การแพร่กระจายของเต่าปูลู *Platysternon megacephalum* Gray, 1831 ในประเทศไทย และกรณีศึกษาสถานภาพประชากรและการจัดการด้านการอนุรักษ์ ณ เขตรักษาพันธุ์สัตว์ป่าเชียงดาว จังหวัดเชียงใหม่

นางเครือวัลย์ พิพัฒน์สวัสดิกุล

วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิทยาศาสตรดุษฎีบัณฑิต
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DISTRIBUTION OF THE BIG-HEADED TURTLE *Platysternon megacephalum* Gray, 1831 IN THAILAND AND A CASE STUDY ON POPULATION STATUS AND CONSERVATION MANAGEMENT AT CHIANG DAO WILDLIFE SANCTUARY, CHIANG MAI PROVINCE

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เครือวัลย์ พิพัฒน์สวัสดิกุล: การแพร่กระจายของเต่าปูลู *Platysternon megacephalum* Gray, 1831 ในประเทศไทย และกรณีศึกษาสถานภาพประชากรและการจัดการด้านการอนุรักษ์ ณ เขตรักษาพันธุ์สัตว์ป่าเชียงดาว จังหวัดเชียงใหม่ (DISTRIBUTION OF THE BIG-HEADED TURTLE *Platysternon megacephalum* Gray, 1831 IN THAILAND AND A CASE STUDY ON POPULATION STATUS AND CONSERVATION MANAGEMENT AT CHIANG DAO WILDLIFE SANCTUARY, CHIANG MAI PROVINCE)
อ. ที่ปรึกษาวิทยานิพนธ์: รศ. ดร. กำธร ธีรคุปต์, อ. ที่ปรึกษาวิทยานิพนธ์ร่วม: Harold K. Voris, Ph.D., 99 หน้า.

การศึกษาการแพร่กระจายของเต่าปูลูในประเทศไทย ได้ดำเนินการตั้งแต่เดือนธันวาคม พ.ศ. 2549 ถึง เดือนเมษายน พ.ศ. 2552 โดยทำการสำรวจตามลำห้วยบนภูเขาทั้งในและนอกพื้นที่ป่าอนุรักษ์ทั่วประเทศ ยกเว้นภาคใต้ พบว่าเต่าปูลูมีการแพร่กระจายอยู่ใน 10 ลุ่มน้ำหลักของประเทศไทย ทางภาคเหนือ ภาคตะวันออกเฉียงเหนือ ภาคกลาง และภาคตะวันตก ผลการศึกษาได้รายงานการพบเต่าปูลูในเขตลุ่มน้ำน่านซึ่งเป็นลุ่มน้ำใหม่ที่ไม่เคยมีรายงานการพบเต่าปูลูมาก่อน และภายในจำนวน 10 ลุ่มน้ำข้างต้นนี้เป็นพื้นที่ใหม่ที่สำรวจพบเต่าปูลูจำนวน 22 พื้นที่ โดยพบที่ระดับความสูง 430-1,350 เมตรจากระดับน้ำทะเล ตามลำห้วยเล็กๆ ที่มีน้ำไหลแรงในป่าดิบแล้งและป่าดิบเขา ส่วนการศึกษาด้านสถานภาพประชากร การเคลื่อนที่ อาณาเขตที่อยู่อาศัยของเต่าปูลู และผลกระทบจากมนุษย์นั้น ได้ทำการศึกษาที่เขตรักษาพันธุ์สัตว์ป่าเชียงดาว จังหวัดเชียงใหม่ ตั้งแต่เดือนกรกฎาคม พ.ศ. 2549 ถึง เดือนกรกฎาคม พ.ศ. 2552 โดยใช้วิทยุติดตามและการสัมภาษณ์ ผลการศึกษา พบว่าเต่าปูลูกระจายตัวอยู่ใกล้เคียงกัน มีเขตอาศัยซ้อนทับกันบ้าง มีรูปแบบการเคลื่อนที่ไม่แน่นอนภายในเขตอาศัย ไม่มีความสัมพันธ์ระหว่างเพศกับ ขนาดที่อยู่อาศัย และรูปแบบการเคลื่อนที่ แต่มีความแตกต่างกันอย่างมีนัยสำคัญระหว่างความถี่ในการเคลื่อนที่ ของตัวเต็มวัยเพศผู้และเพศเมีย (χ^2=18.96, p<0.001) และไม่มีความแตกต่างกันระหว่างระยะทางที่เคลื่อนที่กับปริมาณน้ำฝนและอุณหภูมิ ส่วนการศึกษาผลกระทบของมนุษย์ต่อเต่าปูลู พบว่าความแตกต่างระหว่าง เพศ อายุ และระดับการศึกษา ของชุมชน มีผลต่อการคุกคามเต่าปูลูในเขตรักษาพันธุ์สัตว์ป่าเชียงดาว อย่างมีนัยสำคัญ (χ^2=20.44, p<0.001; χ^2=96.58, p<0.001; χ^2=21.56, p=0.006) เช่นเดียวกับความร่วมมือด้านการอนุรักษ์ (χ^2= 6.58, p= 0.037; χ^2= 35.07, p<0.001; χ^2=47.19, p<0.001) การศึกษาครั้งนี้ได้เสนอแนะการจัดการด้านการอนุรักษ์ที่เหมาะสม และควรดำเนินการอย่างเร่งด่วน

สาขาวิชา วิทยาศาสตร์สิ่งแวดล้อม ลายมือชื่อนิสิต .....
ปีการศึกษา 2552 ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์หลัก .....
ลายมือชื่อ อ.ที่ปรึกษาวิทยานิพนธ์ร่วม .....

4889652820 : MAJOR ENVIRONMENTAL SCIENCE
KEYWORDS : *Platysternon megacephalum*/ DISTRIBUTION/ MOVEMENT AND HOME RANGE SIZE/ IMPACT

KRUEWAN PIPATSAWASDIKUL: DISTRIBUTION OF THE BIG-HEADED TURTLE *Platysternon megacephalum* Gray, 1831 IN THAILAND AND A CASE STUDY ON POPULATION STATUS AND CONSERVATION MANAGEMENT AT CHIANG DAO WILDLIFE SANCTUARY, CHIANG MAI PROVINCE. THESIS ADVISOR: ASSOC. PROF. KUMTHORN THIRAKHUPT, Ph.D., THESIS CO-ADVISOR: HAROLD K. VORIS, Ph.D., 99 pp.

The distribution of the big-headed turtle, *Platysternon megacephalum* Gray, 1831, in Thailand was studied from December 2006 to April 2009. Mountain streams of protected and unprotected areas throughout Thailand, except in the southern peninsular region, were ground surveyed. This study confirms the occurrence of *P. megacephalum* in one new river basin, Nan and nine previously reported river basins in the north, northeastern, north central and western parts of Thailand. Among these, twenty-two new localities were reported with elevations between 430 and 1,350 m asl in small, often fast flowing mountain streams in dry dipterocarp and monetane rain forests. During August 2008 to August 2009, their population status, movement, home range and threats of *P. megacephalum* in Thailand, and a case study on population status and conservation management were studied at Chiang Dao Wildlife Sanctuary, Chiang Mai Province by radio telemetry and interview. The results revealed that most of the turtles lived near one another with some slight overlaps. Their re-sighting positions were not uniformly distributed within the boundaries of their respective home ranges. No correlations were found among the turtles in terms of the pattern or order of movements but there were significant differences between frequency of movement and the adults (χ^2=18.96, p<0.001). An analysis of variance (ANOVA) revealed no significant relationships between the interval adjusted minimum stream distances moved by the turtles and either rainfall or temperature. Significant differences in *P. megacephalum* hunting was found with human gender (p<0.001), age (p<0.001) and level of education (p=0.006) and with the conservation agreement with gender (p=0.037), age (p<0.001) and level of education (p<0.001). This study recommends a proper management plan that should be implemented rapidly.

Field of Study : Environmental Science
Academic Year : 2009

Student's Signature
Advisor's Signature K. Thirakhupt
Co-Advisor's Signature H. Voris

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CHAPTER I

INTRODUCTION

Southeast-Asia holds the richest diversity of terrestrial turtles in the world, encompassing over 25 % of the world`s chelonian species (Altherr & Freyer, 2000) while Thailand is one of the world's leading nations in chelonian biodiversity, with at least 26 species, or about 10% of the world's total chelonian species diversity (Thirakhupt & van Dijk, 1994). At present, many turtle and tortoise species in Thailand are under intensive human threats mostly by hunting for food and the pet trade.

The big-headed turtle, *Platysternon megacephalum* Gray, 1831, is one of the five endangered turtles and tortoises of Thailand (Nabhitabhata & Chan-ard, 2005). It is classified as an endangered species on the IUCN Red List (2008) due to threats posed by human hunting for consumption and trade and habitat degradation (van Dijk & Palasuwan, 2000). This small to medium-sized turtle is best known for its huge head that cannot be withdrawn into the shell, and a long tail (Burnie & Don, 2001).

Most recent works on turtles and tortoises in Thailand have focused on their taxonomy, distribution and conservation status (Nutaphand, 1979; Chan-ard & Nabhitabhata, 1986; Nabhitabhata, 1989; Thirakhupt & van Dijk, 1997). Movement patterns of animals which are fundamental to the understanding of their life histories have not been much investigated (Swingland & Greenwood, 1983; Gregory et al., 1987). Many studies of home range reveal the interaction between an individual and functions such as microhabitiat utilization, food acquisition, aestivation and reproduction. Thus, examining movement patterns can lead to a better understanding of many aspects of a species' ecology (Swingland & Greenwood, 1983; Gibbons et al., 1990; Doody et al., 2002; Litzgus & Mousseau, 2004) that are elevant to conservation.

To date, the information on the distribution and status of this species is very incomplete, especially the exact locations and numbers of occurrence. Therefore, a more comprehensive knowledge from this research of its current distribution range and areas of occurrence as well as its habitat characteristics and movement would be very useful for its future conservation management.

OBJECTIVES

1. To assess the occurrence and the distribution range of *Platysternon megacephalum* in Thailand.

2. To investigate the annual movement patterns and home ranges of *Platysternon megacephalum* in Chiang Dao Wildlife Sanctuary.

3. To study the impact of Chiang Dao Wildlife Sanctuary villagers to the big-headed turtle.

ANTICIPATED BENEFITS

1. This research will explore the present distribution of the big-headed turtle in Thailand and provide a more comprehensive knowledge of its current distribution range and areas of occurrence.

2. This research will provide the information on movement pattern and home range size of *P. megacephalum* in Chiang Dao Wildlife Sanctuary, Chiang Mai Province and will suggest the conservation management for the big-headed turtle at Chiang Dao Wildlife Sanctuary.

CHAPTER II

LITERATURE REVIEWS

2.1 The big-headed turtle, *Platysternon megacephalum* Gray, 1831

2.1.1 Description and taxonomy

The big-headed turtle, *Platysternon megacephalum* Gray, 1831 is a monotypic species of turtle, it is unique enough to be placed in its own family, the Platysternidae, and has no close relatives (Ernst & Barbour, 1989). This species is classified in:

Phylum: Chordata
Class: Reptilia
Order: Testudines
Family: Platysternidae
Genus and species: *Platysternon megacephalum* Gray, 1831
Subspecies: 5 subspecies have been described:
P. m. megacephalum Gray, 1831,
P. m. peguense Gray, 1870,
P. m. shiui Ernst and McCord, 1987,
P. m. vogeli Wermuth, 1969,
P. m. tristernalis Schleich and Gruber, 1984

The species is at present believed to contain three subspecies (Ernst & Laemmerzahl, 2002). Based on some studies of morphology and mtDNA the family Platysternidae was traditionally considered to be close to the New World snapping turtles (family Chelydridae), but recent research of the complete mitochondrial genome by Parham et al. (2006) argued for a placement in the Testudinoidea.

2.1.2 Distribution

P. megacephalum is found in Southeast Asia, including southern and eastern China, Vietnam, Laos, Cambodia, Thailand and Myanmar (Ernst & Barbour, 1989; Bonin et al., 2006). In Thailand, the first recorded distribution of this freshwater turtle was at Mae Hong Son, Phetchabun, Chaiyaphum and Kanchanaburi Provinces (Gairdner & Smith, 1915). Later, Wermuth (1969), Pritchard (1979) and Iverson (1992) extended the range to Chiang Mai Province while Taylor (1970) confirmed that the species had been taken in Chiang Mai, Loei and Kanchanaburi Provinces. This was subsequentially extended to include Skon Nakhon Province (Nutaphand, 1979; Humphrey & Bain, 1990) and also reported at new sites in Lampang, Tak and Kanchanaburi Provinces (Unakornsawas, 1995; Thirakhupt & van Dijk, 1995). Thus, Nabhitabhata & Chan-ard (2005) summarized that the species distribution range as being Chaiyaphum, Chiang Mai, Kanchanaburi, Loei, Mae Hong Son, Phetchabun, Phrae and Tak Provinces, to which Kamsook et al. (2006) recently confirmed the presence of *P. megacephalum* at Phu Khiao Wildlife Sanctuary, still within the Chaiyaphum Province.

From above, this species has been found in nine of the 25 main river basins of Thailand consisting of the; Mae Nam Salawin, Mae Nam Ping, Mae Nam Kok, Mae Nam Wang and Mae Nam Yom in the north, Mae Nam Pasak in the center, Mae Nam Khong and Mae Nam Chi in the northeast and Mae Nam Mae Klong in the west. van Dijk (2002) stated that the habitat sites of *P. megacephalum* in Thailand occur only above 800 m altitude, while streams inhabited by the animals may dry out for several weeks at the height of the dry season. Habitat availability is considered of substantial importance and most areas of occurrence are now restricted to within protected areas (van Dijk & Palasuwan, 2000).

2.1.3 Morphology

The most striking feature of *Platysternon megacephalum* is its large head, which cannot be retracted due to its size (Ernst & Barbour, 1989; Bonin et al., 2006). The dorsal surface of the head is covered by an enlarged scute. The temporal region of the skull shows little emargination, and an enlarged postorbital separates the parietal and squamosals (Ernst & Barbour, 1989). The sheath covering the upper jaw is large and extends almost to the edge of the dorsal scute. The carapace may reach up to 18.5 cm in length (Bonin et al., 2006). The digits are webbed, and each consists of three phalanges. A long tail is present, and the vertebral column contains two biconvex cervical vertebrae. The carapace, head, and limbs are yellowish-brown to olive-colored and may exhibit some mottling (Ernst & Barbour, 1989; Bonin et al., 2006).

Juvenile big-headed turtles are more brightly marked than the adults and have more pronounced serrations at the rear of the carapace. Also, the tail is often longer than that of an adult. (Inger & Schmidt, 1957; Kirkpatrick, 1995; McCarthy, 1991)

2.1.4 Habitat

In all known localities, the primary habitat of the big-headed turtle remains the same. It prefers to live in fast-moving cool mountain streams or brooks filled with boulders and broken rock (Kirkpatrick, 1995) in steep hill and mountain areas, at slopes of on average 45 degrees. These streams are characterized by exposed bedrock, areas of accumulated large boulders, stream pools and small waterfalls, usually narrower than a meter wide and less than 10 cm deep. The water is clear, ranging in temperature between 18 and 24 degrees Celsius (van Dijk, 2002) based on Doi Chiang Dao, 1997; Phu Luang, 1997 & 1998; Hainan, 2001).

Furthermore, Ernst & Barbour (1989) and Kirkpatrick (1995) also reported that big-headed turtles are located in countries that most

people consider to be tropical, water temperature in the mountain streams favored by the turtles can reach 12 degrees C (53 °F). Streams inhabited by big-headed turtle may dry out for several weeks at the height of the dry season and local park rangers assert that big-headed turtles migrate overland in search of streams still containing water (van Dijk, 2002).

2.1.5 Natural History

Kirkpatrick (1995) stated that the behavior of big-headed turtle in its natural environment, especially details concerning mating and reproduction is almost totally unknown. This turtle feeds on a variety of meats, fishes and invertebrates in captivity and thus are probably carnivorous in nature although its feeding habits are known only from captive studies. Crow (2005) reported that it is omnivorous due to plant species in the feces of freshly collected specimens. At night, they probe about the stream bottom for small animals and may even leave the water to search along the bank and among low shrubs for food and they are accomplished climbers and in captivity have been known to climb out of aquaria and over wire fences (Ernst & Barbour, 1989).

The reproductive habits of big-headed turtle are almost completely unknown except for a few details. Nesting is speculated to occur from May to August with a single captive egg hatched September (Kirkpatrick, 1995). One or two white eggs are laid at a time. Unlike most turtle eggs, they are not spherical or lozenge-shaped. Instead, the eggs are ellipsoidal and resemble bird eggs. Weissinger (1987) and Ernst & Barbour (1989) mentioned that this species has been reported to lay one or two white, ellipsoidal to elongate-tapered (37x22 mm) eggs per clutch and hatchlings are 38-40 mm in carapace length. Alderton (1993) agreed that two eggs appear to be the usual clutch size. Budde (1991) stated that one to 6 eggs comprise a clutch, although 2-3 are more normal. Meanwhile, Iverson (1992) and KÖhler (2005) reported that big-headed turtles lay one to four large elongate eggs per clutch, although one or two egg clutches are most common.

Nesting is speculated to occur from May to August based on a single captive egg that hatched in September. One or two white eggs are laid at a time. Unlike most turtle eggs, they are not spherical or lozenge-shaped. Instead, the eggs are ellipsoidal and resemble bird eggs (Kirkpatrick, 1995).

2.1.6 Sexual dimorphism

P. megacephalum is slightly sexually dimorphic. Male big-headed turtles possess concave plastrons while their vents are located beyond the rim of the carapace, while female big-heads have flat plastrons and their vents are at or inside the rim of the carapace (Kirkpatrick, 1995).

2.1.7 Population and status

P. megacephalum is a turtle that has been very common in food markets of southern China. This species is marketed by pet traders and is bought as souvenirs by tourists (Kirkpatrick, 1995). This species is listed in the International Union for the Conservation of Nature and Natural Resources IUCN Red List 2008 as endangered and is a protected species in Thai Wildlife Protection Law 1992. (The Preservation and Protection of Wild Animals Act No. 2, B.E. 2546)

2.2 Radio-telemetry Technique

2.2.1 Radio-tracking technique in Thailand

The best method to obtain detailed information on movement is through radiotelemetry (Pough et al., 2001). Advances in the field of wildlife telemetry have made it possible to acquire detailed data on many aspects of wildlife biology, including habitat use, home range size, mortality, survivorship, and migration timing and routes. Since many wildlife species are secretive and difficult to observe, radiotelemetry has provided a valuable

tool to learn more about their respective life histories, even when dense vegetation precludes effective visual searching (Palomares & Delibes, 1991). An important consideration for using radio telemetry techniques is assuring that they do not affect significantly the behavior, physiology, reproductive success, and survival of the animals (Boardman et al., 1998).

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. The technology has developed drastically over the past 40 years (Millspaugh & Marzluff, 2001). Radiotelemetry 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 & Judd, 1975), *Testudo kleinmanni* (Geffen & Mendelsson, 1988), *Xerobates agassizi* (Barrett, 1990), *Gopherus Polyphemus* (Butler et al*.,* 1995) and *Testudo graeca* (Anadón et al., 2006).

In Thailand, radio-tracking was first used in studying wildlife by Tsuji, Poonswad & Jirawatkavi in 1987 in a study of hornbills at Khao Yai National Park. The only two studies using radio-tracking on tortoises in this country have been one on the elongated tortoise (*Indotestudo elongata*) at Huai Kha Khaeng Wildlife Sanctuary, Uthai Thani Province by Tharapoom (1996) and one by Wanchai (2007) on the home range size and activities of the black asian giant tortoise (*Manouria emys phayrei*) at Kaeng Krachan National Park, Prachuap Khiri Khan Province.

2.2.2 Home range and activity patterns

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 an animal, with the season, and with such ecological condition as available food and intraspecific strife (Smith, 1974). In poor habitat, the home range is usually 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. Adult males usually have larger home ranges than females and juveniles (Smith & Smith, 2006).

