Tropical Natural History 12(2): 165-174, October 2012

Home Range of the Impressed Tortoise, *Manouria impressa* (Günther, 1882) at Phu Luang Wildlife Sanctuary, Loei Province, Thailand

PRATYAPORN WANCHAI[1,2], CRAIG B. STANFORD[3], KUMTHORN THIRAKHUPT[2*] AND SOMYING THANHIKORN[4]

[1]*Biological Science Program, Faculty of Science, Chulalongkorn University, Bangkok 10330, THAILAND*
[2]*Department of Biology, Faculty of Science, Chulalongkorn University, Bangkok 10330, THAILAND*
[3]*Department of Anthropology, University of Southern California, Los Angeles, CA 90089, USA*
[4]*Wildlife Research Section, National Park, Wildlife and Plant Conservation Department, Bangkok 10900, THAILAND*
* Corresponding author. E-mail: kumthorn.t@chula.ac.th
Received: 6 February 2012; Accepted: 13 July 2012

ABSTRACT.– Home range sizes of *Manouria impressa* were studied at Phu Luang Wildlife Sanctuary, Loei Province, Thailand, from January 2010 - June 2011. A total of thirteen *M. impressa*, consisting of ten adults (five males and five females) and three juveniles were radio-tracked. The median annual home ranges (minimum convex polygon) for all individuals varied from 2.71 ha - 17.69 ha, and were 1.21 ha - 12.09 ha and 0.21 ha - 12.06 ha in the wet and dry seasons, respectively. The median home range sizes within each season and year-round were not significantly different between adult males, females and juvenile tortoises. The median home range sizes in the wet season were larger than in the dry season for most individuals, and dry season ranges did not entirely lie within wet season ranges and visa versa.

KEY WORDS: Radio-tracking, home range, *Manouria impressa*, turtle ecology

INTRODUCTION

Thailand is one of the world's leading nations in chelonian biodiversity, with at least 26 known species (Thirakhupt and van Dijk, 1994). At present, many turtle and tortoise species in Thailand and other countries are under intensive threats from humans, for example from hunting for food and the pet trade as well as habitat destruction and change (Gibbons et al., 2000, Moll and Moll, 2004, Shepherd and Nijman, 2008, Chen and Lue, 2009). However, most recent works on the turtles and tortoises of Thailand have been concerned with their taxonomy, distribution and status (Nutaphand, 1979, Chan-ard and Nabhitabhata, 1986, Nabhitabhata, 1989, Thirakhupt and van Dijk, 1997), but there have been very few detailed studies on aspects of their behavior and ecology, such as their home range size and activity patterns.

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

Manouria impressa is classified as a vulnerable (Vu) species by IUCN (2008) and CITES (2007) places it in Appendix II. The species appears to be rare in its natural habitat, and exhibits poor breeding and a low survival rate in captivity, ruling out

captive breeding and reintroduction based on conservation strategies. Although *M. impressa* is locally hunted for food and to supply the pet trade, little is known of its habits, diet, reproduction and activities in the wild. Moreover, the *distribution* record of this species in Thailand is still *incomplete*. A greater knowledge of its distribution range, areas of occurrence, habitat characteristics, home range size and other activities in the wild would be very useful for the development of viable conservation management strategies.

MATERIALS AND METHODS

Study Area.– This study was conducted at Phu Luang Wildlife Sanctuary (PLWS), covering an area of 897 km² in the south of Loei Province in the Northeast of Thailand at 17° 3' – 17° 24'N and 101° 16' – 101° 21'E. PLWS covers an area of 897 km² and had an average annual rainfall, *obtained from* PLWS *weather station* at elevation of 1,400 m above mean sea level (amsl), from 1954 to 2000 of 1229 mm (Forest Research Center, 2002), with most of the rain occurring from April to October. Summer starts from late February to April with an average temperature of 20-28 °C. The rainy season is from May to October. On the other hand, the temperature drops significantly during November – January to 4-16 °C. The sanctuary is covered by various forest types, notably dry deciduous dipterocarp, mixed deciduous, dry evergreen, montane evergreen and coniferous forests, plus tropical grassland. This study was conducted at 900 – 1400 m amsl where *M. impressa* was found (Chan-ard et al*.,* 1996). The Forest Research Center (2002) at the Faculty of Forestry, Kasetsart University, reported that the forest type at 500-900 m amsl is tropical dry evergreen forest whereas at 900-1,400 m amsl is tropical montane evergreen forest.

