การใช้วิทยุติดตามในการศึกษาขนาดของเขตอาศัยและกิจกรรมของเต่าเดือย *Manouria impressa* (Günther, 1882)

นายปรัชญาพร วันชัย

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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RADIO-TELEMETRY STUDY OF HOME RANGE SIZE AND ACTIVITIES OF THE IMPRESSED TORTOISE, *Manouria impressa* (Günther, 1882)

Mr. Pratyaporn Wanchai

A Dissertation Submitted in Partial Fulfillment of the Requirements
for the Degree of Doctor of Philosophy Program in Biological Science
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Thesis Title	RADIO-TELEMETRY STUDY OF HOME RANGE SIZE AND ACTIVITIES OF THE IMPRESSED TORTOISE, *Manouria impressa* (Günther, 1882)
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Field of Study	Biological Science
Thesis Advisor	Associate Professor Kumthorn Thirakhupt, Ph.D.
Thesis Co-advisor	Professor Craig B. Stanford, Ph.D.

Accepted by the Faculty of Science, Chulalongkorn University in Partial Fulfillment of the Requirements for the Doctoral Degree

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ปรัชญาพร วันชัย : การใช้วิทยุติดตามในการศึกษาขนาดของเขตอาศัยและกิจกรรมของเต่าเดือย *Manouria impressa* (Günther, 1882) (RADIO-TELEMETRY STUDY OF HOME RANGE SIZE AND ACTIVITIES OF THE IMPRESSED TORTOISE, *Manouria impressa* (Günther, 1882)) อ.ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.ดร. กำธร ธีรคุปต์, อ.ที่ปรึกษาวิทยานิพนธ์ร่วม : ศ.ดร. Craig Stanford, 126 หน้า.

การศึกษาอาณาเขตที่อยู่อาศัยและกิจกรรมการดำรงชีวิตของเต่าเดือย *Manouria impressa* (Günther, 1882) ที่เขตรักษาพันธุ์สัตว์ป่าภูหลวง จังหวัดเลย ได้ดำเนินการ ตั้งแต่เดือน มกราคม 2553 – ตุลาคม 2554 โดยใช้วิทยุติดตาม เต่าเดือยตัวเต็มวัยจำนวน 10 ตัว เป็นตัวผู้ 5 ตัว และตัวเมีย 5 ตัว และตัวที่ยังเจริญไม่เต็มวัย 4 ตัว ถูกนำมาติดเครื่องส่งสัญญาณวิทยุ เพื่อทำการติดตามเก็บข้อมูลในภาคสนาม พบว่าค่ามัธยฐานของเขตอาศัยตลอดทั้งปีของเต่าเดือยเพศผู้ คือ 9.84 ±2.91 เฮกแตร์ เพศเมีย คือ 9.44±6.32 เฮกแตร์ และตัวที่ยังไม่เต็มวัย คือ 7.26 ± 6.45 เฮกแตร์ ขนาดของเขตอาศัยตลอดทั้งปีของเพศผู้ เพศเมียและตัวที่ยังเจริญไม่เต็มวัย ไม่มีความแตกต่างอย่างมีนัยสำคัญทางสถิติ เมื่อศึกษาเป็นฤดูกาลพบว่า ขนาดของเขตอาศัยในฤดูฝนของเพศผู้เพศเมียและตัวที่ยังเจริญไม่เต็มวัยมีขนาดกว้างกว่าในฤดูแล้งอย่างมีนัยสำคัญทางสถิติ จากการศึกษาพบว่าเต่าเดือยอาศัยอยู่ในระดับความสูงตั้งแต่ 1,013 เมตร-1,425 เมตรจากระดับน้ำทะเล สามารถจำแนกถิ่นอาศัยของเต่าเดือยได้ 4 ประเภท ได้แก่ ป่าดิบเขา ป่าไผ่ ป่าดิบเขาป่าไผ่ และป่าดิบเขาแคระ โดยตลอดทั้งปีพบว่า เต่าเดือยตัวเต็มวัยและตัวที่ยังเจริญไม่เต็มวัยจะอยู่ในบริเวณป่าดิบเขาซึ่งเป็นบริเวณที่มีแหล่งอาหารคือเห็ดขึ้นอยู่ทั่วไป (เพศผู้ = 79.26% เพศเมีย = 60.86% ตัวที่ยังเจริญไม่เต็มวัย = 80.85%) และพบว่าเต่าเดือยทั้งตัวเต็มวัยและยังไม่เต็มวัย ส่วนใหญ่จะมีพฤติกรรมการซุกซ่อนตัวโดยเต่าเดือยจะซุกตัวใต้ใบไม้หรือกองไม้แห้ง สำหรับการศึกษาปัจจัยทางกายภาพในถิ่นที่อยู่อาศัยของเต่าเดือยพบว่าอุณหภูมิอากาศและความชื้นสัมพัทธ์เฉลี่ยตลอดปีในบริเวณที่พบ เต่าเดือยเพศผู้ เพศเมีย และตัวที่ยังเจริญไม่เต็มวัย ไม่แตกต่างอย่างมีนัยสำคัญทางสถิติ และจากข้อมูลการศึกษาด้านอาหารพบว่า เต่าเดือยกินเฉพาะเห็ดเท่านั้น อาหารหลักของเต่าเดือยในฤดูฝนคือเห็ดในสกุล *Russula* และในฤดูแล้งคือ เห็ดในสกุล *Auricularia* จากแบบสอบถามมีรายงานการพบเต่าเดือยในสถานที่ที่ไม่เคยมีรายงานมาก่อน 8 สถานที่ และสามารถยืนยันได้ 4 สถานที่ได้แก่ อุทยานแห่งชาติดอยสุเทพ-ปุย เขตรักษาพันธุ์สัตว์ป่าทุ่งใหญ่นเรศวรตะวันตก เขตรักษาพันธุ์สัตว์ป่าภูเขียว และอุทยานแห่งชาติภูกระดึง

สาขาวิชา วิทยาศาสตร์ชีวภาพ ลายมือชื่อนิสิต .....

ปีการศึกษา 2555 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก .....

ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .....

5173923823 : MAJOR BIOLOGICAL SCIENCE
KEYWORDS : *Manouria impressa* / HOME RANGE/ACTIVITIES

PRATYAPORN WANCHAI : RADIO-TELEMETRY STUDY OF HOME RANGE SIZE AND ACTIVITIES OF THE IMPRESSED TORTOISE, *Manouria impressa* (Günther, 1882). ADVISOR : ASSOC. PROF. KUMTHORN THIRAKHUPT, Ph.D., CO-ADVISOR : PROF. CRAIG STANFORD, Ph.D., 126 pp.

Field work was conducted at Phu Luang Wildlife Sanctuary, Loei Province, Thailand from January 2010 - October 2012. A total of fourteen *M. impressa*, consisting of ten adults, five males and five females, and four juveniles were radio-tracked. The median annual home ranges (minimum convex polygon) were 9.84 ±2.91, 9.44±6.32 and 7.26 ± 6.45 ha for adult males, adult females and juveniles, respectively. The median home range sizes within each season and year-round were not significantly different among adult male, female and juvenile tortoises. The median home range sizes in the wet season were larger than in the dry season for most individuals, and dry season ranges did not entirely lie within wet season ranges and vise versa.

The majority of individuals observed were inactive either in wet (May–October) or dry (November–April) season. Hiding is the main activity of tortoises for all seasons. However, in the wet season, the frequency of active behavior; walking, resting, basking, eating and mating was higher than in dry season. Adults tended to be more active than juveniles either both year-round and in the wet season. There were no significant differences between males and females in the wet season but males tended to be more active than females in the dry season. The elevation usages ranged from 1,013-1,425 m amsl and significant differences among seasons, sexes and age classes were not found. In year round result, montane forest was the most utilized habitat in both adults (male = 79.26%, female = 60.86%) and juveniles (80.85%), montane forest mixed with bamboo was the second most utilized habitat (male = 14.05%, female = 30.75%, juvenile = 9.04%) whereas montane scrub forest was the least utilized (male = 2.16%, female = 2.36%, juvenile = 4.26). The year-round averages for air temperature and relative humidity where the males, females and juveniles were found were not significantly different. The result suggested that *M. impressa* was a specialist feeder, consuming only mushrooms. They showed no interest in other herbs surrounding the mushrooms. In wet season, *Russula* spp. (41.95%) was the main diet followed by *Boletus* spp. (23.34%). In dry season, both adults and juveniles fed on only 2 genus, *Auricularia* spp. and *Russula* spp. *Auricularia* spp. (60%) were eaten most frequently followed by *Russula* spp. (40%).

From questionnaires distributed, a total of 8 new locations had positive response. Four locations; Doi Suthep-Pui National Park, Thungyai Naresuan (West) Wildlife Sanctuary, Phukaew Wildlife Sanctuary and Phu Kradueng National Park were confirmed to have *M. impressa*.

Field of Study : Biological Science Student's Signature .....

Academic Year : 2012 Advisor's Signature .....

Co-advisor's Signature .....

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Finally, I would like to dedicate my work to my family for their love and support for everything. Finally, I would like to thank and express my deepest gratitude to all my teachers at all levels.

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CHAPTER I

INTRODUCTION

Thailand is one of the world's leading nations in chelonian biodiversity, with at least 31 species, or about 10% of the world's total chelonian species diversity (Thirakhupt and van Dijk, 1994; Rhodin et al., 2010; Chuaynkern and Chuaynkern, 2012). At present, many turtle and tortoise species in Thailand and other countries are under intensive threats from humans, for example from hunting for food and the pet trade as well as habitat destruction and change (Gibbons et al., 2000, Moll and Moll, 2004, Shepherd and Nijman, 2008, Chen and Lue, 2009). However, most recent works on the turtles and tortoises of Thailand have been concerned with their taxonomy, distribution and status (Nutaphand, 1979, Chan-ard and Nabhitabhata, 1986, Nabhitabhata, 1989, Thirakhupt and van Dijk, 1997), but there have been very few detailed studies on aspects of their behavior and ecology, such as their home range size and activity patterns.

M. impressa is classified as a vulnerable (Vu) species by IUCN (2008) and CITES (2007) places it in Appendix II. The species appears to be rare in its natural habitat, and exhibits poor breeding and a low survival rate in captivity, ruling out captive breeding and reintroduction based on conservation strategies. Although *M. impressa* is locally hunted for food and to supply the pet trade, little is known of its habits, diet, reproduction and activities in the wild. Moreover, the distribution record of this species in Thailand is still incomplete. A greater knowledge of its distribution range, areas of occurrence, habitat characteristics, home range size and other activities

in the wild would be very useful for the development of viable conservation management strategies.

OBJECTIVES

1. To determine the home range size of the impressed tortoise, *Manouria impressa* at Phu Luang Wildlife Sanctuary.
2. To describe activities, habitat use, diets and some environmental conditions which affect the activities of *M. impressa*.
3. To study the present distribution range of *M. impressa* in Thailand.

CHAPTER II

LITERATURE REVIEW

2.1 Description and taxonomy of *Manouria impressa*

This species is classified in:

Phylum: Chordata

Class: Reptilia

Order: Testudines

Family: Testudinidae

Genus: *Manouria*

Species: *Manouria impressa*

Synonyms

- *Geoemyda impressa* Günther, 1882
- *Geoemyda latinuchalis* Vaillant, 1894
- *Testudo pseudemys* Boulenger, 1903
- *Testudo latinuchalis* Siebenrock, 1909
- *Testudo impressa* Smith, 1922
- *Geochelone impressa* Pritchard, 1967
- *Manouria impressa* Bour, 1980
- *Manowria impressa* Zhou & Zhou, 1991

2.2 Morphology and sexual dimorphism

Manouria impressa is one of the two tortoise species in the genus *Manouria*. It is believed to be the most primitive genus of living tortoises, based on a lack of many derived morphological features of other tortoises, such as mental glands, carpal bone alignment (Auffenberg, 1969), and primitive gular scute structure (Crumly, 1982, 1984; Highfield, 1990), and preference for a wet rather than arid habitat (Crumly, 1982).

The oval carapace (to 31 cm) is flattened dorsally, has an indentation at the broad cervical, and is strongly serrated around its entire rim. Posterior marginals are somewhat upturned, and pleurals somewhat concave. Vertebrals are wider than long, and the 5th is expanded. Günther (1882) reported a slight indication of a medial keel on the 4^{th} and/or 5^{th} vertebrals. Well-defined growth annuli surround the flat vertebral and marginal areolae. Eleven marginals lie on each side, and two supracaudals. The carapace is yellowish brown to brown with dark seams, but some have dark radiations along the outer border of each scute (Figure 2.3). Large black blotches occur on the marginals. The plastron is well-developed with a deep anal notch and a broad anterior notch which somewhat separates the gulars. Its forelobe is longer but narrower than the hindlobe. The plastral formula is: abd > hum > fem > gul >< an > pect; the gulars are thickened and extend slightly beyond the carapacial rim. The bridge is wide; the inguinal is large and often subdivided, and the axillary is small to moderate. The plastron is yellowish brown with darkened seams, and some dark streaking may be present. The head is large with a nonprojecting snout and an upper jaw which lacks a hook, or is only slightly hooked. Its large prefrontal is longitudinally divided, and

followed by a large undivided frontal scale; other head scales are small. The maxillae are ridged, but the premaxillae are not. The head is yellow to tan with pink pigment about the snout on some. Forelimbs are black; hindlimbs and tail dark brown. The anterior surface of the somewhat flattened forelimbs is covered with large, overlapping pointed scales (Ernst and Barbour, 2001). All individuals have a single large spur between tail and hide leg (Figure 2.4), giving rise to the colloquial name of "spure" tortoise, for the Thai name "tao dui".

Tail is the most important part for identifying male or female. Male has longer and larger tail than female (Figure 2.5). Moreover, male cloacal opening is well past the imaginary line between the caudal edges of these scutes while female, the cloacal opening is right below this imaginary line (Ruby et al., 2008).

2.3 Distribution

Manouria impressa ranges from Myanmar to Malaysia, Vietnam and Cambodia (Ernst and Barbour, 2001) (Figure 2.1). For Thailand, this species occurs on the mountains of northern, western and southern Thailand, Doi Inthanon National Park (Cheing Mai), Phulung Wildlife Sanctuary (Loei), Ungphang Wildlife Sanctuary (Tak), Huai Kha Khaeng Wildlife Sanctuary (Uthai Thani) and Hala-Bala Wildlife Sanctuary (Narathivart) (Chuaynkern and Chuaynkern, 2012) (Figure 2.1).

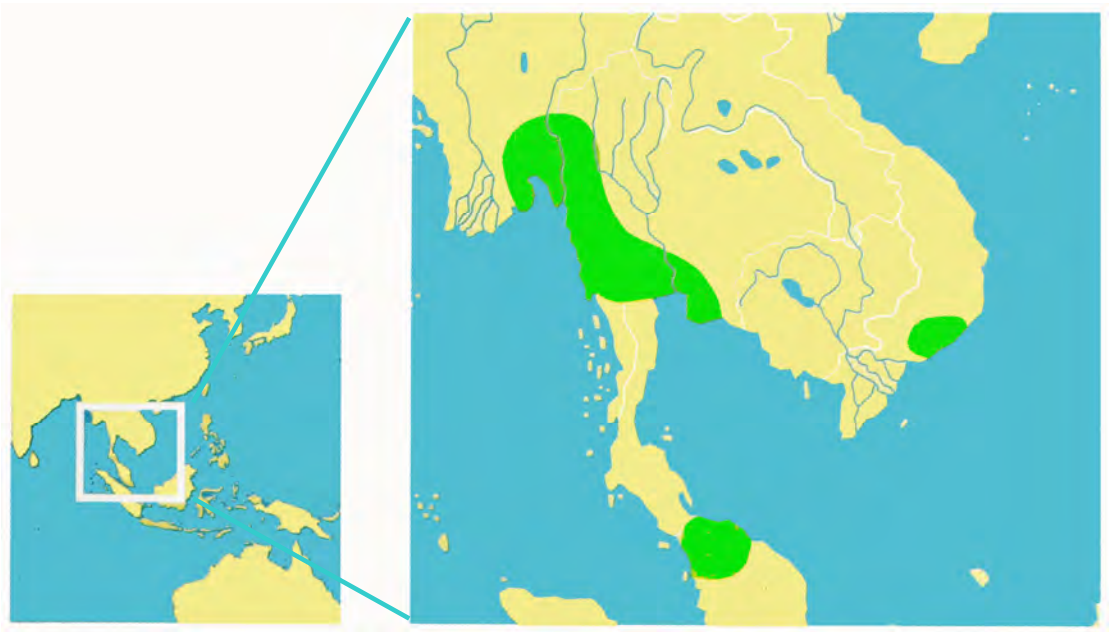

Figure 2.1 Distribution map of *Manouria impressa* (green color), from Bonin et al. (2006).

2.4 Conservation Status

Manouria impressa is listed in the International Union for the Conservation of Nature and Natural Resources (IUCN) Red List 2012 as Vulnerable, as defined by:

VULNERABLE (VU) - A taxon is Vulnerable when it is not Critically Endangered or Endangered but is facing a high risk of extinction in the wild in the medium-term future.

Manouria impressa is also listed on Appendix II of CITES 2007 and in Thai Wildlife Protection Law 1992. Office of Natural Resources and Environmental Policy and Planning classified it as an Endangered Species.

Figure 2.2 Distribution map of *Manouria impressa* in Thailand (red color).

Figure 2.3 A = carapace of *M. impressa* adult (side view)
B = carapace of *M. impressa* adult (top view)
C = plastron of *M. impressa* adult

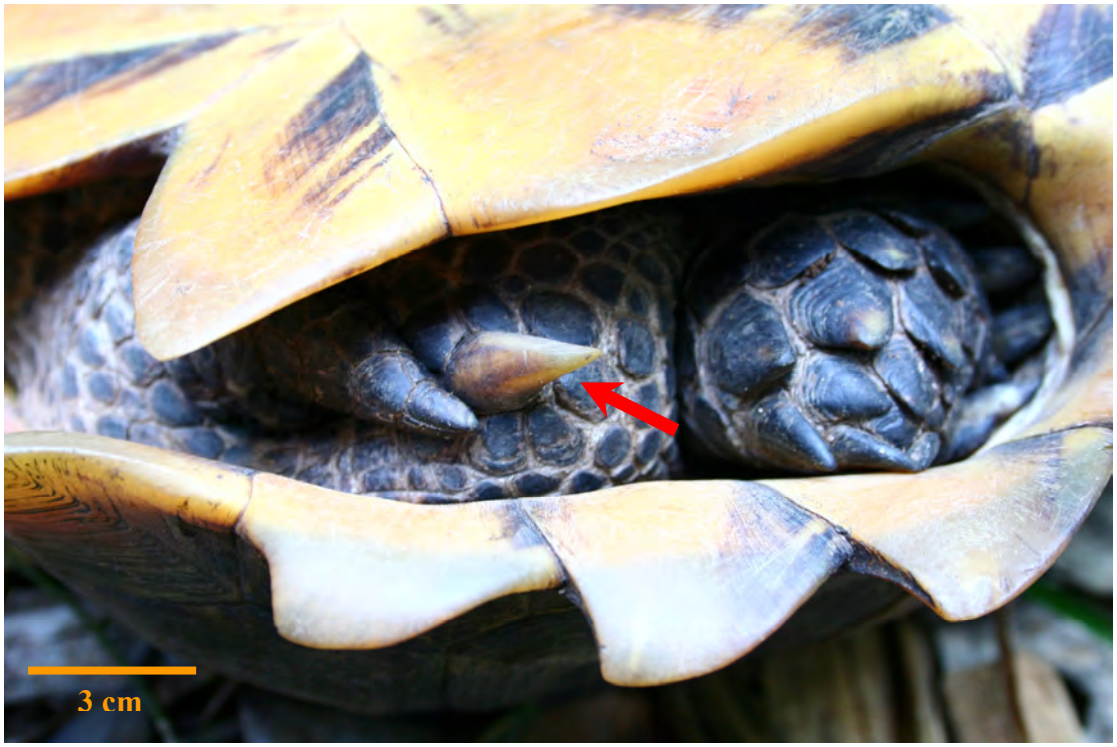

Figure 2.4 Red arrow shows a single large spur of *M.impressa* adult.

Figure 2.5 Male (right) and female (left) of *M. impressa*. Male has longer and larger tail than female.

2.5 Home range and activity pattern

The home range of an animal was first defined by Burt (1943) as the area traversed by the individual in its normal activities of food gathering, mating, and caring for young.

Variations in home range size are associated with the species, sex and age of animal, with the season, and with such ecological condition as available food and intraspecific strife (Smith, 1974). In poor habitat, the home range would be larger than in more adequate habitat (Dice, 1952). Overall size of the home range varies with the available food resources, mode of food gathering, body size, and metabolic needs. Among mammal species, the home range size is related to body size, reflecting the link between body size and energy requirement (food resources). In general, carnivores require a larger home range than herbivores and omnivores of the same size. Males and adults usually have larger home ranges than females and juveniles (Smith and Smith, 2006).

In terrestrial turtle, the yearly activity pattern is often affected by the necessity of a period of hibernation or estivation. In temperate areas, most terrestrial turtles have the highest activity peak in spring, but in xeric habitats the highest peak occurs during rainy periods. The daily activity cycle is in large part a response to temperature and moisture condition rather than to light. The mean daily movement of individual tortoise, regardless of species, seems to be greatest in populations where the shelter is apart from the feeding ground, or where food plants are scarce or widely scattered (Auffenberg and Iverson, 1979).