In aquatic turtles, movements often differ between the sexes (MacCulloch & Secoy, 1983; Pluto & Bellis, 1988; Carter et al., 2000). Sex related differences in habitat use (Plummer & Shirer, 1975; Plummer, 1977; Craig, 1992), diet (Lindeman, 2000) and differential reproductive activities (Moll & Legler, 1971; Obbard &Brooks, 1980) are contributing factors. During the mating season, activities and movements are usually greater in males than females and during the nesting season, activities and movements of females are equal to or exceed that of males (Brown & Brooks, 1993; Jones, 1996; Thomas et al., 1999).

Adult males of several species of freshwater turtles move longer distances and more frequently than females (Bury, 1979b; Gibbons, 1986). This difference may reflect the differential reproductive strategies of males and females (Morreale et al., 1984). Sexual strategies, such as mate searching by males and movement to nesting areas by females, will result in a sexual bias for either sex. Equal movements for males and females are expected while foraging for food, escaping temporary habitats, or moving to overwintering sites.

Home ranges of freshwater turtles generally overlap (Obbard & brooks, 1981; Doody et al., 2002; Litzgus & Mousseau, 2004) and behavioral spacing in freshwater turtles has been difficult to document (Galbraith et al., 1987; Kaufmann, 1992a).

2.2.3 Analysis of Home Range

Home range has biological meaning only when the assumptions of the individual home range model are met and the limitations understood. Site fidelity exists when the area that an individual utilizes is smaller than the area used if an individual's movement was random (Danielson & Swihart 1987; Spencer et al., 1990). There are many different methods to determine home range, from the most basic methods to complicated probabilistic techniques. The simplest home range method is the minimum convex polygon (MCP) method. MCP simply connects the points located on the outside of an animal's home range. This method is subject to sample size and is greatly affected by outliers (Mohr, 1947; Hooge et al., 2001). The Jenrich-Turner home range is another quick and simple method. It is an algorithm that assumes the data follow a bivariate normal distribution. However, this is not always followed by animals in the wild (Jenrich & Turner, 1969). This method, like MCP, is chiefly useful for comparison with older studies.

The harmonic mean method describes the intensity of use of the home range. This technique is useful in determining animal activity centers. The activity area is related directly to the frequency of occurrence of an individual within its home range (Dixon & Chapman, 1980). Unfortunately, the method does not produce a probability density leaving researchers with a limited probabilistic interpretation (Worton, 1989).

The kernel home range method is one of the most robust techniques (Silverman, 1986). Kernel methods can output utilization distributions and allow scientists to examine not only the home range extent, but core areas of activity as well. Vokoun (2003) reasoned that using kernel density estimates for stream fishes has advantages over the traditional practice of reporting linear home ranges as the distance between the most upstream and farthest downstream relocations of an individual fish. This is because kernel density estimates can describe what sections of the

stream are important to fishes, instead of only describing the area a fish traversed. Conversely, Row et al., (2006) suggested using the minimum convex polygon (MCP) method to calculate home-range size in studies of herpetofauna and adjusting the smoothing factor until the area of the 95% kernel equals the area of the MCP.

Additionally, home range estimators were designed to evaluate species that use space with few restrictions, traveling almost anywhere on the landscape (Gail et al., 2001). Many species, however, confine their movements to a geographical feature that conforms to a relatively linear pattern. Because autocorrelation does not negatively influence estimates of linear home ranges, assessment of independence between data points may be more appropriately viewed as a means to identify important behavioral information, rather than as a hindrance. Linear home range was modified for each turtle as the range spanned between the farthest upstream and downstream locations (Plummer et al., 1997). Home range is defined as the total monthly distance between all locations during one year (Plummer & Shirer, 1975).

2.3 Wildlife conservation management in Thailand

2.3.1 Species conservation

Thailand was once a kingdom of abundant forests and wildlife, but no longer. A rapidly growing human population has brought great pressure to bear on the country's natural resources (Elliott, 2004). Thailand's population of more than 63 million, growing at 0.56 % per year, will double over the next 35 years (Department of Provincial Administration, 2009). To feed and house such a rapidly growing population, more than half of the kingdom's forests have been destroyed to provide timber and land for agriculture. If this continues, there will be no forest left in 20 years. Tropical forests are the most important wildlife habitat because they contain more than half of Earth's 30 million or so species of plants and animals (Elliott,

2004). Even where forest survives, there may be no wildlife due to hunting for sport, food, skins, ivory and medicinal products. Some animals are killed because they are considered to be pests. Conservation, then, is essential if industrial and economic developments are to be maintained. Conservation is management of the human use of the biosphere so that it may yield the greatest benefit to present generations whilst maintaining its potential to meet the needs and aspirations of future generations. Three broad aims of conservation are: i) to maintain essential ecological processes and life support systems, ii) to preserve genetic diversity and iii) to ensure the sustainable use of species and ecosystems.

2.3.2 Habitat Conservation

The best way to conserve species is to protect areas where they live from logging, industrial development and hunting. Protected areas must be large. In small areas, animal populations are small and vulnerable to disasters e.g. fire and storms. Elliott (2004) considered there may also be inbreeding depression (loss of viability and extinction. A minimum area of 5,000 sq. km must be protected to ensure long term survival of all species in a tropical forest).

About 18 % of Thailand's land surface is protected in some way but no single area is large enough to support viable populations of large mammal in the long term (see table 2.1).

Table 2.1 Protected area types in Thailand.

Protected area types	Total area (sq.km.)
National park (108)	54,733.44
Wildlife Sanctuary (57)	36,205.37
No Hunting Area (51)	3,776.24
Forest Park (113)	1,238.79

Source: Department of National Parks, Wildlife and Plant Conservation: DNP, 2009

2.4 Human Impact on turtle

Turtles and tortoises are losing vast portions of their original habitats as humans convert wetlands, forests, and grasslands to agricultural fields, grazing lands, and villages and cities (Collins, 1990; Harding, 1997; Thirakhupt & van Dijk, 1997). Pollutants from farms and urban areas have degraded many turtle habitats (Fu, 1997; Harding, 1997). Turtles are also harmed when humans alter rivers and streams by creating dams and channels, or build sea walls or jetties on the beaches where sea turtles lay their eggs. Freshwater and marine turtles may be scattered over their habitats much of the year, but all must return to specific shoreline sites to nest, giving humans the opportunity to take both the female turtles and their eggs for food. The pet trade, which affects mainly small terrestrial and semi-aquatic species, is another threat to turtles (Harding, 1997). Harvesting for use by humans (as food, for medicinal purposes, or for sale as pets) is the greatest threat to turtle species in Asia, while the destruction of habitat is of greater concern in most other regions of the world.

Turtles have long fascinated people of many cultures, and they are often used to symbolize wisdom and long life. Freshwater turtles and tortoises are traded worldwide (Georges et al., 2006; O'Brien et al., 2003; Vargas-Ramirez et al., 2007), in Asia to the point where it has been termed a crises (van Dijk et al., 2000). In many Native American and Asian cultures, turtles are mentioned in myths that explain the origin of the universe. In China and Southeast Asia, turtles are sometimes venerated in religious ceremonies. Despite the reverence turtles have inspired, these animals have a long history of being exploited by humans. People in many parts of the world eat turtle flesh and eggs, and use turtle parts in traditional medicines. Turtle fat is a source of valuable oils. Some turtles, such as the hawksbill turtle, are killed for their decorative shells, which are the source of tortoiseshell used in jewelry. As population status of *P. megacephalum* is endangered (IUCN, 2008); once common in food markets in China but now rare, indicating drastic population. Declines noted in all Range States except Thailand, only remote or well-protected areas may have stable populations.

2.5 Trade Volumes and trends in freshwater turtles of Thailand

Subsistence use of freshwater turtles, and tortoises, has a long history in certain regions and among certain ethnic groups. Trade in small numbers of generally juvenile animals for the international pet trade has occurred for decades. The large-scale exploitation of adult freshwater turtles and tortoises for international commercial trade is a recent development. This international commercial trade has increased tremendously in the past decade. Precise quantities of recent trade volumes are rarely available. Thailand showed a significant rise and fall in live freshwater turtle exports during the 1990's, reaching a peak of over six million animals in 1996 but collapsing to about 470,000 animals exported during the first 7 months of 1999 (Fisheries Department of Thailand, in van Dijk & Palasuwan, 2000). The vast majority of Thailand's turtle exports concern farmed softshells, and export numbers were significantly influenced by import restrictions in consumer countries.

In Thailand, *P. megacephalum* threats are collection for consumption in relation to Traditional Chinese Medicine (TCM), for pet trade, and *ex situ* captive breeding programs, and habitat degradation (van Dijk & Palasuwan, 2000) reported that. In addition, the magnitude of illegal trade from Thailand is unknown, but the potential for collection to supply the TCM demand to the north is undeniable. Potential trade impacts are severe, given the limited size of individual populations and the difficulty in recolonizing depleted areas. The large number and availability of illegally sourced animals indicates a blatant disregard for law and authority by traders both from Thailand and from exporting countries. They concluded that the trade in these species in such significant volumes is of serious conservation concern (Nijman & Shepherd, 2007).

CHAPTER III

DISTRIBUTION RANGE OF THE BIG-HEADED TURTLE, (*Platysternon megacephalum*, GRAY 1831), IN THAILAND

ABSTRACT

The distribution of the big-headed turtle, *Platysternon megacephalum* Gray, 1831, in Thailand was studied from December 2006 to April 2009. Mountain streams of protected and unprotected areas throughout Thailand, except in the southern peninsular region, were ground surveyed. This study confirms the occurrence of *P. megacephalum* in one new and nine previously reported river basins in the northeastern, part of Thailand. Among these, twenty-two new localities with elevations between 430 and 1,350 m asl were reported. Most *Platysternon megacephalum* individuals were found at night in small, often fast flowing mountain streams in dry dipterocarp and montane rain forests. The water temperature on these streams ranged between 15.5 and 20.3 ^{o}C ($\overline{x}$ =19.04±2.10 ^{o}C, n=33), pH values were between 5.32 and 8.07 and water depths were between 14.0 and 95.0 cm. ($\overline{x}$ =41.67± 25.30 cm, n=33). The turtles appear to be most abundant at elevations between 630 to 720 m. *Platysternon megacephalum* populations face serious threats from habitat loss, human consumption, and commercial harvest of turtles. This species urgently needs an aggressive conservation program to insure its survival.

Key words: *Platysternon megacephalum*, big-headed turtle, distribution, Thailand

INTRODUCTION

The geographic range of *P. megacephalum* includes southern China and mountainous areas of Vietnam, Laos, Cambodia, Thailand and Myanmar (Ernst & Barbour, 1989, Bonin et al. 2006). In Thailand, the first records of *P. megacephalum* were from Mae Hong Son, Phetchabun, Chaiyaphum and Kanchanaburi Provinces (Gairdner, 1915). Later, Wermuth (1969) extended the range to Chiang Mai Province while Taylor (1970) confirmed that the species had been taken in Chiang Mai, Loei and Kanchanaburi Provinces (A map showing the provinces of Thailand can be found at (http://en.wikipedia.org/wiki/ Provinces of Thailand). This range was later extended to include Skon Nakhon Province (Nutaphand, 1979, Humphrey and Bain 1990) and also new sites in Lampang (Unakornsawas, 1995) Tak and Kanchanaburi Provinces (Thirakhupt & van Dijk, 1995). Thus, Nabhitabhata & Chan-ard (2005) summarized the species distribution in Thailand as including Chaiyaphum, Chiang Mai, Kanchanaburi, Loei, Mae Hong Son, Phetchabun, Phrae and Tak Provinces.

From the above published reports, this species has been found in ten of the 25 main river basins of Thailand as follows: Mae Nam Salawin, Mae Nam Ping, Mae Nam Kok, Mae Nam Wang and Mae Nam Yom in the north, Mae Nam Pasak in the center, Mae Nam Khong Mae Num Moon and Mae Nam Chi in the northeast and Mae Nam Mae Klong in the west.

OBJECTIVE

Prior to this study our knowledge of the distribution and status of this species was somewhat limited and out of date. The purpose of this study was to explore the present-day distribution and habitat use of *P. megacephalum* in Thailand and to provide baseline data required for conservation decisions. To this end, we surveyed mountain streams throughout non-peninsular Thailand, compiled literature and museum records, and conducted a questionnaire survey.

METHODOLOGY

Museum Surveys

Specimen data records for *P. megacephalum* from Thailand were requested from numerous major museums. The museum collections containing *P. megacephalum* from Thailand were as follows: American Museum of Natural History (AMNH); Chulalongkorn University Museum of Zoology, Thailand (CUMZ); Field Museum of Natural History (FMNH); Florida Museum of Natural History (FLMNH); Institute and Natural History Museum Senckenberg, Germany (SMF); Museum of Comparative Zoology, Harvard University (MCZ); Museum of Zoology, University of Michigan (UMICH); Natural History Museum & Biodiversity Research Center, University of Kansas (KU); Natural History Museum, Basel, Switzerland (NHMB); Thailand Natural History Museum (THNHM); The Natural History Museum, UK (BMNH); Smithsonian Institution National Museum of Natural History (USNM) and Zoologisk Museum Statens Naturhistoriske Museum (ZMUC). Catalogue information, including locality data, from each reference specimen was assessed and then used along with the results of the questionnaire survey to plan the ground surveys.

Questionnaire Surveys

An initial survey concerning *P. megacephalum* was conducted by mailing 263 brief questionnaires to local forestry offices within Thailand. The offices included the national parks, sanctuary units, wildlife research units and the non-hunting units of the National Park, the Wildlife and Plant Conservation Department, and the fisheries offices of the Department of Fisheries, throughout Thailand with the exception of the southern peninsula that lies well outside this turtles known range. The results of the survey were gathered over a one year period (2006-2007) and they were used to identify localities that merited ground surveys. In addition, based on other informal reports and personal communications, several other parks, sanctuaries and unprotected areas were surveyed for *P. megacephalum.* The survey questions were in the Thai language and primarily sought knowledge of first hand observations of the big-headed turtle.

Ground Surveys

From December 2007 to April 2009, intensive investigations were carried out in the areas about which we had positive sighting information. To gain positive confirmation sightings of *P. megacephalum*, I drew upon the knowledge and experience of local hunters and forest rangers who have spent at least some time in the field. Photographs of the big-headed turtles were used to insure good communication with local rangers, and advice was sought as to which catchments were thought to have turtles. Night surveys were conducted between 1900 hrs and 2400 hrs on the mountain streams that had been identified. The survey team consisted with a team of three or four from the Chiang Dao Wildlife Research Station and several local rangers. In addition, in some cases, several local villagers joined the search. The search included the stream banks, stream riffles and pools and under large rocks and logs within the stream. In addition, some streams were searched during day light hours. At each location, up to five night surveys were conducted per stream depending on sightings. Surveys at a site were discontinued as soon as one *P. megacephalum* was observed.

When an animal was observed, it was captured and ecological and morphological data were recorded. Straight-line measurements of each specimen were taken with dial calipers accurate to 0.1 mm for the carapace length (CL), carapace width (CW), plastron length (PL), plastron width (PW), head length (HL) and tail length (TL).

To assess the overall range of *P. megacephalum* in Thailand, locations of all recent findings were plotted on a map which indicates river basins. In presenting the detailed locality data in figure 3.1 I have carefully considered both the practical and ethical implications raised in Fong & Qiao (2010). I recognize that there is a risk of the data being used to facilitate exploitation but because many of the same localities are already published (e.g., Fong & Qiao, 2010) or accessible on the Internet (e.g., EMYS system) I have decided to provide the information to advance turtle research.

RESULTS AND DISCUSSION

Museum Surveys

A total of 29 museum specimen records were reviewed for their collection localities. Eight of the 29 specimens were recorded as coming from Thailand, without more locality details (see table 3.1). One locality record consisted of simply Laos Mountains. The remaining specimens had detailed location data within Thailand and are shown in figure 3.1.

Questionnaire Surveys

Of the 263 questionnaires distributed, 111 (42.2%) were completed and returned. Of these 111 responses, 63 (~57%) reported some evidence of *P. megacephalum* in their region. Positive reports came from 18 Provinces and included 11 of the 25 river basins of Thailand. Each area that had a positive response was visited and ground surveys were conducted to attempt to verify the current presence of *P. megacephalum*.

Ground Surveys

A total of 40 locations were surveyed. At six of the locations no turtles were observed. At 34 of the 40 locations *P. megacephalum* were observed within streams. The survey documents that *P. megacephalum* is widely distributed in the same nine previously reported river basins (North: Mae Nam Salawin, Mae Nam Ping, Mae Nam Kok, Mae Nam Wang, Mae Nam Yom; Northeast: Mae Nam Khong and Mae Nam Chi; Central: Mae Nam Pasak; West: Mae Nam Mae Klong) plus one new river basin (Mae Nam Nan in the north).

Table 3.1 Localities and catalog numbers of *P. megacephalum* specimens from Thailand

Locality	Catalog Number	Georeferened record		Collected Date
		Latitude (N)	Longitude (E)	
Northern				
Chom Thong, Chiang Mai Province	USNM 101665	18°25'	98°44'	Jul 1935
Doi Suthep, Chiang Mai Province	USNM 101652			Jul 1935
Doi Sutkep, Chiang Mai Province	ZMUC R2402	18°48'	98°55'	
Mae Hong Son Province	CUMZ(R) 2008.09.30,1			2003
Me Taw (1642/9831), Raheng	MCZ 29535	16°52'	99°08'	
Northern Thailand	SMF 66464			
Pa Melung, N. Thailand	BMNH 1921.4.1.195-6			
Phrae Province Thailand	CUMZ(R) 2008.09.30,2-5			2003
Upper Me-ping at Muang Kuan	SMF 70531			
Wiang Pa Pao, Chiang Rai Province	USNM 101666	19°22'	99°30'	Jul 1935
Northeastern				
Ban Nong Wai, Dan Sai, Loei Province	USNM 141782	17°21'	101°04'	Nov 1954
Loei Province, Phu Kading	Taylor, 1970	13°02'	99°36'	
Lomlo Mt. Thailand	KU 40084	17°01'	101°05'	
Nam Nao,Thailand	KU 129716	17°01'	101°05'	
Phu Luang, Loei Province	THNHM 13561			
Eastern				
Mount Angka	MCZ 43056	12°40'	99°41'	
Western				
West Siam, Sai Yoke	NHMB 8416	14°07'	99°08'	
No specific locality known				
Thailand	AMNH R96944			1965
Thailand	SMF 72682			
Thailand	FLMNH 85197-8			
Thailand	FLMNH 85288-9			
Thailand	FLMNH 99178			
Thailand	FLMNH 99561			1970
Laos Mountains	BMNH 1882.10.7.1			

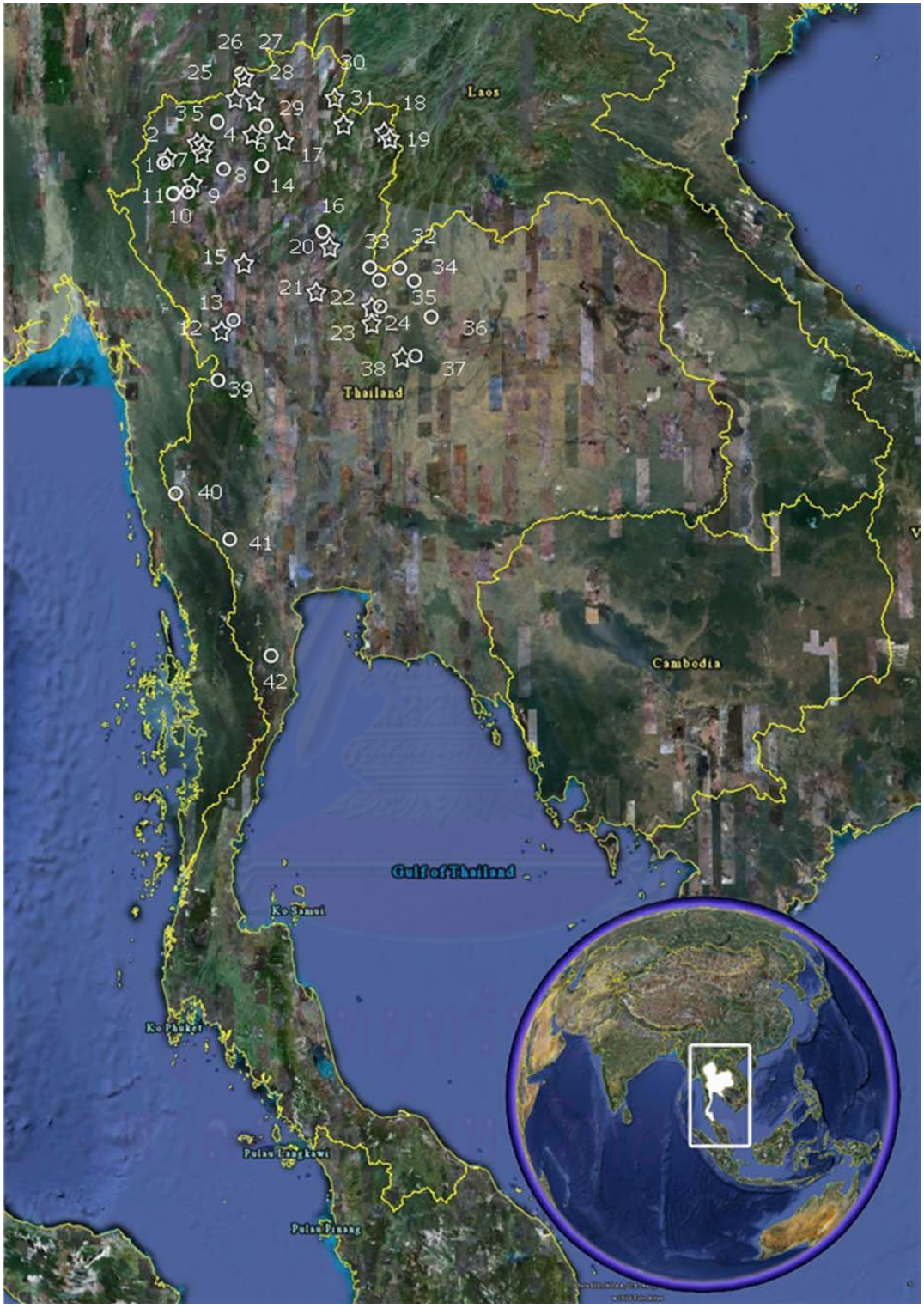

Figure 3.1 The distribution of *P. megacephalum* in Thailand combining previously known localities (circles) and 22 new localities (stars). Details on the localities are presented in Table 3.2.