Field methods.– Tortoises were searched for in their natural habitat. When a specimen was discovered, a 148 MHz transmitter was attached to the lower posterior part of the carapace using two-component epoxy glue (Fig. 1), which is waterproof and long-lasting but harmless to the animal (Boardman et al*.,* 1998). Each transmitter (and so marked tortoise) was assigned a unique frequency allowing subsequent independent tracking of individuals. The post-attachment transmitter weights for adults and juveniles were 35 g and 25 g, respectively, and so did not exceed the recommended 5% of body weight guidelines (Schubauer, 1981). Transmitter life was approximately 18 months. Transmitters were replaced if they did not function properly. Tortoises were located using an ATS receiver (Model FM16) and a handheld ATS 3 element Folding Yagi Antenna.

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

FIGURE 1. An adult female *Manouria impressa* photographed in 2010 at Phu Luang Wildlife Sanctuary. Carapace length = 27.5 cm and weight = 3.2 kg.

Analysis of data.– The home range size of each individual and overlap between two individuals were estimated by the Minimum Convex Polygon Method (MCP) using the BIOTAS software program. The home range size of each individual was calculated using locations tracked over at least 4 months. Overlap between two tortoise home ranges was calculated as the percentage of the total home range of each tortoise, following Geffen and Mendelssohn (1988).

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

RESULTS

The home range sizes of the 13 tortoises tracked over the year are shown in Table 1. The size of home ranges varied greatly among individuals; 2.71 ha - 17.69 ha year-round, 1.21 ha - 12.09 ha in wet season and 0.21 ha - 12.06 ha in dry season. The largest home range size was from female (FMI-7) at 17.69 ha. One juvenile tortoise, JMI-4 had a wider home range size than some of the adults. Home range sizes showed no significant correlation with the carapace length or body mass ($P>0.05$; Spearman Rank Order Correlation).

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

TABLE 1. Home range sizes and specimen data for 13 *M. impressa* radio tracked individuals at Phu Luang Wildlife Sanctuary.

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

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

males, females and juveniles in the wet season (Table 2).

Throughout the year, the home range of most individuals overlapped with some of the others. However, there was no evidence that any individual held or defended its territory. The overlaps of home ranges between males, females and juveniles are shown in Figure 2 and Table 3. Annual home range overlaps varied from 0 - 87.8%, with the highest home range overlap (87.8%) occurring between male MMI-5 and female FMI-8. The mean overlap of home ranges between juveniles and adults was 28.8% (range = 2.96 – 75.2%) and a small overlap occurred between the two juveniles, JMI-1 and JMI-4.

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

TABLE 2. Median home range sizes (ha) of male, female and juvenile *M. impressa* tortoises in wet season, dry season and throughout the year.

Season	Male					Female					Juvenile				
	Median	Min	Max	SD	N	Median	Min	Max	SD	N	Median	Min	Max	SD	N
Year-round	9.84	3.85	13.43	2.91	5	9.44	2.77	17.7	6.32	5	7.26	2.71	11.82	6.45	2
Wet	8.31	2.63	10.89	3.27	5	7.07	1.92	12.09	4.09	5	4.8	2.06	7.54	3.88	2
Dry	1.2	1.1	5.72	2.03	5	2.31	0.34	12.36	4.87	5	0.46	0.28	3.64	1.90	3

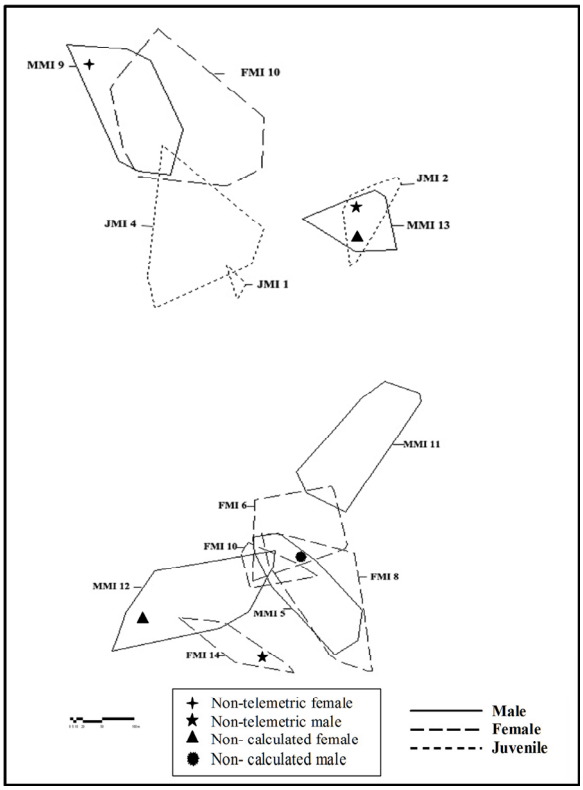

FIGURE 2. A comparison of annual home range overlap and size for five males, five females and three juveniles *M. impressa* at Phu Luang Wildlife Sanctuary.