2.6 Natural history

The natural history of this tortoise is poorly known. Most recent works were from short term field observations but there is no study on long term ecology such as home range size and activity pattern in the wild.

McMorris and Burns (1975) suggested that the natural habitat of this species seems to be fairly dry. They spend much time hiding under leaf litter and not usually associated with water bodies. The tortoises rely on heavy dew or rain-drenched. They also found that a female laid 17 eggs between 16 and 29 May.

Nutaphand (1979) reported that this species inhabits forests and mountainous areas, feeds on plants and bamboo shoots, and forages in dense undergrowths at an altitude of 700 to 2,000 feet. During the rainy season, it wanders around eating grass shoots and looking for a mate. Mating behavior coincided with the rainy period.

Weissinger (1987) reported that this tortoise inhabits evergreen forests and bamboo thickets on hills and mountains where it is active only during the rainy season.

Chan-ard et al. (1996) reported that the natural diet is composed almost entirely of the mushrooms *Pleurotus*, *Amanita*, *Auricularia*, and *Termitomyces*, and to a lesser degree of *Tricholoma*, *Russula*, and *Favolus*. They observed courtship activity from mid-March to September and reported that a courting male approaches a female from the front and bobs his head up and down while simultaneously opening and closing the mouth. If receptive, the female will raise her body high, and the male will move to her rear and mounts. The male stretches his neck and vocalizes during copulation, but does not bite or ram the female (Ernst and Barbour, 2001).

Cox et al. (1998) reported that a female laid about a dozen eggs per clutch. The eggs are laid in a shallow cavity and then covered with leaves. Hatchlings are yellowish to light brown with rounded, medially keeled, heavily serrated carapaces. Hatchling carapace is approximately 50 mm long (Espenshade and Buskirk, 1994).

Koulang (2008) study eleven tortoises, seven of them obtained from local people and four were found in the wild. The habitats were evergreen and bamboo forest at high elevation from 668-755m with 15.0 Cº-37.0 Cº temperature during the study period. *M. impressa* were found under logs, in leaf litters, under bamboo canes, and in holes. The micro-temperature of the hiding place was significantly lower than the ambient temperature. Humidity of the habitat was 85% average with 60% min and 96% max. Canopy cover was not important for habitat preference. *M. impressa* spent most of the time hiding, and it preferred to move from one hiding place to another at night. This species mainly consumed wild mushrooms. Home range sizes of male and female did not show a statistically significant difference. This tortoise occupied a home range size of 0.07 to 0.35 km^2.

2.7 Radio-telemetry

Radio telemetry was designed to track animals remotely in their natural environments in order to conduct studies on animal numbers, habitat use, behavior, survival, movement, and distribution patterns, among others. The technology has been developed drastically over the 40 years (Millspaugh and Marzluff, 2001).

Radio-telemetry has become widely used for studying turtle migration, dispersal, home range, habitat use, physiology, and the effectiveness of relocation efforts, such as *Gopherus berlandieri* (Rose and Judd, 1975), *Testudo kleinmanni* (Geffen and Mendelsson, 1988), *Xerobates agassizi* (Barrett, 1990), *Gopherus agassizii* (Barrett, 1990), *Gopherus polyphemus* (Butler et al., 1995) and *Testudo graeca* (Anadón et al., 2006). An important consideration for using radio transmitter techniques is assuring that they do not affect significantly the behavior, physiology, reproductive success, and survival of the animals (Boardman et al., 1998).

In Thailand, the radio-tracking technique was used in studying wildlife for the first time by Tsuji, Poonswad and Jirawatkavi in 1987, in a study of hornbills at Khao Yai National Park. The only 3 studes for tortoises and turtle in Thailand has been used in studying elongated tortoise, *Indotestudo elongata* at Khao Nang Rum Wildlife Research Station, Huai Kha Khaeng Wildlife Sanctuary (Tharapoom, 1996), *Manouria emys phayrei* at Kaeng Krachan National Park, Western Thailand (Wanchai, 2007) and *Platysternon megacephalum* at Chiang Dao Wildlife Sanctuary (Pipatsawasdikul, 2009).

CHAPTER III

METHODOLOGY

3.1 Study area

Topography

Phu Luang Wildlife Sanctuary (PLWS) is located in the Phu Luang mountain area, in the south of Loei Province, Thailand, at 17°3'-17°24'N and 101°16'-101°21'E. The sanctuary covers an area of 897 km², covering area of the tambon Pla Ba and Tha Sala of Phu Ruea district, Phon Sung, Wang Yao and I Pum of Dan Sai, Nong Ngio and Saikhao of Wang Saphung, and Phu Ho of Phu Luang district. The reserve is named after its highest mountain, which peaks at 1,571 m. The reserve covers the whole mountain plateau around the peak, which has an altitude of around 1,200 m above mean sea level. To west of the reserve the Loei River originates. Phu Luang means a large mountain or the Mountain of the King, formed by an uplift of the earth's crust and a slide of soft soil down to the lower land.

Environment and Climate

The sanctuary is covered by various forest types, notably dry deciduous dipterocarp, mixed deciduous, dry evergreen, montane evergreen and coniferous forests, plus tropical grassland. An average annual rainfall, obtained from PLWS weather station at elevation of 1,400 m above mean sea level (amsl), from 1,954 to

2,000 of 1,229 mm (Forest Research Center, 2002)), with most of the rain occurring from April to October.

There are overall 3 types of climate on Phu Luang, similar to a plain, with different temperatures. Summer starts from late February to April with an average temperature of 20-28 °C. The rainy season is from May to October. On the other hand, the temperature drops significantly during November – January to 4-16 °C. The Forest Research Center (2002) at the Faculty of Forestry, Kasetsart University, reported that the forest type at 500-900 m amsl is tropical dry evergreen forest whereas at 900-1,400 m amsl is tropical montane evergreen forest. This study was conducted at 900 – 1,400 m amsl where *M. impressa* was found (Chan-ard et al*.,* 1996).

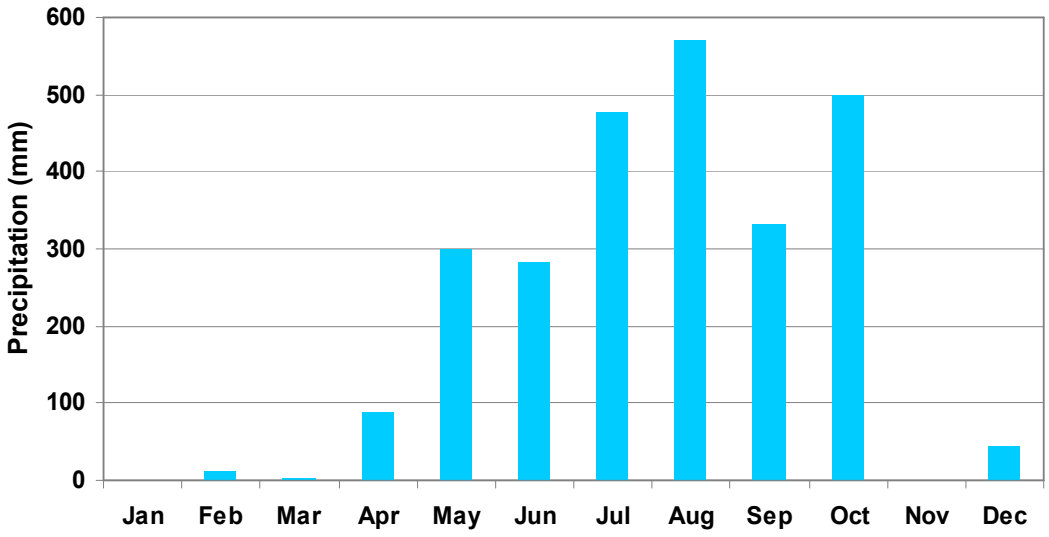

Figure 3.1 Total precipitation in PLWS from January 2010 - October 2011 (PLWS weather station).

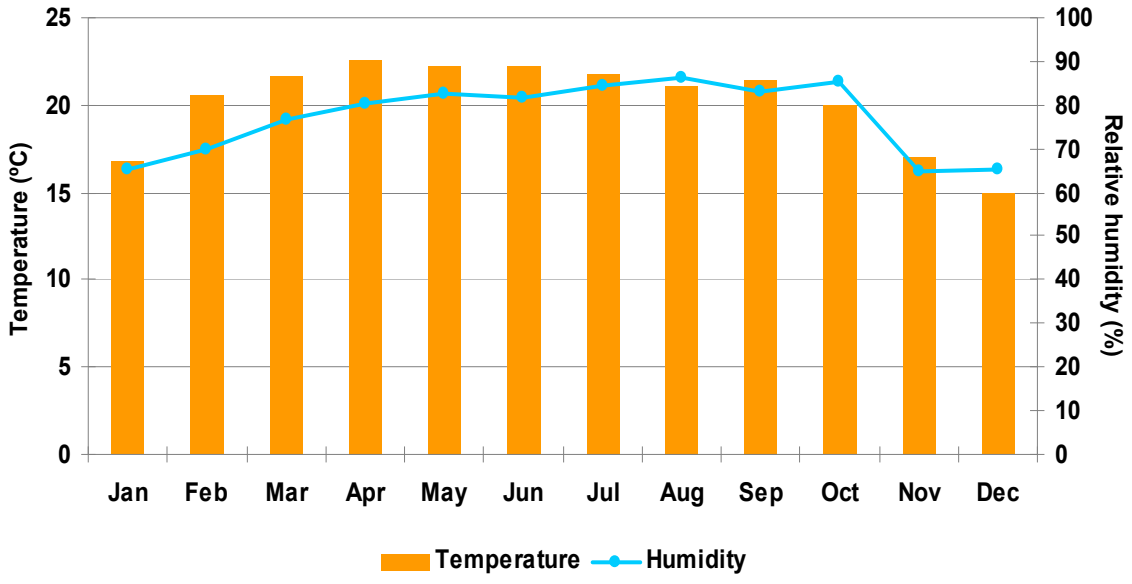

Figure 3.2 Averages temperature and relative humidity in PLWS from January 2010 - October 2011 (PLWS weather station).

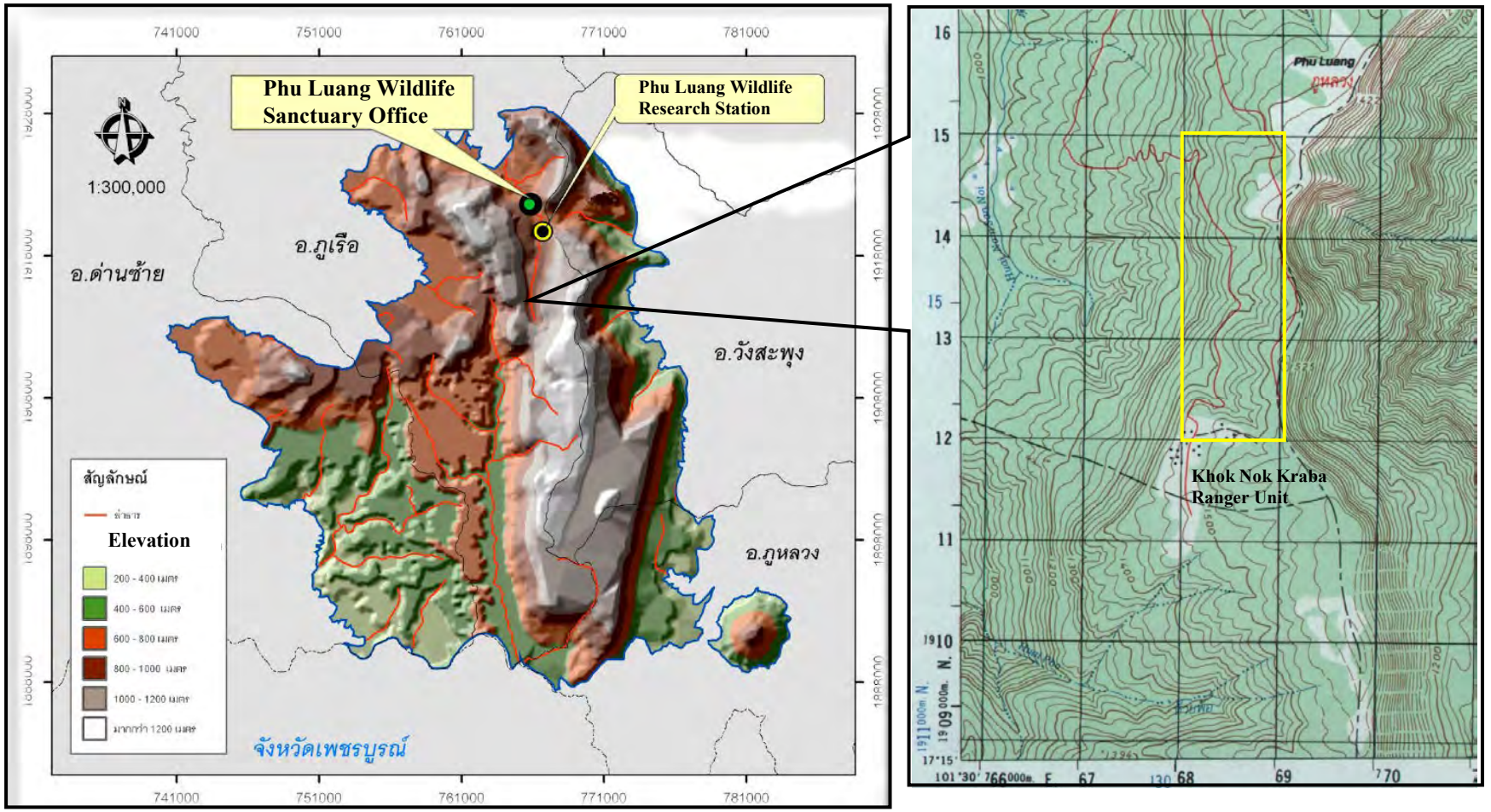

Figure 3.3 Map of Phu Luang Wildlife Sanctuary, Loei Province. Yellow box indicates the study area.

3.2 Equipment

3.2.1 Radio-telemetry equipment

1. Advanced Telemetry Systems (ATS) receiver (Model FM16) (Figure 3.4).

2. Handheld ATS 3 element Folding Yagi Antenna (Figure 3.5)

3. Transmitters used in this study; (Figure 3.6)

- Model 1, transmitter dimention: depth 1 cm., width 2 cm., length 4.5 cm., used 20 cm. antennas, mass 14 g. for adult.

- Model 2, transmitter dimention: depth 1 cm., width 2 cm., length 3.5 cm., used 20 cm. antennas, mass 10 g. for juvenile.

4. GPS model Garmin GPS V

5. Thermo-Hygrometer

6. Spring balance, 10 kg.

Figure 3.4
ATS receiver
(Model FM16)

Figure 3.5
Handheld ATS 3 elements
Folding Yagi Antenna

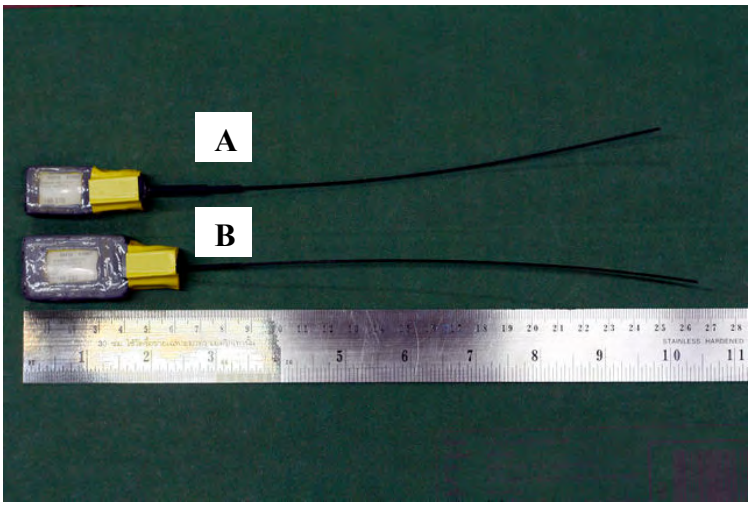

Figure 3.6
148 mhz
Radiotransmitters
A = Model 1
B = Model 2

3.3 Study methods

3.3.1 Radio-telemetry technique

Tortoises were searched for in their natural habitat. When a specimen was discovered, a transmitter was attached to the lower posterior part of the carapace using two-component epoxy glue (Figure 3.7), which is waterproof and long-lasting but harmless to the animal (Boardman et al., 1998). Each transmitter (and so marked tortoise) was assigned a unique frequency allowing subsequent independent tracking of individuals. The total amount of time for radio attachment was about 30 minutes. The post-attachment transmitter weights for adults and juveniles were 25 g and 18 g, respectively, and so did not exceed the recommended 5% of body weight guidelines (Schubauer, 1981). Transmitter life was approximately 16 months and transmitters were replaced if they did not function properly.

Tortoises were located using a ATS receiver (Model FM16) and a handheld ATS 3 elements Folding Yagi Antenna.

A

B

Figure 3.7 Attachment of a transmitter on *M. impressa*; A = Adult and B = Juvenile.

CHAPTER IV

Home range of the impressed tortoise, *Manouria impressa* (Günther, 1882) at Phu Luang Wildlife Sanctuary, Loei Province

Introduction

The impressed tortoise, *Manouria impressa* (Günther, 1882) (Reptilia: Testudines), occurs in montane areas of Southeast Asia where it ranges from Myanmar, Thailand, Laos, Vietnam and Cambodia to Malaysia (Ernst and Barbour, 2001, Fritz and Havas, 2007). Within Thailand this species occurs in the mountains of northern, northeastern and western Thailand (Cox et al., 1998), where it inhabits evergreen forests and bamboo thickets (Weissinger, 1987).

M. impressa is classified as a vulnerable (Vu) species by IUCN (2008) and CITES (2007) places it in Appendix II. The species appears to be rare in its natural habitat, and exhibits poor breeding and a low survival rate in captivity, ruling out captive breeding and reintroduction based on conservation strategies. Although *M. impressa* is locally hunted for food and to supply the pet trade, little is known of its habits, diet, reproduction and activities in the wild. A greater knowledge of its distribution range, areas of occurrence, habitat characteristics, home range size and other activities in the wild would be very useful for the development of viable conservation management strategies.

Materials and methods

Field work was conducted from January 2010 - May 2011. A total of thirteen *M. impressa*, consisting of ten adults (five males and five females) and three juveniles were initially radio-tracked in the study area. Each tortoise was expected to be located up to 6-10 times per month. When the tortoise was found, the location was obtained by GPS, with a minimum accuracy within 20 meters for all locations and the positions are given in Universal Transverse Mercator (UTM). After one year of study, the data of five males, five females and two juveniles were available for home range analysis, with that from a third juvenile available for only the dry season.

Analysis of data

The home range size of each individual and overlap between two individuals were estimated by the Minimum Convex Polygon Method (MCP) using the BIOTAS software program. MCP was chosen, because it is the most commonly and widely used home range estimators. The advantages of MCP are simplicity, flexibility of shape and ease of calculation (White and Garrott, 1990) and should be accurately represent the maximum home range area for most herpetofauna (Row and Demers, 2006). The home range size of each individual was calculated using locations tracked over at least 4 months. Overlap between two tortoise home ranges was calculated as the percentage of the total home range of each tortoise, following Geffen and Mendelssohn (1988).

Because of the small sample size of tracked tortoises, nonparametric statistics were used to analyze the data. The size of the home range was estimated year-round and also separated into the wet (May-October) and dry (November-April) seasons. The difference in median home range size between the sexes and between the dry and wet seasons were analyzed using Mann-Whitney U-tests at a confidence level of 95%. The Spearman Rank Order Correlation was used to determine the correlation between home range size and carapace length or body mass.

Results

The home range sizes of the 13 tortoises tracked over the year are shown in Table 4.1. The size of home ranges varied greatly among individuals; 2.71 ha - 17.69 ha year-round, 1.21 ha - 12.09 ha in wet season and 0.21 ha - 12.06 ha in dry season. The largest home range size was from female (FMI-7) at 17.69 ha. One juvenile tortoise, JMI-4 had a wider home range size than some of the adults. Home range sizes showed no significant correlation with the carapace length or body mass ($p > 0.05$; Spearman Rank Order Correlation).

Of the three marked juveniles, one (JMI-1) was lost in the wet season due to transmitter failure, and so only the data from two juveniles could be used for the annual home range analysis. The median home range sizes within either the dry or wet season or over the year between adult males, adult females and juveniles were not significantly different, but between seasons they were significantly larger for adult males, adult females and juveniles in the wet season (Table 4.2).

Throughout the year, the home range of most individuals overlapped with some of the others. However, there was no evidence that any individual held or defended its territory. The overlaps of home ranges between males, females and juveniles are shown in Figure 4.1 and Table 4.3. Annual home range overlaps varied from 0 - 87.8%, with the highest home range overlap (87.8%) occurring between male MMI-5 and female FMI-8. The mean overlap of home ranges between juveniles and adults was 28.8% (range = 2.96 – 75.2%) and a small overlap occurred between the two juveniles, JMI-1 and JMI-4.

The home range of each female overlapped with at least one male, with a mean overlap of 32.1% (range = 1.29 – 66.2%), whilst the mean overlap between two females was 26.60% (range = 9.76 – 45.6%). Correspondingly, most male home ranges overlapped with at least one female, with a mean overlap of 26.2% (range = 1.19 – 87.8%). However, males typically did not overlap with each other, with only one small overlap being observed between male home ranges, MMI1-2 and MMI-4 (Figure 4.1). Furthermore, MMI-13 was found eating mushrooms at the same rotten log with a non-telemetric male in the dry season (March) (Figure 4.2), and, on another occasion, was found submerged in a shallow stream at the same position with a non-telemetric home range female (Figure 4.3).

