Figure 9 Behaviors of white-handed gibbon (A. vocalizing, B. feeding, C. stool and urinate, D. autogrooming and E., F. allogrooming).

Play behavior of the juveniles was higher in percentage than that of the adults. Play behavior was the third most common activity for the juveniles. The juveniles played essentially throughout the day. Usually the smaller juvenile played more than the larger juvenile. When the adult female had an infant, the smaller juvenile trended to play with its mother.

Gibbon rarely showed *Aggressive* behavior within the group; however, I witnessed four to five times that the adult male gibbon behaved aggressively towards invading close individuals which came to his family's territory. The adult male chased the invader out of the territory. In addition, the adult female expelled the sub-adult female from the family group. During this incident, the adult female chased the sub-adult female so that she moved downwards - approximately five meters in height above the ground. Furthermore, on some occasions, the greater racket-tailed drongos (*Dicrurus paradiseus*) attacked the adult female, because she appeared to be near the bird nest which contained eggs.

Gibbons are diurnal primates, but they tend to go to sleep early. Usually at approximately 15:20 o'clock, gibbons began to rest on the roosting tree for the whole night. The gibbons selected specific trees for sleeping. They always stayed at the center of their home range. They often slept in the group of trees in the same area which they used repeatedly for sleeping. The small juvenile slept close to the adult female. Before sleeping, the adult female groomed the small juvenile for a very long time until it fell asleep. The adult male and the sub-adult slept apart, each in a separate tree, which was approximately 30-50 meters away.

Other behavior includes bathing in the sun, defecating and urinating. Gibbons did sun bathing in the morning, particularly in the winter they bathed for a long time. On some days, gibbons defecated more than others. Many times gibbons urinated after defecation. When gibbons defecated or urinated, they often hung by both arms and lifted both legs to their body.

Apart from the general differences discussed above, the details of each behavior over the course of the day were not very different from other research (e.g., Palombit, 1997; Bartlett, 1999;

Punnadee and Damiana, 2004). It is particularly noteworthy that in all populations, gibbons start resting early in the afternoon at around 15 o'clock (Palombit, 1997).

In addition to these general activities, there were interesting other behaviors between white-handed gibbon and other primates. When I observed the family G1, I came into contact also with the Phayre's leaf monkeys (*Trachypithecus phayrei*, Blyth 1847), Assamese macaques (*Macaca assamensis*, McClelland 1839), and rhesus macaques (*Macaca mulatta*, Zimmermann 1780). Depending on the species, the white-handed gibbon showed different behaviors when they met these primates. The gibbons seemed not to be afraid of the Phayre's leaf monkeys. On several occasions, I saw the white-handed gibbons and Phayre's leaf monkeys eating the ripe figs on the same tree. And one time, Phayre's leaf monkeys passed the sleeping site of G1's family, who remained silent. In contrast, the white-handed gibbons seem to be afraid of the macaques. In this study I could not see an encounter or confrontation between gibbons and macaques. However, when the white-handed gibbon heard the sound of macaques, they would move away or remain very quiet.

1.3 Home Range: The size of the home range of family G1 for the whole year (Nov. 2003 - Oct. 2004) was 59.71 ha (95% Kernel) and 28.83 ha (50% Kernel) (Figure 10A). Most areas of G1's home range were composed of dry evergreen forest (95%) with an additional 5% being hill evergreen forest. In the dry season, G1's home range was slightly smaller with 52.20 and 21.52 ha (95 and 50% Kernel method) (Figure 10B). During the rainy season, G1 home range was even smaller at 48.74 and 19.89 ha (95 and 50% Kernel method) (Figure 10C).