TABLE 3. Percent overlap of 13 home ranges for *M. impressa* at Phu Luang Wildlife Sanctuary.

Tortoise no.	Males					Females					Juveniles		
	MMI 5	MMI 9	MMI 11	MMI 12	MMI 13	FMI 6	FMI 7	FMI 8	FMI 10	FMI 14	JMI 1	JMI 2	JMI 4
Males													
MMI-5	-	0	0	3.64	0	24.5	0	87.8	18.5	0	0	0	0
MMI-9	0	-	0	0	0	0	64.1	0	0	0	0	0	3.56
MMI-11	0	0	-	0	0	4.44	0	0	0	0	0	0	0
MMI-12	3.20	0	0	-	0	0	0	1.19	9.08	4.17	0	0	0
MMI-13	0	0	0	0	-	0	0	0	0	0	0	52.9	0
Females													
FMI-6	24.3	0	5.30	0	0	-	0	26.6	13.5	0	0	0	0
FMI-7	0	35.7	0	0	0	0	-	0	0	0	0	0	5.42
FMI-8	66.2	0	0	1.29	0	20.2	0	-	9.76	0	0	0	0
FMI-10	62.5	0	0	44.0	0	45.9	0	43.7	-	0	0	0	0
FMI-14		0	0	17.5	0	0	0	0	0	-	0	0	0
Juveniles													
JMI-1	0	0	0	0	0	0	0	0	0	0	-	0	10.7
JMI-2	0	0	0	0	75.2	0	0	0	0	0	0	-	
JMI-4	0	2.96	0	0	0	0	8.12	0	0	0	0.25	0	-

TABLE 4. Comparison of median home range sizes and average carapace lengths of three Thai tortoise species.

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

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

The comparison between the home range sizes of *M. impressa* with two other native tortoise species, *Manouria emys phayrei* and *Indotestudo elongata,* is shown in Table 4. The median home range size of *M. impressa* from this study was similar to those of *I. elongata* but was much smaller than those for *M. emys pheyrai* (Table 3). Tharapoom (1996) studied one male and three females of *I. elongata* in mixed deciduous and dry evergreen forests at elevations from 400-600 m amsl at Huai Kha Khaeng Wildlife Sanctuary, Western Thailand, and reported year-round home range sizes from 7.04 ha - 9.86 ha, with the only male tortoise recorded having a similar home range size to that of the three females.

Wanchai (2007) observed eleven *M. emys phayrei*, consisting of four males, four females and three juveniles, at elevations between 700 to 1,200 m amsl in a dry evergreen forest at Kaeng Krachan National Park, Western Thailand, and reported a year-round home range from 30.3 ha – 105.1 ha and 2.00 ha - 14.8 ha for adults and juveniles, respectively. Comparison between these home ranges suggested that the median home range sizes of males and females of *M. impressa* in this study were significantly smaller than those for *M. emys phayrei*. However, the comparison of the year-round home range sizes among *M. impressa* adults, *I. elongata* adults and *M. emys phayrei* juveniles, that are all similar in their average of carapace length, revealed no significant difference in home ranges.

DISCUSSION

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

There was no significant difference in the home range sizes of *M. impressa* within either the dry or the wet season, nor all year-round between adult males and females in this study. This result is similar to that observed for *I. elongata* in the deciduous forests of Western Thailand (Tharapoom, 1996). Median home range sizes of adult male and female *M. emys phayrei* at 700 to 1,200 m amsl in the dry evergreen forest of Western Thailand were also not significantly different (Wanchai, 2007). Similar results have also been reported for the Egyptian tortoise, *Testudo kleinmanni*, in Northwestern Negev, Israel (Geffen and Mendelssohn, 1988), North American wood turtles, *Clemmys insculpta*, in Central Pennsylvania (Kaufmann, 1995) and *Gopherus agassizii* in the Picacho Mountains of Arizona (Barret, 1990). However, this result is opposite to some terrestrial and aquatic species, in which males have been reported to have a larger home range size than females (Auffenberg and Weaver, 1969, Rose and Judd, 1975, Schubauer et al., 1990, Lue and Chen, 1999, Smith, 2006). The lack of a significant difference between the median home range sizes of males, females and juveniles is probably due to the small sample size and variation in habitat quality and spatial arrangement, as indicated by the high variation among individuals. Diemer (1992) studied 22 gopher tortoises with different sex and age classes, and reported that the longest movement in the study was made by a sub-adult. Rose and Judd (1975) reported that the mean home range sizes of adult male and juvenile Texas tortoises, *Gopherus berlandieri*, were not significantly different.