Table 4.1 Home range sizes and specimen data for 13 *M. impressa* radio tracked individuals at Phu Luang Wildlife Sanctuary.

Tortoises	Home Range (ha)			Tracking period	Carapace	Body mass	Sex
	Wet Season	Dry Season	Year-round	(Months)	length	(kg)	
JMI-1	-	0.28	-	4	17	1	Juvenile
JMI-2	2.06	0.46	2.71	10	17	1	Juvenile
JMI-4	7.54	3.64	11.82	12	20	1.50	Juvenile
MMI-5	8.31	1.16	9.35	12	29	3.50	Male
FMI-6	7.57	2.31	9.44	12	28.5	3.50	Female
FMI-7	7.08	12.36	17.69	12	27.5	3.20	Female
FMI-8	12.09	3.18	12.40	12	30	3.40	Female
MMI-9	4.86	1.10	9.84	12	25	2.50	Male
FMI-10	1.92	1.14	2.77	12	24	1.70	Female
MMI 11	10.89	1.31	10.20	12	26	2.80	Male
MMI 12	4.84	5.72	13.43	12	25	2	Male
MMI 13	2.63	1.20	3.85	12	24	2	Male
FMI 14	2.83	0.34	3.21	12	25.5	3.20	Female

JMI = Juvenile *M. impressa*; MMI = Male *M. impressa***;** FMI = Female *M. impressa*

Table 4.2 Median home range sizes (ha) of male, female and juvenile *M. impressa* tortoises in wet season, dry season and throughout the year at Phu Luang Wildlife Sanctuary.

Season	Male					Female					Juvenile				
	Median	**Min**	**Max**	**SD**	**N**	**Median**	**Min**	**Max**	**SD**	**N**	**Median**	**Min**	**Max**	**SD**	**N**
Year-round	9.84	3.85	13.43	2.91	5	9.44	2.77	17.70	6.32	5	7.26	2.71	11.82	6.45	2
Wet	8.31	2.63	10.89	3.27	5	7.07	1.92	12.09	4.09	5	4.80	2.06	7.54	3.88	2
Dry	1.20	1.10	5.72	2.03	5	2.31	0.34	12.36	4.87	5	0.46	0.28	3.64	1.90	3

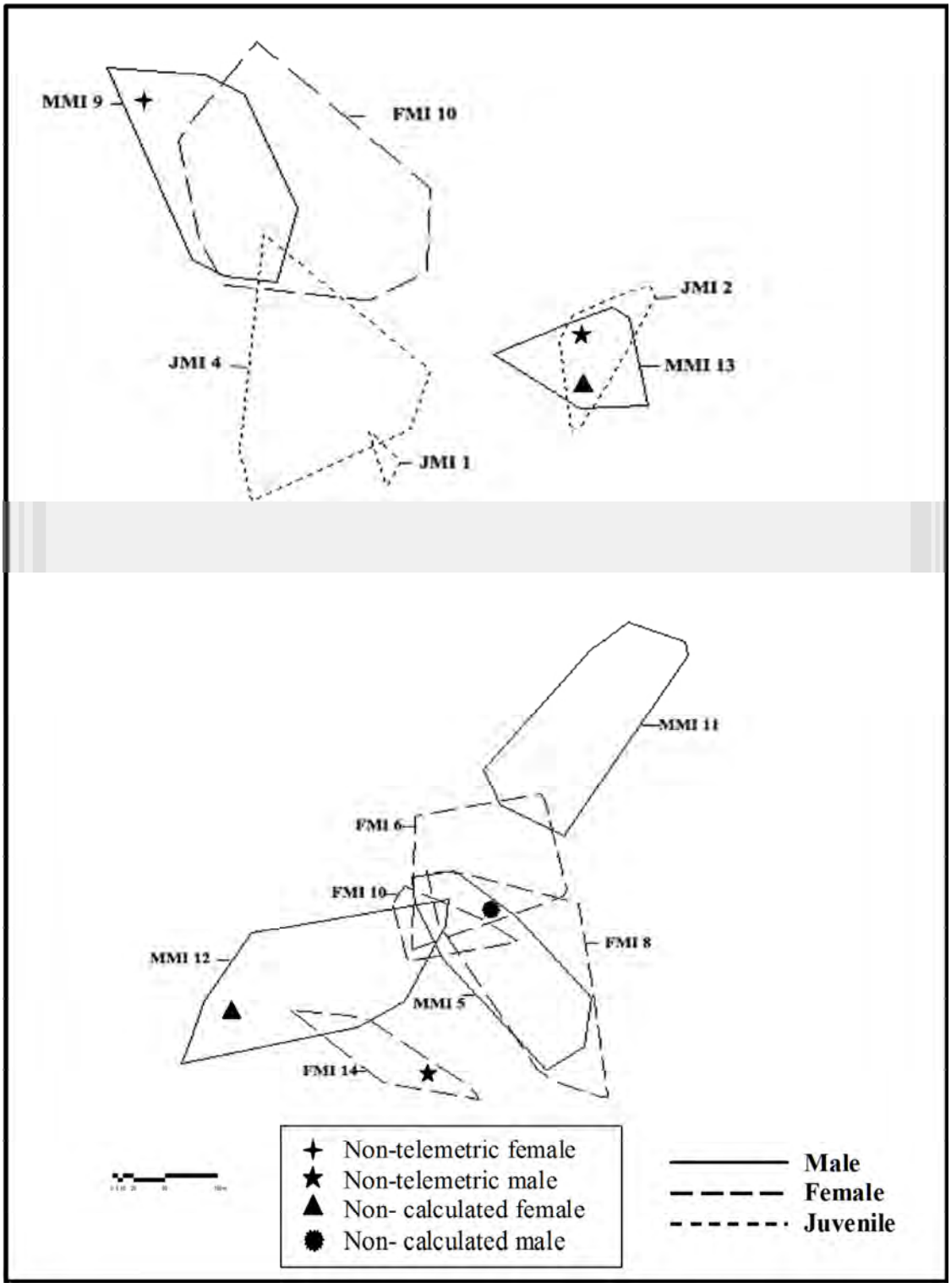

Figure 4.1 A comparison of annual home range overlap and size for five male, five female and three juvenile *M. impressa* at Phu Luang Wildlife Sanctuary.

Table 4.3 Percent overlap of 13 home ranges for *M. impressa* at Phu Luang Wildlife Sanctuary.

Tortoise no.	Males					Females					Juveniles		
	MMI-5	MMI-9	MMI-11	MMI-12	MMI-13	FMI-6	FMI-7	FMI-8	FMI-10	FMI-14	JMI-1	JMI-2	JMI-4
Males													
MMI-5	-	0	0	3.64	0	24.5	0	87.8	18.5	0	0	0	0
MMI-9	0	-	0	0	0	0	64.1	0	0	0	0	0	3.56
MMI-11	0	0	-	0	0	4.44	0	0	0	0	0	0	0
MMI-12	3.2	0	0	-	0	0	0	1.19	9.08	4.17	0	0	0
MMI-13	0	0	0	0	-	0	0	0	0	0	0	52.9	0
Females													
FMI-6	24.3	0	5.3	0	0	-	0	26.6	13.5	0	0	0	0
FMI-7	0	35.7	0	0	0	0	-	0	0	0	0	0	5.42
FMI-8	66.2	0	0	1.29	0	20.2	0	-	9.76	0	0	0	0
FMI-10	62.5	0	0	44	0	45.9	0	43.7	-	0	0	0	0
FMI-14		0	0	17.5	0	0	0	0	0	-	0	0	0
Juveniles													
JMI-1	0	0	0	0	0	0	0	0	0	0	-	0	10.7
JMI-2	0	0	0	0	75.2	0	0	0	0	0	0	-	
JMI-4	0	2.96	0	0	0	0	8.12	0	0	0	0.25	0	-

The home range of MMI-9 and FMI-7 had a high percentage of overlap (64.1%), potentially suggesting a pair, but no mating behavior between them was seen. Rather MMI-9 mated with a non-telemetric female in his home range. The home range of MMI-5 overlapped with three females (FMI-6, FMI-8 and FMI-10) and he was observed to mate with two of them (FMI-8 and FMI-6). Furthermore, FMI-6 was also found in the same hole with MMI-11. Although the home range of FM1-10 overlapped with two males (MMI-5 and MMI-12), mating behavior between them was not seen. MMI-12 and FMI-14 were found under the same rock at the same position but mating behavior between them was not seen. Rather, MMI-12 was seen mating with a non-calculated home range female while FMI-14 mated with a non-telemetric male.

The comparison between the home range sizes of *M. impressa* with two other native tortoise species, *Manouria emys phayrei* and *Indotestudo elongata,* is shown in Table 4.4 The median home range size of *M. impressa* from this study was similar to those of *I. elongata* but was much smaller than those for *M. emys pheyrai* (Table 4.4). Tharapoom (1996) studied one male and three females of *I. elongata* in mixed deciduous and dry evergreen forests at elevations from 400-600 m amsl at Huai Kha Khaeng Wildlife Sanctuary, Western Thailand, and reported year-round home range sizes from 7.04 ha - 9.86 ha, with the only male tortoise recorded having a similar home range size to that of the three females.

Wanchai (2007) observed eleven *M. emys phayrei*, consisting of four males, four females and three juveniles, at elevations between 700 to 1,200 m amsl in a dry evergreen forest at Kaeng Krachan National Park, Western Thailand, and reported a year-round home range from 30.3 ha – 105.1 ha and 2.00 ha – 14.8 ha for adults and

juveniles, respectively. Comparison between these home ranges suggested that the median home range sizes of males and females of *M. impressa* in this study were significantly smaller than those for *M. emys phayrei*. However, the comparison of the year-round home range sizes among *M. impressa* adults, *I. elongata* adults and *M. emys phayrei* juveniles, that are all similar in their average of carapace length, revealed no significant difference in home ranges.

Figure 4.2 Two *M. impressa* males eating mushrooms, Genus *Auricularia* at a rotten log.

Figure 4.3 A tracked male (MMI-13) (red arrow) and a female (yellow arrow) submerging in a shallow stream.

Table 4.4 Comparison of median home range sizes and average carapace lengths of three Thai tortoise species.

Tortoises Species	Average of Carapace length ± SD (cm)		Study period (Month)	n	Home range (ha)		
	Adult	Juvenile			Male(n) ± SD (Min-Max)	Female(n) ± SD (Min-Max)	Juvenile(n) ± SD (Min-Max)
Manouria emys phayrei (Wanchai 2007)	46.0 ± 4.43	26.3 ± 0.14	12	8	64.7(4) ± 30.6 (30.3-105.1)	55.8(4) ± 7.24 (48.3-63.1)	8.50(3) ± 6.39 (2.00-14.8)
Indoestudo elongata (Tharapoom 1996)	26.3 ± 0.71	-	12	4	8.00(1) ± 0 (8.00)	8.71(3) ± 1.42 (7.04-9.86)	-
Manouria impressa (This study)	26.5 ± 2.15	18.5 ± 1.73	12	10	9.84(5) ± 2.91 (3.85-13.4)	9.44(5) ± 6.32 (2.77-17.7)	7.26(2) ± 6.45 (2.71-11.8)

Discussion

Despite a limited sample size of tracked tortoises during a single year, the home range sizes of *M. impressa* were found to be highly variable within sex and age class. Variation in home range size has been found in many terrestrial species, such as Texas Tortoise, *Gopherus berlandieri* (Rose and Judd, 1975), Bolson tortoise, *Gopherus flavomarginatus* (Aguirre et al., 1984), and the Yellow-margined Box Turtle, *Cuora flavomarginata* (Lue and Chen, 1999). Koulang (2008) studied six *M. impressa* in the Central Cardamom Protected Forest on the Cardamom Mountains in southwest Cambodia from September 2007 - March 2008. He reported that this tortoise was found in montane evergreen and bamboo forests at high elevations up to 668 – 755 m amsl and occupied a home range size of 1 - 14 ha by MCP. However, the average home range sizes of males and females did not show a statistically significant difference and one sub-adult female occupied a larger home range than some adults, which is similar to the result found in this study. Furthermore, there was no significant relationship between the body weight of the tortoise and its home range size. The difference in home range size between seasons and age classes were not reported.

There was no significant difference in the home range sizes of *M. impressa* within either the dry or the wet season, nor all year-round between adult males and females in this study. This result is similar to that observed for *I. elongata* in the deciduous forests of Western Thailand (Tharapoom, 1996). Median home range sizes of adult male and female *M. emys phayrei* at 700 to 1,200 m amsl in the dry evergreen forest of Western Thailand were also not significantly different (Wanchai, 2007). Similar results have also been reported for the Egyptian tortoise, *Testudo kleinmanni*,

in Northwestern Negev, Israel (Geffen and Mendelssohn, 1988), North American wood turtles, *Clemmys insculpta*, in Central Pennsylvania (Kaufmann, 1995) and *Gopherus agassizii* in the Picacho Mountains of Arizona (Barret, 1990). However, this result is opposite to some terrestrial and aquatic species, in which males have been reported to have a larger home range size than females (Auffenberg and Weaver, 1969, Rose and Judd, 1975, Schubauer et al., 1990, Lue and Chen, 1999, Smith, 2006). The lack of a significant difference between the median home range sizes of males, females and juveniles is probably due to the small sample size and variation in habitat quality and spatial arrangement, as indicated by the high variation among individuals. Diemer (1992) studied 22 gopher tortoises with different sex and age classes, and reported that the longest movement in the study was made by a sub-adult. Rose and Judd (1975) reported that the mean home range sizes of adult male and juvenile Texas tortoises, *Gopherus berlandieri*, were not significantly different.

Median home range sizes of adult *M. impressa* in the wet season were found to be significantly larger than in the dry season, consistent with that previously reported for *M. emys phayrei* and *I. elongata* (Tharapoom, 1996, Wanchai, 2007). This may be due to adaptation to the lack of resources in the dry season that is associated with undesirable environmental conditions, such as a high temperature, low humidity, low rainfall and a limited availability of food plants. Many tortoises are inactive in the dry season and hide under fallen branches or leaf litter for at least 1-2 months. The inactive period is usually interpreted as a mechanism for energy conservation that reduces the metabolic rate when little food is available (Gregory, 1982). An adaptation to the lack of resources has also been reported in the desert

tortoise, *Gopherus agassizii*, during droughts, when it uses a smaller home range and travels a shorter distance (Duda et al., 1999).

Although in this study the home ranges of individual *M. impressas* overlapped, there was no evidence that any individual held or defended a territory. Rather, the overlap in the home ranges between males and females in this study were potentially associated with mating behavior and / or resource sharing. Indeed, mating behavior was observed for most of the adult tortoises (6/10) in their home range. The overlap in home range of individuals may be associated with the abundance of food as two adult males were found eating mushrooms at the same rotten log. Moreover, MMI9, FMI 10 and JMI4 were found eating mushrooms at the same area but at different time. *Gopherus aggassizii* males are known to be highly territorial in and around their burrows, but territoriality is generally not a feature of turtle or tortoise biology. Kaufmann (1995) reported that the home ranges of male and female wood turtles, *Clemmys insculpta,* overlapped throughout the active season, whilst the home ranges of male, female and juvenile Bolson tortoises, *Gopherus flavomaginatu*s, overlapped throughout the year (Aguirre et al., 1984). In addition, Egyptian tortoises, *Testudo klenmanni*, revealed no territoriality (Geffen and Mendelssohn, 1988), whilst leopard tortoises*, Stigmochelys pardalis,* showed overlapping home ranges (McMaster and Downs, 2009). Studies on *Gopherus polyphenus* and *G. berlandieri* indicated that they did not defend territories but had hierarchical dominance (Diemer, 1992, Rose and Judd, 1975).

Body size may also influence the home range size of *M. impressa*, *I. elongata* and *M. emys phayrei*. Adult *M. emys phayrei* have a larger body size than *M. impressa* and *I. elongata*, and so usually require more nutrients and energy, resulting

in the need to roam a larger home range to acquire the resources, while *M. emys phayrei* juveniles had a similar average carapace length with *M. impressa* and *I. elongata*, and accordingly the year-round home range size between them was not significantly different. Hailey and Coulson (1996) studied the movement of two African tortoises, *Stigmochelys pardalis* (mean body mass 4.0 kg) and *Kinixys spekeii* (mean body mass 0.62 kg), and found that *S. pardalis* made longer movement and used a larger home range than *K. spekeii*.

The lack of a significant correlation between the home range size and the carapace length or body mass within a species has previously been reported in some turtle and tortoise species. Barrett (1990) reported that the home range size of *Xerobates agassigii* was not significantly correlated with carapace length. Likewise, North American wood turtles (*Clemmys insculpta*), leopard tortoises (*Stigmochelys pardalis*), Egyptian tortoises (*Testudo kleinmanni*) and Kemp's Ridley sea turtles (*Lepidochelys kempii*) showed no significant relationship between their annual home-range size and body mass (Geffen and Mendelssohn, 1988, Kaufmann, 1995, Schmidt et al., 2003, McMaster and Downs, 2009).

CHAPTER V

Activity Budget of the Impressed Tortoise, *Manouria impressa* (Günther, 1882), in Phu Luang Wildlife Sanctuary, Loei Province

Introduction

Manouria impressa appears to be rare in its natural habitat due to habitat destruction, poaching for food and collecting for the pet trade (van Dijk and Palasuwan, 2000). However, it is difficult to maintain in captivity and has only recently been captive-bred. The natural history of *M. impressa* is poorly known, and most recently accepted data have been based on short term field studies, with no long term study of its ecology in the wild being available. McMorris and Burns (1975) reported that *M. impressa* spends much of its time hiding under leaf litter, and Nutaphand (1979) reported that they are active during the rainy season (May - October) when they eat grass shoots and look for mates. Weissinger (1987) reported the species is only active during the rainy season and Chan-ard et al. (1996) reported that, for the *M. impressa* kept in an enclosure at Phu Luang Wildlife Research Station, they usually entered brumation during November and emerged after the first substantial rain, which usually falls in late February. Based on a study of six *M. impressa* (four males and two females) in the Central Cardamom Protected Forest on the Cardamom Mountains in southwest Cambodia from September 2007 - March 2008, Koulang (2008) reported that the mean ambient temperature near the hiding place was 23.9 $\pm$ 1.8 $^{\circ}$C (range of 20.0 $^{\circ}$C - 29.2 $^{\circ}$C), whilst that at the microhabitat of

the hiding place was 20.6 ±1.0 °C (range of 18.0 °C - 22.7 °C). Normally, the microhabitat temperature is significantly lower compared to the ambient temperature of the hiding places.

The purpose of this study was to describe the annual activity patterns and any differences in activity between the wet and dry seasons, and the preferred microhabitat of *M. impressa*. This study provides new basic information on its ecology and behavior that could be used for captive breeding and conservation management.

Materials and methods

Animals were radiotracked from January 2010 through to October 2011 inclusive. A total of 14 *M. impressa* individuals comprised of ten adults (five males and five females) and four juveniles were tracked using radio-transmitters (148 MHz).

Each tortoise was located 6 – 10 times per month by direct observation, using an ATS receiver (Model FM16) and a handheld ATS 3 element folding Yagi antenna. When a tortoise was located, the activity when first seen was recorded in terms of being active or inactive, where the active state was defined into one of the seven categories of (1) walking, (2) eating, (3) basking (staying on the forest floor, fully exposed to the sun, usually with limbs spreading wide and neck stretching out), (4) resting (immobile; staying in the open or in partial cover, plastron touching the ground, neck and limbs mostly extended), (5) soaking (sitting in a shallow stream or swamp), (6) courting/mating (male following a female, circling around her, and mounting or attempting to mount), and (7) nesting (female building or guarding a

nest). Individuals hiding under leaf litter or rocks and fallen branches were classified as “inactive” (Figure 5.1).

Analysis of the data.– The percentage of active and inactive periods were estimated and categorized with respect to whether in the wet (May – October) or dry (November – April) season. The difference in the percentage of active and inactive periods between the sexes, age classes and between the wet and dry seasons were analyzed using ANOVA (Sheffe’s Post hoc Comparison), accepting significance of differences at the $p < 0.05$ level. Before using ANOVA, raw data were checked for normality at a confidence level of 95 %, to meet parametric statistical assumptions. The mean annual temperature, mean relative humidity and rainfall at the study site were obtained from the nearby ranger weather station (1-3 km from the field site). In addition, the ambient temperature and relative humidity were also recorded at the position where tortoises were located using a thermo-hygrometer at 1 m above the forest floor. The differences in mean ambient temperature and relative humidity between adults and juveniles, and between the wet, cold-dry and hot-dry seasons were analyzed using ANOVA (Sheffe’s Post hoc Comparison) using the SPSS 11.5 for Windows software and accepting significance of differences at the $p < 0.05$ level.

