

Chapter 4

Results and Discussion

In this study, 13 yellow tortoises of different sex, age and size classes (Table 3.1) were tagged with transmitters and tracked for information during June 1995 through May 1996 at Khao Nang Rum Wildlife Research Station (KNR), Huai Kha Khaeng Wildlife Sanctuary, Uthai-Thani Province. Nine wild animals: 4 adult males, 4 adult females and 1 immature male were found in the forest area around KNR (Figure 10) at different times between June 1995 to January 1996. Four captive animals were from different locations in Thailand and had been in captivity for at least two years. Eleven out of 13 tortoises mentioned above provided enough information on home range size, seasonal activity, habitat use and survival rate for at least one season. Data were compared between groups of males and females and between groups of captive and wild tortoises in order to see the differences between sexes and the possibility for survival of the captives after reintroduction to the new area.

4.1 Home range size

The home range size of each individual was estimated using the Minimum Convex Polygon method from software developed by the University of Idaho (Ackerman et al, 1990) on a personal computer. In this study, small sample size of tortoises was studied, so median and non parametric statistics were used to analyse the data. Sizes of the home range were estimated year round and also separated into wet season (June-October) and dry season (November-April). Table 4.1 shows that the size of home ranges varied greatly among individuals. They were $32,398 \text{ m}^2$ to $450,591 \text{ m}^2$; $37,685 \text{ m}^2$ to $189,134 \text{ m}^2$ and $80,093 \text{ m}^2$ to $704,122 \text{ m}^2$ in wet season, dry season and year round, respectively. Home range diagrams of tortoises in the wet season, the dry season and year-round are showed in Figures 11-12, respectively. Individual tortoises also showed great

Table 4.1 Home range sizes of yellow tortoises, *Indotestudo elongata* at Khao Nang Rum Wildlife Research Station.

Tortoise Number	Home range (m ²)		
	Wet season (Jun-Oct) / No. of Fixes	Dry season (Nov-Apr) / No. of Fixes	All year (Jun-May) / No. of Fixes
SKR 1 (c, m [*])	108520.50 / 9	179039.50 / 13	368795.00 / 24
SKR 2 (c, m)	99173.00 / 6	-	-
SNR 9 (c, f)	39631.50 / 8	75276.50 / 13	150266.00 / 23
UNK 10 (c, f)	68282.50 / 9	189314.00 / 14	366285.00 / 23
KNR 8 (w, m)	63942.00 / 11	45187.50 / 15	80093.00 / 29
KNR 20 (w, m)	84037.50 / 7	-	-
KNR 37 (w, m)	-	37685.00 / 13	-
KNR 5 (w, f)	450591.00 / 7	38268.50 / 9	704122.00 / 18
KNR 14 (w, f)	58505.00 / 7	38079.00 / 14	87068.50 / 24
KNR 19 (w, f)	32398.50 / 8	45900.00 / 14	98608.50 / 24
KNR 36 (w, f)	-	41699.00 / 14	-

Note : c = captive, w = wild, m = male, f = female, m^{*} = immature male, SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province; SNR = specimen from a forest near Srinakarin Reservoir, Kanchanaburi Province; KNR = specimen from Khao Nang Rum, Uthai Thani Province; UNK = Unknown

Table 4.2 Median home range sizes of male, female, captive and wild yellow tortoises, *Indotestudo elongata* in the wet season, the dry season and year-round.

Tortoises	Home range (m ²)		
	Wet season (Jun-Oct) / No. of Fixes [n]	Dry season (Nov-Apr) / No. of Fixes [n]	All year (Jun-May) / No. of Fixes [n]
male	91,605.25 / 18 [4]	45,187.5 / 28 [3]	224,444.0 / 29 [2]
Female	58,505.0 / 22 [5]	43,799.5 / 51 [6]	150,266.0 / 66 [5]
Captive	83,727.75 / 32 [4]	17,9039.5 / 40 [3]	366,285.0 / 70 [3]
Wild	63,942.0 / 44 [5]	39,983.75 / 79 [6]	92,838.5 / 95 [4]

Note: n = no. of individuals

Table 4.3 Comparison of Average home range size of another tortoises species.

Tortoise species	Average of Carapace length (mm)		Habitat type	Home range (m ²) size		Studied by	Study time
	Male	Female		Male	Female		
<i>Indotestudo elongata</i>	271	260.6	Tropical forest	224,444*	150,266*	Tharapoom(1997)	12 months
<i>Gopherus agassizii</i>	250.5	228.6	Desert	357,900	176,800	O'Connor et al(1994)	5 months
<i>G. polyphemus</i>	-	-	Drained Lakeland	4,700	800	Mc Rae et al(1981)	12 months
<i>Terrapene ornata</i>	-	-	Arid grassland	21,067	13,391	Nieuwolt(1996)	8 months