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

conservation that reduces the metabolic rate when little food is available (Gregory, 1982). An adaptation to the lack of resources has also been reported in the desert tortoise, *Gopherus agassizii*, during droughts, when it uses a smaller home range and travels a shorter distance (Duda et al., 1999). McMaster and Downs (2009) reported that tortoise inactivity in colder periods affect the ability to relocate them.

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

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

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

ACKNOWLEDGEMENTS

This project was supported by the Thai government budget 2010, under the Research Program on Conservation and Utilization of Biodiversity and the Center of Excellence in Biodiversity, Department of Biology, Chulalongkorn University (CE_D_21_2010),

Science Achievement Scholarship of Thailand (SAST), Departments of Anthropology and Biological Sciences, University of Southern California, Los Angeles, USA and the Turtle Conservancy, New York, USA. We are particularly grateful to Mr. Chainarong Doodduem, head of Phu Luang Wildlife Sanctuary. Special thanks to all staff of the Sanctuary for their field assistance.

LITERATURE CITED

Aguirre, G., Adesr, G.A. and Marafka, D.J. 1984. Home range and movement patterns of the Bolson tortoise, *Gopherus flavomarginatus*. Acta Zoologica Mexicana Nueva. 1: l-28.

Auffenberg, W. and Weaver, G. 1969. *Gopherus berlandierz* in southeastern Texas. Bulletin of Florida State Museum. 13: 141-204.

Barrett, S.L. 1990. Home range and habitat of the desert tortoise (*Xerobates agassizii*) in the Picacho Mountains of Arizona. Herpetologica 46: 202-206.

Boardman, W.I., Goodlett, T., Goodlett, G. and Hamilton, P. 1998. Review of radio transmitter attachment and techniques for turtle research and recommendations for improvement. Herpetological Review. 29: 26-33.

Chan-ard, T. and Nabhitabhata, J. 1986. The reptiles of the Huai Kha Khaeng Wildlife Sanctuary. Khao Nang Rum Annual Research Papers 1. Wildlife Conservation Division, RFD.

Chan-ard, T., Thirakhupt, K. and van Dijk, P.P. 1996. Observations on *Manouria impressa* at Phu Luang Wildlife Sanctuary, northeastern Thailand, Chelonian Conservation and Biology. 2: 109-113.

Chen, T. H. and Lue, K.Y. 2009. Changes in the Population Structure and Diet of the Chinese Stripe-Necked Turtle (*Mauremys sinensis*) Inhabiting a Disturbed River in Northern Taiwan. Zoological Studies. 48: 95-105.

CITES. 2007. CITES species database [Online]. Available from:http://www.cites.org

Cox, M., van Dijk, P.P., Nabhitabhata, J. and Thirakhupt, K. 1998. A photographic Guide to Snakes and other Reptiles of Thailand and South-East Asia. Bangkok: Asia Books.

Diemer, J.E. 1992. Home Range and Movment of the Tortoise *Gopherus polyphemus* in Northern Florida. Journal of Herpetology. 26: 158-165.

Duda, J.J., Krzysik, A.J. and Freilich, J.E. 1999. Effects of drought on desert tortoise movement and activity. Journal of Wildlife Management. 63:1181-1192.

Ernst, C.H. and Barbour, R.W. 2001. Turtles of the World. Washington, D.C: Smithsonian Institution Press.

Forest Research Center. 2002. Final Report: Database and Management Plan of Phuluang Wildlife Sanctuary. Forest Research Center, Faculty of Forestry.

Fritz, U., and Havas, P. 2007. Checklist of Chelonians of the World. Vertebrate Zoology. 57: 149-368

Geffen, E. and Mendelssohn, H. 1988. Home range use and seasonal movements of the Egyptian tortoise (*Testudo kleinmanni*) in the northwestern Negev, Israel. Herpetologica. 44: 354-359.

Gibbons, J.W., Scott, D.E. , Ryan, T.J., Buhlmann, K.A., Tuberville, T.D., Metts, B.S., Greene, J.L., Mills, T., Leiden, Y., Poppy, S. and Winn, C.T. 2000. The global decline of reptiles, déjà vu amphibians. BioScience. 50: 653-666.