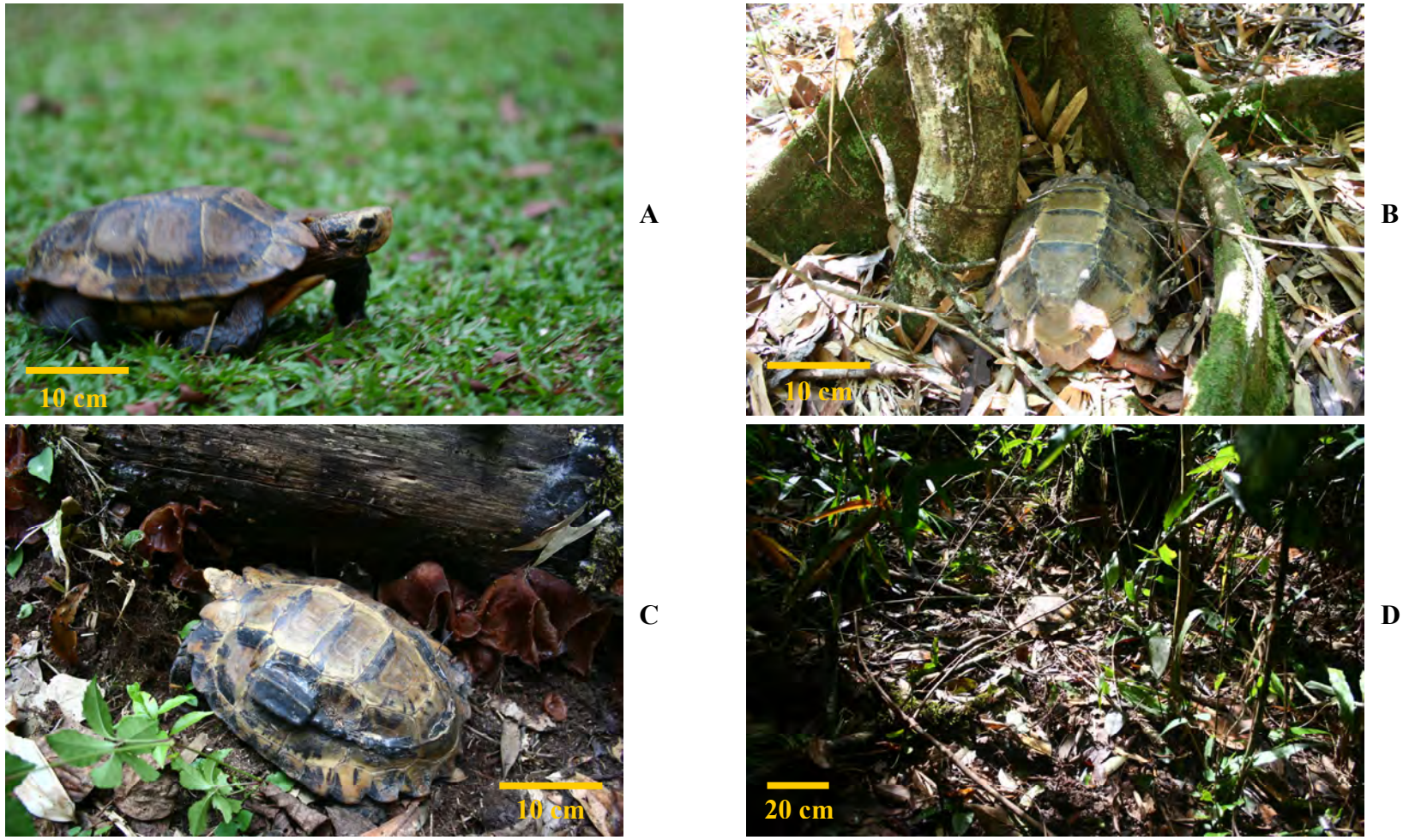

Figure 5.1 Types of *M. impressa* activities (A) walking, (B) resting, (C) eating and (D) basking.

E

F

G

H

Figure 5.1 (cont.) Types of *M. impressa* activities (E) soaking (F) courting/mating (G) nesting and (H) hiding.

Results

The air temperature, as obtained from nearby ranger weather station ranged from 6.5 – 33.0 ºC (mean ± SE = 19.9 ± 1.7 ºC) with an average temperature during the wet, cold-dry and hot-dry seasons of 21.7 ± 0.3 ºC, 15.3 ± 0.4 ºC and 22.8 ± 0.5 ºC, respectively. The relative humidity at the study site ranged from 60 – 100%. The average (± SE) relative humidity in the wet, cold-dry and hot-dry seasons were 85.2 ± 0.4%, 66.2 ± 0.4% and 78.6 ± 0.6%, respectively. The average air temperature and relative humidity during the rainy and hot-dry seasons were both significantly higher than those in the cold-dry season (ANOVA, $p < 0.05$).

The air temperature and relative humidity were also recorded at the precise position where tortoises were located, so as to allow the importance of any potential microhabitat-dependent variations to be evaluated. The mean ambient temperature and relative humidity for each activity are shown in Table 5.1 Active tortoises were found at ambient temperatures ranging from 12.0 – 30.0 ºC (mean ± SE = 22.8 ± 0.14 ºC) and a relative humidity from 60 – 100% (mean ± SE = 82.2 ± 0.5%). However, large numbers of individuals were inactive (hiding) in the same period when the temperature and humidity ranged from 11.7 – 27.5 ºC (mean ± SE = 20.10 ± 0.13 ºC) and 60 – 100% (mean ± SE = 75.7 ± 0.4%), respectively. For all individuals, there was no significant difference in the temperature between each active behavior. However, basking tended to occur at the highest mean ambient temperatures (25.2 ºC and 24.4 ºC for males and females, respectively). The mean air temperature and relative humidity during the observed hiding behavior was significantly lower than that during the periods of activity (ANOVA, $p < 0.05$).

Table 5.1. Mean (± SE) air temperature and relative humidity (RH) during *Manouria impressa* activity in Phu Luang Wildlife Sanctuary (PLWS), Loei Province, Thailand from January 2010 to October 2011 inclusive.

Sex or age class (n)	Activity															
	Walking		Resting		Eating		Basking		Soaking		Mating		Nesting		Hiding	
	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH	Temp	RH
Male (n = 5)	23.2 ± 0.2 (N = 38)	82.6 ± 1.2 (N = 38)	22.0 ± 0.3 (N = 54)	81.3 ± 1.3 (N = 54)	23.4 ± 0.6 (N = 9)	84.2 ± 2.0 (N = 9)	24.4 ± 0.8 (N = 5)	79.0 ± 4.5 (N = 5)	22.2 ± 0.5 (N = 25)	85.0 ± 1.5 (N = 25)	23.6 ± 1.0 (N = 8)	79.5 ± 2.0 (N = 8)	-	-	19.6 ± 0.2 (N = 271)	77.0 ± 0.7 (N = 271)
Female (n = 5)	23.6 ± 0.4 (N = 39)	80.6 ± 1.4 (N = 39)	22.7 ± 0.3 (N = 51)	82.1 ± 1.1 (N = 51)	23.7 ± 0.7 (N = 12)	82.1 ± 1.1 (N = 12)	25.2 ± 1.0 (N = 5)	79.0 ± 3.7 (N = 5)	21.7 ± 0.4 (N = 19)	84.7 ± 1.0 (N = 19)	23.6 ± 1.0 (N = 8)	79.5 ± 2.0 (N = 8)	22.9 ± 1.5 (N = 4)	82.5 ± 3.2 (N = 4)	19.7 ± 0.2 (N = 319)	74.8 ± 0.6 (N = 319)
Juvenile (n = 4)	22.7 ± 0.8 (N = 13)	83.3 ± 3.5 (N = 38)	22.9 ± 0.6 (N = 14)	80.1 ± 1.9 (N = 14)	24.0 ± 0.7 (N = 4)	82.8 ± 2.3 (N = 4)	-	-	23.0 ± 0.6 (N = 8)	81.8 ± 3.7 (N = 8)	-	-	-	-	21.9 ± 0.3 (N = 141)	75.1 ± 0.9 (N = 141)

N = total number of observations

Activity Level.– There were no significant differences in activity budgets between males and females (p = 0.48) but there were significant differences between adults and juveniles. Adults tended to be more active than juveniles either both all year-round (p = 0.04) and in the wet season (p = 0.02) but not in the dry season (Table 5.2).

In both the wet and the dry seasons, the majority of individuals observed were inactive. However, the frequency of active behavior in the wet season was higher than in the dry season (all $p < 0.05$). There were no significant differences between the activity level of males and females in the wet season (p = 0.52) but males tended to be more active than females and juveniles during the dry season (Table 5.2).

Table 5.2. Proportion of active and inactive *Manouria impressa*, as percentage of observations, all year-round and in the wet or dry season in Phu Luang Wildlife Sanctuary.

Sex or age class (n)	Year-round		Wet season (May-October)		Dry season (November-April)	
	Active (%)	Inactive (%)	Active (%)	Inactive (%)	Active (%)	Inactive (%)
Male (n = 5)	33.1 (N = 153)	67 (N = 310)	44.6 (N = 116)	55.4 (N = 144)	18.2 (N = 37)	81.8 (N = 166)
Female (n = 5)	31.2 (N = 145)	68.8 (N = 320)	43 (N = 116)	57 (N = 154)	14.9 (N = 29)	85.1 (N = 166)
Juvenile (n = 4)	21.8 (N = 41)	78.2 (N = 147)	29.6 (N = 29)	70.4 (N = 69)	13.3 (N = 12)	86.7 (N = 78)

N = total number of observations

Activities varied by season (Figure 5.2). Hiding was the most frequently observed activity for tortoises in all seasons, followed by walking and resting. During the cold-dry season (November – February), most individuals were hiding and no movement was observed for any individual during December and January. Most tortoises remained hidden until February when they emerged from their shelters as the first rain arrived (Figure 5.3). However, if the rain did not continue for several consecutive days, the tortoises remained in their shelter and did not emerge until the subsequent hot-dry season. In the hot-dry season (March and April), most of the tracked tortoises emerged from their shelter and became active. Substantial rain arrived in April and continued for several days, and mushrooms, the main diet of *M. impressa* in this study, were available at this time. Of the activities; walking, resting, basking, eating and mating were the main activity observed in this month. In May, which is usually the first month of the rainy season, many species of mushrooms were available. Activity levels, and especially walking, resting, eating, basking and mating, also peaked in this month. By late September tortoises became less active, which coincides with when many species of mushrooms were no longer available. In October, when the temperatures were lower and mushrooms were not available, most tortoises became inactive.

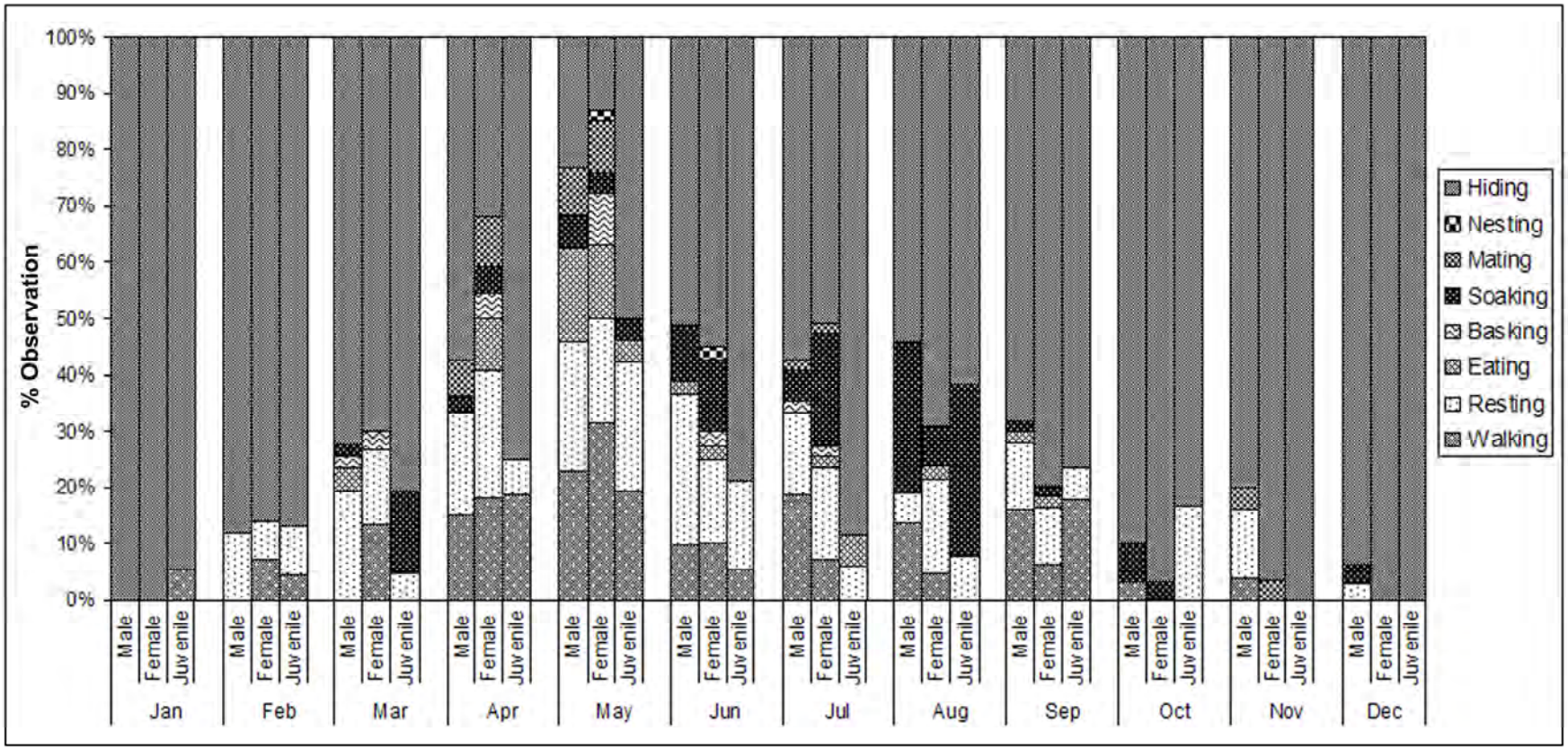

Figure 5.2 Frequencies of the different observed activities of male, female and juvenile *Manouria impressa* all year-round in Phu Luang Wildlife Sanctuary.

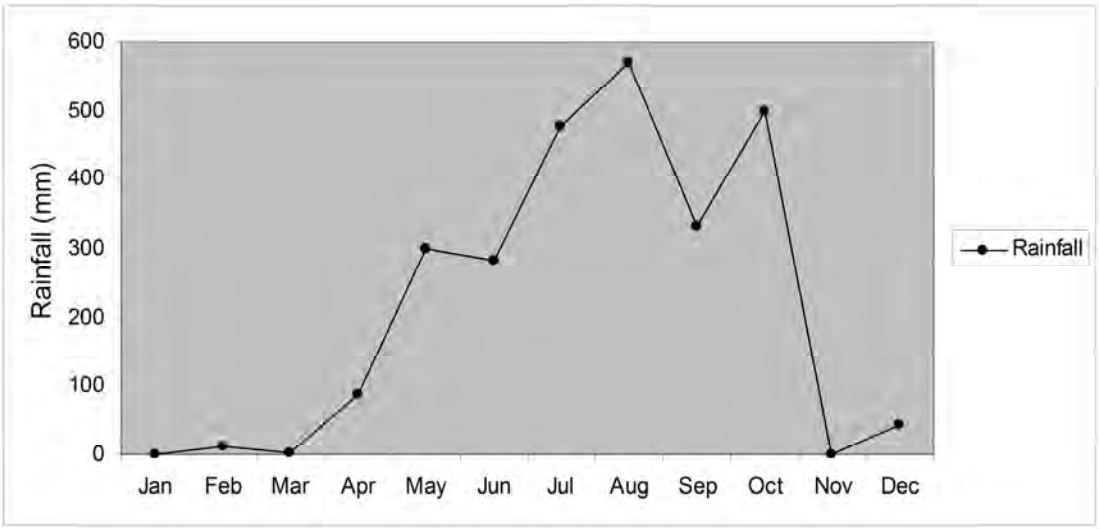

Figure 5.3. Total rainfall at Phu Luang Wildlife Sanctuary (PLWS) from January 2010 - October 2011(PLWS weather station).

Note on types of activities.

- Feeding behavior was observed during March – September but peaked in May, when a high abundance and diversity of mushrooms were available. *M. impressa* in this study fed on at least eight different species of forest mushrooms and were not found to consume any other vegetation or fruit.

- Basking behavior was only seen in adults and was observed from March through July.

- Soaking was found in all seasons but the proportion of observations of this behavior was highest in the rainy season during July and August.

- Courting and mating were observed in all seasons but peaked in the rainy season. At the beginning of the rainy season in May 2010, one male was found mating with a female and 4 days later the same male was found mating with another female.

Re-mating between the same male and female was also observed but in different years and not in the same year.

- Two cases of nesting were also found in this study. Nest building was first seen on May 4th, 2011, where a female was collecting plant materials next to the nest, back sweeping while backing towards the nest. On May 10th the female was still collecting new materials for the nest building and on May 16th she was still beside the nest. On May 19th the female had left the nest and the nest was investigated. The nest was situated in bamboo forest on a hill slope at 1,375 m amsl. Its site was close to a bamboo grove and was shaded from direct sunlight. Most nest materials consisted of dry bamboo leaves (Figure 5.5) and the female also used this material to cover her eggs. The diameter of the nest was 100 cm and the height was 25 – 30 cm. Damaged and broken eggs were found in the nest and the clutch size was estimated at 8 – 10 eggs. The second nest was found while a female was guarding it on June 28th (Figure 5.6), 2011. The female sat on the nest and displayed aggression towards the observers. The nest was located in montane forest mixed with bamboo on a sloped area near the top of the mountain at 1400 m amsl. The nest site was similar to that of the first female, but the composition was quite different, consisting of small sticks and leaf litter (Figure 5.7). The diameter of the nest was about 100 cm and the height was 40 – 45 cm. Clutch size was estimated at 8 – 10 eggs, but all the eggs were broken. The female did not guard the nest the next day but still spent time near to the nest, 5 to 10 m away. Both nests were presumably destroyed by predators, since eggshells were found inside and beside the nest (Figure 5.8).

Figure 5.4. The first nest of *M. impressa* at Phu Luang Wildlife Sanctuary. Photographed on May 19, 2011.

Figure 5.5 Nest materials of the first nest, combinding mainly of bamboo leaves and small sticks.

Figure 5.6 The second nest, a female of *M. impressa* sitting on the nest and guarding the nest.

Figure 5.7 Nest materials of the second nest, combinding mainly of small sticks and tree leaves.

A

B

Figure 5.8 Broken eggshells found inside and beside the nest; A = first nest and B = second nest.

Discussion

M. impressa in this study were active when the ambient temperature and relative humidity ranged from 12.0 – 30.0 ºC (mean = 22.8 ºC) and 60 – 100% (mean = 82.2%), respectively, and they were inactive at temperature and humidity ranges from 11.7 – 27.5 ºC (Mean = 20.1 ºC) and 60 – 100% (Mean = 75.7%), respectively. Similarly, Koulang (2008), who studied six *M. impressa* at the Central Cardamom Protected Forest on the Cardamom Mountains of southwest Cambodia from September 2007 – March 2008 inclusive, reported that the range of ambient temperature and relative humidity near the position where *M. impressa* were located was 20.0 – 29.2 ºC (Mean = 23.9 ºC) and 60 – 96% (Mean = 85%), respectively. Although most activities occurred in every season, there were seasonal differences in the relative frequencies of activities. Hiding is the main activity of tortoises in all seasons. This result was similar to that reported by Koulang (2008) in that *M. impressa* spent more time hiding than walking or any other activities. Our results also agreed with that reported by McMorris and Burns (1975) and Weissinger (1987), who reported that *M. impressa* spent most of its time hiding under leaf litter and was active during the rainy season.

There were no nocturnal observations in this study. However, Koulang (2008) suggested that *M. impressa* may be more active at night. Also Chan-Ard et al. (1996) reported that *M. impressa* seems to be more active at twilight and during rain showers. For adult tortoises, feeding occurred more frequently in the wet season, during March-September, especially in May. This difference presumably reflects the availability of food. Seasonal change may affect food plant availability for tortoises. Many species

of mushrooms were easily found in May – July. In contrast, during the dry season, there are very few edible mushrooms available. The first observation of basking occurred in March, perhaps due to their attempt to raise or regulate body temperature after the hiding period. The tortoise might require more basking time to reach a body temperature that would enable them to feed and digest food (Joshua et al., 2010). Elevating body temperatures via basking should enhance the feeding rate (Spencer et al., 1998), digestion, metabolism and activity, all of which would help tortoises capitalize on the food available in the spring. For juveniles, they simply did not venture into open areas and that may be a strategy for predator avoidance. However, the hiding places of juveniles were frequently located in unshaded areas where sunlight can enter during the day and may provide basking opportunities.

The nesting ecology of *M. impressa* is not well documented. No previous study has documented natural nests, with most studies based upon captive tortoises. McMorris and Burns (1975) found that a female laid 17 eggs while Cox et al. (1998) reported that females laid about a dozen eggs per clutch. The eggs are laid in a shallow cavity and then covered with leaves. Only one example of nesting ecology in a natural habitat of this genus was previously available, where it was reported that *M. emys emys* nesting occurred in July during the monsoon period (Mortensen, 2004), where the nest was situated on top of a small hill in the secondary forest, with half the perimeter being the edge of a steep slope and the rest moderately sloped to almost flat. Both nests of *M. impressa* in this study were located on a sloped area and near bamboo grove. This location may have been selected to ensure that the nest was protected against flooding and runoff during heavy rainfalls.