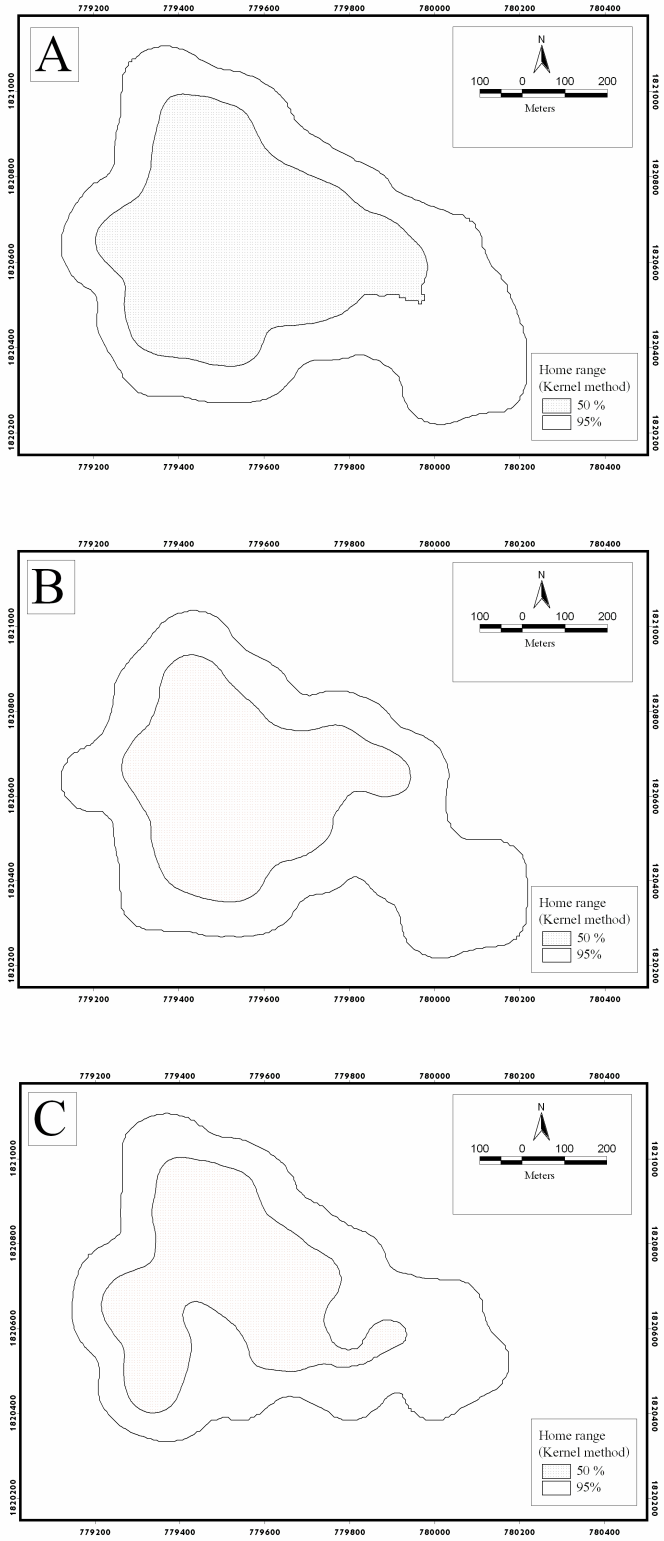

Figure 10 Home range of the white-handed gibbon by the Kernel method (A. home range for the whole year, B. home range in the dry season and C. home range in the wet season).

When comparing these results to other studies, it is probably not surprising that home ranges of gibbons in evergreen forests are considerably smaller. For example, at Khao Yai NP, home ranges are about 24 ha on average (see also Ellefson, 1968; Chivers, 1972 for other areas.). Most likely, the different sizes of home ranges are caused by the different distribution, abundance and available of food plants species in each different area (details in chapter 1.4). However, when comparing these results with research of Muangkhum (2001) who studied the home range size of white-handed gibbons inhabiting the dry evergreen forest in Huai Kha Khaeng wildlife sanctuary, the size of G1 family's home range was much larger. Over three periods even the 50% Kernel home ranges were much larger than at Huai Kha Khaeng: whole year 11.48 ha, in the dry season 10.64 ha and in the wet season 8.76 ha. It is still possible that this difference is caused by differences in food distribution and abundance, but it is also possible that such a difference has been caused by different methods of data collection and analysis. In any case, the current results show one of the largest home ranges ever recorded for white-handed gibbons. Only the study by Yimkao (2005) in deciduous forest at Mae Hong Son found similarly large home ranges of white-handed gibbons at 40 to 61 ha.