Most of these turtles were observed in streams during dry periods between November and April. They were observed both at night and during the day and although nearly all were collected under water, a few were observed resting above the water line on a log or rock within the stream bed. Based on the results of this study, *P. megacephalum* was found in 22 new localities in ten river basins in Thailand (see table 3.2). *Platysternon* are found in Thailand as far north as the Fang District, Chiang Mai Province in the Mae Nam Kok river basin (20° 3' 30.6'' N. Lat., 99° 7' 14.7'' E. Long.) and as far south as the Thong Pha Phum District, Kanchanaburi Province in the Mae Nam Mae Klong river basin (14° 41' 25.7" N. Lat., 98° 24' 28.9'' E. Long.). In fact, the latter is one of the most southern localities that has been recently confirmed for the species. The elevations of the localities ranged from 430 to 1,350 m asl.

From observations made in this study, *P. megacephalum* is primarily nocturnal as reported by Kirkpatrick (1995). During the daytime they were observed underwater beneath logs or rocks and wedged into cracks between boulders near either a small waterfall or a fast-flowing water location. At night, they were observed walking along the stream bottom apparently searching for food or waiting for prey. They were seen in rocky mountain streams ranging in width from 6.7 m to less than 1 m in dry dipterocarp and montane rain forests. The mass of the 34 turtles ranged from 15 to 1,625 g and the following sections present essential new information on traditional morphological characters associated with the 34 *Platysternon* turtles observed in the ground survey.

Carapace and plastron - Among the 34 individuals, one dead and 15 had carapace lengths of less than 140 mm and were considered juveniles. The smallest juvenile had a carapace length of only 52.4 mm and was observed at Thung Jor watershed management unit. The largest female among the four adult females captured was observed at Phu Suan Sai National Park. She had a carapace length of 209.6 mm and a carapace width of 148.1 mm. Her plastron measured 164.2 mm in length and 121.7 mm in width. The carapace length ranged from 145.2 to 209.6 mm among the four females while the

Table 3.2 Localities of *P. megacephalum* in Thailand. In columns three and four, the numbers in parenthesizes refer to the localities in figure 1 and the uppercase letters refer to the following items: D=District, P=Province, NP=National Park, WS=Wildlife Sanctuary, WU=Watershed Management Unit, DE=DE forest, MT=Monetane rain forest)

River Basin	Locality confirmed from this study	Site	Georeferened record		Altitude (m asl)	Forest type	Authority
			Latitude (N)	Longitude (E)			
NORTH							
Mae Nam Salawin	Khun Yuam (D), Mae Hong Son (P, 1)	Mae Surin Waterfall (NP)	18° 54' 34.4"	98° 6' 18.6''	1,120	DE	Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard,2005; this study
		Mae Hong Son (P)					CUMZ(R) 2008.09.30,1
	Mueang (D), Mae Hong Son (P, 2)	Maesamad (WU)	18° 59' 18.2"	98° 9' 24.0''	1,300	MT	This study
	Pai (D), Mae Hong Son (P, 3)	Mae Lao-Mae Sae (WS)	19° 10' 21.4"	98° 33' 5.8''	1,004	DE	This study
Mae Nam Ping	Mae Taeng (D), Chiang Mai (P, 4)	Tung Jor (WU)	18° 9' 59.4''	98° 38' 43.3''	1,250	DE	This study
	Chiang Dao (D), Chiang Mai (P, 5)	Chiang Dao (WS)	19° 25' 48.3''	98° 49' 18.9"	920	DE	Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard, 2005; this study
	Phrao D, Chiang Mai (P, 6)	Si Lanna (NP)	19° 16' 4.4"	99° 18' 50.6"	860	DE	This study
	Samoeng (D), Chiang Mai (P, 7)	Samoeng (WS)	19° 2' 1.7"	98° 37' 48.9''	1,189	DE	This study

Table 3.2 (Continue) Localities of *P. megacephalum* in Thailand. In columns three and four, the numbers in parenthesizes refer to the localities in figure 1 and the uppercase letters refer to the following items: D=District, P=Province, NP=National Park, WS=Wildlife Sanctuary, WU=Watershed Management Unit, DE=DE forest, MT=Monetane rain forest)

River Basin	Locality	Site	Georeferenced record		Altitude (m asl)	Forest type	Authority
			Latitude (N)	Longitude (E)			
Mae Nam Ping	Mueang (D), Chiang Mai (P, 8)	Doi Suthep-Pui (NP)	18° 48' 41.2''	98° 56' 6.7"	605	DE	Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard, 2005; this study
		Doi Suthep	18° 48'	98° 55'			USNM 101652
		Doi Suthep					ZMUC R2402
	Mae Wang (D), Chiang Mai (P, 9)	Khun Wang (WU)	18° 38' 49.6"	98° 31' 6.8"	1,160	DE	This study
	Mae Chaeam (D), Chiang Mai (P, 10)	Doi Inthanon (NP)	18° 31' 16.9''	98° 27' 29.2''	1,031	MT	Nabhitabhata et al., 2000; Nabhitabhata &Chan–ard, 2005; this study
	Chom Thong (D), Chiang Mai (P, 11)		18° 25'	98° 44'			USNM 101665
	Mueang (D), Tak (P, 12)	Lan Sang (NP)	16° 43' 57.6"	98° 58' 42.4''	900	DE	This study
	Me Taw (D), Tak (P, 13)		16° 52'	99° 08'			MCZ 29535
		Upper Me-ping at Muang Kuan					SMF 70531

Table 3.2 (Continue) Localities of *P. megacephalum* in Thailand. In columns three and four, the numbers in parenthesizes refer to the localities in figure 1 and the uppercase letters refer to the following items: D=District, P=Province, NP=National Park, WS=Wildlife Sanctuary, WU=Watershed Management Unit, DE=DE forest, MT=Monetane rain forest)

River Basin	Locality confirmed from this study	Site	Georeferenced record		Altitude (m asl)	Forest type	Authority
			Latitude (N)	Longitude (E)			
Mae Nam Wang	Mueang Pan (D), Lampang (P, 14)	Chae Son (NP)	18° 50' 50.1"	99° 27' 25.1"	700	DE	Unakornsawas, 1995; this study
	Si Satchanalai (D), Sukhothai P (15)	Si Satchanalai (NP)	17° 35' 47.8"	99° 15' 26.6''	430	DE	This study
Mae Nam Yom	Mueang (D), Phrae (P, 16)	Lum Nam Nan (NP)	17° 58' 50.6"	100° 18' 19.7"	1,100	DE	Wongkom 2004; CUMZ(R) 2008.09.30.2-5; this study
	Song Khwae (D), Nan (P, 17)	Tham Sakoen (NP)	19° 22' 15.4"	101° 33' 21.8''	663	DE	This study
Mae Nam Nan	Pua (D), NNan (P, 18)	Doi Phu Kha (NP)	19° 15' 53.4"	101° 6' 25.1''	850	DE	This study
	Bo Khau (D), Nan (P, 19)	Khun Nan (NP)	19° 10' 32.1"	101° 11' 8.5''	960	DE	This study
	Nam Pad (D), Uttraradit (P, 20)	Klong Tron Waterfall (NP)	17° 47' 12.9"	100° 24' 19.8''	603	DE	This study
	Tha Pla (D), Uttraradit (P, 21)	Lum Nam Nan (WS)	17° 13' 0.3"	100° 14' 15.9''	497	DE	This study
	Nakhon Thai (D), Pitsanulok (P, 22)	Phu Hin Rong Kla (NP)	17° 0' 42.0"	100° 58' 27.7''	1,204	Mt	This study
	Khao Kho (D), Phetchabun (P, 23)	Thung Salaeng Luang (NP)	16° 48' 24.6"	100° 58' 37.6''	654	DE	This study
Mae Nam Kok	Chai Prakan (D), Chiang Mai (P, 24)	Pha Daeng (NP)	19° 44' 1.4''	99° 3' 40.2"	860	DE	This study

Table 3.2 (Continue) Localities of *P. megacephalum* in Thailand. In columns three and four, the numbers in parenthesizes refer to the localities in figure 1 and the uppercase letters refer to the following items: D=District, P=Province, NP=National Park, WS=Wildlife Sanctuary, WU=Watershed Management Unit, DE=DE forest, MT=Monetane rain forest)

River Basin	Locality confirmed from this study	Site	Georeferenced record		Altitude (m asl)	Forest type	Authority
			Latitude (N)	Longitude (E)			
Mae Nam Kok	Fang (D), Chiang Mai (P, 25)	Doi Pa Hom Pok (NP)	20° 3' 30.6''	99° 7' 14.7''	1,350	Mt	Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard, 2005; this study
NORTHEAST							
Mae Nam Khong	Meaung (D), Prayao (P, 29)	Doi Luang (NP)	19° 10' 26.3"	99° 45' 3.9''	685	DE	This study
	Phu Sang (D), Prayao (P, 30)	Phu Sang (NP)	19° 42' 43.3"	100° 25' 32.9''	676	DE	This study
	Phu Ruea (D), Loei (P, 31)	Phu Ruea (NP)	17° 29' 56.9"	101° 20' 18.5''	1,099	DE	Taylor, 1970; Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard, 2005; this study
	Na Haeo (D), Loei (P, 32)	Phu Suan Sai (NP)	17 30' 46.2"	100 56' 33.7''	940	DE	This study
	Phu Ruea (D), Loei (P, 33)	Phu Ruea (NP)	17 29' 56.9"	101 20' 18.5''	1,099	DE	Taylor, 1970; Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard 2005, this study

Table 3.2 (Continue) Localities of *P. megacephalum* in Thailand. In columns three and four, the numbers in parenthesizes refer to the localities in figure 1 and the uppercase letters refer to the following items: D=District, P=Province, NP=National Park, WS=Wildlife Sanctuary, WU=Watershed Management Unit, DE=DE forest, MT=Monetane rain forest)

River Basin	Locality confirmed from this study	Site	Georeferenced record		Altitude (m asl)	Forest type	Authority
			Latitude (N)	Longitude (E)			
Mae Nam Khong	Phu Luang WS, Loei P (34)	Phu Luang (WS)	17° 20' 1.4"	101° 31' 48.5''	1,220	DE	Chan–ard,2005; THNHM 13561; this study
Mae Nam Chi	Phu Kradung (D), Loei (P, 35)	Phu Kradung (NP)	16° 52' 19.5 "	101° 45' 24.9''	1,287	Mt	Taylor, 1970; Nabhitabhata et al., 2000; Nabhitabhata & Chan–ard, 2005; this study
	Phu Khiao (D), Chaiyphum (P, 36)	Phu Khiao (WS)	16° 23' 11.1"	101° 33' 2.8''	891	DE	KumsooK et al., 2006
CENTRAL							
Mae Nam Pasak	Mueang (D), Phetchabun (P, 37)	Tat Mog (NP)	16° 22' 35.7"	101° 22' 51.3''	652	DE	This study
	Lomlo Mt. Nam Nao (D), Phetchabun (P, 38)	Nam Nao, Phetchabun	17° 01'	101° 05'			KU 40084, KU 129716 Gairder, 1915; Nabhitabhata et al., 2000; Nabhitabhata &Chan–ard, 2005

Table 3.2 (Continue) Localities of *P. megacephalum* in Thailand. In columns three and four, the numbers in parenthesizes refer to the localities in figure 1 and the uppercase letters refer to the following items: D=District, P=Province, NP=National Park, WS=Wildlife Sanctuary, WU=Watershed Management Unit, DE=DE forest, MT=Monetane rain forest)

River Basin	Locality confirmed from this study	Site	Georeferenced record		Altitude (m asl)	Forest type	Authority
			Latitude (N)	Longitude (E)			
WEST							
Mae Nam Mae Klong	Umphang (D), Tak (P, 39)	Umphang (WS)	16° 6' 10.6"	98° 56' 54.6''	645	DE	Thirakhupt & Van Dijk, 1995; Nabhitabhata et al., 2000;Nabhitabhata & Chan–ard, 2005; this study
Mae Nam Mae Klong	Thong Pha Phum (D), Kanchanaburi (P, 40)	Thong Pha Phum (NP)	14° 41' 25.7"	98° 24' 28.9''	933	DE	Thirakhupt & Van Dijk, 1995; Nabhitabhata et al., 2000;Nabhitabhata & Chan–ard, 2005;this study
	Sai Yoke, Kanchanaburi (P, 41)		14° 07'	99° 08'			NHMB 8416
Eastern							
Mae Nam Prachin Buri	Mount Angka, Phachin Buri (P, 42)		12° 40'	99° 41'			MCZ 43056
No specific locality known			Thailand				AMNH R96944, SMF 72682, FLMNH 85197-8, 85288-9, 99178, 99561
			Laos Mountains				BMNH 1882.10.7.1

carapace width ranged from 104.7 to 148.1 mm. The plastron length ranged from 115.0 to 164.2 mm among the four females while the plastron width ranged from 91.8 to 121.7 mm. The largest male among the 14 adult males was captured at Tad Mog National Park and was nearly as large as the largest female with a carapace length of 192.3 mm and a width of 144.5 mm. His plastron measured 148.9 mm in length and 144.0 mm in width. The carapace length ranged from 141.1 to 182.3 mm among the 14 males while the carapace width ranged from 106.4 to 144.5 mm. The plastron length ranged from 114.2 to 148.9 mm among the 14 males while the plastron width ranged from 95.5 to 144.0 mm.

The carapace of both sexes is quite flat, and squared-off anteriorally and rounded posteriorly. The carapace coloration of adults was variable: light brown, reddish brown, olive, yellowish brown and dark grey (Fig. 3.2). Carapacial scutes lacked growth annuli in old adults, and had a radiating pattern in young adults. Plastron color also varied: yellow, brownish, olive with yellowish and dark grey with dark brown, or light brown seams and a large black blotch in the center. The carapaces of juveniles are more brightly colored; dark brown, greenish brown and green with a serrated posterior at the carapacial rim, while plastrons are orange with a large black blotch at the center (Fig. 3.3).

Head - The head is oversized and triangular such that the turtle cannot withdraw its head into its shell. Head width ranged from 50.5 to 70.3 mm and head length ranged from 53.0 to 88.9 mm in 18 adult animals over 140 mm CL. The following ratios describe the head in proportion to carapace measurements: HW/CW 0.38-0.51 ($\overline{x}$ =0.47± 0.03, n=18), HW/CL 0.31-0.37 ($\overline{x}$ $\overline{X}$ =0.34±0.02, n=18), HL/CW 0.44-0.68 ($\overline{x}$ =0.54± 0.06, n=18), HL/CL 2.05-2.87 ($\overline{x}$ =2.53± 0.26, n=18)]. The top and sides of the turtle's head are covered with large horny scales. The head is yellow brown to olive and dorsally may have some dark yellow or brown spots. The snout, chin, jaws and throat are brown with yellow, orange, pink or red mottling. The mouth may show either dark or light mottling. Pink or brown blotches also appear in their cheeks or necks.

Limbs – The toes are slightly webbed with strong claws. Four toes of forelimbs and five toes of hind limbs are light to dark brown and covered with large scales. Pink or brown blotches seldom appear in their thighs.

Tail – The tail is long and whiplike, covered with large scales, and is usually as long as the carapace [tail length 140.0-227.6 mm in adult animals over 140 mm CL, TL/CL 0.97-1.39 ($\bar{x}$ =1.15±0.11, n=18)].

Figure 3.2 The different color patterns on the carapaces of adult big-headed turtles; (A1) brown, (B1) reddish-brown, (C1) olive, (D1) yellowish-brown and (E1) the new morph, dark grey; all with a squared-off front and rounded back end. The plastrons are usually (A2, D2) yellow, (B2) brownish, (C2) olive with yellowish and (E2) the new dark grey morph. These specimens are from (A) the Mae Samard Watershed Management Unit, Mae Hong Son Province in the Salawin river basin, (B) the Umphang Wildlife Sanctuary, Tak Province in the Mae Klong river Basin, (C) the Tad Mok National Park, Phetchabun Province in the Pasak river basin, (D) the Pha Daeng National Park, Chiang Mai Province in the Kok river basin and (E) the Phu Suan Sai National Park, Loei Province in the Khong river basin.

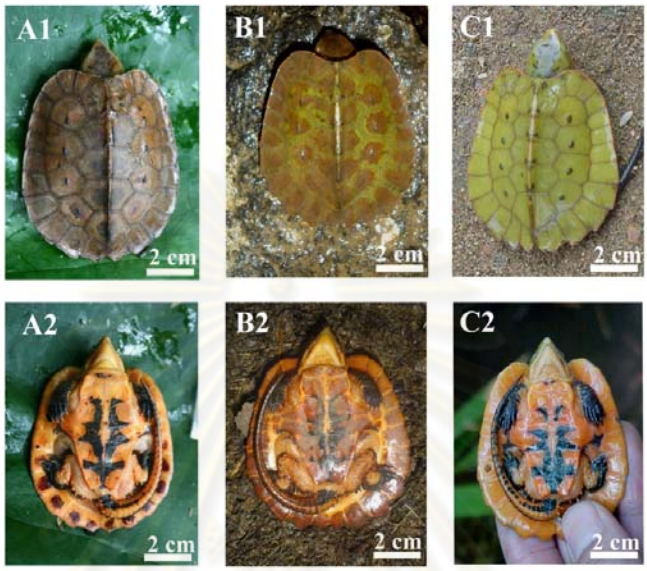

Figure 3.3 Carapaces of juvenile big-headed turtles showing the different color morphs of (A1) dark-brown, and the new color morph of (B1) greenish-brown and (C1) green; and also showing the more serrated posterior carapacial rim with a yellowish or orangey seam, while the plastron are orange (A2, B2, C2) with a clear dark edging to the seams. These specimens are from (A) the Doi Inthanon National Park, Chiang Mai Province, (B) the Tung Jor Watershed Management Unit, Chiang Mai Province in the Ping river basin and (C) the Lum Nam Nan National Park, Phrae Province in the Yom river basin.

DISCUSSION

A comparison of historical data on the distribution of *P. megacephalum* in Thailand from the literature and museum specimens with the results of our current field surveys show some changes in occurrence over time. I surveyed a total of 40 locations and of these 16 had previous records of big-headed turtles. Of these 16 locations that had previous records we found turtles in 12 locations and were unable to confirm their presence in 4 locations. Thus, I can confirm that most historical localities in Thailand still have big-headed turtles. I expected that the effect of habitat alteration and hunting pressures over the last 30-50 years would result in many fewer locations with big-headed turtles but this was not the case. In addition, our surveys resulted in several new locality records. This result is encouraging but it may partly be a reflection of our focused survey efforts with the help of local rangers and villagers. Further, the survey results do not inform us about the size or health of the populations.