A congeneric species, *M. emys phayrei,* appears to be different in some activity patterns. Wanchai (2007) reported that during the wet season, (May - October) *M. emys phayrei* adults were mostly found eating. This too may be because of food availability and *M. emys phayrei* eats many kinds of plant foods which were easily found in the forest throughout the rainy season, especially the bamboo shoot. In addition, many kinds of mushroom at PLWS which are the main diet of *M. impressa* are available for only a short term period during May to July. Therefore, the longer inactive period of *M. impressa* should be suitable for their survival as they can save their energy during food limitation.

During the cold-dry season, both adult and juvenile tortoises spent the majority of their time hiding. This may be an adaptation to the lack of resources in the dry season (November - April). The inactive period is usually interpreted as a mechanism for energy conservation that reduces metabolic rate when little food is available (Gregory, 1982). Activity patterns of turtles and tortoises influenced by seasonal change and other environmental factors have been reported by several authors. In cold months, the yellow-margined box Turtle, *Cuora flavomarginata* is less active and reduces foraging (Lue and Chen, 1999). The extreme continental climate of central Asia (hot and dry summer followed by a very cold winter) limits the activity of the steppe tortoise, *Testudo horsfieldi*, to within the spring only (Lagarde et al., 2003).

In this study, in late February (end of the cold-dry season) when the first rain arrived and the temperature rose, some *M. impressa* tortoises emerged from their hiding places. Rain might alter established periods of activity and tortoises respond by becoming active. However, mushrooms were not available during this month, and

most tortoises retreated into their shelter. This result is similar to that reported by Chan-ard et al. (1996) who observed that *M. impressa* kept in the enclosure at PLWS usually emerged from brumation after the first substantial rain. The beginning of activities following the first rain is also reported in *Gopherus berlandieri* (Rose and Judd, 1975) and the Egyptian tortoise, *Testudo kleinmanni* (Geffen and Mendelssohn, 1988). Most tortoises were active during April due to two major factors: rising temperature and availability of mushrooms.

M. impressa at PLWS used hiding places, such as burrows, under fallen branches, under rocks and shallow streams, to avoid extreme heat. Use of burrows and shelters has been experimentally demonstrated to reduce evaporative water loss in many reptiles (Bulova, 2002). The reason for the observed *M. impressa* soaking in shallow streams might not only be associated with thermoregulation. Many times tortoises were observed to be submerged in shallow streams or swamps covered by litter with only their nose exposed. From this position it is camouflaged and so potentially may be to avoid detection by predators. Another possible indirect benefit is that being submerged might also help get rid of ticks. All of the tortoises in this study had many ticks on their carapace (Figure 5.9) and softer parts of the neck and legs. All the examined ticks (20) were found to be *Amblyomma geoemydae*, a widespread tortoise and turtle tick in South and Southeast Asia (Robbins et al., 2006). Mortensen (2004) suggested that submersion in *M. emys emys* might help it to reduce the tick load.

In conclusion, this study provides new information of the life history of *M. impressa* that has refined our understanding of this species. Because Impressed tortoises are difficult to maintain in captivity, with almost one hundred percent

mortality during the adaptation process to captivity, then data from their natural habitat are important. Such data would likely be of great benefit in, if not essential to, establishing suitable husbandry protocols and conservation programs.

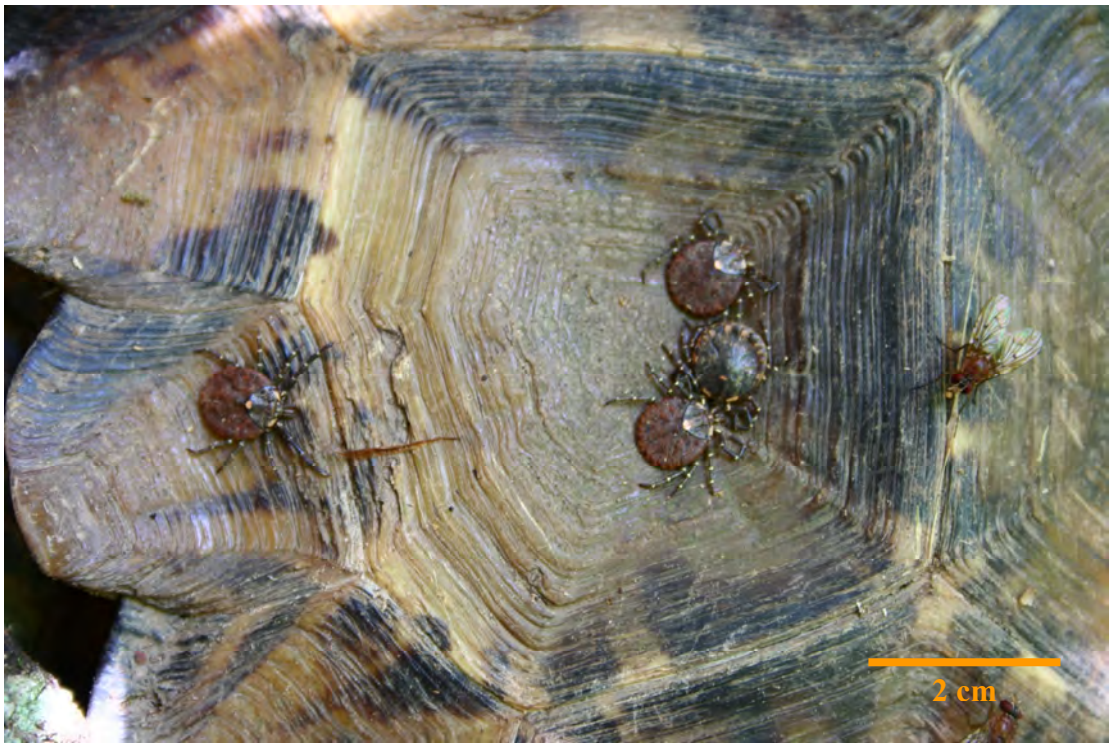

Figure 5.9 Ticks, *Amblyomma geoemydae* on *M. impressa* carapace.

CHAPTER VI

Habitat use of the impressed tortoise, *Manouria impressa* (Günther, 1882) in Phu Luang Wildlife Sanctuary, Loei Province

Introduction

The natural history of *Manouria impressa* is poorly known. Most recent works were from short term field observations and there is no long term study on its ecology in the wild. McMorris and Burns (1975) reported that the natural habitat for this species seems to be fairly dry and they spend much time hiding under leaf litter. Nutaphand (1979) reported that this species inhabits forests and mountainous areas, feeds on plants and bamboo shoots, and forages in dense undergrowths at an altitude of 700 to 2,000 meters. Weissinger (1987) reported that this tortoise inhabits evergreen forests and bamboo thickets on hills and mountains.

Koulang (2008) studied eleven tortoises, seven of them were obtained from local people and four were found in the wild in the Central Cardamom Protected Forest on the Cardamom Mountains in southwest Cambodia from September 2007 - March 2008. He reported that the habitats were evergreen and bamboo forest at high elevation from 668-755m during the study period. *M. impressa* were found under logs, in leaf litters, under bamboo canes and in holes.

The purpose of this study was to describe the habitat used, microhabitat used, elevation usage and temperature/relative humidity of habitats and microhabitats of *M. impressa*.

Materials and methods

This study was carried out from January 2010 through October 2011. Fourteen *M. impressa* of different sexes and age classes, consisting of ten adults (five males and five females) and four juveniles were tracked using radio-transmitters (148 MHz). Each tortoise was located up to 6–10 times per month by direct observation, using an ATS receiver (Model FM16) and a handheld ATS 3 element folding Yagi antenna. When a tortoise was found, elevation, the type of habitat and understory cover were noted.

Habitats were classified into 5 types (1) montane forest, (2) montane scrub forest, (3) bamboo forest and (4) montane forest mixed with bamboo.

Microhabitats were classified into 8 types (1) under stone, (2) in the hole, (3) under the log, (4) under leaf litter, (5) under tree root or tree hole, (6) under fallen branches, (7) in shallow stream and (8) on the ground (in open area and out of the shade or shelter).

Understory cover were divided into three categories: full cover, canopy was dense enough to shade out most of the sunlight; semi-cover, the canopy was broken and sunlight could penetrate to the forest floor; and open cover.

Temperature and relative humidity were recorded in each observation. Ambient temperatures recorded near the hiding places were measured using a thermo-hygrometer at 1 m. above the forest floor. The surface temperature and relative humidity at the tortoise site were measured using a thermo-hygrometer by putting it near to the place where the tortoise was staying. All temperatures and relative

humidity were reported in degrees Celsius (°C) and in percentage (%RH), respectively.

Analysis of data - The differences in elevation usage, mean air temperature, surface temperature, and relative humidity among adult males, adult females and juveniles and among wet season, cold-dry season and hot-dry season were analyzed using ANOVA (Sheffe's Post hoc Comparison) at confidence level of 95 %. Before using ANOVA, raw data were checked for normality at a confidence level of 95 %, to meet parametric statistical assumptions.

Results

The elevation usages ranged from 1,013-1,425 m amsl and significant differences among seasons, sexes and age classes were not found (Table 6.1).

In year round result, montane forest was the most utilized habitat in both adults (male = 79.26%, female = 60.86%) and juveniles (80.85%), montane forest mixed with bamboo was the second most utilized habitat (male = 14.05%, female = 30.75%, juvenile = 9.04%) whereas montane scrub forest was the least utilized in all seasons (male = 2.16%, female = 2.36%, juvenile = 4.26%).

In the rainy season, tortoises were mostly found in montane forest (male = 78.46%, female = 64.41%, juvenile = 69.39%), followed by montane forest mixed with bamboo (male = 13.08%, female = 22.22%, juvenile = 11.22%).

In the cold-dry season, tortoises were also mostly found in montane forest (male = 85.37%, female = 55.94%, juvenile = 100%) followed by montane forest mixed with bamboo (male = 8.13%, female = 39.86%).

Table 6.1. Means of elevation usages of *M. impressa* at Phu Luang Wildlife Sanctuary, Loei Province,Thailand.

Sex	N	Elevation (m)							
		Year-round		Wet		Cold-dry		Hot-dry	
		Mean (Min-Max)	SE	Mean (Min-Max)	SE	Mean (Min-Max)	SE	Mean (Min-Max)	SE
Male	410	1,311.29 (1,022-1,425)	4.08	1,314.63 (1,022-1,425)	5.34	1,305.85 (1,104-1,413)	8.27	1,309.30 (1,113-1,413)	9.63
Female	457	1,306.36 (1,022-1,413)	3.98	1,309.07 (1,022-1,413)	5.09	1,301.66 (1,104-1,413)	7.25	1,305.90 (1,104-1,413)	13.02
Juvenile	180	1,309.45 (1,013-1,420)	6.30	1,310.60 (1,013-1,420)	9.06	1,313.09 (1,113-1,413)	11.49	1,301.27 (1,113-1,413)	13.73

In the hot-dry season, adult males and juveniles were mostly found in montane forest (male = 72.50%, juvenile = 39.86%) followed by montane forest mixed with bamboo (male = 26.25%, juvenile = 16.22%). Females spent most of the time in montane forest mixed with bamboo (50.00%) followed by montane forest (40.38%).

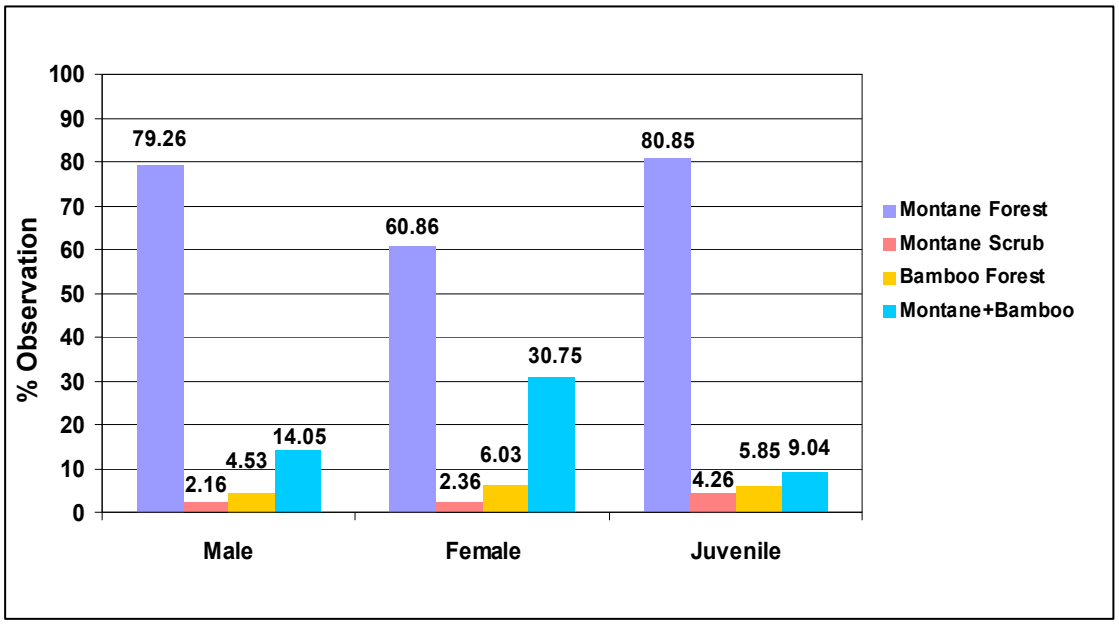

Figure 6.1 Percentages of year-round habitat use by *M. impressa* at Phu Luang Wildlife Sanctuary, Loei Province,Thailand.

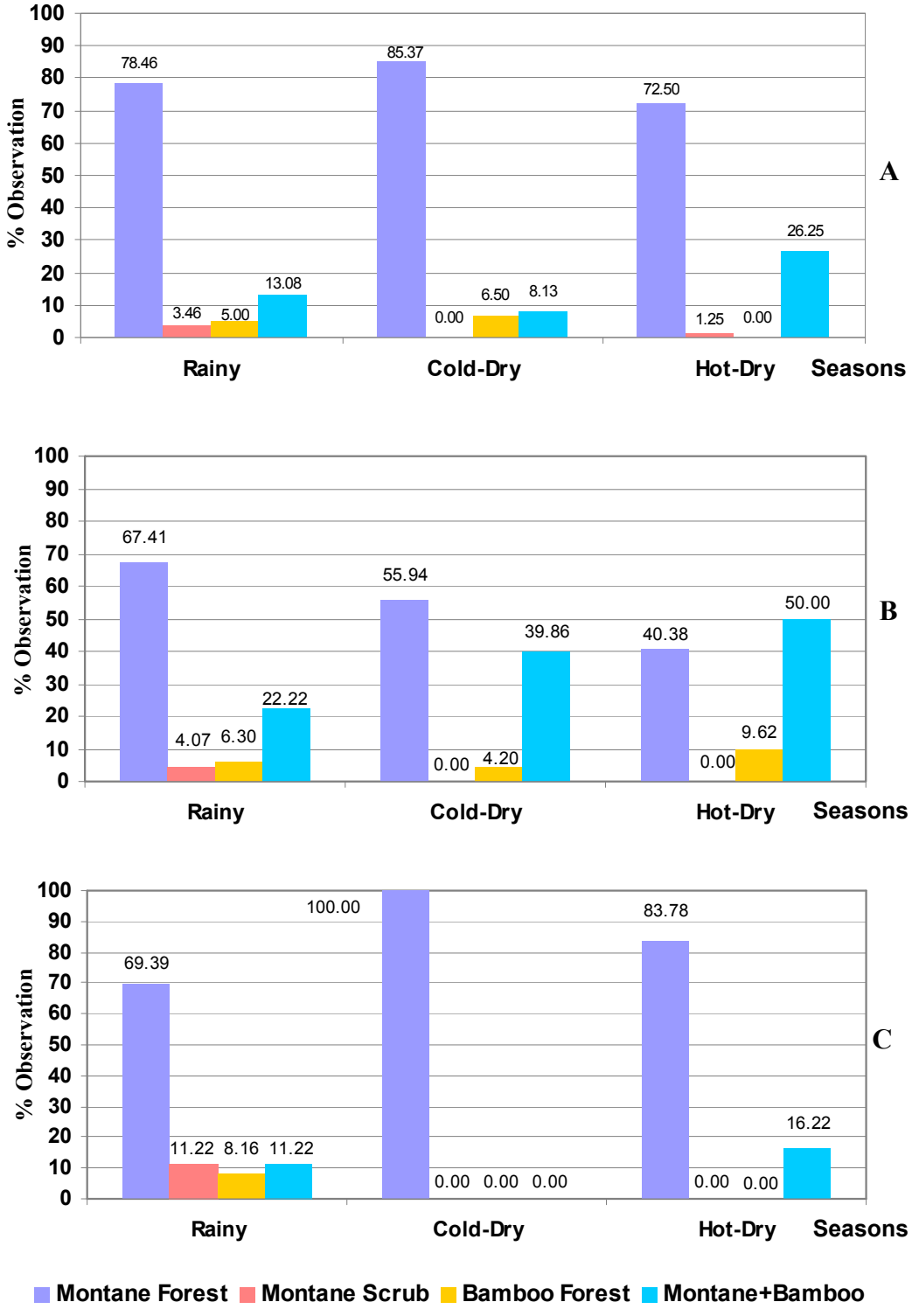

Figure 6.2 Percentages of habitat use of *M. impressa* in different seasons at Phu Luang Wildlife Sanctuary.
A = Male, B = Female and C = Juvenile.

Microhabitat use

The utilization of microhabitat is shown in Table 6.2. It was found that *M. impressa* in this study utilized 8 microhabitats.

Table 6.2 Percentages of microhabitat used by *M. impressa* in year round at Phu Luang Wildlife Sanctuary.

Microhabitat	Percent of observation (n)		
	Male	**Female**	**Juvenile**
Under stone	10.15 (47)	9.03 (42)	17.00 (32)
In the hole	6.27 (29)	3.87 (18)	0 (0)
Under the log	7.77 (36)	3.87 (18)	2.66 (5)
Under leaf litter	12.10 (56)	11.40 (53)	45.21 (85)
Under tree root	3.46 (16)	8.82 (41)	4.26 (8)
Under fallen branches	29.80 (138)	33.76 (157)	11.17 (21)
In shallow stream	5.62 (26)	5.16 (24)	4.26 (8)
0n the ground	24.84 (115)	24.10 (112)	15.44 (29)

n = Number of observation

Considering year-round, under fallen branches was the most microhabitat used for adult males (29.80 %) and adult females (33.76%) followed by on the ground

(male = 24.84%, female = 24.10%) and under leaf litter (male = 12.10%, female = 11.40%), respectively. In addition, juveniles were mostly found under leaf litter (45.21%) followed by under stone (17.00%) and on the ground (15.44%).

In rainy season and hot-dry season, both males and females were most encountered on the ground (male = 35.00%, female = 31.85%) followed by under fallen branches (Male = 15.38%, Female = 26.30%) while juveniles spent most of their time under leaf litter (39.80%). During hiding period in cold-dry season, both adults and juveniles used similar micro-habitat type. They were mostly found hiding under fallen branches (male = 55.28%, female = 45.28%, juvenile = 45.28%). During hot-dry season, males and females were mostly found under fallen branches (male = 32.50%, female = 48.38%) while juveniles were mostly found under leaf litter (59.46%).

Microhabitat temperature and humidity

The microhabitat temperatures at the positions where tortoises were located ranged from 11.30 ºC - 30.00 ºC. The averages of ground surface temperatures of males, females and juveniles were 19.96±3.06 ºC, 20.26±3.14 ºC and 20.80±2.74ºC, respectively. The averages of ground surface temperatures were not significantly different between sexes and age classes (ANOVA, $p \leq 0.05$).