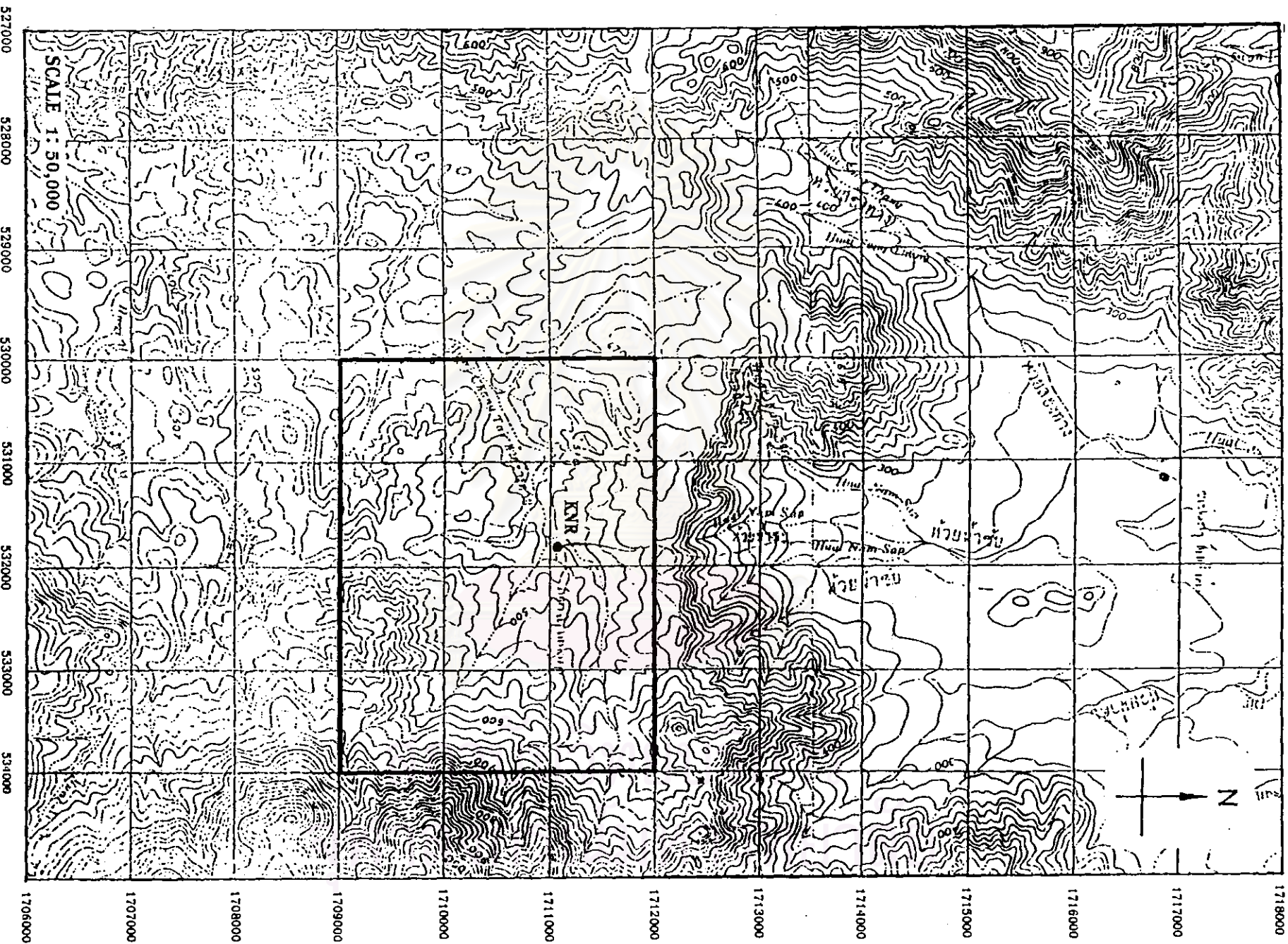


Figure 10. Study area around KNR

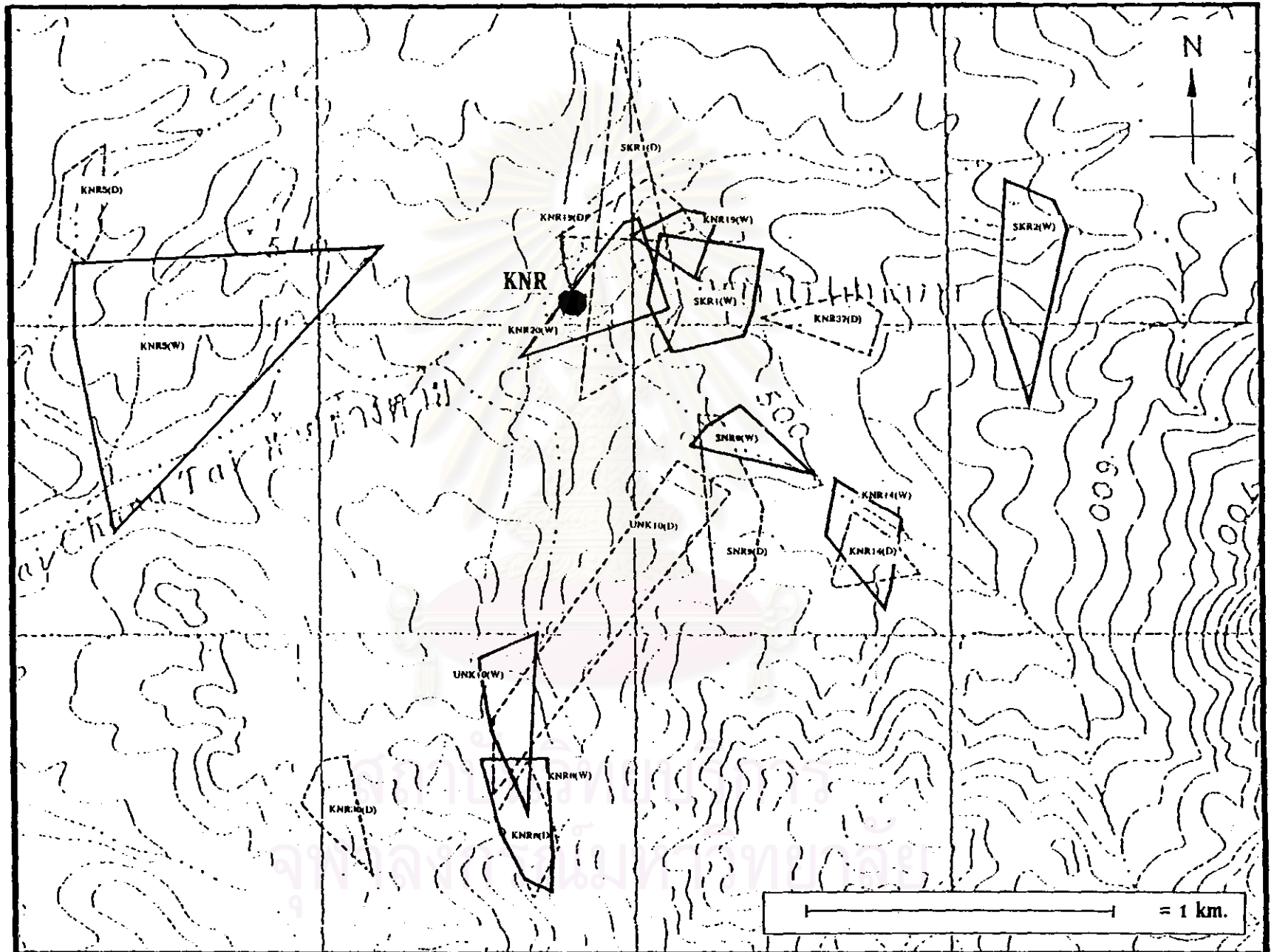


Figure 11. Home range diagrams of yellow tortoises, *Indotestudo elongata* in the wet (W) and the dry season (D).