Combining all the data from all available published reports, museum specimens and ground surveys, *P. megacephalum* was found to be present in 11 out of the 25 river basins of Thailand. However, in contrast to information from researchers 20-30 years ago (Nutaphand, 1979; Humphrey & Bain, 1990), my recent ground survey did not find *P. megacephalum* in the Mae Nam Moon river basin. Although records of *P. megacephalum* in Phu Khiao District, Chaiyaphum Province in the Mae Nam Chi river basin exist and I obtained positive sightings information from the questionnaire, I could not confirm this by survey due to local security restrictions upon access to the area. In this area, Kamsook et al. (2006) reported that three big-headed turtles were found at altitudes of 870, 876 and 891 m asl. Moreover, in the Mae Nam Pasak river basin, *P. megacephalum* have been reported in the Nam Nao National Park, Phetchabun Province, on several occasions over recent and earlier times (Gairdner, 1915; Nabhitabhata et al., 2000; Nabhitabhata & Chan-ard, 2005), yet in this study I did not find any big-headed turtles in the Nam Nao National Park but rather observed them at the nearby Tat Mog National Park, Mueang District, Phetchabun Province.

The coloration of *P. megacephalum* shells has been reported to be quite variable, ranging from yellowish-brown to olive in color (Ernst & Barbour, 1989; Kirkpatrick, 1995; Bonin et al., 2006). In this study, I observed two new color morphs: dark grey carapace for old adults and greenish-brown carapaces in juveniles (see figures 3.2 and 3.3). In addition, I note that the same carapace color can often be found at several localities thus questioning the value of color morphs as a marker of subspeciation. In view of this within locality variation and our small sample sizes the three subspecies proposed by Nutaphand (1979) and Wermuth (1969) are not recognized in this study. However, a comprehensive study of geographic variation in coloration, morphology, and genetic markers is needed to address the relationships among the big-headed turtle populations within Thailand.

Previous to this work, *P. megacephalum* in Thailand was reported to occur only above 800 m asl and in streams that are usually narrower than a meter wide and less than 10 cm deep (Kirkpatrick, 1995; van Dijk, 2002). In contrast, our results found *P. megacephalum* to occur between 430 and 1,350 m asl with the most common elevations between 630 and 720 m asl (n=7). Moreover, *P. megacephalum* was found in streams both wider and narrower than one meter, with water depths between 14.0 and 95.0 cm. Furthermore, while *P. megacephalum* was reported to be restricted to locations with fast moving water (Ernst & Barbour, 1989; Kirkpatrick, 1995), I found two individuals in still water, albeit during the dry season. *Platysternon* is known to live in waters with a temperature of 12 to 17 °C (Ernst & Barbour, 1989; Kirkpatrick, 1995), and even up to 24 °C (van Dijk, 2002). These results (15.5-20.3 ^{o}C) fall within these values.

Results from informal interviews with local people at the localities visited show that *P. megacephalum* are less common now than in the past due to hunting. However, the ground surveys suggest that a few large populations may be present in remote areas that are difficult to access or near villages where turtles are not regularly sold or eaten. These findings strongly support the notion that a monitoring program is needed to detect trends in the numbers of big-headed turtles in Thailand.

Unfortunately, in many of the areas visited, I found that big-headed turtle was consumed regularly and occasionally traded between villagers or sold at local markets. During this study, the Royal Thai Police seized 81 big-headed turtles (17 live and released, 64 dead) in Loei (4 Dec 2007); 26 individuals in Phrae (29 Jan 2008); 25 turtles in Lampang (7 Mar 2008); 6 dead in Loei (29 Jul 2008); 5 animals in Loei (2 Aug 2008); and 2 big-heads in Nan Province (3 Sep 2008). These incidents demonstrate that *P. megacephalum* is threatened by continuous poaching for local consumption and trade. Although the cited raids and confiscations of *P. megacephalum* are known to villagers, recent information indicates that the illegal trade continues. Notwithstanding this situation, it is still the case that Thailand is truly one of the last strongholds of this monotypic genus of turtle. *Platysternon* is far worse off in adjacent countries that are more heavily impacted by the strong Chinese demand for this turtle (Stuart & Timmins, 2000).

Habitat availability for big-headed turtles is of major importance and fortunately most areas of occurrence in Thailand are largely within protected areas (van Dijk & Palasuwan, 2000). Although *P. megacephalum* were found in protected areas in this and earlier studies, I still know that they are being illegally harvested and are likely declining in numbers. Important factors in the long term persistence of big-headed turtles are going to be the maintenance of the appropriate natural forest ecosystems and the elimination of poaching. Based on their current limited distribution and threats, *P. megacephalum* should remain an endangered species of Thailand. Further I recommend strong legislative action for the protection of this species and a long term monitoring program to detect future changes in distribution and population numbers (e.g. see Chen & Lue, 2009). Enforcement authorities should be encouraged to be more vigilant in preventing the consumption and trade. Educational programs that foster national pride in natural resources and conservation awareness should be developed with the local communities that share their land with big-headed turtles.

CHAPTER IV

MOVEMENTS AND HOME RANGE SIZE OF THE BIG-HEADED TURTLE *Platysternon megacephalum* GRAY, 1831 IN CHIANG DAO WILDLIFE SANCTUARY, CHIANG MAI PROVINCE

ABSTRACT

Movements and home range sizes of the big-headed turtle, *Platysternon megacephalum* Gray, 1831 were examined in forest streams of Chiang Dao Wildlife Sanctuary, northern Thailand. Three juveniles, three adult males and three adult females were tracked in 2008 and 2009 using radio telemetry.

The results revealed that most of the turtles lived near one another with some slight overlaps. Their re-sighting positions were not uniformly distributed within the boundaries of their respective home ranges. No correlations were found among the turtles in terms of the pattern or order of movements but there were significant differences between frequency of movement and the adults (χ^2=18.96, p<0.001).

Key words: *Platysternon megacephalum*, big-headed turtle, movement, home range size

INTRODUCTION

Movement patterns of animals are fundamental to understanding their life histories (Swingland & Greenwood, 1983; Gregory et al., 1987). Many studies of home range reveal the interaction between an individual and functions such as microhabitat utilization, food acquisition, aestivation and reproduction. Thus, examining movement patterns can lead to a better understanding of many aspects of a species' ecology (Swingland & Greenwood, 1983; Gibbons et al., 1990; Doody et al., 2002; Litzgus & Mousseau, 2004) that are relevant to conservation.

Most recent work on turtles and tortoises in Thailand has focused on their taxonomy, distribution and conservation status (Nutaphand, 1979; Chan-ard & Nabhitabhata, 1986; Nabhitabhata, 1989; Thirakhupt & van Dijk, 1997). Nearly no publication on *P. megacephalum* can be found in activity and movement since that time. Meanwhile, the behavior of *P. megacephalum* in its natural environment is almost totally unknown (Kirkpatrick, 1995).

OBJECTIVE

The general goal of this chapter is to describe the movement patterns and home ranges of *P. megacephalum*. Radio-telemetry data are used to investigate the movements and activities of the sexes of big-headed turtles. The knowledge gained from this study represents new and useful basic information on this mountainous turtle species which can be used for determining reserve areas and future sustainable management for the big-headed turtle.

METHODOLOGY

Study area

Chiang Dao Wildlife Sanctuary, CDWS

This study was conducted from May 2008 to September 2009 on the Chiang Dao Wildlife Sanctuary (CDWS). The study site was designated the 19th Wildlife Sanctuary of Thailand on August 24, 1978, covering an area of approximately 325,625 rais or about 521 square kilometers. It is located between $19^0$34'-19^0 62' N and 98^0 64'-98^0 95' E. It includes portions of Mueang Haeng subdistrict of Wiang Haeng district and Mueang Ngai, Chiang Dao, Mueang Kong and Mae Na subdistricts of Chiang Dao district in Chiang Mai province. Doi Luang Chiang Dao in CDWS is Thailand's third highest mountain with an elevation of 2,175 m asl (Figure 4.1).

Exact locations are not given in this chapter because of the endangered status of the big-headed turtle in CDWS.

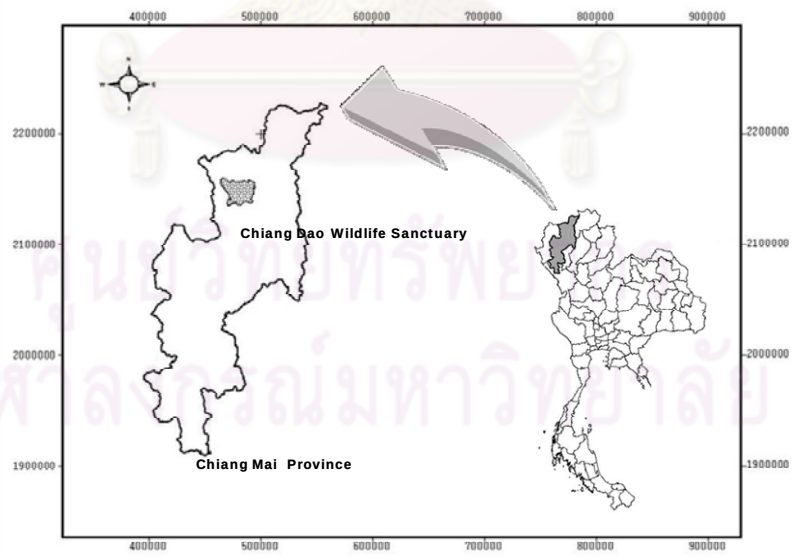

Figure 4.1 Chiang Dao Wildlife Sanctuary (CDWS) in Chiang Mai Province, covering 521 square kilometers and was designated on August 24, 1978.

Topography

Smitinand (1966) described the CDWS as being comprised of a limestone mountain outpost of the eastern Upper Tenasserim range, rising precipitously above the broad, flat, alluvial valley of the Mae Ping River. The topography of the site is steep, with a number of cliffs, rising to three peaks (one being the third highest mountain in Thailand), which form a horseshoe-shaped valley. On higher ridges and peaks, where extreme erosion has occurred, barren limestone is a common feature. Surface water is limited and only found below 910 m asl and drainages flow from west to east, to the Mae Ping and the Mae Teang rivers.

Climate

CDWS is in a Savanna zone. This area has three distinct seasons: the cool season, hot season and rainy season. In the rainy season (May to Sep) the southwest monsoon usually arrives from India at the end of May, and from then until November the weather in Chiang Mai and Northern Thailand gets very wet. Between 1998-2008, rainfall is usually heaviest in August or September and the temperature is cold in winter with the lowest temperature about 4.0 °C and the highest temperature about 41.5 °C. (Figure 4.2)

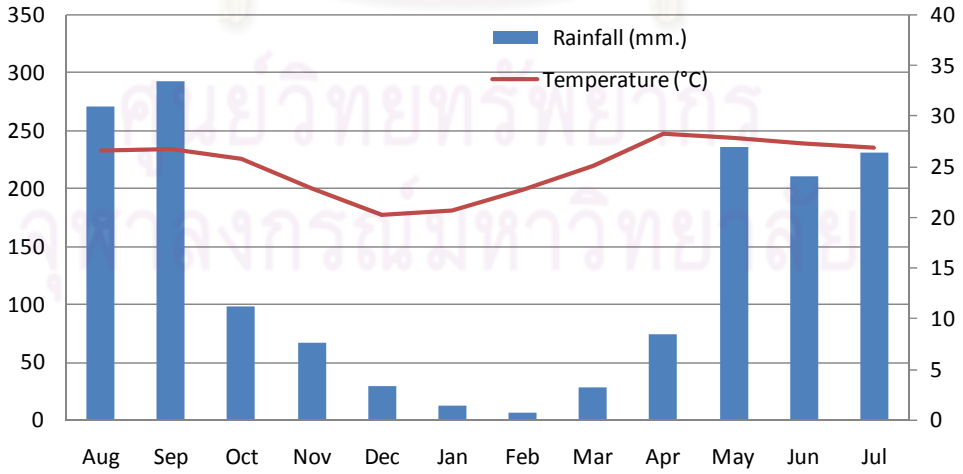

Figure 4.2 Rainfall and temperature average ten years from August 1998 to July 2008 at the Chiang Dao watershed research station.

Flora and Fauna

Smitinand (1966) wrote the first vegetation analysis of Doi Chiang Dao mountain and enumerated 109 families and 570 species of vascular plants on the mountain and noted the following forest types on Doi Chiang Dao were including

(i) elevation-mixed deciduous forest (below 500 m)
(ii) dry evergreen forest (500-600 m)
(iii) teak (*Tectona grandis* L., Verbenaceae) forest (600-700 m)
(vi) hill evergreen forest (700-1,900 m)
(iv) summit-open hill evergreen forest (1,900 m)

Seangnin (2005) stated that forest types in CDWS are dry evergreen forest (34.57%), dry dipterocarp forest (25.93%), hill evergreen forest (24.69%), deciduous forest (11.11%) and other (1.23%). There were found 82 families, 202 genera and 264 species of vascular plants above 1,600 m in CDWS during a botanical survey (Chamnongpakdee, 2005). Niyomwan et al. (2005) reported fifty species of mammals, 165 species of birds, 34 species of reptiles and 33 species of amphibians in CDWS from the study during March 2003 and June 2005.

Subwatershed sampling

All subwatersheds in CDWS were surveyed for the occurrence of big-headed turtles by direct observation. When an animal was observed, it was captured immediately, weighed in grams, measured using a caliper and marked using a nail cutter. On all captured turtles, measurements of the length and width of the carapace, plastron, scutes and tail were made in mm. In addition, position, forest type, stream width, water depth, speed of water, pH, water and air temperature were recorded. Later data were analyzed to assess the distribution and relative density of turtles. Finally, a subbasin with the highest relative density of turtles was selected for radio-telemetry work.

Radio-telemetry and data collection

After turtles were handcaptured by visual searching normally at night or during the day. After capture the measurements included the straight-line carapace length (CL) and plastron length (PL) to the nearest 0.1 mm using venier calipers, and the mass to the nearest gram using a pesola spring balance. Individuals with carapace length of less than 140 millimeters were classified as juveniles. Sex was determined by examining the plastron curvature. After the attachment of a transmitter within 24 h each turtle was noted by a unique flaw and released at its point of capture.

Each big-headed turtle was equipped with a 172 or 173 mhz transmitter. Model RI-2BT 173 mhz transmitters were used for 400-2000 g turtles while model PD-2T 172 mhz radios were used for 200-400 g turtles and model BD-2T 172 mhz were equipped for 25-200 g animals (Figure 4.3). The transmitter was attached to the rear marginal scutes of the carapace using two-component epoxy which is waterproof and long-lasting but harmless to the animal (Boarman et al., 1998). Marine epoxy was used for covering the edges to aid in adhesion and to seal any openings between shell and transmitter. The transmitter (including epoxy) represented at most 5% of the turtle's body mass (Schubauer, 1981) and was removed from the turtle at the end of the study. The total amount of time for attachment was about 30 minutes. Post-attachment transmitter weight was 10 g, 2.75 g and 0.95 g for adult and juvenile. Turtles were released at the point of capture within 24 hours.

Figure 4.3 Transmitters
A = Model RI-2BT 173 mhz (10g)
B = Model PD-2T 172 mhz (2.75g)
C = Model BD-2T 172 mhz (0.95g)

Transmitter life for the three models was approximately 12 months (RI-2BT 173 mhz), 3 months (PD-2T 172 mhz), and 4 weeks (BD-2T 172 mhz). Each turtle was assigned a unique frequency. Transmitters generally lasted 4 weeks and 3 months were replaced after failure. Turtle were not captured after they were radio-marked except to replace a failing transmitter or to repair loose epoxy.

Turtles were located on 2-4 consecutive nights a month (either night or day) during Aug 2008 to Aug 2009 in order to collect field data for two seasons (wet and dry season). The transmitted radio signals were picked up by the Yagi antenna (Figure 4.4). Using the antenna allows the field researcher to locate the turtle by using a TRX-1000s receiver (Model FM172) and TX-100 (Figure 4.5a, b). At each location, the Universal Transverse Mercator (UTM) coordinates (3D differential receiver status, NAD83 datum) were recorded with a GPSmap 72CS (Garmin International Inc, Olathe, KS). The activity and behavior of the turtle was also noted when located.

Continuous air and water temperatures were obtained via probes that transferred the data to a HOBO Micro Station data logger (Onset Corp., Cape Cod, Massachusetts, USA). Moreover, temperature at the turtle sites were measured using a data logger and given in degrees Celsius (Figure 4.6-4.9).

Figure 4.4 Handheld ATS3 element folding Yagi Antenna

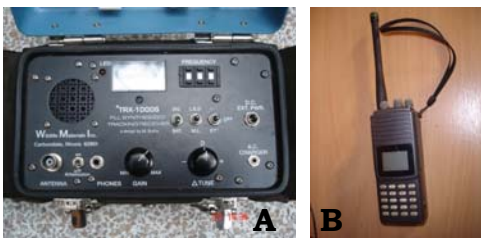

Figure 4.5 Receivers

A = Model TX-100

B = Model TRX-1000s

Figure 4.6 Water temperature data logger

Figure 4.7 Light data logger

Figure 4.8 Humidity data logger

Figure 4.9 Air temperature data logger

Data Analyses

An attempt was made to locate each turtle at least once a month over a one year period (Aug 2008 to Aug 2009). Due to logistical issues and the remote location of the subwatershed time intervals between turtle sightings was not the same from month to month. Thus, the study period was treated as 360 days and intervals in days were recorded between turtle sightings. This method allowed me to adjust all of the move distances by the elapsed interval in the appropriate number of days.

The distances between turtle sightings were measured as the shortest distance in meters along the course of the stream in the subwatershed (MSD). They were measured using the measuring tool in ArcView 3.2 on a 1:50,000 topography map of the subwatershed. These distances are treated as an estimate of the minimum stream distances moved by the turtles. Because the time intervals between turtle sightings were not equal I calculated an interval adjusted minimum stream distances moved (IAMSD). This was calculated by dividing the minimum stream distance (MSD) by the interval (days) between sightings (Bodie & Semlitsch, 2000). Although these distances are useful they do greatly underestimate the turtles' actual day to day movements.

To determine linear home range size I used the stream distance between the two most distant sightings over the one year period for an individual. I refer to this at the linear home range (LHR). This was used rather than MCP and kernel estimates because big-headed turtle movements were typically limited to within the stream and tributary habitat, and kernel estimates yielded home ranges outside of those habitats.

RESULTS AND DISCUSSION

Selected subwatershed

Ten subwatersheds were identified in CDWS. Surveys revealed big–headed turtles in all ten subwatersheds. Figure 4.10 exhibits the distribution of all 18 big-headed turtles found at elevations between 490-1,180 m asl in this protected area.

The results of abundance estimates for *P. megacephalum* on ten drainages throughout CDWS showed that the Num Mae Ka subwatershed has the highest abundance at 1.20 turtles/km (Table 4.1). Therefore, this basin was selected for my radio-telemetry study.