The gibbons' home range is the area, in which they used to do everything. Because much of the behavior relates to locomotion and feeding, the size of the home range usually relates to the abundance and distribution of foods. The home range of G1 showed some variation in size over the season: in the dry season it was larger (52.20 ha) than in the wet season (47.74 ha). Because available biomass of food plants is likely lower in the dry season than in the wet season, the white-handed gibbons had to move farther for foraging in the dry season. Thus, it is likely that the larger size of home range in the dry season relates to lower food abundance. In addition, although the size of the home range was different in the two seasons, there was a core area of approximately 41 ha (67% of the whole year home range), which the white-handed gibbons used in both seasons (Figure 11). This core area appears to be important for white-handed gibbons, because it may harbor important food sources for example figs which bear fruits or other important food plants.

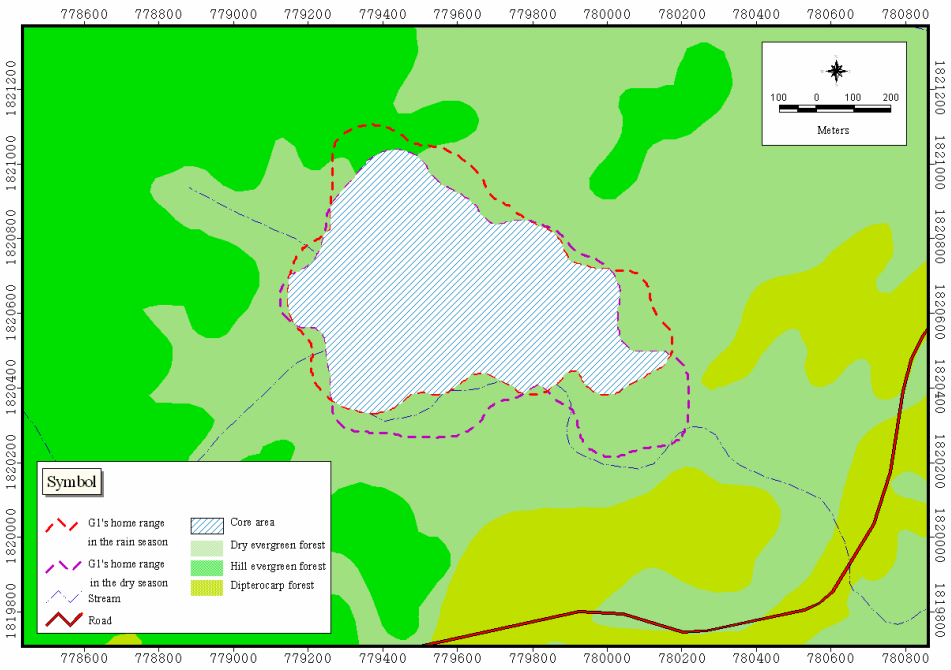

Figure 11 The core area of G1's home range

Throughout this study, there were four additional gibbon families (GA, GF, GB and GE), which had their home range boundaries connected to the home range of G1 (Figure 12). One additional fifth family (GD) lived south of the areas unconnected to the home range of G1. Each of these families was different in size, individual color, and age structure (Table 2). In fact, I encountered many gibbon individuals of various family groups while I was observing G1. The details of all the gibbon families encountered are shown in Appendix Table1. Based on these encounters, the average family group size in the study area was 3.33 individuals (n = 6).