W = ————— D = - - - - -

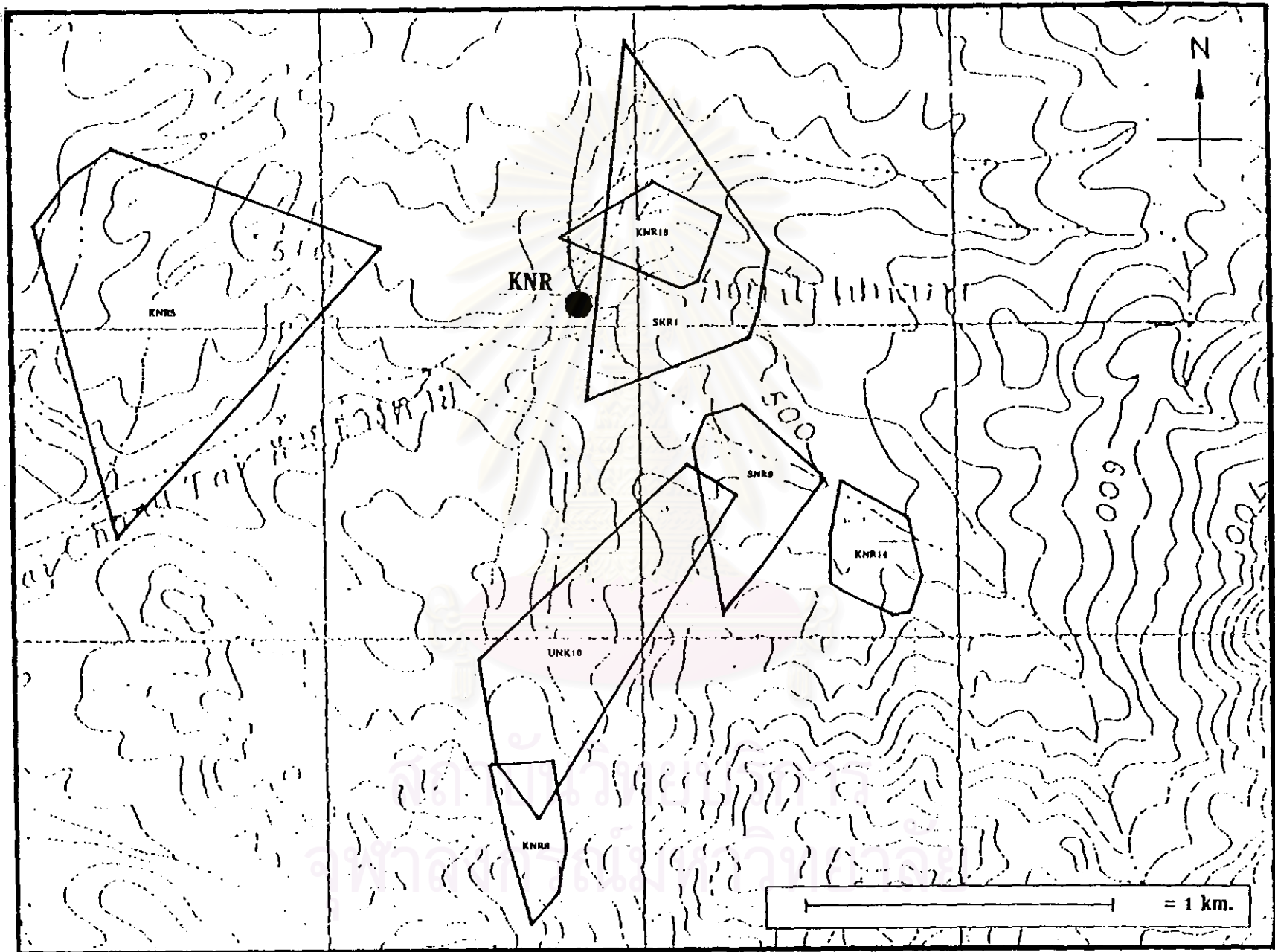


Figure 12. Home range diagrams of yellow tortoises, *Indotestudo elongata* for year-round.

differences in home range sizes between seasons. Table 4.2 shows that home range sizes of male and female tortoises were not significantly different in both seasons and year round though males tended to have a wider home range than females in general. Captive animals also tended to have a wider home range than wild animals in both seasons and year round, but only the median home range size of the captives in the dry season was significantly larger than the home range size of wild tortoises (Mann-Whitney u test, $p \leq 0.05$).

The median home range size of male tortoises in the wet season was significantly larger than the median home range size in the dry season (Table 4.2). This result was similar to the result of female tortoises. However, for captive tortoises, the median home range size in the dry season was significantly larger than that in the wet season. This result was opposite to the result of wild tortoises (Wilcoxon matched paired test, $p \leq 0.05$), and this may be due to adaptation to the lack of resources in dry season. Further studies on factors affecting home range size in both seasons and year round such as the abundance of food, weather condition and adaptation to a new area by captive tortoises should be conducted in the future.

Comparison of year round home range size of yellow tortoises with the average home range sizes of previous studies of other tortoise species are shown in Table 4.3. McRae et al (1981) reported that in a drained lakeland in Georgia, U.S.A., males of *Gopherus polyphemus* had the significantly larger average home range size than females. Similar result was also reported by O'Connor et al (1994) on *Gopherus agassizii* in the desert habitat in Nevada, U.S.A. However, in semi-arid grassland in New Mexico, U.S.A., average home range sizes of *Terrapene ornata luteola* males and females were not significantly different although males tended to have a wider range.



a



b

Figure 13. Resting places of yellow tortoise, *Indotestudo elongata*
a. in the hollow of a tree stump
b. in the hollow



c



d

Figure 13.(cont.) c. and d. beneath grass and dry leaves.

Table 4.4 Observed daytime activity of yellow tortoises, *Indotestudo elongata* in the wet season.

Tortoise No. (Observed time)	Daytime activity in wet season (%)		
	Inactive	Active	No. of fixes
SKR 1 (c,m) (9.38 - 17.00)	100	0	14
SKR 2 (c,m) (9.57 - 15.37)	85.71	14.29	7
SNR 9 (c,f) (9.40 - 18.00)	83.78	16.22	37
UNK 10 (c,f) (9.25 - 17.35)	100	0	11
KNR 8 (w,m) (9.43 - 10.45)	94.64	5.36	56
KNR 20 (w,m) (6.00 - 18.00)	95.05	4.95	222
KNR 26 (w,m) (10.25-18.00)	83.33	16.67	12
KNR 37 (w,m) (14.45-15.50)	100	0	2
KNR 5 (w,f) (9.43 - 10.45)	100	0	10
KNR 14 (w,f) (10.00 - 17.00)	90.48	9.52	21
KNR 19 (w,f) (6.00 - 18.00)	80.91	19.09	372

Note : c = captive, w = wild, m = male, f= female, m* = immature male,

SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province;

SNR = specimen from a forest near Srinakarin Reservoir, Kanchanaburi Province;

KNR = specimen from Khao Nang Rum, Uthai Thani Province; UNK = Unknown

Table 4.5 Observed daytime activity of yellow tortoises, *Indotestudo elongata* in the dry season.