The microhabitat relative humidity at the positions where tortoises were located ranged from 60-100%. The averages of the relative humidity of males, females and juveniles were 84.22±8.57%, 83.94±8.88% and 82.55±0.60%,

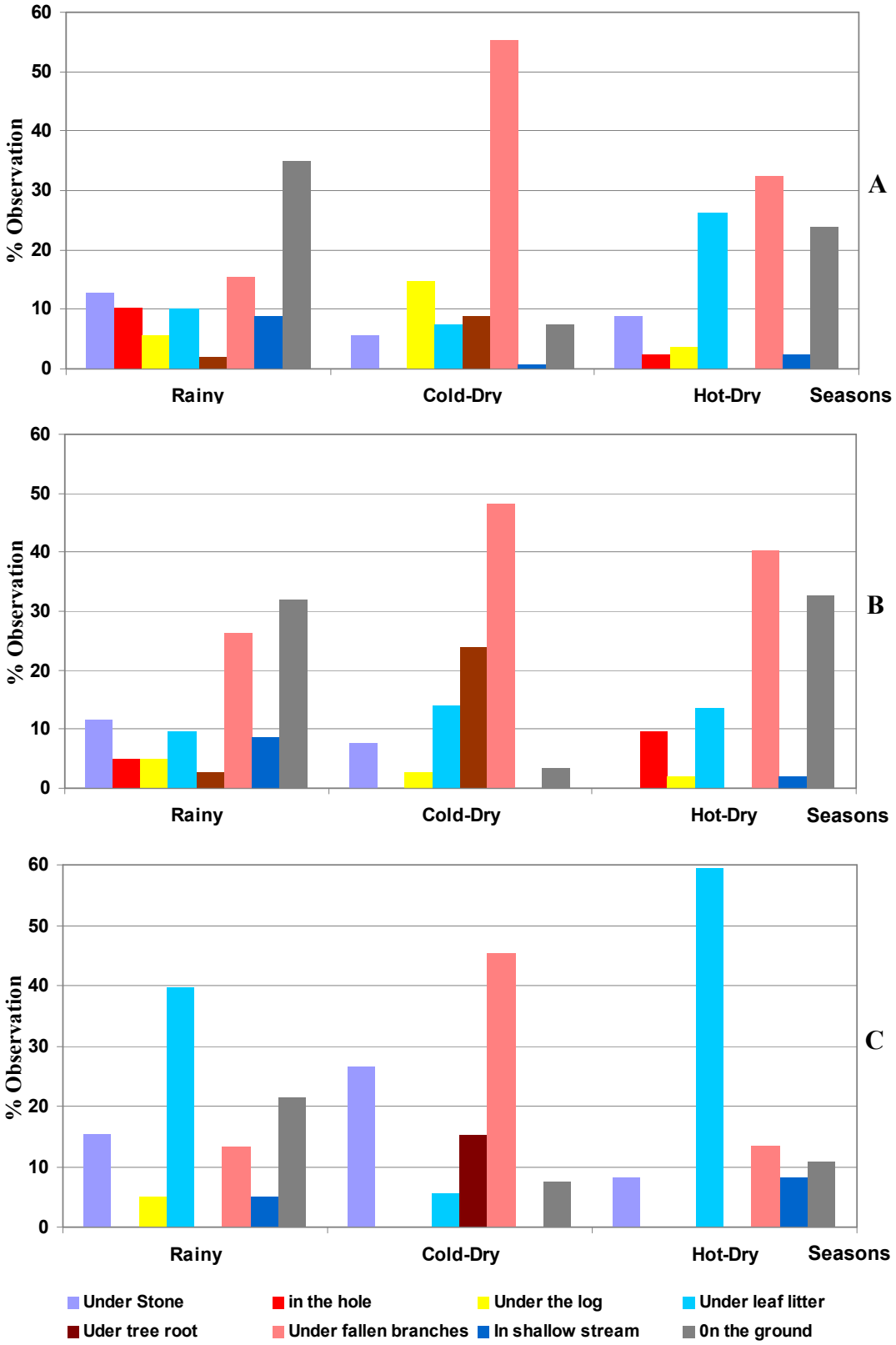

Figure 6.3 Percentages of micro habitat use of *M. impressa* in different seasons at Phu Luang Wildlife Sanctuary.
A = Male, B = Female and C = Juvenile.

respectively. The averages of ground surface humidity were not significantly different between sexes and age classes (ANOVA, $p \leq 0.05$).

Ambient temperatures near the hiding places were also recorded. The averages of the ambient temperature of males, females and juveniles were 21.05±3.19ºC, 21.15±3.35 ºC and 22.10±3.12ºC, respectively. The averages of ambient temperatures were not significantly different between sexes and age classes (ANOVA, $p \leq 0.05$).

Ambient relative humidity at the positions where tortoises were located ranged from 60-100%. The averages of ambient relative humidity of males, females and juveniles were 78.87±10.28%, 77.00±10.42% and 76.58±10.42%, respectively. The averages of the ambient relative humidity were not significantly different between sexes and age classes (ANOVA, $p \leq 0.05$).

The microhabitat temperature was recorded at the bottom of the plastron when a tortoise was hiding or sitting. Normally, it was significantly lower comparing to the ambient temperature around the hiding place ($p < 0.05$). The relative humidity above the ground where a tortoise was staying was normally higher significantly than surrounding relative humidity (ANOVA, $p > 0.05$).

Understory cover

Results from Table 6.5 suggested that both adults and juveniles mostly spent their time under full understory cover in all seasons.

Table 6.3 Ambient and microhabitat temperatures of *M. impressa* in Phu Luang Wildlife Sanctuary, Loei Province, Thailand from January 2010-October 2011.

Sex	N	Air (ºC)				Microhabitat (ºC)			
		Min	Max	Mean	SD	Min	Max	Mean	SD
Male	410	11.70	27.50	21.0573	3.19	11	27.20	19.61	3.04
Female	457	11.80	30	21.15	3.35	11.20	30	19.70	3.14
Juvenile	180	12.0	28.5	22.10	3.12	12	26.80	20.80	2.74

N = Number of obsetvation

Table 6.4 Surrounding and microhabitat humidity of *M. impressa* in Phu Luang Wildlife Sanctuary, Loei Province, Thailand from January 2010-October 2011.

Sex	N	Air (%)				Microhabitat (%)			
		Min	Max	Mean	SD	Min	Max	Mean	SD
Male	410	60	100	78.87	10.28	65	100	84.25	8.57
Female	457	60	100	77.00	10.42	65	100	83.03	8.88
Juvenile	180	60	100	76.58	10.42	60	100	82.55	9.62

N = Number of obsetvation

Table 6.5 Percentages of understory cover used by *M. impressa* in Phu Luang Wildlife Sanctuary, Loei Province, Thailand from January 2010-October 2011.

Understory cover	Wet			Cold-dry			Hot-dry		
	Male	**Female**	**Juvenile**	**Male**	**Female**	**Juvenile**	**Male**	**Female**	**Juvenile**
Close	83.08	85.56	88.78	95.93	96.5	73.58	81.25	67.31	89.19
Median	11.92	8.52	5.1	1.63	0	24.53	10	11.54	10.81
Open	5	5.93	6.12	2.44	3.5	1.89	8.75	21.15	0

Discussion

Manouria impressa in PLWS exhibits seasonal variation in habitat use and this shifts were coactive with changes in behavior within the yearly activity cycle. The patterns of seasonal variations in habitat use have been recorded in many turtles such as the desert tortoise, *Xerobates agassizi*. They occupied larger dens in summer than in other seasons and moved to steeper rocky slopes in winter (Barrett, 1990). In the spotted turtle*, Clemmys guttata*, in spring (May-June), they aggregated in ponds to court and mate. In late June, females nested on open rock outcrops. During July and August, turtles spent about half of their time buried in terrestrial forms on rock outcrops and in forests. From September to April, they hibernated in sphagnum swamps (Litzgus and Brooks, 2000).

In year round, montane forest was the most utilized habitat in both adults and juveniles, similarly to the previous study of *M. impressa* in southwest Cambodia by Koulang (2008). He reported that *M. impressa* were found mainly in montane evergreen and bamboo forest. However, habitat and microhabitat use in each season were not reported.

The elevation usage of *M. impressa* in this study ranged from 1,013-1,425 m amsl. This is much higher than *M. impressa* studied by Koulang (2008) in southwest Cambodia which were found at elevations from 668-755 m. A congeneric species, *M. emys phayrei* at KNP, reported by Wanchai (2007) was located between the elevations from 750 – 1,200 m. In this study, there was no significant difference in elevetion usage among seasons by *M. impressa* of different ages and sexes which is similar to the desert tortoise *Xerobates agasszi* reported by Barret (1990).

In wet season (May-October), both adults and juveniles were mostly found in montane forest. This may be associated with food abundance because many kinds of mushroom, the main diet of *M. impressa* in this study normally occur in montane forest during this season. Habitat selection associated with food abundance was also reported in *M. emys phayrei* (Wanchai, 2008). Only in the rainy season (May-October) at KNP, adults *M. emys phayrei* were frequently found in bamboo forest and he suggested that habitat selection of *M. emys phayrei* associated with food abundance.

During the cold-dry season, both adults and juveniles were mostly found under fallen branches in montane forest. However, some tortoises, especially female changed habitat type to bamboo forest or montane forest mixed with bamboo. This may be because these habitats can provide denser shelter for tortoises which allow them to take advantage for hiding.

During hot-dry season, both adults males and juveniles were mostly found in montane forest whereas females were mostly found in montane forest mixed with bamboo. In this study, two cases of nesting were found in bamboo forest and montane forest mixed with bamboo at the start of the rainy season (May). Therefore, females may spent the time during this period (March-April) looking for nest site. Moreover, this result is quite different from *M. emys phayrei* studied by Wanchai (2008). In hot-dry season (March-April); male, female and juvenile *M. emys phayrei* were frequently found soaking in shallow stream or swamp. This may be resulting from ecological condition differences between the two locations. Keang Krachan National Park streams flow all year round. In contrast, streams at PLWS are completely dry during the dry season (November–April). *Manouria impressa* might

not have soaking places. *M. impressa* at Phuloung Wildlife Sanctuary used hiding places such as tree holes, under fallen branches or under rocks to avoid extreme heat.

Microhabitats of *M. impressa* in this study seem to have high humidity in both rainy and dry seasons which is similar to Koulang (2008) report in that *M. impressa* were mostly found at high humid and wet microhabitats and the microhabitat temperatures of the hiding places were significantly lower than the ambient temperatures. Previous studies reported that *M. impressa* inhabit in forested areas of low to moderate humidity (Stuart and Platt, 2004) and its habitat seems to be fairly dry (McMorris and Burns, 1975; Nabhitabhata, 1991). However, their microhabitats have not been reported.

In the cold-dry season, adults and juveniles were mostly found under fallen branches. Dense cover of fallen branches may be suitable for them during hiding period. However, microhabitat used during wet and hot-dry seasons of adults and juveniles were different. Adult males and females were mostly found under fallen branches while juveniles encountered under leaf litter. Throughout the year, basking was not found for juveniles, they simply did not venture to open areas and that may be the strategy for predator avoiding. However, many times during field observations, it was found that hiding places of juveniles, especially under leaf litter were located in unshaded area where sunlight can enter during the day and may provide juvenile benefit for basking.

Our results suggested that adults and juveniles of *M. impressa* mostly spent their time under full understory cover. This is quite different from Koulang (2008) study as he reported that the canopy of the forest above the *M. impressa* habitats: full canopy cover, semi canopy cover, and open canopy was not significantly different.

However, this result was similar to Mortensen (2004) who reported that *M.e.emys* preferred places with full cover canopy for 66% of the observations. Also with Wanchai (2008) reported that both adults and juveniles *M. emys phayrei* mostly spent their time under full cover canopy. The use of canopy cover seems to be associated with body temperature control. Johns (1997 in Montensen, 2004) suggested that canopy cover is important in body temperature control of poikilothermic animals living in tropical regions. Places in open canopy cover during the day time tend to be very hot, maybe up to 30 °C which could cause heat stress and dehydration if they are exposed for a long period. Thus, tortoises living under close conopy cover are able to avoid from heat stress. Observations on the tortoises in open canopy showed that they were associated with basking. The preference for an open canopy is likely to be linked to the thermoregulation requirements of tortoises.

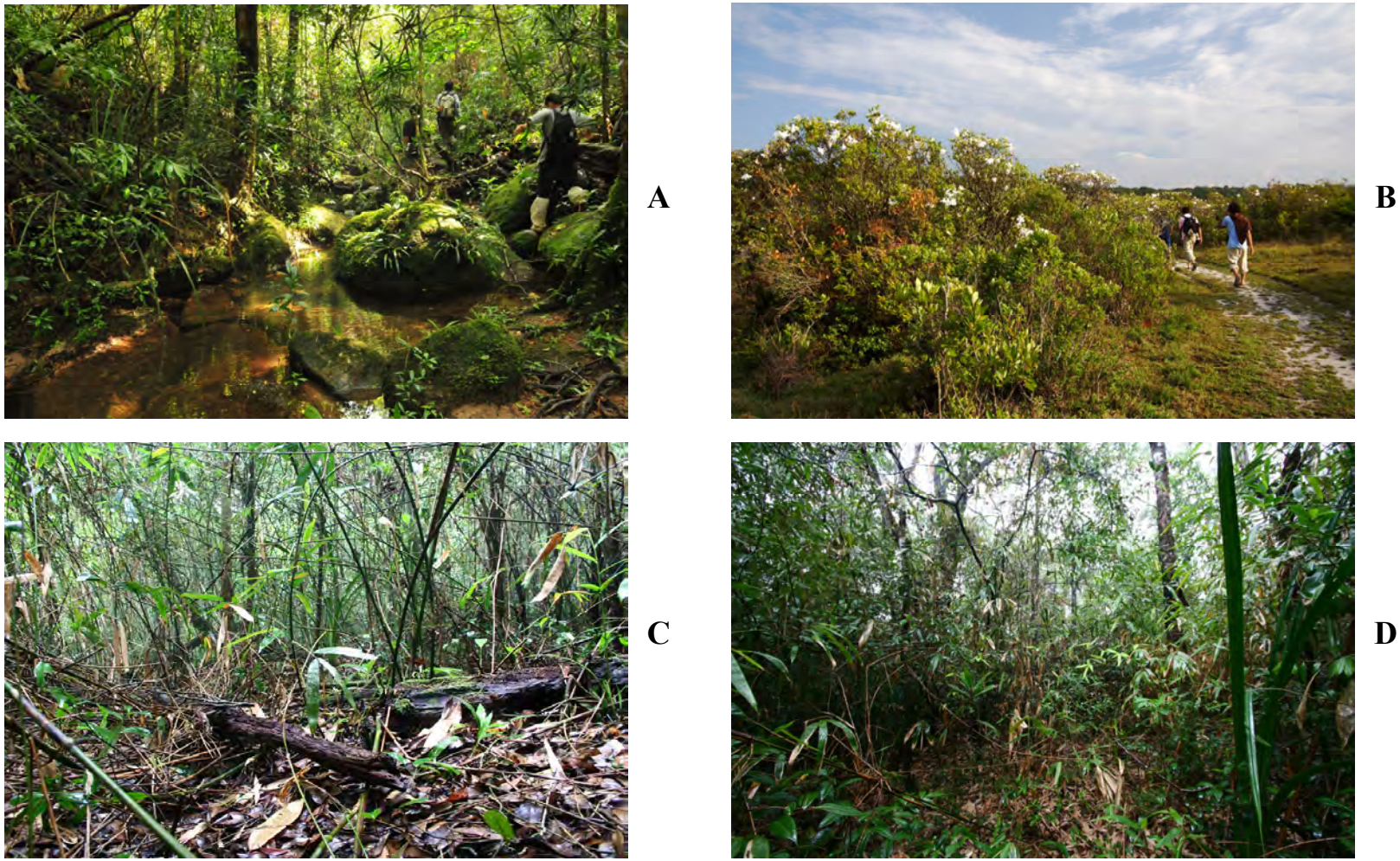

Figure 6.4 Habitats of *M. impressa* at Phu Luang Wildlife Sanctuary; (A) montane forest, (B) montane scrub forest, (C) bamboo forest and (D) montane forest mixed with bamboo.

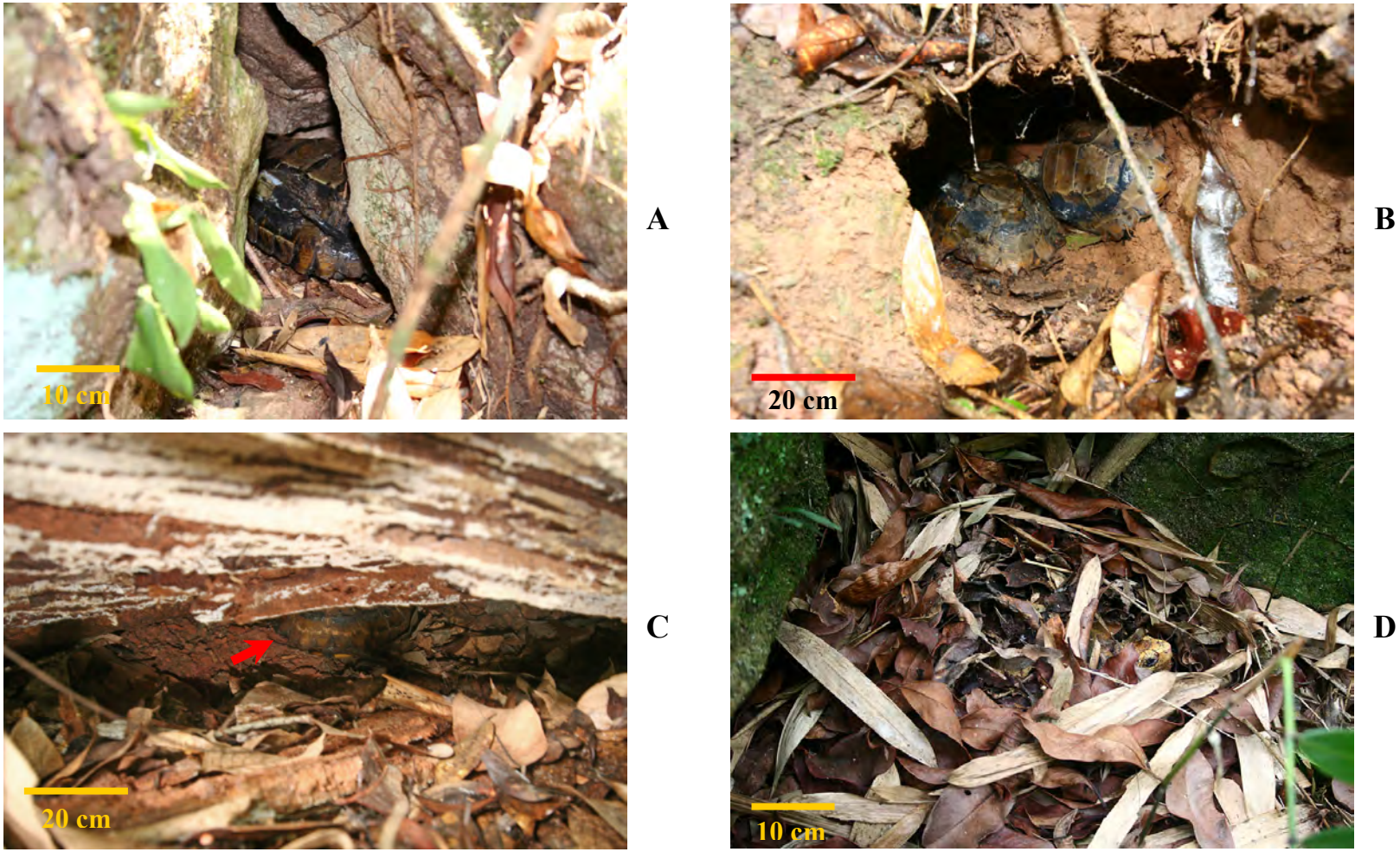

Figure 6.5 Microhabitats of *M. impressa* at Phu Luang Wildlife Sanctuary; (A) under stone, (B) in the hole, (C) under the log and (D) under leaf litter.

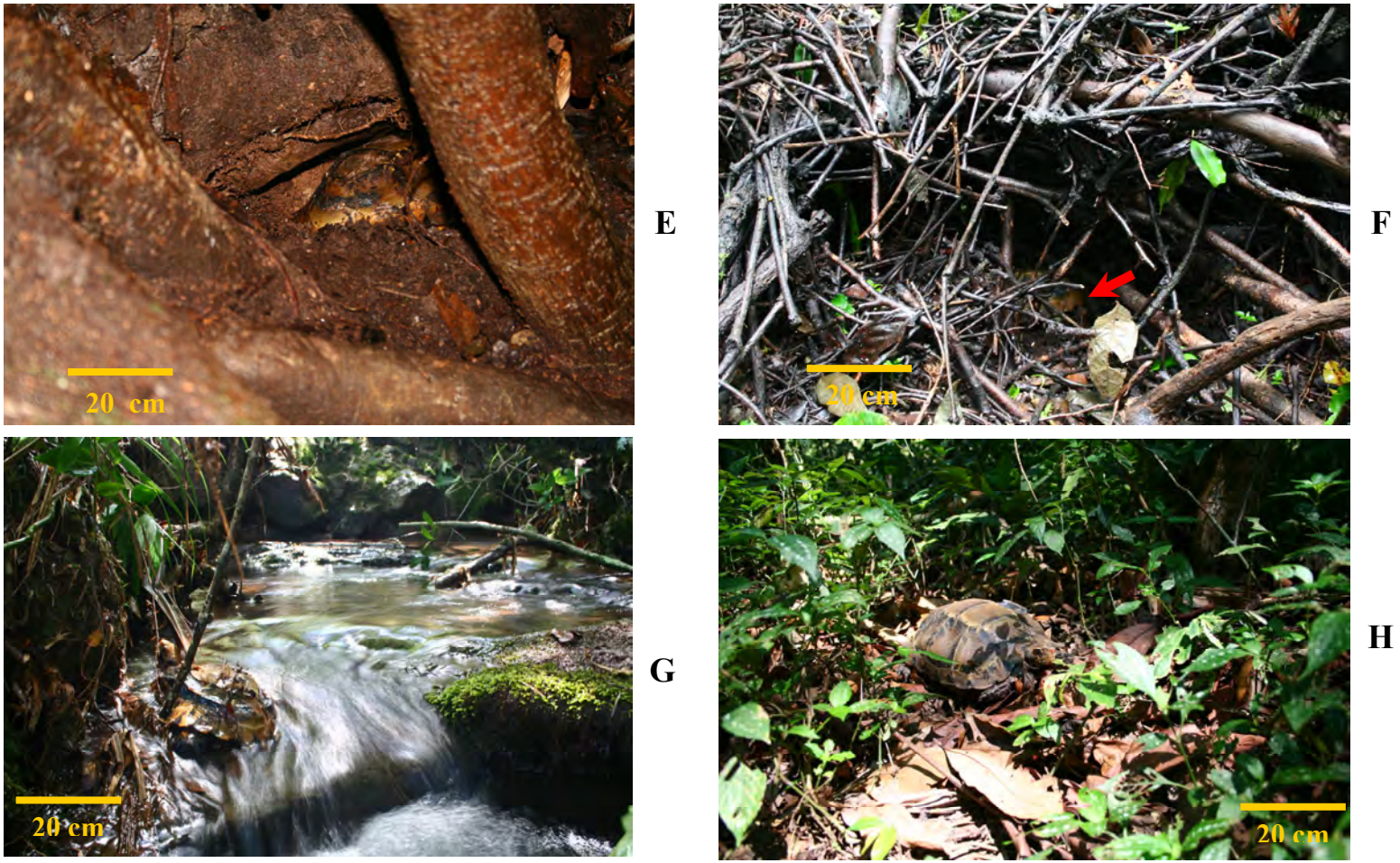

Figure 6.5 (cont.) Microhabitats of *M. impressa* at Phu Luang Wildlife Sanctuary; (E) under tree root, (F) under fallen branches, (G) in shallow stream, (H) on the ground.