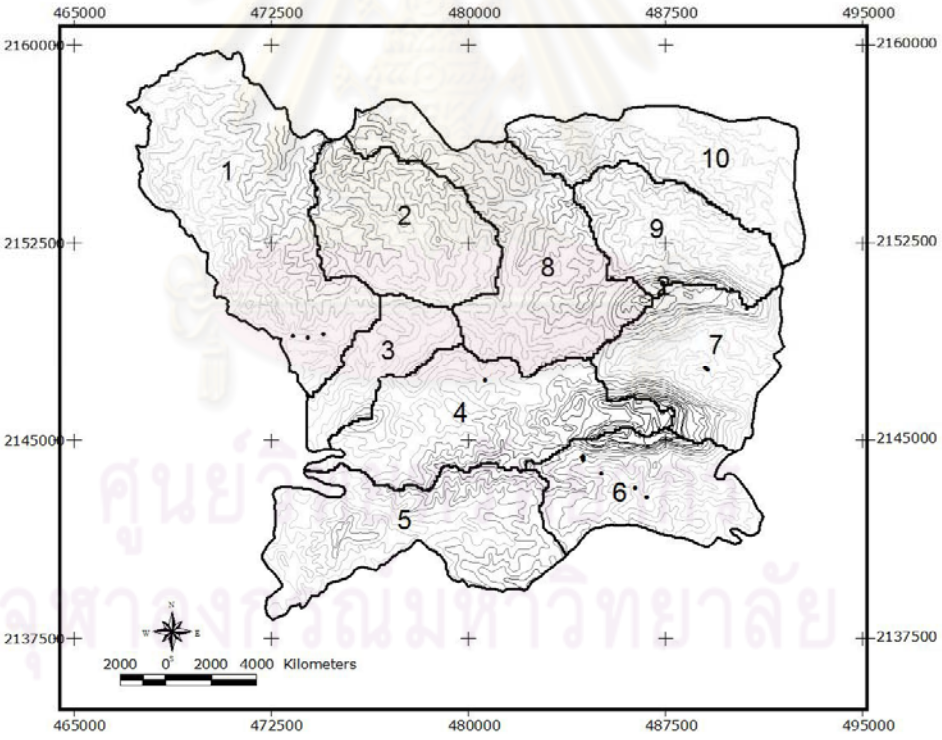

Figure 4.10 *P. megacephalum* was found within the following subwatersheds: Huai Mae Mun (1), Huai Ban (2), Huai Hom (3), Num Mae Moen (4), Huai Mae Kok (5), Num Mae Ka (6), Huai Mae Pha Tang (7), Huai Mae Khong (8), Num Mae Khon (9) and Num Mae Ngai (10). Black dots show where big-headed turtles were found.

Table 4.1 Abundance estimates for *P. megacephalum* in ten subwatersheds throughout CDWS.

Subwatershed	Transect length (m)	Number of turtles found	Turtles/km	Altitude of turtles found
Huai Mae Mun	8,225	4	0.49	680-700
Huai Ban	4,092	1	0.24	850
Huai Hom	4,190	-	-	-
Num Mae Moen	11,981	1	0.08	490
Huai Mae Kok	3,641	-	-	-
Num Mae Ka	8,318	10	1.20	650-1,180
Huai Mae Pha Tang	3,204	2	0.62	590-600
Huai Mae Khong	7,039	-	-	-
Num Mae Khon	6,632	-	-	-
Num Mae Ngai	3,371	-	-	-

Tracking effort

From August 2008 to September 2009, a total of 14 big-headed turtles ranging from 60.5 mm to 166.5 mm in straight carapace length and 150 g to 1,775 g in mass were fitted with transmitters. All of them were found either in the stream or adjacent to the stream in Num Mae Ka stream (Figure 4.11-4.14). However, only the data on nine turtles in the Num Mae Ka subwatershed were analyzed because of transmitter loss or failure. Three were identified as males (BHM1775, BHM8001, BHM 8002), three were females (BHF5001, BHF5002, BHF5003) and three were juveniles (BHJ485, BHJ450, BHJ425), (see table 4.2).

Table 4.2 Morphometric data on nine radio tracked *P. megacephalum* at Num Mae Ka steam, CDWS.

Animal Code	Mass (g.)	Head length (mm.)	Head width (mm.)	Carapace length (mm.)	Carapace width (mm.)	Plastron length (mm.)	Plastron width (mm.)	Tail length (mm.)
BHJ425	420	51.9	42.1	131.5	96.3	107.8	76.7	150.0
BHJ450	450	54.7	47.9	139.4	108.6	116.0	85.8	159.2
BHJ485	485	53.8	46.1	140.0	105.9	116.2	90.7	158.2
BHF5001	500	56.8	49.2	143.7	104.8	115.5	85.9	203.8
BHF5002	500	56.9	51.5	150.5	109.7	120.5	88.5	170.4
BHF5003	500	58.8	49.8	146.5	111.5	116.0	86.8	172.8
BHM8001	800	67.2	57.7	163.4	119.4	124.4	90.6	165.1
BHM8002	800	64.8	56.6	159.1	119.7	124.4	86.2	184.0
BHM1775	1,775	66.3	58.1	166.5	120.4	130.0	93.4	192.1

BHJ = juvenile big-headed turtle, BHF = female big-headed turtle, BHM = male big-headed turtle

Figure 4.11 Attachment of a transmitter on the carapace

Figure 4.12 Study site of big-headed turtle, on the Num Mae Ka stream.

Figure 4.13 Dry evergreen forest along the study stream.

Figure 4.14 Small steep waterfalls exited throughout the Num Mae Ka stream.

Movement locations

One hundred and eight locations for nine big-headed turtles are given in figure 4.15. All turtles exhibited disproportionate use of stream habitats by moving up and down from their holes. Most of them lived near one another with some slight overlaps. The spatial distributions were rather separated and sporadic. Their re-sighting positions were not uniformly distributed within the boundaries of their respective home ranges.

Three hundred and sixty days of monitoring of individuals revealed that home range overlap or the proportion of all turtles sharing a particular stretch of stream with a given turtle was highest in females (52.47%) and similar among males (25.56%) and juveniles (21.97%). Habitats used by all turtles were restricted to the stream.

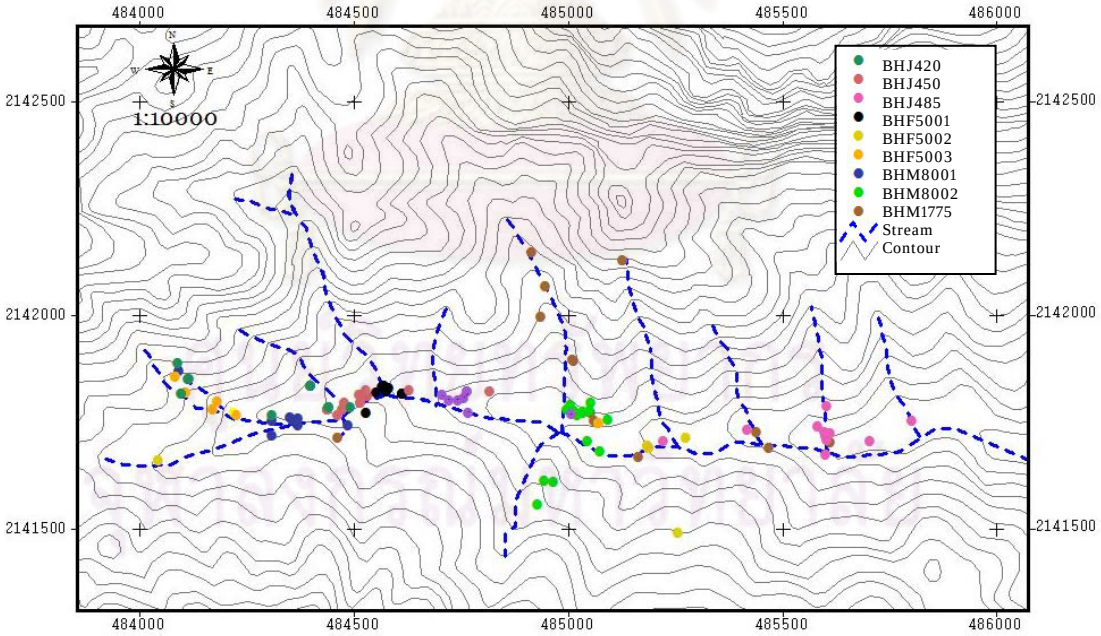

Figure 4.15 Sighting locations of tracked *P. megacephalum* on the Num Mae Ka stream, CDWS.

The frequency distribution of IMSD

The frequency distribution of the interval adjusted minimum stream distances (Figure 4.16) demonstrates a highly skewed distribution with the monthly modal range of movements being less than 20 m and median value being only 86.33 m.

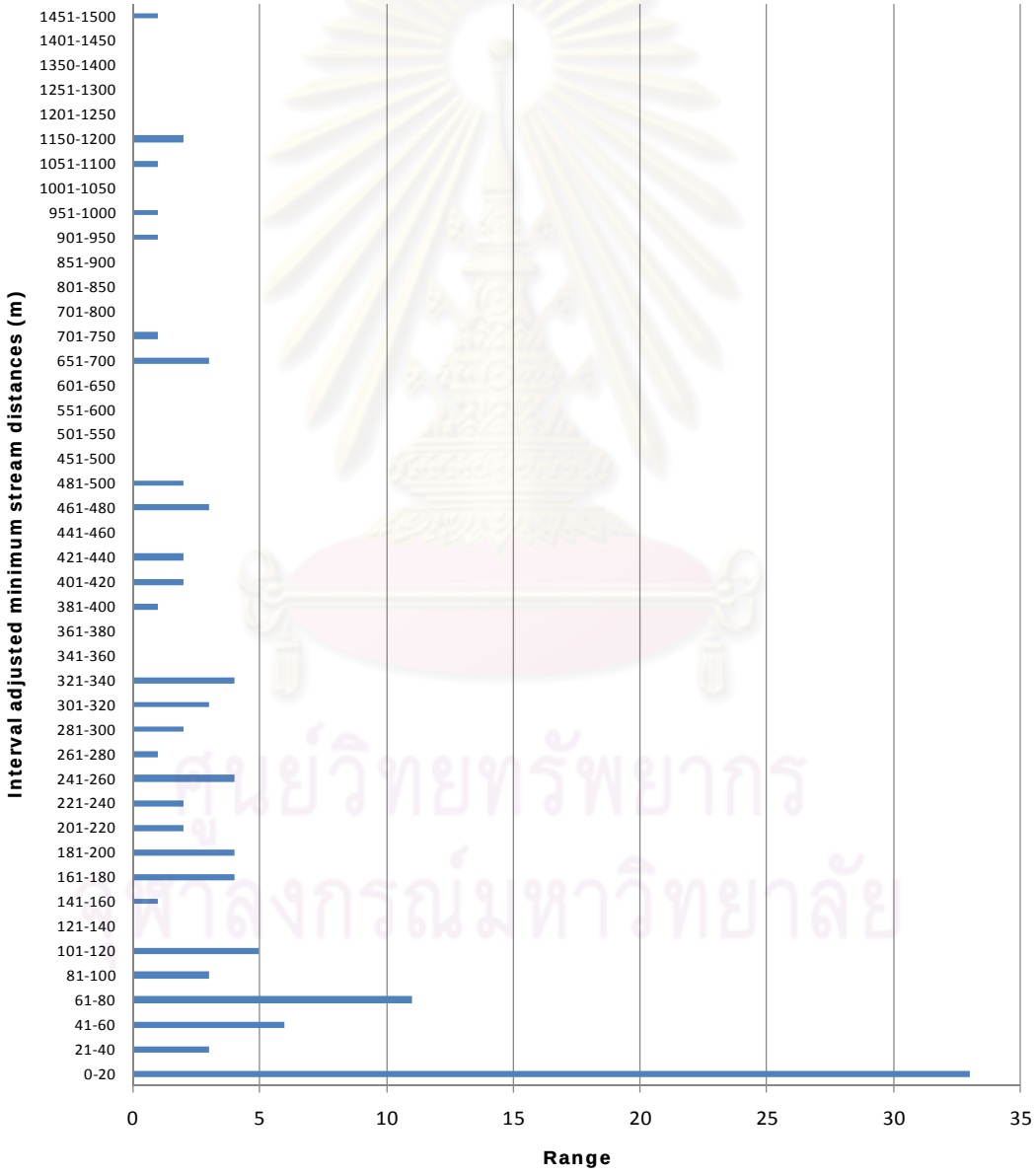

Figure 4.16 The frequency distribution of the interval adjusted minimum stream distances.

Linear home range (LHR)

Table 4.3 presents all moved distances and LHR of nine tracked big-headed turtles. Average MSD, IMSD of male (3,536 m, 11,91 m) were larger than female (2,108.07 m, 7.80 m) and juvenile (1,712.31 m, 5.54 m) whereas average male LHR (622.82 m) was smaller than in female (773.15). There were no significant correlations between sexes and MSD (Spearman's R^2= 0.532, p=0.141), IMSD (R^2=0.548, p=0.127), and LHR R^2=0.174, p =0.654) where as there was significant correlation between MSD and LHR (R^2=0.783, p =0.013).

Table 4.3 Minimum stream distances (MSD), interval adjusted minimum stream distances (IAMSD) and linear home range (LHR) of nine tracked *P. megacephalum* in Num Mae Ka stream, CDWS.

Turtle	Carapace length (mm)	Tracking Period	MSD (m)	IAMSD (m)	LHR (m)
BHJ425	131.5	(18Nov.08 – 11Aug.09)	1,512.96	4.80	416.70
BHJ450	139.4	(16Aug.08 – 17Jul.09)	1,986.08	6.66	383.68
BHJ485	140.0	(16Aug.08 – 17Jul.09)	1,637.89	5.15	578.36
BHF500_1	143.7	(16Aug.08 – 17Jul.09)	438.96	11.58	95.67
BHF500_2	150.5	(16Aug.08 – 17Jul.09)	3,307.95	10.39	1,232.92
BHF500_3	146.5	(18Nov.08 – 11Aug.09)	2,577.31	1.42	990.87
BHM800_1	163.4	(12Sep.08 – 17Jul.09)	2,774.80	8.48	442.20
BHM800_2	159.1	(16Aug.08 – 17Jul.09)	2,087.23	8.18	274.53
BHM1775	166.5	(16Aug.08 – 17Jul.09)	5,748.06	19.07	1,151.72

BHJ = juvenile big-headed turtle, BHF = female big-headed turtle, BHM = male big-headed turtle

Minimum stream distances (MSD) and interval adjusted minimum stream distances (IAMSD)

The minimum stream distances moved (MSD) and the interval adjusted minimum stream distances (IAMSD) moved are presented in tables 4.4 and 4.5. These distances varied greatly among individuals. BHM1775 had a maximum MSD (5,748.06 m) and IAMSD (19.07 m) whereas BHF5001 had a minimum MSD (438.96 m) and IAMSD (1.42 m). Another two males had

equally IAMSD (8.18 m, 8.48 m), similar to two females (10.39 m, 11.58 m) while juveniles had similar IAMSDs at 5.15 m, 6.66 m and 4.80 m. Although all nine radioed turtles varied in their movement patterns, all locations remained within the Mae Ka stream where they were originally captured.

Relationship of movements to temperature and rainfall

Figure 4.17 presents rainfall and air temperature data collected during the study period at the Chiang Dao watershed research station, about 15 km from the study area. On the basis of these data and average 10 year data from the same weather station (Figure 4.2) I assigned months as wet (May to September; 10 years average rainfall more than 100 mm) or dry (October to April; 10 years average rainfall less than 100 mm). Figure 4.18 shows graphically the interval adjusted minimum stream distances for A) three males, B) three females, and C) three juvenile big-headed turtles with temperature and rainfall. The dry and wet seasons are designated by shading.

An analysis of variance (ANOVA) revealed no significant relationships ($p < 0.05$) between the interval adjusted minimum stream distances moved by the turtles and either rainfall or temperature.

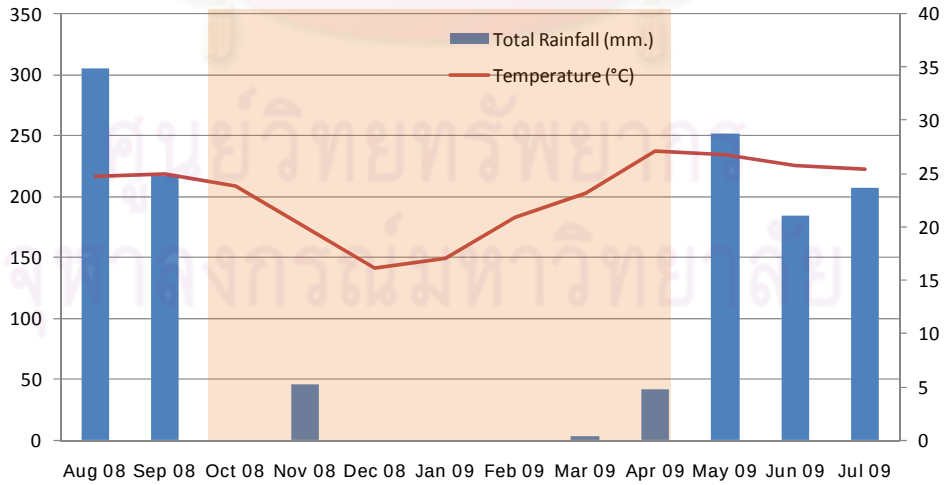

Figure 4.17 Rainfall and air temperature data collected during the study period at the Chiang Dao watershed research station from Aug 2008 to July 2009. Shaded area shows dry season

Table 4.4 The minimum stream distance moved between each sighting for each of nine turtles.

Tracking date	Day surveyed	Turtle								
		BHM1775	**BHM8001**	**BHM8002**	**BHF5001**	**BHF5002**	**BHF5003**	**BHJ485**	**BHJ450**	**BHJ425**
16/08/08-12/09/08	27	715.00		187.30		330.00		329.12	175.00	
13/09/08-18/11/08	87	320.00	1,468.23	28.80	118.15	1,150.30		284.95	112.97	
19/11/08-2/12/08	108	157.25	321.00	47.60	8.95	1,158.00	952.50	421.86	35.40	44.06
2/12/08-6/01/09	143	465.50	13.48	59.17	15.14	0.00	0.00	28.58	472.22	282.24
7/01/09-3/02/09	171	665.10	53.30	68.74	77.85	0.00	0.00	48.80	478.86	422.45
4/02/09-20/02/09	188	208.30	242.51	265.30	16.50	0.00	1,067.80	13.42	486.50	81.08
21/02/09-3/03/09	199	161.28	187.50	305.85	64.32	0.00	0.00	0.00	70.44	0.00
4/03/09-26/03/09	222	325.40	68.80	68.38	0.00	0.00	0.00	0.00	66.17	0.00
27/03/09-30/04/09	257	389.20	91.57	225.84	0.00	0.00	171.98	6.36	0.00	0.00
1/05/09-22/05/09	279	935.83	70.52	180.75	0.00	0.00	105.95	183.28	69.92	109.88
23/05/09-14/06/09	302	1,148.50	0.00	237.50	0.00	669.65	77.78	243.46	18.60	405.73
15/06/09-17/07/09	335	256.70	257.89	412.00	92.82	0.00	201.30	78.06	0.00	167.52
18/07/09-11/08/09	360			313.95	45.23	486.74	0.00		101.34	0.00
Total moved		**5,748.06**	2,774.80	2,401.18	**438.96**	3,794.69	2,577.31	1,637.89	2,087.42	1,512.96
Monthly moved		**479.01**	252.25	184.71	**36.58**	291.90	234.30	136.49	160.57	137.54

Table 4.5 The interval adjusted minimum stream distance (IAMSD) moved between each sighting for each of nine turtles.