Tortoise No. (Observed time)	Daytime activity in dry season (%)		
	Inactive	Active	No. of fixes
SKR 1 (c,m*) (9.59 - 17.50)	95.24	4.76	21
SKR 2 (c,m) (10.05 - 14.37)	100	0	8
SNR 9 (c,f) (7.23 - 18.00)	80.39	19.61	51
UNK 10 (c,f) (8.10 - 15.00)	100	0	19
KNR 8 (w,m) (9.39 - 18.00)	100	0	71
KNR 20 (w,m) (6.00 - 18.00)	100	0	4
KNR 37 (w,m) (14.45 - 15.50)	100	0	13
KNR 5 (w,f) (9.15 - 18.11)	100	0	20
KNR 14 (w,f) (9.20 - 17.00)	93.75	6.25	64
KNR 19 (w,f) (6.00 - 18.00)	100	0	198
KNR 36 (w,f) (9.24 - 14.35)	100	0	11
KNR53 (w,m*) (10.00 - 16.52)	100	0	7

Note : c = captive, w = wild, m = male, f = female, m* = immature male

SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province;

SNR = specimen from a forest near Srinakarin Reservoir, Kanchanaburi Province;

KNR = specimen from Khao Nang Rum, Uthai Thani Province; UNK = Unknown

Table 4.6 Observed daytime activity of yellow tortoises, *Indotestudo elongata* for year-round.

Tortoise No. (Observed time)	Daytime activity for year-round(%)		
	Inactive	Active	No. of fixes
SKR 1 (c,m) (9.38 - 17.50)	97.14	2.86	3.5
SKR 2 (c,m) (9.57 - 15.37)	93.33	6.66	15
SNR 9 (c,f) (7.23- 18.00)	81.82	18.18	88
UNK 10 (c,f) (8.10 - 17.35)	100	0	30
KNR 8 (w,m) (9.39 - 18.00)	97.60	2.34	128
KNR 20 (w,m) (6.00 - 18.00)	95.30	4.70	298
KNR 37 (w,m) (14.45 - 15.50)	100	0	15
KNR 5 (w,f) (9.15-18.11)	100	0	30
KNR 14 (w,f) (9.20-17.00)	90.70	9.30	86
KNR 19 (w,f) (6.00 - 18.00)	87.54	12.46	883

Note : c = captive, w = wild, m = male, f= female, m* = immature male,

SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province;

SNR = specimen from a forest near Srinakarin Reservoir, Kanchanaburi Province;

KNR = specimen from Khao Nang Rum, Uthai Thani Province; UNK = Unknown

Table 4.7 Median percentage of daytime activity of yellow tortoises in the wet season

Yellow Tortoise (ObservedTime)	Daytime activity in wet season (%)		
	Inactive	Active	No. of fixes
Male(6) (6.00 - 18.00)	94.85	5.16	299
Female(5) (6.00 - 18.00)	90.48	9.52	451
Wild(7) (6.00-18.00)	94.64	5.36	695
Captive(4) (9.25-18.00)	92.86	7.15	69
All tortoises(11) (6.00-18.00)	94.64	5.36	750

Table 4.8 Median percentage of daytime activity of yellow tortoises in the dry season

Yellow Tortoise (ObservedTime)	Daytime activity in dry season (%)		
	Inactive	Active	No. of fixes
Male(6) (6.00 - 18.00)	100	0	96
Female(6) (6.00 - 18.00)	100	0	363
Wild(8) (6.00 - 18.00)	100	0	388
Captive(4) (7.23 - 18.00)	99.62	2.38	99
All tortoises(12) (6.00-18.00)	100	0	459

Table 4.9 Median percentage of daytime activity of yellow tortoises for all year

Yellow Tortoise (ObservedTime)	Daytime activity for all year (%)		
	Inactive	Active	No. of fixes
Male(5) (6.00 - 18.00)	97.14	2.86	456
Female(5) (6.00 - 18.00)	90.7	9.3	1117
Wild(6) (6.00-18.00)	96.45	3.52	1440
Captive(4) (7.23-18.00)	95.24	4.73	168
All tortoises(10) (6.00-18.00)	96.22	3.78	1573

Table 4.10 Daily activity in the wet and the dry season of yellow tortoise No.KNR19 and No.KNR20.

Tortoise No.	Daily activity (%)											
	Wet season						Dry season					
	Day (6.00 - 18.00)			Night (18.10 - 5.50)			Day (6.00 - 18.00)			Night (18.10 - 5.50)		
	Inactive	Active	No. of fixes	Inactive	Active	No. of fixes	Inactive	Active	No. of fixes	Inactive	Active	No. of fixes
KNR 19 (w,f)	80.91	19.09	372	89.12	10.88	147	100	-	198	86.06	13.94	165
KNR 20 (w,m)	95.05	4.95	222	95.77	4.23	71	no data	no data	no data	no data	no data	no data

Note : w = wild, f = female, m = male, KNR = specimen from Khao Nang Rum, Uthai thani Province

Table 4.11 Daily activity of yellow tortoise No.KNR19 (all year).

Tortoise No.	Daily activity all year (%)					
	Day (6.00 - 18.00)			Night (18.10 - 5.50)		
	Inactive	Active	No. of fixes	Inactive	Active	No. of fixes
KNR 19 (w,f)	84.18	15.82	570	94.46	5.54	312

Note : w = wild, f = female, KNR = specimen from Khao Nang Rum, Uthai Thani Province

4.2 Seasonal Activity

Most tortoises were often found beneath leaf litter, and some tortoises were found among the buttresses of big trees and inside hollow tree trunks and logs (Figure 13). The majority of all individuals were resting (Figure 13) when encountered either in wet or dry season (Tables 4.4 and 4.5). In wet season, 7 of 11 tortoises were found while active (4.95-19.09%) whereas in dry season, only 3 of 12 tortoises were found during a period of activity (9.76-19.61%).