CHAPTER VII

Diet of the Impressed Tortoise, *Manouria impressa* (Günther, 1882), in Phu Luang Wildlife Sanctuary, Loei Province

Introduction

The impressed tortoise has been declining in the wild due to exploitation for the food markets, and habitat loss as the result of agricultural expansion and uncontrolled forest fires (van Dijk and Palasuwan, 2000). Additionally, the tortoise's collection for the pet trade seems to be a huge problem at present (van Dijk and Palasuwan, 2000). On the other hand, breeding this species in captivity has proved impossible, with almost 100% mortality during the adaptation process to captivity (Espenshade et al., 1994).

Very little is known about diet of impressed tortoise in the wild. Nutaphand (1979) reported that this species feeds on plants and bamboo shoots. Ernst and Barbour (1989) reported that *M. impressa* diet was plants, grass, bamboo shoots, and possibly fruits. Chan-ard et al. (1996) reported that *M. impressa* kept in the enclosure at Phu Luang Wildlife Research Station ate many kinds of wild mushrooms. Koulang (2008) reported that most *M. impressa* were kept in the enclosure at the Central Cardamom Protected Forest of Cambodia fed on many kinds of mushrooms, only 2 genus were identified as *Fistulinella* and *Auricularia*. Unidentified plant species, likely *Alocasia* and a small unidentified plant species under the mushrooms was also found eaten by *M. impressa.* Moreover, once it attempted to eat fruit but the fruit

was too big and the tortoise could not eat it because it always sliced out from its mouth (Koulang, 2008).

The purpose of this study was to identify and describe the diet of the impressed tortoises, *Manouria impressa* (Günther, 1882) in their natural habitat.

Materials and methods

This study was carried out from January 2010 through October 2011. Fourteen *M. impressa* of different sexes and age classes, consisting of ten adults (five males and five females) and four juveniles were tracked using radio-transmitters(148 MHz). Each tortoise was located up to 6–10 times per month by direct observation, using an ATS receiver (Model FM16) and a handheld ATS 3 element folding Yagi antenna. When the tortoise was located and observed, diet items eaten at the time or shortly before were recorded. All food items were photographed, morphology of each mushroom was characterized and some were brought back for identification.

Results

During the study period, a total of 36 diet items was collected, representing at least nine different mushroom species (Figure 7.1). All mushrooms were identified to genus and to species if possible.

The result showed that *M. impressa* at Phu Luang Wildlife Sanctuary fed on a variety of mushroom species. Of nine genera from a total of 36 diet items, three were identified to species and six were identified to genus (Table7.1).

Adult tortoises fed on varieties of mushroom species, three were identified to species; *Russula virescens*, *Armillariella tabescens* and *Trametes versicolor* and six were identified to genus, *Auricularia* spp., *Boletus* spp., *Russula* spp., *Amanita* spp., *Psilocybe* sp. and *Marasmius* sp.. The diets of juveniles were similar to adults (Table 7.1). One species was identified as *Armillariella tabescens* and the rest were identified to genus; *Boletus* spp*., Russula* spp. and *Tylopilus* sp.

The year-round result showed that *Russala* spp. were the main diet items of *M. impressa;* 42.86% for male, 46.67% for female and 40 % for juvenile followed by *Boletus* spp. (Table 7.2).

Russula spp. (43.34%) were the main diet items in wet season followed by *Bolotes* spp. (23.34%). In dry season, both adults and juveniles fed on only 2 genus, *Auricularia* and *Russula*. *Auricularia* spp. (60%) were eaten most frequently followed by *Russula* spp. (40%) (Table 7.2).

Table 7.1 Mushroom species consumed year-round by *Manouria impressa* at Phu Luang Wildlife Sanctuary, observed during January 2010 – October 2011.

Genus or Species	Family	Observation (%) (no. of observation)			location
		Male	Female	Juvenile	
Auricularia spp.	Auriculariaceae	14.29 (2)	6.25 (1)	16.66 (1)	on rotten log
Boletus spp.	Boletaceae	21.43 (3)	18.75 (3)	16.66 (1)	on the ground
Russula spp.+*Russula virescens*	Russulaceae	42.85 (6)	43.75 (7)	33.33 (2)	on the ground
Amanita spp.	Agaricaceae	14.29 (2)	12.50 (2)	0 (0)	on the ground
Armillariella tabescens	Physalacriaceae	7.14 (1)	0 (0)	16.66 (1)	on the ground, rotten log and tree trunk
Trametes versicolor	Polyporaceae	0 (0)	6.25 (1)	0 (0)	on the ground and tree trunk
Tylopilus sp.	Boletaceae	0 (0)	0 (0)	16.66 (1)	on the ground and on rotten log
Marasmius sp.	Marasmiaceae	0 (0)	6.25 (1)	0 (0)	on the ground and on rotten log
Psilocybe sp.	Strophariaceae	0 (0)	6.25 (1)	0 (0)	on the ground

Table 7.2 Mushroom species consumed by *Manouria impressa* in each season at Phu Luang Wildlife Sanctuary, observed during January 2010 – October 2011.

Genus	**Family**	**Observation** (%) (no. of observation)	
		Wet Season	**Dry Season**
Auricularia spp.	Auriculariaceae	3.22 (1)	60 (3)
Boletus spp.	Boletaceae	22.6 (7)	0 (0)
Russula spp.+*Russula virescens*	Russulaceae	41.95 (13)	40 (2)
Amanita spp.	Agaricaceae	12.9 (4)	0 (0)
Armillariella tabescens	Physalacriaceae	6.45 (2)	0 (0)
Trametes versicolor	Polyporaceae	3.22 (1)	0 (0)
Tylopilus sp.	Boletaceae	3.22 (1)	0 (0)
Marasmius sp.	Marasmiaceae	3.22 (1)	0 (0)
Psilocybe sp.	Strophariaceae	3.22 (1)	0 (0)

* Wet season = May-September; Dry season = January – April

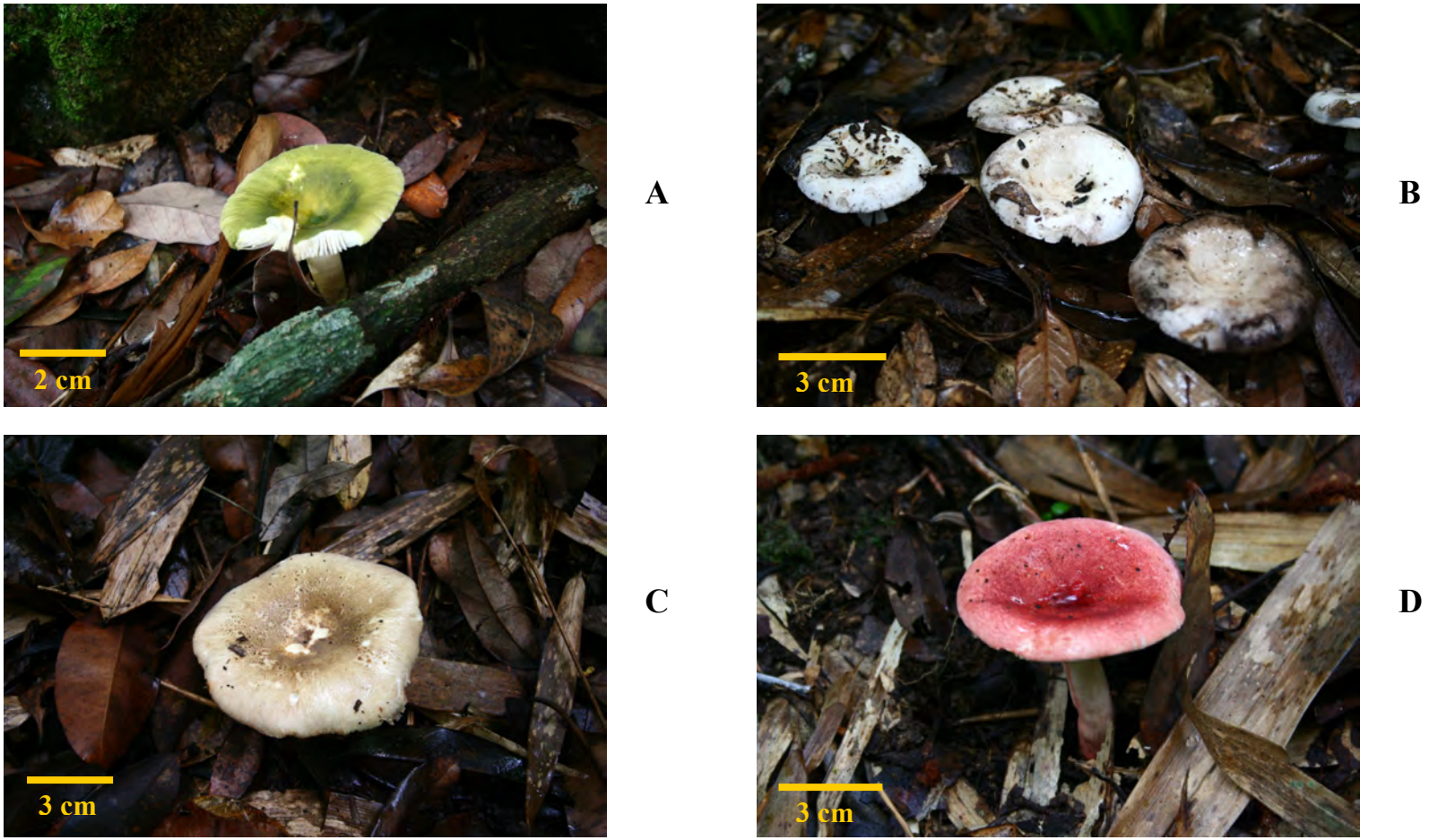

Figure 7.1 Diets of *M. impressa*; at Phu Luang Wildlife Sanctuary A = *Russula virescens* and B-D = *Russula* spp..

E

F

G

H

Figure 7.1 (cont.) Diets of *M. impressa* at Phu Luang Wildlife Sanctuary; E–G = *Boletus* spp. and H = *Tylopilus* sp..

I

J

K

L

Figure 7.1 (cont.) Diets of *M. impressa* at Phu Luang Wildlife Sanctuary; I-J = *Amanita* spp. and K-L = *Auricularia* spp..

M

N

O

P

Figure 7.1 (cont.) Diets of *M. impressa* at Phu Luang Wildlife Sanctuary; M = *Armillariella tabescens*, N = *Trametes versicolor*, O = *Marasmius* sp. and P = *Psilocybe* sp..

Discussion

The result suggested that *M. impressa* in this study were specialist feeder eaten only mushrooms and they showed no interest in other herbs surrounding the mushrooms. The result agrees with Chan-ard et al. (1996) and Koulang (2008), they reported that *M. impressa* fed on many kinds of mushrooms. However, this result appears to be different from some previous reports. Previous studies reported that *M. impressa* fed on bamboo shoots, plants and fruits (Nutaphand,1979; Ernst and Barbour, 1989; Koulang, 2008). Although bamboo shoots and *Alocasia* which were reported eaten by *M. impressa* by Koulang (2008) normally occure at the study site, they were not observed eaten by *M. impressa* in this study. This indicates that *M. impressa* in this study is selective forage for mushrooms. This pattern of diet selection was also reported in *M. emys emys* by Montensen (2004) who reported that in places with a wide variety of different herb species, the *Alocasia* species were always selected if present. Similarly with Wanchai (2007) who reported that *M. e. phayrei* selectively foraged for bamboo shoots and tortoises showed no interest in other plants surrounding the bamboo shoots.

Selecting high quality diets may be important to the growth rate of chelonians (Okamoto, 2002; Mushinsky, 2003). Mushrooms have high content of protein (varies between 27 - 48% on the dry weight, depending on mushrooms species), vitamins and minerals (Crisan and Sands, 1978; Wani et al., 2010), which are the important nutrients required for growth, metabolism, and for other body functions (Bowen et al. 1995). Moreover, mushrooms have higher protein content than most other vegetables in general and most of the wild plants (Bano and Rajarathnam, 1988; Wani et al.,

2010). This indicates that mushrooms can provide a higher rate of intake of energy and all essential nutrients than other food plants. The mushrooms also can be easily digested. The digestibility of mushroom protein to be as high as 72 - 83% (Wani et al., 2010). Therefore, it is possible to provide necessary nutrients without creating more discomfort.

Furthermore, mushrooms naturally contain a lot of water, up to 90% (Crisan and Sands, 1978). This should be suitable for tortoise's survival as they can store water for reabsorption later during dry season which water is a limited resource in study site.

In this study, *Russula* spp. were the main diet items of both adults and juveniles for year-round and rainny season, followed by *Boletus* spp.. Also, *Russula* and *Boletus* spp. were the most common mushrooms at the study site and North-eastern region (Chamratpan, 2003). However, *Auricularia* spp. were most frequently observed eaten by *M. impressa* in dry season. *Auricularia* spp. grow on the tree or rotten log and can be found all year.

Most mushrooms comsumed by *M. impressa* were edible. *Russula* spp., *Boletus* spp., *Tylopilus* sp. and *Auricularia* spp. were common edible mushrooms for local people and North-eastern Thai people. Moreover, a chemical compound extracted from *T. versicolor*, polysaccharide-K, is used as an immuno adjuvant therapy for cancer (Oba et al., 2007). However, a few genera were poisonous to human. For example, *Psilocybe*, widely known as "magic mushroom", is best known for its psychedelic properties and the Thai law put it as prohibited plant (Allen and Merlin, 1992).

Diets that include potentially toxic items have been reported in other chelonian species. Legarde et al. (2003) reported that most of the plants consumed by steppe tortoises *Testudo horsfieldii* have high contents of substances that are toxic to herbivorous mammals. *M. e. emys* amd *M. e. pheyrei* mostly consumed *Alocasia* that has high content of calcium oxalates, which are poisonous substances that can produce sores and numbing on ingestion (Mortensen, 2004; Wanchai, 2008). There was no report that why chelonian species consume toxic plants. One resonable explanation could be that this diet component is ingested for medicinal reasons to control intestinal parasites (Legarde et al., 2003).

CHAPTER VIII

Distribution range of *Manouria impressa* in Thailand

Introduction

Manouria impressa ranges from Myanmar to Malaysia, Vietnam and Cambodia (Ernst and Barbour, 2001). For Thailand, this species was reported to occur on the mountains of northern, western and southern regions, for example at Doi Inthanon National Park (Chiang Mai province), Phulung Wildlife Sanctuary (Loei province), Umphang Wildlife Sanctuary (Tak province), Huai Kha Khaeng Wildlife Sanctuary (Uthai Thani province) and Hala-Bala Wildlife Sanctuary (Narathivart province) (Nabhitabhata and Chan-ard, 2005). However, the distribution record of this species in Thailand is still incomplete since there are many informal reports from many localities. Therefore, the data of the distribution and status of this species are out of date and need to be evaluated . The purpose of this study was to study the present distribution of *M. impressa* in Thailand. A better knowledge of its distribution range or the areas of occurrence would be very useful for the development of viable conservation management strategies.

Method

A survey concerning *M. impressa* was conducted by mailing 50 questionnaires to the units under the National Park, Wildlife and Plant Conservation Department. The units where *M. impressa* could be or was expected to be found such as having montane forest or having altitude more than 650 m amsl were chosen. The survey was

conducted for 1-year period (2011-2012) and the results were used to identify ground survey localities. The survey questions were in Thai language with information and a photograph of *M. impressa*. Furthermore, field surveys in some positive areas and other informal reported localities, personal communications and the survey of museum specimens with known localities were performed.

Result and Discussion

From 50 questionnaires distributed, 15 (37.5%) were completed and returned. Seven responses reported some evidences of *M. impressa* in their regions. Some areas which had a positive response were visited, and ground surveys were conducted to verify the current presence of *M. impressa*.

A total of 8 new locations was reported; Thungyai Naresuan (West) Wildlife Sanctuary (TNWWS) (Kanchanaburi province), Thungyai Naresuan (East) Wildlife Sanctuary (TNEWS) (Tak province), Phukaew Wildlife Sanctuary (PKWS) (Chaiyaphum province), Nam Nao National Park (NNNP) (Phetchabun province), Doi Suthep-Pui National Park (DSPNP) (Chaing Mai province), Doi Chiang Dao Wildlife Sanctuary (DCWS) (Chaing Mai province), Phu Kradueng National Park (PDNP) (Loei province) (Figure 8.1).

Of these 8 locations with positive response, 4 locations were confirmed to have *M. impressa*. There are Doi Suthep-Pui National Park, Thungyai Naresuan (West) Wildlife Sanctuary, Phukaew Wildlife Sanctuary and Phu Kradueng National Park. In each locality, a picture of *M. impressa* was taken by the forest ranger as evidence (Figure 8.2 - 8.5).

Two localities, Nam Nao National Park and Doi Chiang Dao Wildlife Sanctuary were serveyed in the field, but no evidence of *M. impressa* was observed in each location. However, one *M. impressa* shell was seen in the local market at Doi Chiang Dao (Chiang Dao District) but this shell was probably brought from other area (Thirakhupt, personal communication).

At two locations, Kao Loung National Park and Thungyai Naresuan (East) Wildlife Sanctuary, ground survey was not conducted due to local security restrictions upon access to the area. However, Thirakhupt and van Dijk (1996) reported that *M. impressa* shells were collected at Umphang Wildlife Sanctuary (Tak province) which is close to the border with Thungyai Naresuan (East) Wildlife Sanctuary. Therefore, it is possible that *M. impressa* exists in Thungyai Naresuan (East) Wildlife Sanctuary.

From previous reports in all areas of its distribution range, *M. impressa* occured only above 650 m (Koulang, 2008). However, one individual of *M. impressa* in this study was found at about 450 m by the ranger at Phu Kradueng National Park. Moreover, its habitat was quite different from others. Other *M. impressa* found in this study were encoutered in montane forests or evergreen forests whereas *M. impressa* at Phu Kradueng National Park was found in deciduous dipterocarp forest where it seems to be fairly dry. However, this result is associated with some previous reports in that *M. impressa* inhabit in forested areas of low to moderate humidity (Stuart et al., 2001) and its habitat seems to be fairly dry (McMorris and Burns, 1975; Nabhitabhata, 1991).

Results from the interviews with rangers and local people at various localities visited suggest that *M. impressa* is less common now than in the past due to habitat destruction, uncontrol forest fire and hunting. Almost 100% from the interview

showed that there are still hunting for *M. impressa* (also other turtle species) in the area and the interviewees suggested that *M. impressa* were preferably consumed by the local people than by trade. Most interviewees said that local people did not hunt *M. impressa* directly but they met them in unexpected purpose or they met them in the forest when doing something else beside finding tortoises. Especially, while they were collecting the mushrooms and they took the tortoise back for food or cooked it in the forest (one carapace was found in the study site (Figure 8.6.)). After a *M. impressa* is eaten, some local people will use its carapace as a rice dipper in their rice container because they believe that they will have enough rice to eat for a long time. For the plastron, they will use it as traditional medicine since they belive that the plastron could make them stronger. Moreover, *M. impressa* carapace used to make musical instrument was seen at walking street market, Chiang Mai province (Figure 8.7).

At Phu Rua National Park, the ranger reported that *M. impressa* were sighted in the area long time ago. At present, they are not found in the area because of habitat destruction. The ranger at Phu Kradueng National Park suggested that uncontrol forest fire is the most important factor for *M. impressa* declining at Phu Kradueng National Park.