Tracking date	Day surveyed	Turtle								
		BHM1775	BHM8001	BHM8002	BHF5001	BHF5002	BHF5003	BHJ485	BHJ450	BHJ425
16/08/08-12/09/08	27	26.48		6.94		12.22		12.19	6.48	
13/09/08-18/11/08	87	5.33	24.47	0.48	1.97	19.17		4.75	1.88	
19/11/08-2/12/08	108	7.49	15.29	2.27	0.43	55.14	45.36	20.09	1.69	1.63
2/12/08-6/01/09	143	13.30	0.39	1.69	0.43	0.00	0.00	0.82	13.49	4.70
7/01/09-3/02/09	171	23.75	1.90	2.46	2.78	0.00	0.00	1.74	17.10	20.12
4/02/09-20/02/09	188	12.25	14.27	15.61	0.97	0.00	62.81	0.79	28.62	2.32
21/02/09-3/03/09	199	14.66	17.05	27.80	5.85	0.00	0.00	0.00	6.40	0.00
4/03/09-26/03/09	222	14.15	2.99	2.97	0.00	0.00	0.00	0.00	2.88	0.00
27/03/09-30/04/09	257	11.12	2.62	6.45	0.00	0.00	4.91	0.18	0.00	0.00
1/05/09-22/05/09	279	42.54	3.21	8.22	0.00	0.00	4.82	8.33	3.18	4.78
23/05/09-14/06/09	302	49.93	0.00	10.33	0.00	29.12	3.38	10.59	0.81	11.59
15/06/09-17/07/09	335	7.78	7.81	12.48	2.81	0.00	6.10	2.37	0.00	7.61
18/07/09-11/08/09	360			12.56	1.81	19.47	0.00		4.05	0.00
Average IAMSD		19.07	8.18	8.48	1.42	10.39	11.58	5.15	6.66	4.80

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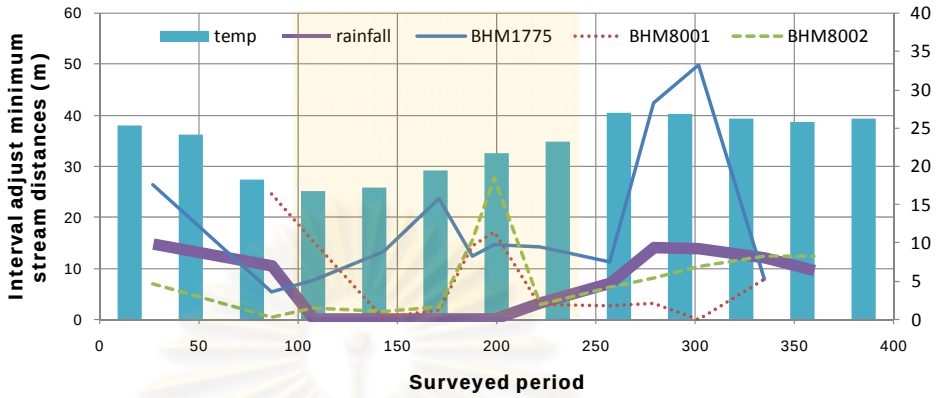

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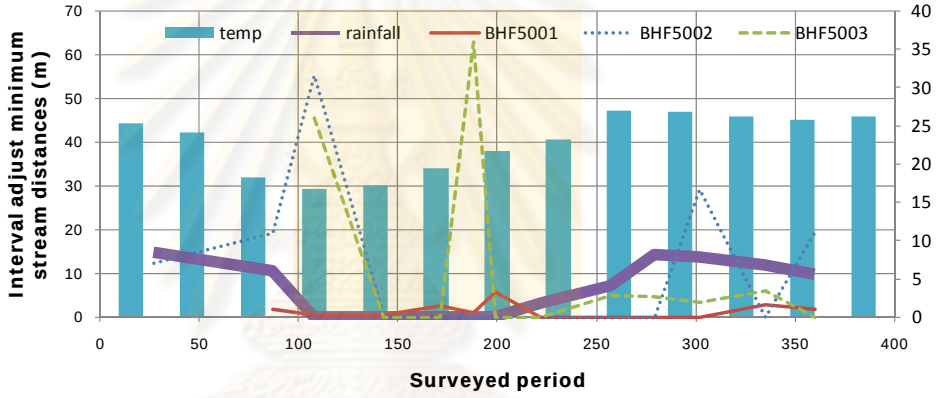

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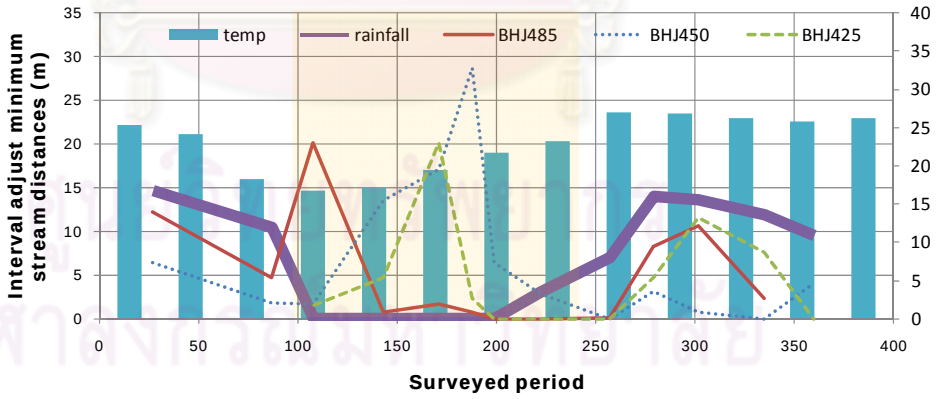

Figure 4.18 Interval adjusted minimum stream distances with rainfall and temperature for A) three males, B) three females, and C) three juvenile big-headed turtles are shown. Shaded area designates the dry season.

Seasonal movements

Seasonal movements of nine tagged big-headed turtles are shown in table 4.6. In wet season, all males moved farther than in dry season but varied among females and juveniles. However, no significant correlation between seasonal movement and sexes in wet season (Spearman's R=0.635, p=0.066) nor dry season (R=0.316, p=0.407).

Table 4.6 Minimum stream distances moved (MSD) of nine tagged big-headed turtles in wet season and dry season in the Num Mae Ka stream.

Turtle	MSD (m)		
	Wet season	Dry season	Year round
BHJ425	683.13	829.83	1,512.96 (18Nov08 – 11Aug09)
BHJ450	477.83	1,609.59	2,087.42 (16Aug08 – 17Jul09)
BHJ485	1,118.87	519.02	1,637.89 (16Aug08 – 17Jul09)
BHF500_1	385.03	2,192.28	2,577.31 (16Aug08 – 17Jul09)
BHF500_2	2,636.69	1,158.00	3,794.69 (16Aug08 – 17Jul09)
BHF500_3	385.03	182.76	567.79 (18Nov08 – 11Aug09)
BHM800_1	1,796.64	978.16	2,774.80 (12Sep08 – 17Jul09)
BHM800_2	1,360.30	1,040.88	2,401.18 (16Aug08 – 17Jul09)
BHM1775	3,376.03	2,372.03	5,748.06 (16Aug08 – 17Jul09)

Patterns of movement between individual turtles

The patterns of the interval adjusted minimum stream distances moved over the year were highly variable among the nine turtles. The pattern further demonstrates that most movements were relatively short but nearly all of the turtles made a few relatively long distance moves (Figure 4.19). Only two pairs of patterns proved to show a significant correlation. One male and female comparison (BHM8002 and BHF5001; r=0.178) and one female and juvenile comparison (BHF5002 and BHJ485; r=0.928) were significantly correlated at p< 0.05.

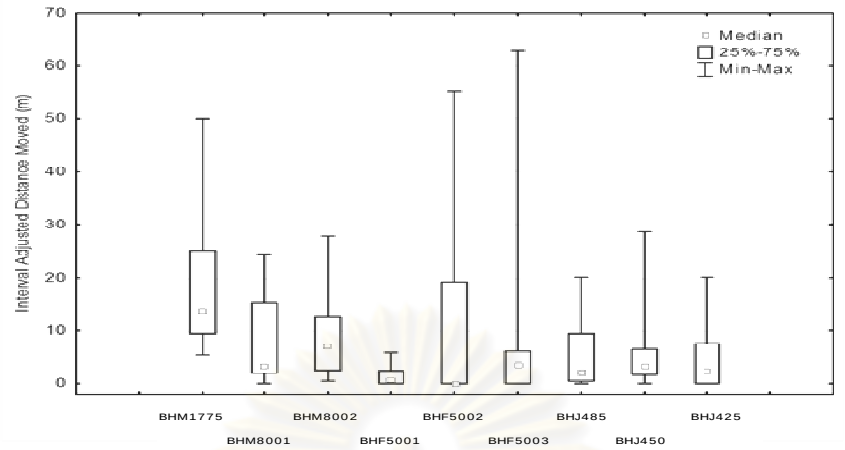

Figure 4.19 Box whisker plots of the interval adjusted minimum stream distances moved by each turtle. The pattern further demonstrates that most movements were relatively short but nearly all of the turtles made a few relatively long distance moves.

Differences between the sexes

Although I found almost no correlation among the turtles in terms of the pattern or order of movements there are movement differences between the sexes. A review of table 4.4 shows that the distribution of zero movements differs greatly between the sexes. The three males had only one instance of no movement while the females had 17 instances of no movement. This difference is highly significant (χ^2=18.96, p<0.001).

Natural History

Habitat use

Streams inhabited by *P. megacephalum* are small fast-moving streams in steep hill or mountain areas. The streams were filled with boulders and broken rock and may dry out for several weeks at the height of the dry season as reported by Kirkpatrick (1995). The capture sites had six irregular small waterfalls and many stream pools. Water depth measurements were taken along their stream habitats with values from about 8 cm to 46 cm and an average of sixty measurements was 18.49 cm. Genera of plants along the dry evergreen forest stream-bank in their habitat types are list in Appendix C.

The air temperature at the position where turtles were located ranged from 10.21 ºC to 28.31ºC (20.18±2.59). The averages of air temperature during wet season and dry season were 21.03±1.36 ºC and 19.28±3.21 ºC. The water temperature ranged from 13.80 ºC to 25.02°C (19.97±1.86). The averages of water temperature during wet season, dry season were 20.77± 1.03 ºC and 18.87±2.16 ºC. Similar to chapter 1, the water temperature ranged from 15.5–20.3 ºC (n=32). These data contrast with van Dijk (2002), water temperatures of *P. megacephalum* streams were noted ranging between 18 ºC and 24 ºC (based on Doi Chiang Dao, Thailand, 1997; Phu Luang, Thailand, 1997 & 98; Hainan, 2001) and lower values of 12 ºC to 17°C were reported by Ernst & Barbour (1989) and Kirkpatrick (1995).

Observations made in the present study confirmed that *P. megacephalum* was most active after the sunset or primarily active during twilight as revealed by Kirkpatrick's (1995) description that big-headed turtles are crepuscular or nocturnal and daily behavior patterns are very hard to determine as a result of individual and geographical variability. All of the obtained telemetry locations were in the streams and no tagged turtle was found on the forest floor or stream bank. This strongly suggests that turtles were mostly moving up and down the stream and not over land.

Diet

According to the study, two faeces (2.5x1.5 cm and 2.7x1.8 cm) of untracked turtles were accidentally collected on 30 April 2009 (Figure 4.20). After examined for the type of food, these these faeces contained crab shells (*Dromothelphusa* spp.). As informed by Kirkpatrick (1995) and van Dijk (2002) that *P. megacephalum* feeds on a variety of fishes and invertebrates including snails, shrimps and crabs. Because of only two small faecal samples, it could not be confirmed that big-headed turtle at CDWS is exclusively carnivorous as reported by Ernst & Barbour (1989); Humphrey & Bain (1990); Kirkpatrick (1995). However, Crow (2005) questioned that it is omnivorous due to fruit, naturally available along the stream within the study site in Hong Kong.

Figure 4.20 *P. megacephalum* and its faeces collected on 30 Apr 2009 from Num Mae Ka stream, CDWS.

Even though intensive observation could not get the complete data on this stream, telemetry revealed that the species was using its stream habitat all year long. The monitoring also suggests that nesting occurred along this stream although the nest of *P. megacephalum* was not seen during the study.

This study is a preliminary investigation into the spatial ecology of the big- headed turtle in the CDWS. Although sample sizes were small and the study period relatively short, the results provide important groundwork for further research in the area. There have been very few ecological studies of big-heads to date and little is known of their behavior. The designation of this species as threatened highlights the urgency and importance of research to provide essential information on their biology and ensure their successful recovery.

Growth

Figure 4.21 exhibited the same BHM8002 big-headed male that was marked on 28 Mar 2006 and measured later twice, on 16 Aug 2008 and 11 Aug 2009. Its growth estimates are presented in table 4.7. In twenty-eight months, CL, PL and TL normally increased but carapace width and plastron width decreased. After about thirty- six months had passed, CL went from 156.0 mm to 165.5 mm (0.88%), PL went from 122.6 mm to 125.4 mm

(0.09%) and TL went from 170 mm to 176.3 mm (1.26%). From March 2006 to August 2009, CW and PW went from 120.0 mm to 137.0 mm (5.13%) and 92.1 mm to 94.5 mm (1.05%). Sixteen months later, they downed to 110.5 mm (-2.52%) and decreased to 87.5 mm (-1.54). The average increments of CW and PW in a single year were -7.76mm (-7.02%) and -2.05 mm (-2.34%). These changes made the BHM8002 shape slimmer than flatter.

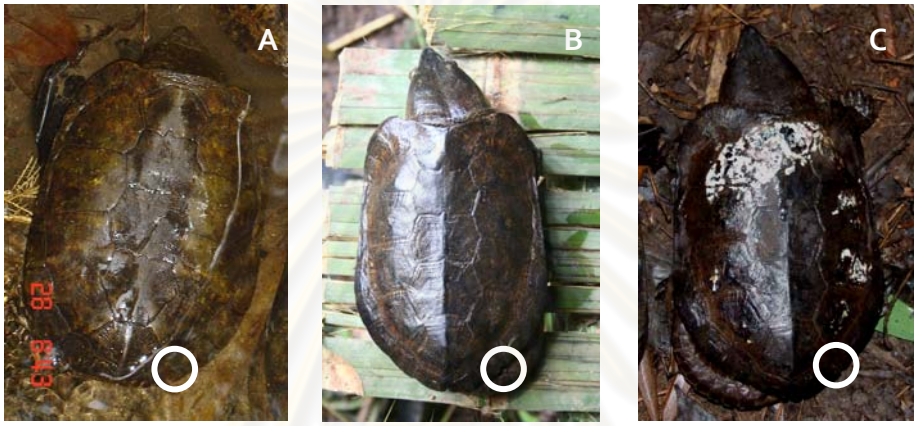

Figure 4.21 The same BHM8002 big–headed turtle studied during 2006 to 2009, write circles show notched on the similar 11th marginal scute.

A = photo on 28 Mar 2006

B = photo on 16 Aug 2008

C = photo on 11 Aug 2009

Table 4.7 Growth of the BHM8002 turtle from March 2006 to August 2009**.**

Date	Morphological measurement (mm)				
	CL	CW	PL	PW	TL
28 Mar 2006	156.0	120.0	122.6	92.1	170.0
16 Aug 2008	159.1	119.7	124.4	86.2	184.0
11 Aug 2009	165.5	110.5	125.4	87.5	186.3
Increment (mm)/year	3.17	-3.17	0.93	-1.53	5.43

Table 4.8 presents growth increments per year for five big-headed turtles from August 2008 to August 2009, the two juvenile turtles underwent an increase of 12.6 mm per year in CL while the three adults increased 5.5 mm per year in CL. Although the growth data come from only five big-headed turtles some conclusions are possible. For example, the smallest turtle in this study measured 52.4 mm CL at first capture and at a growth rate of 12.6 mm per year it would take at least 7 years to reach 140 mm CL and about 4.5 additional years to reach the size of BHM8002 (165.5 mm CL). These data support the notion that growth in the big-headed turtle is relatively slow and it appears that it takes from 8 to 15 years for hatchlings to reach adulthood. This finding adds to the need for urgency for the protection of this species.

Table 4.8 Increment per year of five big-headed turtle from August 2008 to August 2009.

Turtle	Increment morphological measurement (mm)/year					Note
	CL	CW	PL	PW	TL	
BHJ420	10.6	8.1	12.9	21.9	3.6	
BHJ450	14.6	9.1	8.4	7.6	11	
BHF5001	-3.2	3.9	4.3	4.0	1.6	
BHM8001	7.9	2.7	5.4	6.2	-64.9	Tail broken
BHM8002	3.17	-3.17	0.93	-1.53	5.43	

Additionally, this data presented the first phase of visual sex discrimination in big-headed turtle. Male turtles displayed a distinct shape. The carapace shape was longer and slender, plastron looks more concave and elongated in shape. This suggests that sexual differentiation of these traits may not be evident until the turtle has reached 7 to 10 years of age. These differences will not be evident in smaller turtles.

DISCUSSION

The greatly variable home range size of big-headed turtle was similar to wood turtle (*Glyptemys insculpta*) along with habitat selectivity, depending on the season and geographic location of the turtles (Harding & Bloomer 1979). Furthermore, this study showed that *P. megacephalum* had larger ranges of activity than red-bellied turtle, *Pseudemys nelsoni* in the order of 120 m in length and agreed with no sex differences (Kramer, 1995). In a study of a river map turtle (*Graptemys geographica*), movement, Pluto and Bellis (1988) found the mean range of activity for females to be 1,210.7 m, less than the average range observed in this study (2,108.07 m). Their study inferred movements based on recapture of marked individuals captured by hand or in basking traps, rather than following individuals through radio telemetry, and thus differences in methodology may account for some of the differences in movement estimates.

This result generally showed that movement and activity are more frequency in male than female. It differ from movement and activity in *Graptemys geographica* male that greater than females (Pluto & Bellis, 1988; Rowe & Moll, 1991) whereas some studies have found the reverse (Gordon & MacCulloch, 1980; Bodie & Semlitsch, 2000). Both terrestrial and aquatic male turtles tend to have larger home ranges than females in general (Auffenberg & Weaver, 1969; Rose & Judd, 1975; Gordon & MacCulloch, 1980; Flaherty, 1982; Pluto & Bellis, 1988; Schubauer et al., 1990; Smith & Smith, 2006).

As Gibbons (1990) noted the limited information on home range in freshwater turtles is highly variable and any differences in the size of home ranges between males and females may be species-specific. These finding that do not demonstrate a difference in home range size between male and female big-headed turtles are not unexpected. Moreover this result is based on small samples they do suggest that male and female big-headed turtles do not differ significant in home range size. Moreover, in a study of *Apalone spinifera,* most individuals had home ranges that included different water bodies such as lake,

river, creeks and marsh. As suggested by Plummer et al. (1997), home range size might be affected by the size of body of water. Furthermore, these results on home range overlap are similar to those of Obbard & brooks (1981); Doody et al. (2002); Litzgus & Mousseau (2004) that the home ranges of freshwater turtles generally overlap.

During dry season (Oct 2008 - Apr 2009), both adult and juvenile turtles started finding their hidden places and spent their time hiding, although movements occasionally occurred, and individual turtles were sometimes observed moving in Jan 2009. This may be due to adaptation to the lack of resources in dry season. They also were concluded generally less active during dry season. By November and December, females and juveniles became inactive. During wet season (May 2009-Sep 2009), all individuals moved with no pattern of movement. Only males had clearly movements while females were more sensitive to the effects of rainfall than were males and juveniles.

In theory, the difference between sexes could also be explained by males moving less during the nesting season, because females might not be receptive to mating (Morreale et al., 1984; Jones, 1996). Doody (2002) reported that linear home range size of the Pig-Nosed turtle, *Carettochelys insculpta*, females remained larger than that of males during the two months after the nesting season. Similar to research in map turtle, *Graptemys geographic,* population, Flaherty (1982) found that the movements of males were fairly evenly distributed over time, whereas female movement increased slowly until it peaked in July. Females maintained a high activity level until September, but exhibited their longest movements during the summer period, which coincided with the completion of nesting.

The present home range differ from those of home range above but like home ranges of wood turtles that sex may (Daigle, 1997) or may not (Ross et al., 1991; Kaufmann, 1995; Tuttle & Carroll, 1997; Arvisais et al., 2002) have an impact on home range size. It does not appear that the size or dominance rank affect home range size either (Kaufmann, 1995; Tuttle &

Carroll, 1997). While home ranges of wood turtles are generally small (213 m–680 m), they are capable of making long distance movements between 1 and 3 km (Ernst & McBreen, 1991; Daigle, 1997). Females have been known to move several kilometers to find a suitable nesting site (Walde, 1998; Ernst, 2001a; 2001b).

Such Kirkpatrick (1995) stated that *P. megacephalum* nesting is speculated to occur from May to Aug. This result was opposite to those, females rather immobile in dry season (Oct 2008 to Apr 2008). However, the nest did not found from this study.

CHAPTER V

HUMAN IMPACT ON THE BIG-HEADED TURTLE *Platysternon megacephalum* Gray, 1831 POPULATION, CHIANG DAO WILDLIFE SANCTUARY, CHIANG MAI PROVINCE

ABSTRACT

A study of human impact on *Platysternon megacephalum* at Chiang Dao Wildlife Sanctuary was undertaken during January to September 2009. Analyses were based on interviews and a questionnaire survey conducted with local people living both within and near CDWS. The data were analyzed using SPSS. Results revealed that the hunting period for this turtle is not specific but it always happens in dry season. Most local hunters do not aim to hunt them directly but the turtles are a by-catch while the hunters are looking for other things. About 54 percent of respondents have experienced collecting turtles for food and 2.64 percent have sold the turtles. However, 61.84 percent of informants reported that they agreed with the importance of the conservation of this species. This was especially true for young informants (55.22%).

Although *P. megacephalum* are not at immediate risk in this sanctuary, this species is very likely to be at risk in the near future. In order to prevent these creatures from reaching dangerously low population number or even locally extinction, it is imperative that existing laws be enforced on the ground, and that villagers become an active part of the protection strategy.