From the median percentage of activity, there were no significant differences between sexes and between captive and wild tortoises either in wet or dry season (Mann-Whitney u test, $p \leq 0.05$) (Tables 4.7 and 4.8).

For year-round daytime activity, all individual tortoises spent most of their time at rest (Table 4.6). From median percentage activity, females tended to have more activity than males but there were no significant differences between sexes and between captive and wild (Mann-Whitney u test, $p \leq 0.05$) (Table 4.9)

Yellow tortoises spent the majority of their time resting during the dry season more than in the wet season (Wilcoxon matched paired test, $p \leq 0.05$) (Tables 4.7 and 4.8). The seasonal change may have influence on the activity of tortoises directly or indirectly. It may have directly affected body function of tortoises, in that many reptiles have "preferred" body temperature and, while active, they are able to maintain their temperatures within a relatively narrow range by behavioral means (Porter, 1972). It may indirectly affect some food plants of yellow tortoises. Many kinds of mushrooms were easily found in the forest during the wet season and many workers at KNR often found yellow tortoises eating mushroom while they were looking for edible mushrooms during or after rain.

In this study, the activity of two individuals (KNR19 and KNR20) were observed around the clock for one day during the wet season. KNR19 was also observed around the clock for a day in the dry season (Table 4.10). In the wet season period, KNR19 and KNR20 spent most of their time in rest. KNR19 was more active during daytime than nighttime and was more active than KNR20 either during daytime or nighttime. In dry season, KNR19 spent the entire of daytime in rest and showed little activities at night.

Table 4.11 demonstrates that, overall, KNR19 spent most of the time resting and was found to be more active during the day.

During this study, two interactions between males and females were observed. The first was early in the wet season while they were staying together (May 1995), and the second late in the wet season (October 1995). For the latter, they were found copulating in the evening. From relocation, the tortoise KNR19, SKR1, SKR9 and UNK10 could go across a shallow stream in the dry season.

Comparisons to the previous studies of terrestrial turtles and tortoises, the activity patterns of *Terrapene carolina bauri* (Dodd et al., 1994), were similar between males and females, but varied seasonally, and the majority of *T. carolina bauri* were resting when encountered. This result was similar to *Indotestudo elongata* in this study. In the activity study of *Gopherus polyphemus* (McRae et al., 1981), it was found that its activities were severely restricted during winter while the activities of *I. elongata* were restricted during the dry season. During spring and summer, females of *G. polyphemus* were more sedentary than males but there were no significant differences in activity patterns between sexes of *I. elongata*. In *Terrapene ornata luteola*, females rested significantly less and spent significantly more time walking than males, a result similar to the activity of *Testudo hermanni* studied by Calzolari and Chelazzi (1991). During daytime *T. ornata luteola* usually stayed in kangaroo rat burrows or in

Table 4.12 Ambient temperature and relative humidity (R.H.) at the positions where yellow tortoises, *Indotestudo elongata* were located.

Tortoise No.	Inactive Temp (°C) & R.H. (%)		Active Temp (°C) & R.H. (%)	
	Mean Temp (No. of fixes) [Min-Max]	Mean R.H. (No. of fixes) [Min-Max]	Mean Temp (No. of fixes) [Min-Max]	Mean R.H. (No. of fixes) [Min-Max]
SKR 1 (c, m*)	27.88± 3.88(33) [21.0-37.2]	75.64 ±17.07(32) [38-100]	No data	No data
SKR 2 (c,m)	29.42 ±5.50(14) [16.0-40.5]	71.80 ±16.63(12) [78-100]	27.2(1)	92(1)
SNR 9 (c,f)	26.31 ±3.27(72) [18.5-36.1]	82.49 ±20.05(70) [31-100]	29.70±5.19(16) [23.0-38.3]	80.13±17.80(16) [51-100]
UNK 10 (c,f)	27.37 ±4.10(30) [20.0-36.6]	79.64 ±17.18(28) [45-100]	No data	No data
KNR 8 (w,m)	26.68 ±5.15(125) [15.0-40.5]	78.80 ±16.95(105) [38-100]	26.30±2.17(3) [24.0-28.3]	86.33±4.04(3) [84-97]
KNR 20 (w,m)	22.14 ±1.41(281) [20.0-26.6]	96.45 ±6.28(11) [84-100]0	22.56±3.54(14) [19.0-33.8]	72(1)
KNR 26 (w,m)	26.56±2.10(10) [23.8-37.1]	93.40±7.95(10) [77-100]	23.85±1.63(2) [22.70-25.0]	100(2)
KNR 37 (w,m)	25.66 ±4.58(11) [17.0-33.3]	77.67 ±21.24(15) [34-100]	No data	No data
KNR 53 (w,m*)	29.29±2.62(7) [26.6-33.8]	73.33±16.12(9) [45-100]	No data	No data
KNR 5 (w,f)	25.32 ±4.34(30) [16.0-34.4]	85.10 ±13.00(28) [38-100]	No data	No data
KNR 14 (w,f)	27.24 ±4.14(78) [17.0-38.8]	77.86 ±17.22(63) [36-100]	28.14±4.43(8) [24.0-37.0]	85.88±12.69(8) [66-100]
KNR 19 (w,f)	22.26 ±3.90(773) [16.0-39.0]	82.82 ±41.73(19) [55-100]	24.26±3.12(110) [20.0-33.0]	85.60±15.71(5) [68-100]
KNR 36 (w,f)	24.75±5.33(11) [17.0-36.1]	74.70±14.41(10) [52-100]	No data	No data

Note : c=captive, w=wild, m=male, f=female, m*=immature male, SKR=specimen from Sakaeat Experimental Station, Nakorn Ratchasima Province; SNR= specimen from Srinakarin Reservoir, Kanchanaburi Province; KNR= specimen from Khao Nang Rum, Uthai Thani Province; UNK = Unknown

clumps of vegetation, while *I. elongata* were often found beneath leaf litter during inactive periods.

4.3 Temperature and Relative Humidity (R.H.)

The temperature and R.H. was recorded in habitats of located tortoises. When a tortoise's activity was checked by radio-telemetry, the temperature was also recorded by the equipment but not R.H.