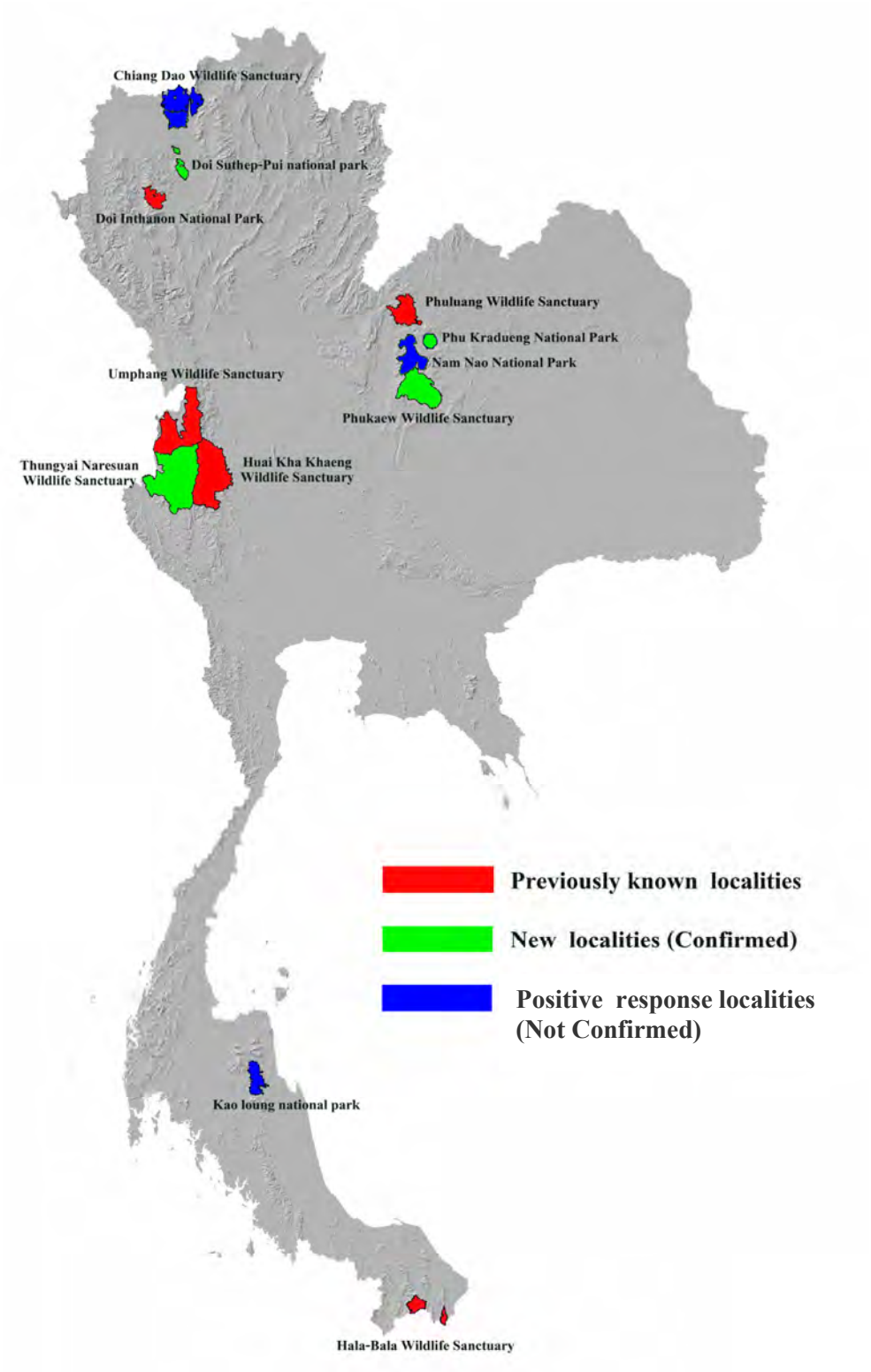

Figure 8.1 Distribution range of *M. impressa* in Thailand, previously known localities (red) and new localities (green) combinding with positive response localities (blue).

Figure 8.2 *M. impressa* juvenile was photographed by the forest ranger at Thungyai Naresuan (West) Wildlife Sanctuary.

Figure 8.3 *M. impressa* adult was photographed by the forest ranger at Doi Suthep-Pui National Park.

Figure 8.4 *M. impressa* adult was photographed by the forest ranger at Phu Kradueng National Park.

Figure 8.5 *M. impressa* adult was photographed by the forest ranger at Phukaew Wildlife Sanctuary.

Figure 8.6 *M. impressa* carapace was found in the study site at Plu Luang Wildlife Sanctuary. This adult turtle was seperated into two parts, carapace and plastron, indicating that it was killed by a poacher and the plastron was probably taken away.

Figure 8.7 *M. impressa* (red arrow) and *Indotestudo elongata* (yellow arrow) carapaces used as a part of musical instrument.

CHAPTER IX

CONCLUSION AND RECOMMENDATION

CONCLUSION

Home range size

Home range sizes of *M. impressa* in this study varied greatly among individuals; 2.71 ha - 17.69 ha year-round, 1.21 ha - 12.09 ha in wet season and 0.21 ha - 12.06 ha in dry season. The median home range sizes within season and year-round between males, females and juveniles were not significantly different. The median home range sizes of males, females and juveniles in wet season were significantly larger than in dry season. The home range of most individuals overlapped with some of the others. Home range sizes showed no significant correlation with the carapace length or body mass**.**

Activities

M. impressa in this study were active when the ambient temperature and relative humidity ranged from 12.0 – 30.0 ºC and 60 – 100%, respectively, and they were also inactive at about the same ranges of temperature and humidity indicated above. In both wet and dry seasons, the majority of individuals observed were inactive. However, the frequency of active behavior in the wet season was higher than in the dry season. When the first rain arrived and the temperature rose, some *M.*

impressa tortoises emerged from their hiding places. Activity levels, and especially walking, resting, eating, basking and mating were peaked in May when many species of mushrooms were available.

Habitat use

Manouria impressa in PLWS exhibits seasonal variation in habitat use. Montane forest was the most utilized habitat throughout the year in both adults and juveniles. Habitat selection of *M. impressa* may associate with food abundance. The elevation usages ranged from 1013-1,425 m amsl and significant differences between sexes and among age classes were not found.

M. impressa mostly spent their time under full cover canopy. Microhabitats of *M. impressa* seem to have high humidity in both rainy and dry seasons. The microhabitat temperatures at the positions where tortoises were located ranged from 11.30 ºC - 30.00 ºC and the micro-habitat relative humidity at the positions where tortoises were located ranged from 60-100%.

Diet

M. impressa was a specialist feeder, consuming only mushrooms. They showed no interest in other herbs. In wet season, *Russula* spp. (41.95%) was the main diet followed by *Boletus* spp. (23.34%). In dry season, both adults and juveniles fed on only 2 genus, *Auricularia* spp. and *Russula* spp. *Auricularia* spp. (60%) were eaten most frequently followed by *Russula* spp. Most mushrooms comsumed by *M. impressa* were edible and preferable by local people.

Distribution range

From questionnaires distributed, a total of 8 new locations was positive response and four locations, Doi Suthep-Pui National Park, Thu ngyai Naresuan (West) Wildlife Sanctuary, Phukaew Wildlife Sanctuary and Phu Kradueng National Park were confirmed to have *M. impressa*. Results from the interviews with rangers and local people at various localities visited suggest that *M. impressa* is less common now than in the past due to habitat destruction, uncontrol forest fire and hunting.

RECOMMENDATIONS

- Activities at night time should also be conducted to find out the real activity patterns. Koulang (2008) suggested that *M. impressa* may be more active at night and also Chan-Ard et al. (1996) reported that *M. impressa* seems to be more active at twilight.
- The research on breeding in captivity should be conducted because in many countries this species is a popular pet. The results of this study such as diet and physical factors of *M. impressa* can provide many important information for both conservation and successful captive breeding.
- Local people should not be allowed to go into the sanctuary to collect mushrooms because *Manouria impressa* consume only mushrooms and there is a high possibility that they will be collected as well.
- The areas where *M. impressa* might be existed such as eastern Thailand or the border between Thailand and Cambodia should be surveyed in the future. Other areas which have positive responses but have never been observed due

to security reason, including the areas already conducted but no evidence should be studied again to confirm the distribution range of *M. impressa* in Thailand.

- The population of *M. impressa* is patchy on geographical range. Therefore, the genetic variation among the subpopulations is interesting to study in the future.

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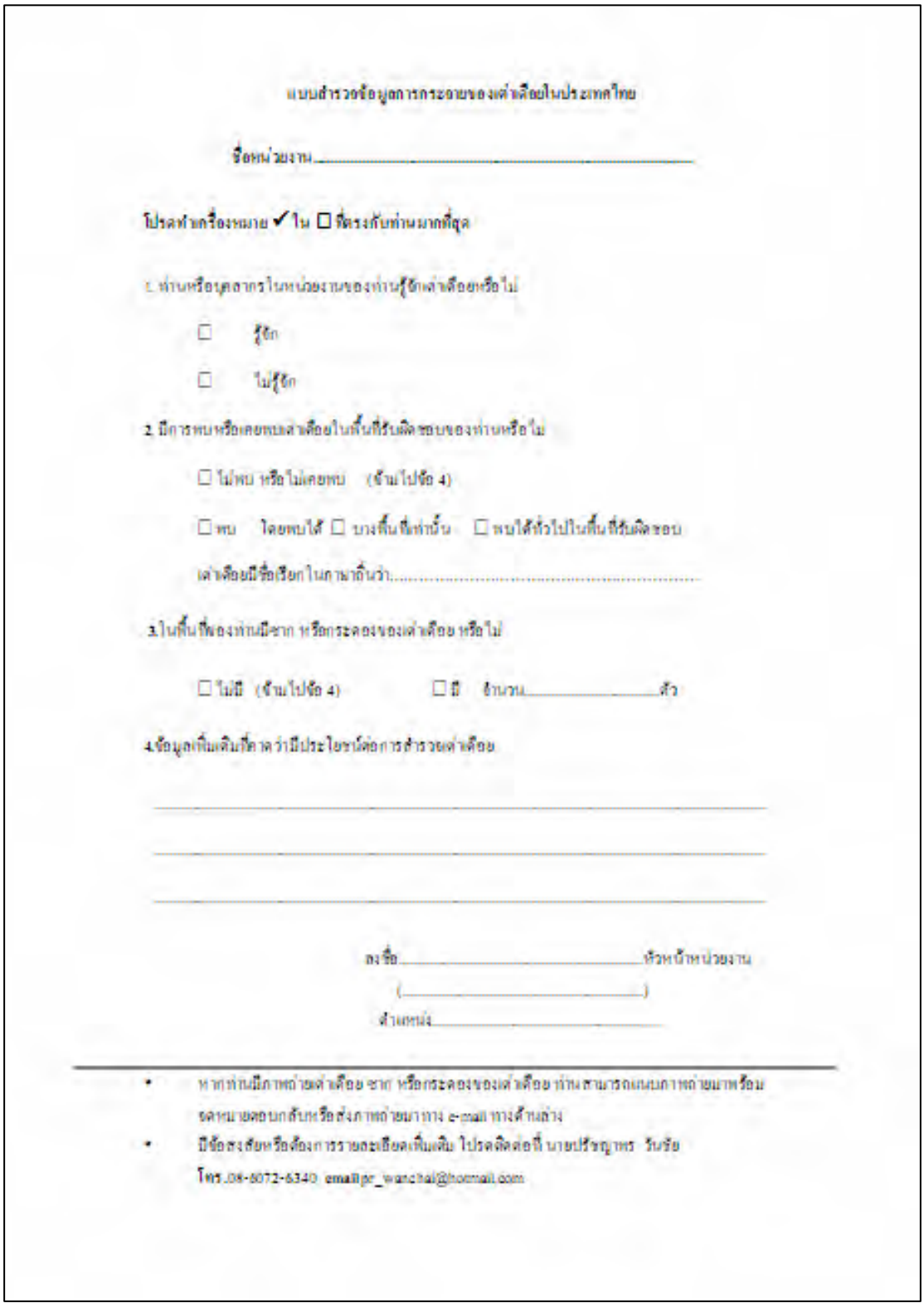
APPENDIX

Information and a photograph of *M. impressa* that sent to the units under the National Park, Wildlife and Plant Conservation Department.



แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☐ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☐ พบ โดยพบได้ ☐ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....

3. ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☐ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

.....

.....

.....

ลงชื่อ.....หัวหน้าหน่วยงาน

(.....)

ตำแหน่ง.....

- หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง
- มีข้อสงสัยหรือต้องการรายละเอียดเพิ่มเติม โปรดติดต่อ นายปรัชญาพร วันรัย

โทร.08-8072-6340 email:pr_wanchai@hotmail.com

The survey questionnaires sent to the units under the National Park, Wildlife and Plant Conservation Department.

แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน เขตรักษาพันธุ์สัตว์ป่าภูเขียว จ.ชัยภูมิ

โปรดทำเครื่องหมาย ✔ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

   ☑ รู้จัก

   ☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

   ☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

   ☑ พบ โดยพบได้ ☑ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

   เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า เต่าจักร

3. ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

   ☑ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

   พบในป่าดิบเขาและป่าดิบแล้งของพื้นที่เขตฯภูเขียว

ลงชื่อ.....หัวหน้าหน่วยงาน

(นายธานี วงศ์นาค)

นิกวิชาการป่าไม้ชำนาญการ ทำหน้าที่

ตำแหน่ง หัวหน้าเขตรักษาพันธุ์สัตว์ป่าภูเขียว

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

* มีข้อสงสัยหรือต้องการรายละเอียดเพิ่มเติม โปรดติดต่อที่ นายปรัชญาพร วันชัย

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ภาพเต่าเดือยที่พบในเขตรักษาพันธุ์สัตว์ป่าภูเขียว

แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน อุทยานแห่งชาติดอยสุเทพ – ปุย

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☑ พบ โดยพบได้ ☑ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า -

3.ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☑ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4.ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

จากการสำรวจชนิดพันธุ์สัตว์ป่าในพื้นที่อุทยานแห่งชาติดอยสุเทพ-ปุย ยังไม่เคยมีการพบซากหรือกระดองของเต่าเดือย แต่มีการสำรวจพบเต่าเดือยที่มีชีวิตอาศัยอยู่ในพื้นที่อุทยานแห่งชาติดอยสุเทพ-ปุย รายละเอียดปรากฏตามเอกสารที่แนบมาพร้อมนี้ จำนวน 1 ชุด (1แผ่น)

ลงชื่อ.....หัวหน้าหน่วยงาน

(นายอัมพร ปานมงคล)

ตำแหน่ง นักวิชาการป่าไม้ชำนาญการ

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

* มีข้อสงสัยหรือต้องการรายละเอียดเพิ่มเติม โปรดติดต่อที่ นายปรัชญาพร วันชัย

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ภาพถ่ายเต่าเดือยที่สำรวจพบในพื้นที่อุทยานแห่งชาติดอยสุเทพ-ปุย

แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน...สถานีวิจัยสัตว์ป่าเขานางรำ.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☑ พบ โดยพบได้ ☐ บางพื้นที่เท่านั้น ☑ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....

3. ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☑ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

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ลงชื่อ.....หัวหน้าหน่วยงาน

(นาย สมโภชน์ ดวงจันทร์ศรี)

ตำแหน่ง...หัวหน้าสถานีวิจัยสัตว์ป่าเขานางรำ

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

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แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน.....เขตรักษาพันธุ์สัตว์ป่าห้วยขาแข้ง.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☑ พบ โดยพบได้ ☐ บางพื้นที่เท่านั้น ☑ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....เต่าเดือย.....

3. ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☑ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

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ลงชื่อ.....หัวหน้าหน่วยงาน

(.....นายสมโภชน์ มณีรัตน์.....)

ตำแหน่ง.....นักวิชาการป่าไม้ชำนาญการ.....

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

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แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน อุทยานแห่งชาติภูเรือ

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☑ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☐ พบ โดยพบได้ ☐ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....

3. ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☐ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

มีเต่าฝล ซึ่งมีลักษณะที่อยู่อาศัย สีสามพันธุ์
คล้ายๆ กัน

ลงชื่อ.....หัวหน้าหน่วยงาน

(นายศิรพล กุนทอง)

ตำแหน่ง นักวิชาการป่าไม้ชำนาญการ
ทำหน้าที่ หัวหน้าอุทยานแห่งชาติภูเรือ

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

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แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน...เขตรักษาพันธุ์สัตว์ป่าทุ่งใหญ่นเรศวร ด้านตะวันตก...

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☑ พบ โดยพบได้ ☑ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า...เต่าเดือย.....

3. ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☑ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

.....

พบได้บางพื้นที่ ส่วนใหญ่บนภูเขาป่าไผ่ ทางด้านตะวันตก ข้อมูลการพบได้จากงาน

ลาดตระเวนเชิงคุณภาพของเขต.

ลงชื่อ.....(นางสาววีรยา โอชะกุล)หัวหน้าหน่วยงาน

(.....นักวิชาการป่าไม้ชำนาญการ ทำหน้าที่

หัวหน้าเขตรักษาพันธุ์สัตว์ป่าทุ่งใหญ่นเรศวรด้านตะวันตก

จังหวัดกาญจนบุรี

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

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แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน.....อุทยานแห่งชาติน้ำหนาว.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☑ พบ โดยพบได้ ☑ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....เต่าเดือย.....

3.ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☐ ไม่มี (ข้ามไปข้อ 4) ☑ มี จำนวน.....1.....ตัว

4.ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

.....มักอาศัยอยู่ตามป่าไผ่ และป่าดิบแล้ง บริเวณเลียบๆ
ลำห้วย แต่ไม่ชอบอยู่ใกล้ลำห้วย.....

.....

ลงชื่อ.....หัวหน้าหน่วยงาน

(นายคมกริช เศรษบุบผา)

ตำแหน่ง.....หัวหน้าอุทยานน้ำหนาว.....

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แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน.....อุทยานแห่งชาติภาคกลาง.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☐ พบ โดยพบได้ ☑ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....เต่า กำ.....

3.ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☑ ไม่มี (ข้ามไปข้อ 4) ☐ มี จำนวน.....ตัว

4.ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

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ลงชื่อ.....หัวหน้าหน่วยงาน

(.....นายประยูร พงศ์พันธ์.....)

ตำแหน่ง.....เจ้าพนักงานป่าไม้ชำนาญงาน.....

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบภาพถ่ายมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

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แบบสำรวจข้อมูลเต่าเดือยที่พบในประเทศไทย

ชื่อหน่วยงาน.....สังกัด.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ รู้จัก

☐ ไม่รู้จัก

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)

☑ พบ โดยพบได้ ☑ บางพื้นที่เท่านั้น ☐ พบได้ทั่วไปในพื้นที่รับผิดชอบ

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....

3. ในพื้นที่ของท่านหรือบริเวณใกล้เคียง มีการครอบครองซาก กระดองหรือเพาะเลี้ยงเต่าเดือย หรือไม่

☑ ไม่มี (ข้ามไปข้อ 3) ☐ มี จำนวน.....ตัว

3. ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

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ลงชื่อ..... .....หัวหน้าหน่วย

งาน (ปฏิบัติงานแทน)

(นายศิศิร หล้าแก้ว)

ตำแหน่ง นักวิชาการป่าไม้ ปฏิบัติการ

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* หากท่านมีภาพถ่ายเต่าเดือย ซาก หรือกระดองของเต่าเดือย ท่านสามารถแนบมาพร้อมจดหมายตอบกลับหรือส่งภาพถ่ายมาทาง e-mail ทางด้านล่าง

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โทร. 08-6072-6340 **email** pr_wanchai@hotmail.com

แบบสำรวจข้อมูลการกระจายของเต่าเดือยในประเทศไทย

ชื่อหน่วยงาน.....อุทยานแห่งชาติภูกระดึง.....

โปรดทำเครื่องหมาย ✓ ใน ☐ ที่ตรงกับท่านมากที่สุด

1. ท่านหรือบุคลากรในหน่วยงานของท่านรู้จักเต่าเดือยหรือไม่

☑ **รู้จัก**

☐ **ไม่รู้จัก**

2. มีการพบหรือเคยพบเต่าเดือยในพื้นที่รับผิดชอบของท่านหรือไม่

☐ **ไม่พบ หรือไม่เคยพบ (ข้ามไปข้อ 4)**

☑ **พบ โดยพบได้** ☑ **บางพื้นที่เท่านั้น** ☐ **พบได้ทั่วไปในพื้นที่รับผิดชอบ**

เต่าเดือยมีชื่อเรียกในภาษาถิ่นว่า.....เต่าเดือย.....

3.ในพื้นที่ของท่านมีซาก หรือกระดองของเต่าเดือย หรือไม่

☑ **ไม่มี (ข้ามไปข้อ 4)** ☐ **มี จำนวน**.....**ตัว**

4.ข้อมูลเพิ่มเติมที่คาดว่ามีประโยชน์ต่อการสำรวจเต่าเดือย

แหล่งที่พบบ่อย บริเวณผนังชั้น ภูกระดึง เส้นทางน้ำตกเดียว

บริเวณน้ำตกถ้ำใหญ่ - น้ำตกเพ็ญพบในช่วงเดือน พค. - มิย.

ลงชื่อ.....**หัวหน้าหน่วยงาน**

(นายสนอง แก้วอำไพ)

ตำแหน่ง.....นักวิชาการป่าไม้ชำนาญการ ทำหน้าที่ หัวหน้าอุทยานแห่งชาติภูกระดึง

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* **มีข้อสงสัยหรือต้องการรายละเอียดเพิ่มเติม โปรดติดต่อที่ นายปรัชญาพร วันชัย**

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BIOGRAPHY

Mr. Pratyaporn Wanchai was born in Khon Kaen Province on May 17, 1981. He received the degree of Bachelor of Science (Biology) from Khon Kaen University in 2004 and the Master of Science Degree (Zoology) from the Department of Biology, Faculty of Science, Chulalongkorn University in 2007. In 2008, he received the schorlarship from Science Achievement Scholarship of Thailand (SAST) to continue his study for the degree of Doctor of Phylosophy in Biological Science Program with a major in Ecology at Faculty of Science, Chulalongkorn University.

His research was supported by the Thai government budget 2010, under the Research Program on Conservation and Utilization of Biodiversity and the Center of Excellence in Biodiversity, Department of Biology, Chulalongkorn University (CE_D_21_2010); Graduate School, Chulalongkorn University; Departments of Anthropology and Biological Sciences, University of Southern California, Los Angeles, USA and the Turtle Conservancy, New York, USA.

During his study from 2008-2013, he attended GIS training course at King Mongkut's University of Technology Thonburi (Bangkuntien), had research experiences working with turtle experts at Departments of Anthropology and Biological Sciences, University of Southern California, Los Angeles and The Behler Chelonian Center, Ojai, California, USA for three months. He attended and presented part of his works in four international conferences organized at Singapore, USA, China and Thailand, and also participated in Chulalongkorn University and Universiti of Brunei Darussalam exchange program at Brunei Darussalam.