When G1's home range (95% Kernel method) was reduced by the home range overlap with their neighbours, the remaining G1's territory was approximately 41 ha. This territory of G1 (41 ha) has the same size than the core area (41 ha), i.e., the overlap of G1's home ranges of dry season and wet season. Figure 12 shows the home range of G1 and its neighbours. It becomes apparent that G1 did not have neighbours in the east and southeast. This lack of neighbours can at least partly be explained by the fact that dry dipterocarp forest predominates in the east and southeast of G1's home range. Dry dipterocarp forest is not a suitable forest for white-handed gibbons.

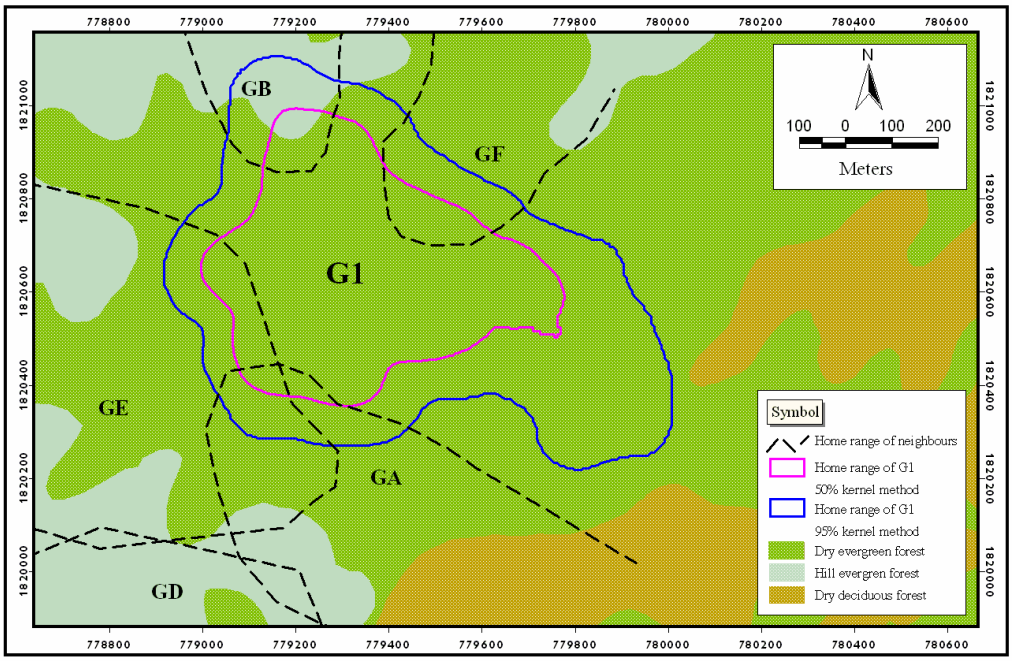

Figure 12 Home range of study group (G1) and neighbours (GA, GB, GD, GE and GF).

Table 2 Age structure and colors of the focal group G1 and its neighbouring family groups (October 2004)

Group	AM	AF	BJ	SJ	Inf	Remark
G1	dark buff	black	-	dark brown	black	study group
GA	buff	black	-	-	black	south
GB	black	black	-	-	-	north
GD	pale buff	buff	buff	buff	-	not connected
GE	pale buff	black	-	-	black	west
GF	black	black	-	black	buff	northeast

1.4 Foods: The focal family of the white-handed gibbons at Huai Mai Sot Yai ate altogether 25 species, 22 genera, and 16 families of plants and various species of climbers (Table 3). Most of the food plants from this study were from Family Euphorbiaceae and F. Moraceae i.e. Mamao Sai (*Antidesma sootepense* Craib) and Sai Yoi Bai Thu (*Ficus retusa* L. var. *retusa*).