Table 4.12 demonstrates the ambient temperature and R.H.(%) at the position where yellow tortoises were relocated during inactive and active periods. KNR8 kept resting in the place that had the widest range of temperature (15.0-40.5 °c) and SNR9 kept inactive in the place that had the widest range of relative humidity (31-100%). During collecting field data, most tortoises were found while resting, so the environmental data of active tortoises were lacking. All of the environmental data were compared between groups of males and females and between groups of captive and wild tortoises. Male tortoises kept resting at significantly higher average temperature than females but the average temperatures were not different greatly (Table 4.13). Captive tortoises kept resting and moving at significantly higher average temperature than wild tortoises. There were no significant differences in the ambient R.H. between sexes and between captive and wild tortoises when they were active and inactive (Table 4.13).

There were no significant differences in the ambient temperature and R.H., at the positions where yellow tortoises were relocated, of male tortoises between inactive and active periods. However, the ambient temperature surrounding active females were significantly higher than of inactive females. There were no significant differences in R.H. between inactive and active periods, though R.H. during active period tended to be a little higher.

Table 4.13 Means and ranges of ambient Temperature and Relative Humidity (R.H.) at the positions where yellow tortoises, *I. elongata* were located during active and inactive periods. Data were compared between groups of males and females and between groups of captive and wild tortoises.

Temp (°c) & R.H.(%)	Tortoises			
	male(7)	female(6)	wild(9)	captive(4)
Mean Temp(No.of fixes)	24.20±4.10	23.22±4.32	23.13±4.12	27.16±3.91
[Min-Max]	(479)	(994)	(1324)	(149)
Inactive	[15.0-40.5]	[16.0-39.0]	[15.0-40.5]	[16.0-40.5]
Mean R.H.(No. of fixes)	79.26±17.34	80.89±17.45	80.38±16.09	79.48±18.75
[Min-Max]	(193)	(223)	(284)	(142)
Inactive	[34-100]	[31-100]	[34-100]	[31-100]
Mean Temp(No.of fixes)	23.48±3.44	25.14±3.97	24.35±3.37	29.55±5.06
[Min-Max]	(19)	(134)	(137)	(17)
Active	[19.0-33.8]	[23.0-38.3]	[19.0-33.8]	[23.0-38.3]
Mean R.H.(No. of fixes)	89.00±9.95	82.66±15.92	86.63±12.3	79.63±17.31
[Min-Max]	(6)	(29)	(18)	(16)
Active	[72-100]	[51-100]	[66-100]	[51-100]

In the study of *T. ornata luteola*, they were active during ambient temperatures of 13.0-24.0 °C (Nieuwolt, 1996) while in this study, *I. elongata* were active during ambient temperatures of 19.0-38.3 °C.

Mean ambient temperatures and R.H. at the positions where individuals were relocated are demonstrated in Table 4.14. KNR8 lived in the places of widest range of temperature (15.0-40.5 °C) and SNR9 lived in the places of widest range of R.H. (31-100%).

Table 4.15 shows that the average ambient temperature of males were significantly higher than of females (t-test, $p \leq 0.05$) but there were no significant differences in R.H. between sexes.

Table 4.14 Mean ambient Temperature and Relative Humidity (R.H.) at the positions where yellow tortoises, *Indotestudo elongata* were located.

Tortoise No.	Temp (°c) & R.H. (%)	
	Mean Temp (No. of fixes) [Min-Max]	Mean R.H. (No. of fixes) [Min-Max]
SKR 1 (c, m*)	27.88 ±3.88(33) [21.0-37.2]	75.64± 17.07(32) [38-100]
SKR 2 (c,m)	29.42 ±5.50(14) [16.0-40.5]	71.80 ±16.63(12) [48-100]
SNR 9 (c,f)	26.93 ±3.89(88) [18.5-38.3]	82.05 ±19.57(86) [31-100]
UNK 10 (c,f)	27.37 ±4.10(30) [20.0-36.6]	79.64± 17.18(28) [45-100]
KNR 8 (w,m)	26.67± 5.10(128) [15.0-40.5]	79.0±1 16.77(108) [38-100]
KNR 20 (w,m)	22.16 ±1.57(295) [19.0-33.8]	94.42 ±9.26(12) [72-100]
KNR 26 (w,m)	26.11 ±2.23(12) [22.7-31.1]	94.50 ±7.63(12) [77-100]
KNR 37 (w,m)	25.66 ±4.58(11) [17.0-33.3]	77.67± 21.23(15) [34-100]
KNR 53 (w,m*)	29.29 ±2.62(7) [26.6-33.8]	73.33± 16.12(9) [45-100]
KNR 5 (w,f)	25.32 ±4.32(30) [16.0-34.4]	75.09 12.91± (28) [58-100]
KNR 14 (w,f)	27.33± 4.15(86) [17.0-38.8]	78.76 ±16.90(71) [36-100]
KNR 19 (w,f)	22.51± 3.87(883) [16.0-39.0]	84.40 ±14.63(24) [55-100]
KNR 36 (w,f)	24.75± 5.33(11) [17.0-36.1]	74.70 ±14.41(10) [52-100]

Note : c = captive, w = wild, m = male, f= female, m* = immature male,
 SKR = specimen from Sakaerat Experimental Station, Nakorn Rachasima Province;
 SNR = specimen from a forest near Srinakarin Reservoir, Kanchanaburi Province;
 KNR = specimen from Khao Nang Rum, Uthai Thani Province; UNK = Unknown

Table 4.15 Means and ranges of ambient Temperature and Relative Humidity (R.H.) at the positions where yellow tortoises, *I. elongata* were located. Data were compared between groups of males and females and between groups of captive and wild tortoises.

Temp (° c) & R.H. (%)	Tortoises			
	male (6)	female (7)	wild(9)	captive(4)
Mean Temp (No. of fixes) [Min-Max]	24.08±4.16 ^a (460) [15.0-40.5]	23.38±4.25 ^a (1128) [16.0-39.0]	23.22±4.10 ^a (1423) [15.0-40.5]	27.16±3.90 ^b (165) [16.0-40.5]
Mean R.H. (No. of fixes) [Min-Max]	79.06±17.20 ^a (200) [34-100]	80.05±17.48 ^a (239) [31-100]	80.42±16.68 ^a (289) [34-100]	78.02±18.62 ^a (150) [31-100]

Table 4.15 demonstrates that the average ambient temperatures of the captives were significantly higher than the average ambient temperature of the wilds (t-test, $p \leq 0.05$) but there were no significant differences in the average ambient R.H. between the wild and the captive.

T. carolina bauri lived in habitat that had a wide range of temperature (17.0-36.0 °C) and wide range of R.H. (24-94 %) (Dodd et al., 1994) while *I. elongata* could live in habitat that had a wider range of temperature (15.0-40.5 °C) and higher range of R.H. (31-100%).