Key words: *Platysternon megacephalum*, big-headed turtle, human impact

INTRODUCTION

Villagers within and around CDWS

Chiang Dao Mountain has been designated to be a wildlife sanctuary since 1978. Among 24 villages sharing their areas in CDWS as agricultural farm, fourteen villages were established in CDWS before this area was designated and ten villages are located nearby this sanctuary. Besides northern Thais, there are four hill tribes represented including Karen, Hmong, Lisu and Lahu. A total of 2,287 persons live in these villages, consisting of (i) Sun Pa Kia, Pang Pu Wan, Pang Hong in Mae Na District (ii) Ban Tum, Yang Pu Toh, Na Lao Mai, Na Lo kao, Fa Suay in Chiang Dao District (iii) Mae Klong Sai, Mae Pa Sao, Pang Mai Dang, Ban Luang in Muang Kong District (iv) Mae Ja, Ban Mai, Khun kong, Thnong Kratae, Khae Cha-di, Mae Ja Tai, Muang Ngum, Thnong Bua, Huay Pong Kham in Muang Ngai District and (v) Huay Ya Sai, Lao Wu, Mae Tae in Muang Haeng District (Table 5.1 and Figure 5.1).

Most people are agriculturists growing tea, rice, corn, coffee, pear, persimmon, peach, pine, maple, banana, red beans, lychee, ginger and vegetables. Some of these village communities are dependent on wild resources for fuel wood, fodder and timber. Natural forests are a common property and are accessible to all members of the community. Human main activities are hunting, picking mushrooms and gathering other editable species in this area.

Human impact on turtles

Turtles and tortoises are losing vast portions of their original habitats as humans convert wetlands, forests, and grasslands to agricultural fields, grazing lands, villages and cities (Collins, 1990; Harding, 1997; Thirakhupt & van Dijk, 1997). The population status of *P. megacephalum* is endangered (IUCN, 2008). This species was once common in food markets in China but it is now rare, indicating a drastic population decline. In Thailand, only remote areas or well-protected areas may have stable populations (van Dijk & Palasuwan, 2000). Threats were from over-collecting for food and the pet

trade for domestic and international markets and habitat loss. van Dijk & Palasuwan (2000) reported that threats of *P. megacephalum* in Thailand are due to collection for consumption in relation to Traditional Chinese Medicine (TCM), for the pet trade, and *ex situ* captive breeding programs, and habitat degradation. In addition, the magnitude of illegal trade from Thailand is unknown, but the potential for collection to supply the TCM demand is undeniable. Potential trade impacts are severe, given the limited size of individual populations and the difficulty in recolonizing depleted areas.

Table 5.1 Human population numbers within and surrounding CDWS.

District	Village	Population	Tribes
Chiang Dao	Ban Tum	185	northern Thais
	Fa Suay	125	Lisu
	Huay Pong Kham	54	northern Thais
	Khae Cha-di	10	northern Thais
	Khun Ka	38	northern Thais
	Mae Ja Tai	804	Lisu
	Mae Klong Sai	80	Karen
	Mae Pa Sao	45	Karen
	Muang Ngum	91	northern Thais
	Na Lao Mai	101	Lisu
	Na Lo kao	80	Lisu
	Pang Hong	13	Hmong
	Pang Mai Dang	114	Karen
	Pang Pu Wan	38	northern Thais
	Sam Yaeg Muang Haeng	34	northern Thais
	Sun Pa Kia	283	Hmong, northern Thais
	Thnong Bua	27	northern Thais
	Thnong Kratae	35	Lisu
	Yang Pu Toh	10	Karen
Muang Ngai	Ban Mai	151	northern Thais
	Khun kong	112	Lisu
Weing Haeng	Huay Ya Sai	80	Lahu
	Lao Wu	346	Lisu
	Mae Tae	31	Lisu

Source: CDWS, 2007

OBJECTIVE

The general goal of this chapter is to study the human impact on the big-headed turtle at Chiang Dao Wildlife Sanctuary by interview and to suggest the conservation plan for this protected area.

METHODOLOGY

Data collection and analysis

To study the impact from humans on the big-headed turtle population local people who live in CDWS were interviewed about their use, knowledge and concern on *P. megacephalum*. An interview form was used. Then patterns and human activities in CDWS that had impacts on *P. megacephalum* population were analyzed. Finally, a conservation and management plan for *P. megacephalum* in CDWS was recommended. The number of interviews was obtained using the formula of Taro Yamane (1967) from 23 villages within and around CDWS. Interviews were applied to gather information on knowledge, opinion and major impact on *P. megacephalum* at CDWS.

The questions were presented in an informal way to establish greater trust and dialogue, and to increase opportunities for other information to emerge. The structured questionnaires included both fixed-response and open-ended questions. Purposeful sampling was carried out within each village. The questions examined demographics, activities and conservation agreement. A series of comparative tests using Pearson's Chi Square crosstabulations were conducted on non-metric variables to identify instances of significant differences across the groups. As well, the adjusted residual was used to identify which group actually accounted for these significant differences.

RESULT AND DISCUSSION

Villager characteristics, behaviors, and perceptions in CDWS have been studied by specific designed interview during Jan 09 to Sep 09. The data were collected from 24 village sites. The interview team consisted with one or two staffs from the Chiang Dao Wildlife Research Station and local authorities. A Total of 304 interviews were evaluated, villager's characteristics were classified in Table 5.2 and 5.3.

Demographic variables

One hundred seventy-eight men (58.55%) and one hundred twenty-six women (41.45) were interviewed. The ages of prominent villagers were below 20 years; followed by 21-30 years, and 51-60 years which are 23.36, 22.04 and 16.45 percent, respectively. The level of education information showed that 36.51 percent unschooled, while 32.57 percent completed primary school, 22.37 percent finished Secondary school, 7.89 percent graduated from high school and 0.66 percent attended college. The value of 85.48 percent of the hometown of villagers lived in CDWS.

Benefits toward *P. megacephalum*

When focusing on *P. megacephalum* features, it is interesting that 25.7 percent used the common name "Hang Yao" (= long tail) while 19.1 percent knew this turtle by "Hua To" (= big-head) and 12.2 percent referred to it as "Pak Nok Kaeo" (=parrot beak). The data confirmed that 46.9 percent of villagers knew where the big-headed turtle lived in CDWS. This was especially true in nearby villages. In addition, 54.13 percent of all villagers (23.17% of 41-50 years old group and 22.56% of 51-60 years old group) had eaten this animal. Only about 3 percent had sold them. It showed that many of *P. megacephalum* in this study area have been collected for local consumption.

Table 5.2 General information and *P. megacephalum* opinions of villagers in CDWS, Chiang Mai Province.

Characteristic	Age of villager (years) and percentage													
	< 20	**%**	**21-30**	**%**	**31-40**	**%**	**41-50**	**%**	**51-60**	**%**	**> 60**	**%**	**Total**	**%**
Gender	**71**	**23.36**	67	22.04	42	13.82	47	15.46	50	16.45	27	8.88	304	100.00
Male	42	53.85	43	55.13	27	34.62	28	35.90	22	28.21	16	20.51	**178**	**58.55**
Female	29	23.02	24	19.05	15	11.90	19	15.08	28	22.22	11	8.73	126	41.45
Level of education														
Unschooled	4	3.60	3	2.70	8	7.21	34	30.63	**38**	**34.23**	24	21.62	111	**36.51**
Male	2	4.00	1	2.00	4	8.00	20	40.00	16	32.00	7	14.00	50	
Female	2	3.28	2	3.28	4	6.56	14	22.95	22	36.07	17	27.87	61	
Primary school	20	20.20	38	38.38	18	18.18	11	11.11	9	9.09	3	3.03	99	32.57
Male	16	24.24	22	33.33	10	15.15	7	10.61	8	12.12	3	4.55	66	
Female	4	12.12	16	48.48	8	24.24	4	12.12	1	3.03			33	
Secondary school	37	54.41	20	29.41	7	10.29	1	1.47	3	4.41			68	22.37
Male	19	40.43	18	38.30	6	12.77	1	2.13	3	6.38			47	
Female	18	85.71	2	9.52	1	4.76							21	
High school	10	41.67	4	16.67	9	37.50	1	4.17					24	7.89
Male	6	40.00	2	13.33	6	40.00	1	6.67					15	
Female	4	44.44	2	22.22	3	33.33							9	
Bachelor or higher degree			2	100.00									2	0.66
Male													0	
Female			2										2	

Table 5.2 (Continue) General information and *P. megacephalum* opinions of villagers in CDWS, Chiang Mai Province.

Characteristic	Age of villager (years) and percentage													
	< 20	**%**	**21-30**	**%**	**31-40**	**%**	**41-50**	**%**	**51-60**	**%**	**> 60**	**%**	**Total**	**%**
Hometown														
In CDWS	**56**	**21.62**	61	23.55	34	13.13	39	15.06	45	17.37	24	9.27	259	**85.48**
Male	33	21.57	40	26.14	21	13.73	26	16.99	23	15.03	10	6.54	153	
Female	23	21.70	21	19.81	13	12.26	13	12.26	22	20.75	14	13.21	106	
Outside CDWS	15	33.33	6	13.33	8	17.78	8	17.78	5	11.11	3	6.67	45	14.85
Male	10	40.00	3	12.00	5	20.00	3	12.00	4	16.00	0	0.00	25	
Female	5	25.00	3	15.00	3	15.00	5	25.00	1	5.00	3	15.00	20	
Knowledge to *P. megacephalum*														
Yes	5	3.13	31	19.38	30	18.75	37	23.13	**39**	**24.38**	18	11.25	160	**52.81**
Male	4	3.60	24	21.62	24	21.62	25	22.52	24	21.62	10	9.01	111	
Female	1	2.04	7	14.29	6	12.24	12	24.49	15	30.61	8	16.33	49	
No	63	52.94	32	26.89	6	5.04	4	3.36	8	6.72	6	5.04	119	39.27
Male	38	66.67	15	26.32	0	0.00	2	3.51	2	3.51			57	
Female	25	40.32	17	27.42	6	9.68	2	3.23	6	9.68	6	9.68	62	
Not sure	3	12.00	4	16.00	6	24.00	6	24.00	3	12.00	3	12.00	25	8.25
Male	1	10.00	4	40.00	2	20.00	2	20.00	1	10.00			10	
Female	2	13.33			4	26.67	4	26.67	2	13.33	3	20.00	15	

Table 5.2 (Continue) General information and *P. megacephalum* opinions of villagers in CDWS, Chiang Mai Province.

Characteristic	Age of villager (years) and percentage													
	< 20	**%**	**21-30**	**%**	**31-40**	**%**	**41-50**	**%**	**51-60**	**%**	**> 60**	**%**	**Total**	**%**
***P. megacephalum* symbol known**														
Big head	2	3.45	14	24.14	11	18.97	14	24.14	15	25.86			58	19.08
Male	1	2.27	11	25.00	10	22.73	10	22.73	10	22.73	2	4.55	44	
Female	1	7.14	3	21.43	1	7.14	4	28.57	5	35.71			14	
Parrot beak			1	2.70	12	32.43	13	35.14	2	5.41	9	24.32	37	12.17
Male					8	34.78	8	34.78	1	4.35	6	26.09	23	
Female			1	7.14	4	28.57	5	35.71	1	7.14	3		14	
Long tail	6	7.69	20	25.64	12	15.38	13	16.67	**21**	**26.92**	6	7.69	**78**	**25.66**
Male	4	7.27	17	30.91	8	14.55	10	18.18	12	21.82	4	7.27	55	
Female	2	8.70	3	13.04	4	17.39	3	13.04	9	39.13	2	8.70	23	
Not sure	34	57.63	13	22.03	3	5.08	5	8.47	4	6.78		0.00	59	19.41
Male	21	72.41	5	17.24			1	3.45	2	6.90		0.00	29	
Female	13	43.33	8	26.67	3	10.00	4	13.33	2	6.67		0.00	30	
Not known	29	39.19	19	25.68	4	5.41	2	2.70	8	10.81	12	16.22	74	24.34
Male	17	45.95	10	27.03			1	2.70	2	5.41	7	18.92	37	
Female	12	32.43	9	24.32	4	10.81	1	2.70	6	16.22	5	13.51	37	

Table 5.2 (Continue) General information and *P. megacephalum* opinions of villagers in CDWS, Chiang Mai Province.

Characteristic	Age of villager (years) and percentage													
	< 20	**%**	**21-30**	**%**	**31-40**	**%**	**41-50**	**%**	**51-60**	**%**	**> 60**	**%**	**Total**	**%**
Knowledge to *P. megacephalum* habitat in CDWS														
Yes	3	2.11	28	19.72	29	20.42	34	23.94	**38**	**26.76**	18	12.68	**142**	**46.86**
Male	2	1.96	22	21.57	23	22.55	22	21.57	23	22.55	10	9.80	102	
Female	1	2.50	6	15.00	6	15.00	12	30.00	15	37.50			40	
No	65	69.15	33	35.11	8	8.51	6	6.38	8	8.51	7	7.45	94	31.02
Male	39	63.93	16	26.23			4	6.56	2	3.28			61	
Female			17	51.52	8	24.24	2	6.06	6	18.18			33	
Not sure	3	12.00	6	24.00	5	20.00	7	28.00	4	16.00	2	8.00	25	8.25
Male	2	13.33	5	33.33	3	20.00	3	20.00	2	13.33			15	
Female	1	10.00	1	10.00	2	20.00	4	40.00	2	20.00			10	
Benefit of *P. megacephalum*	15	4.93	58	19.08	55	18.09	64	21.05	58	19.08	26	8.55	304	
Good Taste	9	5.49	32	19.51	31	18.90	**38**	**23.17**	37	22.56	17	10.37	**164**	**54.13**
Male	6	5.36	26	23.21	24	21.43	26	23.21	21	18.75	9	8.04	112	
Female	3	5.77	6	11.54	7	13.46	12	23.08	16	30.77	8	15.38	52	
Good price					2	25.00	2	25.00	3	37.50	1	12.50	8	2.64
Male					2	100.00	1	50.00	3	150.00	1	50.00	2	
Female							1	100.00					1	
Not know	62	46.97	35	26.52	9	6.82	7	5.30	10	7.58	9	6.82	132	43.56
Male	37	62.71	17	28.81			2	3.39	3	5.08			59	
Female	25	34.25	18	24.66	9	12.33	5	6.85	7	9.59	9	12.33	73	

Table 5.2 (Continue) General information and *P. megacephalum* opinions of villagers in CDWS, Chiang Mai Province.

Characteristic	Age of villager (years) and percentage													
	< 20	**%**	**21-30**	**%**	**31-40**	**%**	**41-50**	**%**	**51-60**	**%**	**> 60**	**%**	**Total**	**%**
What should do to *P. megacephalum*														
Partly harvested	1	1.59	13	20.63	11	17.46	**18**	**28.57**	15	23.81	5	7.94	63	20.72
Male	1	2.08	12	25.00	11	22.92	13	27.08	7	14.58	4	8.33	48	
Female			1	6.67	0	0.00	5	33.33	8	53.33	1	6.67	15	
Preserved	6	13.04	**12**	**26.09**	9	19.57	5	10.87	**12**	**26.09**	2	4.35	46	15.13
Male	2	7.14	9	32.14	6	21.43	2	7.14	7	25.00	2	7.14	28	
Female	4	22.22	3	16.67	3	16.67	3	16.67	5	27.78			18	
Controlled by law	7	4.96	31	21.99	28	19.86	**32**	**22.70**	28	19.86	15	10.64	**141**	**46.38**
Male	4	4.26	25	26.60	19	20.21	20	21.28	17	18.09	9	9.57	94	
Female	3	6.38	6	12.77	9	19.15	12	25.53	11	23.40	6	12.77	47	
Not sure	**59**	**44.03**	33	24.63	9	6.72	10	7.46	13	9.70	10	7.46	134	44.08
Male	38	57.58	16	24.24	2	3.03	5	7.58	5	7.58			66	
Female	21	30.88	17	25.00	7	10.29	5	7.35	8	11.76	10	14.71	68	
What should do to *P. megacephalum* habitat														
None	2	7.69	8	30.77	3	11.54	4	15.38	7	26.92	2	7.69	26	8.55
Male	1	6.67	8	53.33			2	13.33	3	20.00	1	6.67	15	
Female	1	9.09			3	27.27	2	18.18	4	36.36	1	9.09	11	
Conserved	**61**	**32.45**	43	22.87	29	15.43	21	11.17	23	12.23	11	5.85	**188**	**61.84**
Male	38	33.33	25	21.93	18	15.79	13	11.40	16	14.04	4	3.51	114	
Female	23	31.08	18	24.32	11	14.86	8	10.81	7	9.46	7	9.46	74	

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Table 5.2 (Continue) General information and *P. megacephalum* opinions of villagers in CDWS, Chiang Mai Province.

Characteristic	Age of villager (years) and percentage													
	< 20	**%**	**21-30**	**%**	**31-40**	**%**	**41-50**	**%**	**51-60**	**%**	**> 60**	**%**	**Total**	**%**
Not sure	8	8.00	16	16.00	10	10.00	22	22.00	20	20.00	24	24.00	100	32.89
Male	4	8.16	10	20.41	8	16.33	14	28.57	8	16.33	5	10.20	49	
Female	4	7.84	6	11.76	2	3.92	8	15.69	12	23.53	19	37.25	51	
Conservation action opinion														
Agree	**61**	**30.65**	44	22.11	32	16.08	22	11.06	29	14.57	11	5.53	**199**	**65.46**
Male	37	30.33	26	21.31	20	16.39	14	11.48	21	17.21	4	3.28	122	
Female	24	31.17	18	23.38	12	15.58	8	10.39	8	10.39	7	9.09	77	
Disagree			3	15.00	3	15.00	7	35.00	4	20.00	3	15.00	20	6.58
Male			3	20.00	3	20.00	5	33.33	1	6.67	3	20.00	15	
Female							2	40.00	3	60.00			5	
Not sure	10	11.76	20	23.53	7	8.24	18	21.18	17	20.00	13	15.29	85	27.96
Male	6	14.63	14	34.15	3	7.32	10	24.39	5	12.20	3	7.32	41	
Female	4	9.09	6	13.64	4	9.09	8	18.18	12	27.27	10	22.73	44	

Table 5.3 Differences between demographic variables and perception of *P. megacephalum* impacts through interviews.

Variables	Gender		Age		Education		Hometown	
	χ^2	p-Value	χ^2	p-Value	χ^2	p-Value	χ^2	p-Value
1. Hunting	20.44	<0.001	96.58	<0.001	21.56	0.006	2.36	0.307
2. Preservation	0.12	0.729	9.22	0.100	6.96	0.138	0.13	0.175
3. Controlled by law	7.13	0.008	56.71	<0.001	2.61	0.626	0.13	0.715
4. Partly harvested	10.19	0.001	28.49	<0.001	6.16	0.188	4.50	0.034
5. Conservation agreement	6.58	0.037	35.07	<0.001	47.19	<0.001	4.01	0.135

P. megacephalum conservation in CDWS

Only 46.38 percent of villagers' opinions accepted in not catching because of wildlife law enforcement. The information on conservation showed that about 15.13 percent knew that they should be free in the wild but it is surprising that 44.08 percent were not sure and 20.72 percent wanted to catch them, mostly in 41-50 years' group (These percentages total is more than 100% because respondents could give multiple answers). The big-headed turtle is a traditional animal, informal discussions indicated that some respondents use meat and body parts of this animal for spiritual purposes and for food in local communities. This is one of the evidences that some villagers harvested big-headed turtle illegally in CDWS.

More than 65 percent agreed to meet the conservation practices, 6.58 percent disagreed and 27.96 percent showed their uncertainty. The method to manage *P. megacephalum* habitat was classified into 3 topics which were conservation (61.84%), doing none (8.55%) and not sure (32.89%). Most percentage of conservation was from the below 20 years' informants. Indicating that the young generation is more interested in conservation (30.45% by below 20 years old group and 22.11% by 21-30 years old group).