In the dry season (November 2003 - March 2004), the gibbons consumed foods from 16 species, 13 genera, and 11 families. Most were in F. Euphorbiaceae and F. Moraceae. In the wet season (April – October 2004), the gibbons consumed foods from 17 species, 16 genera, 14 families, most frequently from F. Annonaceae and F. Leguminosae-Papilionoidae i.e. Ma Puan (*Mitrephora vandaeflora* Kurz) and Ma Klam Ton (*Ormosia sumatrana* (Miq.) Prain) In addition to many plant items, the white-handed gibbons ate insects, which they picked up from leaves and branches.

Comparing the plant species across seasons it can be seen that some foods were common for both seasons, whereas some plants were eaten only in a particular season. From the all of food plants (25 species, 22 genera, and 16 families), there were 8 species, 7 genera, and 5 families, which the gibbons consumed in dry season only. The food plants that gibbon consumed in only the wet season consisted of 9 species, 9 genera, and 8 families. In addition, there were 8 species, 7 genera, and 7 families, which the gibbons ate in both seasons such as Ko Riap (*Quercus glabricupula* Barrett.), Ma Pong Ton (*Garcinia succifolia* Kurz), and Kom Yan (*Styrax benzoides* Craib).

Table 3 List of white-handed gibbon's food plants

Family	Scientific Name	Thai Name	Part of Food Plant*											
			2003		2004									
			Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Annonaceae	*Miliusa lineata* (Craib)Aiston	Po Khi Haet										rf	rf	rf
	Mitrephora vandaeflora Kurz	Ma Puan						fl,sh		rf	rf			
	Polyalthia viridis Craib	Yang On				sh			rf					
Burseraceae	*Protium serratum* Engl.	Ma Faen									rf	rf	rf	
Dipterocarpaceae	*Hopea ferrea* Laness.	Ta Khian Hin		yl						sh				
Euphorbiaceae	*Antidesma sootepense* Craib	Mamao Sai	rf											
	Bischofia javensis Blume	Toem	rf	rf										
	Drypetes hainanensis Merr.	Song Kradong Hin								rf				
	Sapium insigne Benth.	Ta Tum Bok					uf							
Fagaceae	*Quercus glabricupula* Barrett.	Ko Riap			yl,fl			yl	yl					
Guttiferae	*Garcinia succifolia* Kurz	Ma Pong Ton					rf	rf						
Labiatae	*Syzygium grande* (Wight)Walp.	Mao				uf				uf	uf			
Leguminosae-Papilionoideae	*Dalbergia oliveri* Gamble	Ket Daeng		yl										
	Ormosia sumatrana (Miq.) Prain	Ma Klam Ton								sh				
Lythraceae	*Lagerstroemia caluculata* Kurz	Ta Baek Daeng										uf	uf	

Table 3 (Continued)

Family	Scientific Name	Thai Name	Part of Food Plant*											
			2003		2004									
			Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
Meliacece	*Dysoxylum hynanensis* var. *larberimum*	Lan Ngo									sh,yl			
Moraceae	*Ficus retusa* L. var. *retusa*	Sai Yoi Bai Thu				yl,rf,sh	rf							
	Ficus benjamina L.	Sai Yoi Bai Laem	yl											
	Ficus altissima Blume	Sai Krang	rf	rf				rf						
	Ficus spp.	Sai	rf,yl	rf	sh,rf	rf		rf	yl	yl	rf			
Mrytaceae	*Canthium umbellatum* Wight	Wa Khi Kwang									uf			
Sapindaceae	*Nephelium hypoleucum* Kurz	Kho Laen						rf						
Styracaceae	*Styrax benzoides* Craib	Kom Yan				fl,uf		uf	uf					
Tiliaceae	*Microcos paniculata* L.	Phlap Phla	rf	rf										
Ulmaceae	*Ulmus lancaefolia* Roxb.ex.Wall.	Lop Lip			uf									
Unknown	Climber	-	yl	uf,rf	yl,fl,sh	yl,sh	yl	rf,sh	fl,yl,sh	rf,yl	uf,rf			

* rf. ripe fruit, uf. unripe fruit, yl. young leaf, fl. flower and sh