4.4 Habitat use

Types of habitats were recorded when each tortoise was located. Yellow tortoises were found in 3 main types of forests such as mixed deciduous, dry evergreen and dry dipterocarp, including ecotonal areas of these types of forests. From the median percentage, most individuals either wild or captive tortoises spent their time in mixed deciduous forest (Table 4.16). During the dry season, captive tortoises spent most of the time in dry evergreen forest whereas wild tortoises mostly spent their time in mixed deciduous forest (Table 4.17). Throughout the year, captive tortoises spent most of their time in dry evergreen and mixed deciduous forest while wild tortoises spent most of the time in mixed deciduous (Table 4.18).

Some tortoises were found in an area after it had been burnt, where all of seedlings, saplings and herbaceous cover had been completely burnt. KNR8 was found once beneath a burnt tree trunk which was covered with a lot of ash. KNR8 was alive without injury. KNR19 used to be found in a secondary growth area while she was resting close to the pile of cutting grass of the station.

Most tortoises were found in mixed deciduous and dry evergreen forest. This may be because of the forest types in the study area comprised 35% mixed deciduous forest and 35% dry evergreen forest, where both types could supply enough shelter and food for those tortoises.

G. agassizii varied widely in their habitat use without any clear fidelity to particular areas (O'Connor et al., 1994). *T. carolina bauri* was often found either in palm-pepper forest or on the lawn (Dodd et al., 1994).

Table 4.16 Percentages of habitat use in the wet season of yellow tortoises, *Intestudo elongata*.

Tortoise No.	Habitat use : Wet season (%)								
	MD	DD	DE	MD& DD	MD& DE	DD& DE	ABA	SGA	No.of fixes
SKR 1.(c, m*)	50.00	35.71	-	7.14	-	7.14	-	-	14
SKR 2.(c, m)	42.86	-	42.86	14.29	-	-	-	-	7
SNR 9.(c, f)	5.41	-	86.49	5.41	2.70	-	-	-	37
UNK 10.(c, f)	54.55	-	9.09	9.09	9.09	9.09	9.09	-	11
KNR 8.(w, m)	6.89	3.45	-	29.31	-	-	60.34	-	58
KNR 20.(w, m)	100	-	-	-	-	-	-	-	8
KNR 26.(w, m)	75.00	-	-	-	-	-	3.25	-	12
KNR 37.(w, m)	50.00	-	-	-	50.00	-	-	-	2
KNR 5.(w, f)	72.73	9.09	-	-	18.18	-	-	-	11
KNR 14.(w, f)	32.00	-	25.69	-	3.85	-	38.46	-	26
KNR 19.(w, f)	37.50	-	-	12.5	37.5	-	-	12.5	16
KNR 53.(w, j)	-	100	-	-	-	-	-	-	2

Note : c = captive, w = wild, m = male, f = female, m* = immature male, SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province, SNR = specimen from Srinakarin, KNR specimen from Khao Nang Rum, UNK = unknown, MD = mix deciduous, DD = dry dipterocarp, DE = dry evergreen, ABA = after burning area, SGA = secondary growth area

Table 4.17 Percentages of habitat use in the dry season of yellow tortoises, *Indotestudo elongata*.

Tortoise No.	Habitat use : Dry season (%)								
	MD	DD	DE	MD& DD	MD& DE	DD& DE	ABA	SGA	No.of fixes
SKR 1.(c, m*)	14.26	33.33	38.10	14.76	9.52	-	-	-	21
SKR 2.(c, m)	75.00	-	12.50	-	12.5	-	-	-	8
SNR 9.(c, f)	6.00	-	36.00	2.00	56.00	-	-	-	50
UNK 10.(c, f)	-	21.05	52.63	5.26	21.05	-	-	-	19
KNR 8.(w, m)	27.94	16.18	-	54.41	54.41	-	1.47	-	68
KNR 20.(w, m)	100	-	-	-	-	-	-	-	4
KNR 37.(w, m)	92.86	-	-	-	7.14	-	-	-	14
KNR 5.(w, f)	100	-	-	-	-	-	-	-	19
KNR 14.(w, f)	61.19	-	31.34	-	5.97	-	1.49	-	67
KNR 19.(w, f)	61.34	-	-	17.69	23.08	-	-	7.69	13
KNR 36.(w, f)	-	61.54	-	-	-	-	-	-	12
KNR 53.(w, j)	-	-	-	100	-	-	-	-	7

Note : c = captive, w = wild, m = male, f = female, m* = immature male, SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province, SNR = specimen from Srinakarin, KNR specimen from Khao Nang Rum, UNK = unknown, MD = mix deciduous, DD = dry dipterocarp, DE = dry evergreen, ABA = after burning area, SGA = secondary growth area

Table 4.18 Percentages of habitat use for year-round by yellow tortoises, *Indotestudo elongata*.

Tortoise No.	Habitat use : year-round (%)								No. of fixes
	MD	DD	DE	MD& DD	MD& DE	DD& DE	ABA	SGA	
SKR 1.(c, m*)	28.57	31.42	20.00	11.43	5.71	2.86	-	-	35
SKR 2.(c, m)	66.66	-	26.67	6.67	6.67	-	-	-	15
SNR 9.(c, f)	5.75	-	57.47	3.45	33.33	-	-	-	87
UNK 10.(c, f)	20.00	13.33	36.67	6.67	16.67	3.33	3.33	-	30
KNR 8.(w, m)	18.25	10.32	-	42.86	-	-	28.57	-	126
KNR 20.(w, m)	100	-	-	-	-	-	-	-	12
KNR 37.(w, m)	87.50	-	-	-	12.25	-	-	-	16
KNR 5.(w, f)	90.00	3.33	-	-	6.67	-	-	-	30
KNR 14.(w, f)	58.06	-	24.73	-	5.38	-	11.83	-	93
KNR 19.(w, f)	43.28	-	10.34	31.03	-	-	-	10.34	29
KNR 53.(w, m*)	-	22.22	11.76	-	-	-	-	-	9

Note : c = captive, w = wild, m = male, f = female, m* = immature male, SKR = specimen from Sakaerat Experimental Station, Nakorn Ratchasima Province, SNR = specimen from Srinakarin, KNR = specimen from Khao Nang Rum, UNK = unknown. MD = mix deciduous, DD = dry dipterocarp, DE = dry evergreen, ABA = after burning area, SGA = secondary growth area

4.5 Survival of captive tortoises

Four captive tortoises from different locations in Thailand were tagged with transmitters and released in the forest at Khao Nang Rum Wildlife Research Station. All of them could survive in their new habitat for at least a year but one of them died after 11 months. The cause of death could not be diagnosed, but a number of elephant tracks were detected around the area of the latest location . So the survival rate of the captive tortoises in this study was 75 percent. However, all tortoises showed seasonal weight increase that was similar to wild tortoises. In general the tortoise's weight (both captives and wilds) would slightly increase and decrease during wet season and dry season, respectively (Figure 14). The abundance of food and water in different seasons may directly affect the weight of tortoises .