Wildlife protection appears not to be the highest priority among local communities. Chi-square tests revealed perception of big-headed turtle hunting was dependent on gender ($p<0.001$), age ($p<0.001$) and level of education ($p=0.006$), however, no significant difference was found with hometown ($p=0.307$) of informants (see Table 5.2). Significant relationships in let big-headed turtle free in the wild occurred with only age ($p<0.001$) but no significant differences were found with gender ($p=0.729$), level of education ($p=0.138$) and hometown ($p=0.175$). In law enforcement, significant association existed with gender ($p=0.008$), age ($p<0.001$) but conversely with level of education ($p=0.626$) and hometown ($p=0.715$). However, χ^2 tests indicated that gender, age and hometown are significantly different to the access of partly harvesting ($p= 0.001$, $p<0.0001$, $p=0.034$, respectively). Significant differences were also found with conservation participation with gender ($p=0.037$), age ($p<0.001$) and level of education ($p<0001$).

Threats to *P. megacephalum* by local villager

Big-headed turtle is an aquatic turtle. They live in streams where there are deep pools near fast moving water. Usually only one, maybe two, will be caught per pool. Occasionally they are observed hiding in shady, shallow, cool water with their body down in a crevice, head poking out. When it is very hot they can sometimes be found in small impounded water pools along the stream. They hide in root hollows and small rock caves. Dogs cannot find these, so the hunters use hooks in a circle with bait in the middle or seek under rocks or logs. Normally they are caught in basket fish traps. All interviewed villagers never observe these turtles dropping eggs, but found dead females usually with 4-6 eggs. When a turtle is captured, it is usually eaten. For the trade, the prices of these turtles range from 600 to 1,000 Baht/kg (the exchange rate at the time of this interview was 33 Thai Baht to 1.00 $US). They could get 2-3 kg on a good day during the hunting season. The hunting period for all turtles was not specific but it also happens in dry season and most of local hunters do not aim to hunt the turtles but look for other animals to gather.

A result of the study indicated that CDWS is home to big-headed turtle and local people in CDWS have been hunting big-headed turtles for trading and for food. Big-headed turtle as pets was not found during observation period. In addition, based on other informal reports and personal communications, more than four big-heads were taken by nearby villagers for trade in 2008 whereas there was not any record of seizure in CDWS. Recently, at least one big-head was killed for food by an interviewed man in Aug 2009. Thus, this sanctuary could not provide a completely safe haven for this freshwater turtle.

The impression that the author gained whilst interviewing local people was that the species is hunted for consumption needs rather than commercial. It was clear that some villagers gather turtles for food despite the fact that they knew that it was illegal to poach turtles. In addition, they implied that they hunted turtles partly because they knew that enforcement of the law and punishment was an unlikely outcome. Unfortunately, my interviews also showed that this attitude of impunity to the law carried over to other villagers that might consider hunting for turtles. These results demonstrate the importance of consistent enforcement of conservation laws among all citizens.

To conclude, *P. megacephalum* populations in CDWS faces two threats that are hunting for commercial purposes and subsistence purposes. It is collected for human consumption throughout its range and some are exported to distant markets. Some villagers want to increase their hunting opportunities while others are simply afraid of wildlife law enforcement. Additionally, it is spared heavy exploitation due to the lack of commercial interest rather than as a result of legislation.

Recommendations on conservation management plan to CDWS

Turtles have evolved a specialized life history. Natural mortality of eggs and hatchlings is high. It takes many years, often decades, to reach full adult size and maturity. Once this full size is reached, the surviving individuals are less

vulnerable to natural predators and can reproduce steadily over many years or even decades. By collecting these ecologically invulnerable adults, humans with the use of fire and tools have broken the security of this evolutionary strategy. And because of the often low annual reproductive output and high natural mortality of eggs and young, the time needed for a turtle population to recover, if left alone, still would be in the order of decades or centuries.

P. megacephalum is a unique chelonian for a number of reasons. In form, it appears to have been assembled from parts of many turtles, while its behavior and natural environment are equally exotic. Although currently not believed to be severely threatened, its small clutch size and specialized habitat leave the big-headed turtle vulnerable (Kirkpatrick, 1995). The IUCN Species Survival Committee on Tortoises and Freshwater Turtles recommended in their 1991 action plan that the status of *P. megacephalum* be evaluated to determine if it is in danger in its natural habitat. This species is considered as endangered and keystone species in its habitat (Kirkpatrick, 1995). It should receive the highest priority for conservation because at present all known populations are declining in its range countries. Public awareness and education are urgently needed. The proper conservation and management of *P. megacephalum* will have to rely on further in-depth research. Although this research could answer some of its natural behavior and lifestyle of this species, hopefully more research will be devoted to this turtle, to reply some of the numerous questions.

The points below are recommendations to CDWS, with particular reference to the impact in big-headed turtle for conservation management plan.

Human management:

1. Priority on hunting prevention should be focused on the male group ages between 41-60 years old. CDWS should be encouraged to set up the wildlife protection network or round table meetings by this group.

2. Conservation incentives and activities should be set up on the male ages below 30 years old and extend to all villagers at all age levels.

3. Educational programs, consisting of simple training programs for young males and females addressing the environmental conservation and relevant laws in order to increase the awareness to all groups are recommended.

4. Villager characters and behaviors should be considered along with the management.

Habitat and species management:

1. Habitat evaluations must be conducted to determine whether the area is capable of supporting a viable *P. megacephalum* population.

2. Mechanisms for community-based natural resource management should be developed and piloted in the buffer zone of the CDWS.

3. Capacity building and technical input for a possible captive breeding at CDWS or another suitable protected area should be considered.

Research and education:

1. Conservation and research activities should be implemented to raise awareness and to promote sustainable use of natural resources.

2. Knowledge on conservation of important native species should be taught in village-level schools.

3. Research on ecology and reproductive biology of *P. megacephalum* wild populations should be investigated with the assistance of local people.

4. Monitoring and long-term data should be gathered and evaluated for successful management.

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APPENDICES

APPENDIX A

Official Letter sent to museum curators
for examining *Platysternon megacephalum* Gray,1831

No. 1277/2550

Department of Biology
Faculty of Science,
Chulalongkorn University,
Phayathai Road, Pathumwan,
Bangkok 10330 Thailand
Tel: 662-218-5259
Fax: 662-218-5260

24 August B.E. 2550 (2007)

Dear museum curator,

Subject : Requests for specimens data

Ms. Kruewan Pipatsawasdikul, a Ph.D. student of Chulalongkorn University who is studying on "Distribution of the big-headed turtle *Platysternon megacephalum* in Thailand and a case study on population status and conservation management at Chiang Dao Wildlife Sanctuary in Chiang Mai Province", would like to investigate the appearance of this species in Thailand. *Platysternon megacephalum* is categorized as endangered species on the IUCN Red List of Threatened Species, 2006 and listed on Appendix II of CITES. In addition, it is a protected species under the Thailand Preservation and Protection of Wild Animals Act (No. 2), B.E. 2546.

Based on the previous data of the turtle observed and reported within the trade and the corresponding widespread and steady destruction of natural forests within its range, the conservation of this turtle in Thailand is urgently needed. Therefore, her study aims to gain more complete data of its population status in Thailand and major ecological data of this species will be studied at Chiang Dao Wildlife Sanctuary and the conservation management plan in this area will be proposed.

It would be highly appreciated that you give her the information of "*Platysternon megacephalum* from Thailand that have been deposited in your museum" (GIS coordinates, specific collecting locality, date of collection, collector, etc.). For further information, please directly contact at her e-mail address: Kwanwongkom@yahoo.com.

Very truly yours,

K. Thirakhupt

(Assistant Professor Dr. Kumthorn Thirakhupt)
Head of Department of Biology

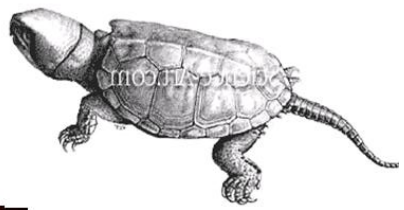
APPENDIX B

Platysternon megacephalum A4poster for questionnaire survey

เต่าปูลู

Big-headed Turtle

(Platysternon megacephalum)



หัวและปาก (Head and Mouth)

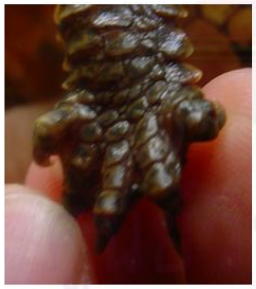
หัวเป็นรูปสามเหลี่ยมขนาดใหญ่ หดเข้าไปในกระดองไม่ได้ เมื่อยังเล็กข้างหัวจะมีเส้นสีดำ 1 คู่ พาดยาวไปทางด้านหลัง และจะหายไปเมื่อโตเต็มวัย ปากเป็นจงอยแหลมคม คล้ายปากนกแก้ว

กระดองหลัง (Carapace)

กระดองหลังสีน้ำตาลแดง เมื่ออายุมากขึ้น สีจะเข้มขึ้นเป็นสีน้ำตาลเข้ม

กระดองท้อง (Plastron)

เมื่อยังเล็ก กระดองท้องมีสีส้มสดใส เมื่อโตเต็มวัยกระดองท้องเป็นสีน้ำตา หรือน้ำตาลเหลือง



ขาและตีน (Leg and Foot)

ขาและตีนมีขนาดใหญ่แข็งแรง หดเข้ากระดองไม่ได้ ขาหน้ามี 5 นิ้ว ขาหลัง มี 4 นิ้ว ทั้งขาหน้าและขาหลัง ปกคลุมด้วยเกล็ดขนาดใหญ่และมีเดือยหนามแหลม กระจายอยู่ทั่ว ฝ่ามือและฝ่าตีนมีเกล็ดขนาดเล็กลง นิ้วมือและนิ้วตีนมีเกล็ดหุ้ม มีพังพืดบางๆ และมีเล็บที่แข็งแรงมาก

หาง (Tail)

มีขนาดใหญ่ แข็งแรงและยาวมาก มีเกล็ดหุ้มด้านข้างทั้ง 2 ด้าน

APPENDIX C

Genera of plants along Num Mea Ka stream-bank,
Chiang Dao Wildlife Sanctuary (CDWS).

List of vascular plants occurring along Num Mea Ka stream-bank, CDWS.

No.	Family	Species	Vernacular
1	Actinidaceae	*Saurauia nepaulensis* DC.	ปลายสาน
2		*S. roxburghii* Wall	ส้านเห็บ
3	Anacardiaceae	*Mangifera caloneura* Kurz	มะม่วงป่า
4		*Semecarpus cochinchinensis* Engl.	รักขาว
5		*Spondias lakonensis* Pierre	มะห้อ
6	Annonaceae	*Cyathocalyx martabanicus* Hook.f.&Thomson	สะบันงาป่า
7		*Mitrephora vandaeflora* Kurz	ปอแฮด
8		*Polyalthia virindis* Craib	ยางโอน
9	Apocynaceae	*Alstonia scholaris* (L.) R.Br.	พญาสัตบรรณ
10		*Wrightia arborea* (Dennst.)Mabb.	โมกมัน
11	Araliaceae	*Trevesia palmata* (Roxb. ex Lindl) Vis	ต้างหลวง
12	Arecaceae	*Arenga pinnata* Merr.	ต๋าว
13		*Daemonorops* spp.	หวาย
14	Begoniaceae	*Begonia* sp 1.	ส้มกุ้ง
15	Bignoniaceae	*Fernandoa adenophyllum* (Wall. *ex* D.Don) Steenis	แคหางค่าง
16		*Radermachera ignea* (Kurz) Steenis	กาสะลองคำ
17	Buddlejaceae	*Buddleja asiatica* Lour	ราชาวดีป่า
18	Burseraceae	*Canarium subulatum* Guillaumin	มะกอกเกลื้อน
19		*Garuga pinnata* Roxb.	ตะคร้ำ
20		*Protium serratum* Engl.	มะแฟน
21	Caprifoliaceae	*Sambucus javanica* Rienw. ex Bl.	สะฟ้านก้น
22	Celastraceae	*Siphonodon celastrineus* Griff.	มะดูก
23	Chloranthaceae	*Chloranthus erectus* (Buch-Ham.) Verdc.	กระดูกไก่
24	Combretaceae	*Terminalia bellirica* (Gaertn.) Roxb.	สมอพิเภก
25	Crypteroniaceae	*Crypteronia paniculata* Blume	กะอาม
26	Datiscaceae	*Tetrameles nudiflora* R.Br. ex Benn.	กะพงงุ้น
27	Dipterocarpaceae	*Hopea odorata* Roxb.	ตะเคียนทอง
28	Elaeocarpaceae	*Elaeocarpus prunifolius* Wall. ex C. Mull	มะมุ่น
29	Euphorbiaceae	*Antidesma bunius* (L.) Spreng	เม่าช้าง
30		*Baccaurea ramiflora* Lour.	มะไฟ
31		*Balakata baccata* (Roxb.) Esser	โพบาย
32	Euphorbiaceae	*Bischofia javanica* Bl.	เติม
33		*Cleidion spiciflorum* (Burm. F.) Merr.	ดีหมี
34	Euphorbiaceae	*Macaranga siamensis* Davies	เต้าหลวง
35		*Ostodes paniculata* Bl.	มะคังดง
36		*Suregada multifrorum* (A.Juss.) Baill.	ขันทองพยาบาท
37	Gnetaceae	*Gnetum montanum* Markgraf	มะม่วย
38	Guttiferae	*Garcinia cowa* Roxb.	มะดะหลวง

List of vascular plants occurring along Num Mea Ka stream-bank, CDWS.

No.	Family	Species	Vernacular
39		*Mesua ferrea* L.	บุนนาค
40	Labiatae	*Callicarpa arborea var. arborea*	ช้าแป้น
41		*Gmelina arborea* Roxb.	ซ้อ
42	Lauraceae	*Actinodaphne* sp 1.	ตองลาด
48		*Archidendron clypearia* (Jack) Niels.	มะขามแป
49		*Erythrina stricta* Roxb.	ทองหลาง
50	Lythraceae	*Lagerstroemia tomentosa* C. Presl	เส้าขาว
51		*L. villosa* Wall.	เสลาเปลือกหนา
52	Magnoliaceae	*Manglietia garrettii* Craib	มณฑาขาว
53		*Michelia baillonii* (Pierre) Finet & Gagnep.	จำปีป่า
54	Marantaceae	*Shumannianthus dichotomous* (Roxb.)	คล้าน้ำ
55	Meliaceae	*Aglaia lawii* (Wight) Sald . & Rama	ประยงค์ป่า
56		*Aphanamixis polystachya* (Wall) R. Parker	ตาเสือ
57		*Chisocheton siamensis* Craib.	ยมมะกอก
58		*Chukrasia tabularis* A. Juss.	ยมหิน
59	Meliaceae	*Melia toosendan* Sieb. & Zucc.	เลี่ยนดอกม่วง
60		*Sandoricum koetjape* (Burm.f.) Merr.	มะติ่น
61		*Toona ciliate* M. Roem.	ยมหอม
62	Moraceae	*Ficus auriculata* Lour.	เดื่อใบใหญ่
63		*F. benjamina* L. var benjamina	ไทรย้อย
64		*F. callosa* Willd.	มะเดื่อกวาง
65		*F. fistulosa* Reinw ex Bl. *var. fistulosa*	มะเดื่อชิ้ง
66		*F. semicordata var. semicordata*	มะเดื่อขน
67	Myristicaceae	*Horsfieldia glabra* (Bl.) Warb.	มะพร้าวนกกก
68		*Knema furfuracea* (Hk. f. et Th.) Warb.	เลือดควายใบใหญ่
69	Myrsinaceae	*Ardisia polycephala* Wall. ex A. DC.	พิลังกาสา
70	Myrtaceae	*Syzygium megacarpum* (Craib) Rathakr. & N.C. Nair	ชมพู่ป่า
71	Olacaceae	*Anacolosa ilicoides* Mast	ก่อแซะ
72	Orchidaceae	*Habenaria* sp 1.	ว่านนกคุ้มไฟ
73		*Pecteilis* sp 1.	นางอั้ว
74	Piperaceae	*Piperomia pellucid* (L.) Humb.	ผักกระสัง
75		*Piper* sp 1.	จะคร้าน
76		*P.* sp 2.	พลูป่า
77	Pittosporaceae	*Pittosporopsis kerrii* Craib	มะขม
78	Poaceae	*Bambusa tulda* Roxb.	ไผ่บงดำ
79		*B. polymorpha* Munro	ไผ่หอม
80		*B. nutans* Wall *ex* Munro	ไผ่บง
81		*Teinostachyum griffithii* Munro	ไผ่บงเลื้อย

List of vascular plants occurring along Num Mea Ka stream

No.	Family	Species	Vernacular
82	Poaceae	*Dendrocalamus strictus* Nees	ไม้ซาง
83		*D. hamiltonii* Nees &Arn. *ex* Munro	ไผ่หก
84		*D. brandisii* Kurz	ไผ่บงใหญ่
89		*Metadina trichotoma* (Zoll. & Mor) Bakh. f.	ขมิ้น
90		*Mitragyna rotundifolia* (Roxb.) O.K.	กระทุ่มเนิน
91		*Tarennoidea wallichii* (Hook. f.) Tirv. & Sastre	คอไก่
92	Rutaceae	*Murraya paniculata* (L.) Jack	แก้ว
93	Sapindaceae	*Dimocarpus longan* Lour. ssp. *longan*	ลำไยป่า
94		*Harpullia arborea* (Blanco) Radlk.	หอมไกลดง
95		*Pometia pinnata* Forst. & Forst.	แดงน้ำ
96		*Sapindus rarak* DC.	มะคำดีควาย
97	Sapotaceae	*Sarcosperma arboretum* Bth.	มะยาง
98	Simaroubaceae	*Picrasma javanica* Blume	กอมขม
99	Sonneratiaceae	*Duabanga grandiflora* (Roxb. ex DC.) Walp.	ลำพูป่า
100	Sterculiaceae	*Pterocymbium macranthum* Kosterm.	ปอกระด้าง
101		*Pterospermum acerifolium* (L.) Willd.	ปอหูช้าง
102		*P. cinnamonemum* Kurz	ตองเต่า
103		*Sterculia lanceolata* Cav. var. *lanceolata*	ลิ้นง่วง
104	Taccaceae	*Tacca chantrieri* Andre	เนระพูสีไทย
105	Vitaceae	*Tetrastigma* sp.	เครือเขาน้ำ
106	Zingiberaceae	*Amomum* sp.	ข่าป่า
107		*Curcuma* sp.	ขมิ้นแดง
108		*Kaempferia rotunda* L.	ว่านหาวนอน
109		*Zingiber* sp.	ขิงป่า

List of Pteridophyte occurring along Num Mea Ka stream-bank, CDWS.

No.	Family	Species	Vernacular
1	Aspleniaceae	*Asplenium nidus* L. *var. nidus*	ข้าหลวงหลังลาย
2		*A. nomale* D.Don	-
3		*A. phyllitidis* D.Don sub sp. *phyllitidis*	-
4	Athyriaceae	*Diplazium esculentum* (Retz) Sw.	กูดกิน
5		*D. polypodioides* Blume	-
6	Lomariopsidaceae	*Bolbitis appendiculata* (Willd) K.Iwats. subsp. *appendiculata Angiopteris evecta* (Forst) Hoffm.	-
7	Ophioglossaceae	*Leptochilus* sp.	ว่านกีบแรด
8	Polypodiaceae	*Microsorium* sp.	-
9		*Pyrrosia stigmosa* (Sw.) Ching	กูดหางนกกะลิง
10		*Pneumatopteris truncata* (Poir) Holttum	ขาไก่
11	Thelypteridaceae	*Antrophyum* sp.	กูดก้านแดง
12	Vittariaceae	-	-

BIOGRAPHY

Ms. Kruewan Pipatsawasdikul was born on April, 18, 1972. She has worked as a forest technician in Department of National Parks, Wildlife and Plant Conservation, Ministry of Natural Resources and Environment. She received her Bachelor Degree of Science (Forestry) in 1993 and Master Degree of Forest Resource Administration (Environment) in 2005 from Kasetsart University. Her Doctoral degree study in Inter-department of Environmental Science, Graduate School, Chulalongkorn University was supported by the John D. and Catherine T. MacArthur Foundation under the collaboration with Field Museum of Natural History, Chicago, U.S.A. and the Department of Biology, Faculty of Science, Chulalongkorn University; the Center of Excellence in Biodiversity, Faculty of Science, Chulalongkorn University, under the Research Program on Conservation and Utilization of Biodiversity (CEB_D_12_2008); and TRF/BIOTEC Special Program for Biodiversity Research and Training grant BRT T_251002.