	X	x	
Zingiberaceae	ເອື້ອງລົ້ມ	*Costus speciosus*	X	x	
Orchidaceae	ເອື້ອງສາຍນົກຈິບ	*Dendrobium* sp.		x	
"	ເອື້ອງຜາ	*Liparis* sp.	X	x	
Araceae	ເຄືອຂຽວ	*Rhaphidophora peepla*	X		
"	ບອນຜາ	*Aglaonema simplex*	X	x	
"	ເຄືອມູກ	*Scindapsus annamicus*	X		
Moraceae	ກົກໜາມຄ່ອຍຜາ	*Streblus taxoides*	X		
"	ດູບເດືອຜາ	*Amorphophallus* sp.	X		
Symplocaceae	ກົກກະເບົາຜາ	*Symplocos cochichinensis*	X		
Dipterocarpaceae	ໄມ້ຈິກ	*Shorea hypochra*	X		
Pandanaceae	ເຕີຍຜາ	*Pandanus* sp.	X		
Gesneriaceae	ສົ້ມແສດ	*Didynocarpus* sp.	X		
Urticaceae	ກົກກອກຂຽວ	*Elatostema* sp.	X		
Euphobiaceae	ກົກຫຳອາວ	*Sauropus* sp.	X		
Dracaenaceae	ກົກຄອນແຄນ	*Dracaena elliptic*	X		
Sapindaceae	ກົກລິ່ງງໍ້	*Pomentia pinnata*	X		
Dioscoreaceae	ກົກຂົ່ມສົ່ງ	*Dioscorea* sp.		x	x
Cactaceae	ເລັບເຫືອກ	*Cereus* sp.		x	
Rhamnaceae	ເຄືອໄສ້ຕັນ	*Ziziphus* sp.	X	x	
"	ຂີ້ຄັ່ງຜາ	*Psycotria malayana*	X		
Rubiaceae	ເຄືອຕົດໝາ	*Paederia tometosa*	X		

Source: Vongsa (2010)

Data collection form for home range of collared Kha Nhou

Recorder:..*Mr. Jeng*.....
Date:....*25/06/2010*.....
Receiving station: *(A),* ***(B)****, (C), ( )…*
Time interval: *(20m), (25m*), (***30m***), *(m)…*

Time	Collared Kha Nhou					
	Numsok (K 61)		**Misok (K 65)**		**Khoamvang (K 55)**	
	Bearings (Degree)	*Note*	*Bearings (Degree)*	*Note*	*Bearings (Degree)*	*Note*
1:00 AM	340 - 65	S, ct	335 - 75	st	55 - 15	st
1:30 AM	330 - 75	st	330 - 65	St,ct	355 - 65	St, er
2:00 AM	…	..	…	..	…	..
2:30 AM	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
11:00AM	…	..	…	..	…	..
11:30AM	…	..	…	..	…	..
12:00AM	…	..	…	..	…	..
…	…	..	…	..	…	..
1:00 PM	…	..	…	..	…	..
1:30 PM	…	..	…	..	…	..
2:00 PM	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
…	…	..	…	..	…	..
11:00PM	…	..	…	..	…	..
11:30PM	…	..	…	..	…	..
12:00PM	…	..	…	..	…	..
12:30PM	…	..	…	..	…	..

Signal record: **VST**= Very strong, **ST**= Strong, **VS**= Very soft, **S**= Soft,
Er= Erratic and **Ct**= Constant.

Appendix Figure 1 Data collection form for home range of collared Kha nyou

Appendix Figure 2 The receiver, two-elements Yagi antenna and telex headphone.

Appendix Figure 3 The 11g radio collar for Laotian rock rat (Holohil Systems Ltd).

Appendix Figure 4 Camera trap were put on limestone crack inside crevice in core area of K 61.

Appendix Figure 5 The crevice or karst hole were chosen for Kha nyou trapping.

Appendix Figure 6 Information record before fitting radio collar (K 65).

Appendix Figure 7 Equip a radio collar process on K 55.

Appendix Figure 8 Test for fit before release back to the wild (K 61).

Appendix Figure 9 Release back to its cavity at the place of capture (K 65).

Appendix Figure 10 K 39 run back to cavity after release (03.01.2011).

Appendix Figure 11 Characteristics of crevice or karst hole inside K 65 home range.

Appendix Figure 12 Characteristics of crevice inside K 61 and K 47 home range.

Appendix Figure 13 Characteristics of limestone karst inside the study area.

Appendix Figure 14 The lavatory of Kha nyou inside home range of K 65.

Appendix Figure 15 Characteristics of Kha nyou (K 55) pellets from trap.

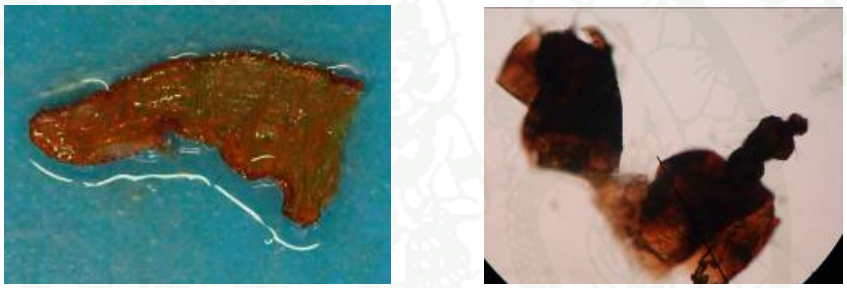
Appendix Figure 16 A big and long used lavatory at tap site of local hunter.

Appendix Figure 17 Signal detecting at day time on permanent receiver station A (Field assistant Mr. Thanonglit Khotpathoom).

Appendix Figure 18 Signal detecting at night time on permanent receiver station B (Field assistant Mr. Jeng).

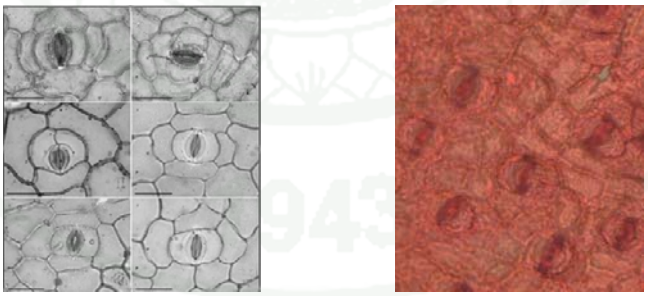
Appendix Figure 19 Signal detected using home in method in the dry season (Field assistant Mr. Jaolo).

Appendix Figure 20 Signal detected using home in method in the wet season.



(a) (b)

Appendix Figure 21 The remains from stomach content (a) fern leaf and (b) ant.



(a) (b)

Appendix Figure 22 (a) stomata characteristics of Araceae leaves in previous research and (b) the stomata of unsatisfied species from stomach content from this study.

Source: Mantovani and Pereira (2005) (a)

CURRICULUM VITAE

NAME : Mr. Thananh Khotpathoom

BIRTH DATE : April 14, 1973

BIRTH PLACE : Savannakhet Province (Lao PDR)

EDUCATION :

YEAR	**INSTITUTION**	**EGREE/DIPLOMA**
1999	Vietnam For. Univ.	B.Sc. (Forestry)

POSITION TITLE : Lecturer

WORK PLACE : Forest Management Department,
Faculty of Forestry,
National University of Laos

SCHOLARSHIP/AWARDS : Thailand International Development Cooperation Agency (TICA)