Gregory, P.T. 1982. Reptilian hibernation. In: C. Gans and F.H. Pough, eds., Biology of the Reptilia. New York: Academic Press. pp. 53-154.

Hailey, A. and Coulson, I.M. 1996. Differential scaling of home-range area to daily movement distance in two African tortoises. Canadian Journal of Zoology. 74: 97-102.

IUCN. 2008. IUCN Red List of Threatened Species [Online]. Available from: www.iucnredlist.org

Kaufmann, J.H. 1995. Home Ranges and Movements of *Wood Turtles*, *Clemmys insculpta*, in Central Pennsylvania. Copeia. 1: 22-27.

Koulang, C. 2008. Behavioural Ecology of Impressed Tortoises, *Manouria impressa* (Günther, 1882) Via Radio Telemetry Study. Master's thesis. Department of Biodiversity Conservation, The Royal University of Phnom Penh.

Lue, K.Y. and Chen, T.H. 1999. Activity, Movement Patterns, and Home Range of the Yellow-Margined Box Turtle (*Cuora flavomarginata*) in Northern Taiwan. Journal of Herpetology 33: 590-600.

McMaster, M.K. and Downs, C.T. 2009. Home Range and Daily Movement of Leopard Tortoises (*Stigmochelys pardalis*) in the Nama-Karoo, South Africa. Journal of Herpetology 43: 561-569.

Moll, D., and Moll, E.O. 2004. The ecology, exploitation, and conservation of river turtles. New York: Oxford Univ. Press.

Mortensen, K.H. 2004. The tortoise *Manouria emys emys*: behaviour and habitat in the wild. Master's thesis, University of Southern Denmark.

Nabhitabhata, J. 1989. Species diversity of Thai herpetofauna. In Biodiversity in Thailand (ed. S Wongsri, S. Laolohakarn). Proceedings 7th Thai Biological Science Conference, Chiang Mai. Science Society of Thailand.

Nutaphand, W. 1979. The Turtles of Thailand. Bangkok: Siamfarm Zoological Gardens.

Rose, F.L. and Judd, F.W. 1975. Activity and Home Range Size of the Texas Tortoise, *Gopherus berlandieri*, in South Texas. Herpetologica. 31: 448-456.

Schmid, J.R., Bolten, A.B., Bjorndal, K.A., Lindberg, W.J., Percival, H.F. and Zwick, P.D. 2003. Home Range and Habitat Use by Kemp's Ridley Turtles in West-Central Florida. Journal of Wildlife Management. 67: 196-206.

Schubauer, J.P. 1981. A reliable radio-telemetry tracking system suitable for studies of chelonians. Journal of Herpetology. 15: 117-120.

Schubauer, J.P., Gibbons, J.W. and Spotila, J.R. 1990. Home range and movement patterns of slider turtles inhabiting Par Pond. In J. W. Gibbons (ed.), Life History and Ecology of the Slider Turtle, Smithsonian Institution Press, Washington, D.C. pp. 223-232.

Shepherd, C.R. and Nijman, V. 2008. Pet freshwater turtle and tortoise trade in Chatuchak Market, Bangkok, Thailand. Petaling Jaya, Malaysia: Traffic Southeast Asia Press.

Smith, T.M. and Smith, R.L. 2006. Elements of Ecology. 6th ed. San Francisco: Pearson Education.

Tharapoom, K. 1996. Radio-Telemetry Study of Home Range Size and Activity of Elongated Tortoise *Indotestudo elongate* (Blyth, 1853) at Huai Kha Khang Wildlife Sanctuary. Master's thesis. Department of Biology, Faculty of Science, Chulalongkorn University, Thailand.

Thirakhupt, K.and van Dijk, PP. 1994. Species diversity and conservation of turtles of western Thailand. Natural History Bulletin of the Siam Society. 42: 207-259.

Thirakhupt, K and van Dijk, P.P. 1997. The Turtle of Western Thailand-Pushed to the Edge by Progress. Proceedings: International Conference (July 11-16, 1993) on Conservation, Restoration, and Management of Tortoises and Freshwater Turtles. New York: S.U.N.Y. Purchase. pp. 272-277.

Wanchai, P. 2007. Radio-telemetry Study of Home Range Size and Activities of the Black Giant Tortoise, *Manouria emys phayrei* (Blyth, 1853). Master's thesis. Department of Biology, Faculty of Science, Chulalongkorn University, Thailand.

Weissinger, H. 1987. Maintenance of *Manouria impressa*, Gunther (1882). Elaphe. 9:9-10.