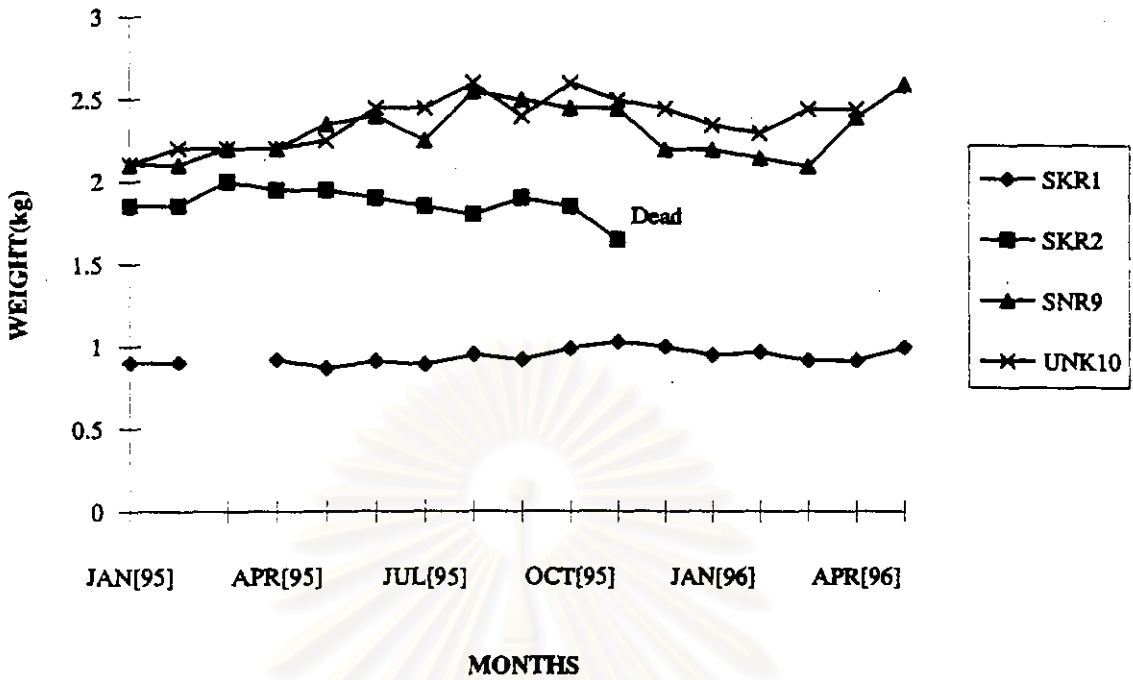
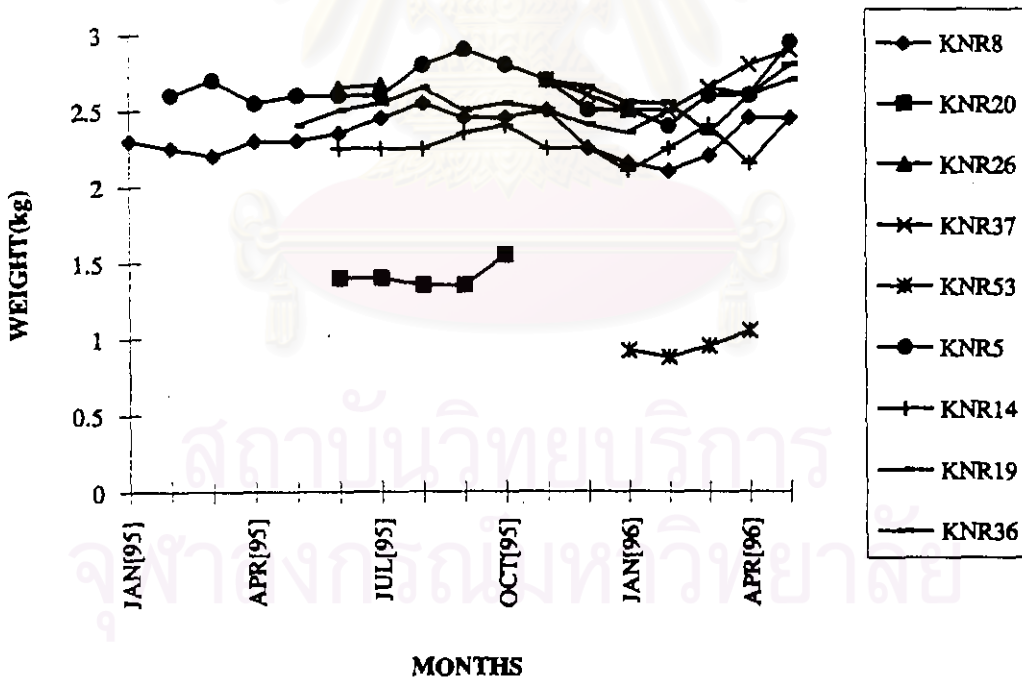


Figure 14. The weight of captive tortoises from January 1995 to May 1996



[KNR19 died in June 1996 ; KNR26 disappeared in August 1995]

Figure 15. The weight of wild tortoises from January 1995 to May 1996

captive tortoises in this study was 75 percent. However, all tortoises showed seasonal weight increase that was similar to wild tortoises. In general the tortoise's weight (both captives and wilds) would slightly increase and decrease during wet season and dry season, respectively (Figure 14). The abundance of food and water in different seasons may directly affect the weight of tortoises .

One of the wild tortoises (KNR26) disappeared after being monitored for 2 months and his transmitter was found on the ground. Another wild tortoise died a week after the field work was finished. The pile of her bones and the transmitter were found and her last weight had been normal. The data of six wild tortoises were collected since this field work was started, two of them died and one of them lost. Therefore, the survival rate of these wild tortoises was 66 percent (Figure 15).



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