RESULTS AND DISCUSSION

1. Ecology and Behavior

1.1 Family structure: During this one-year study, the number of individuals in the family changed (Table 1). At the beginning of the study the gibbon family G1 had 5 members (Figure 5), namely: 1 buff adult male, 1 black adult female, 2 black sub-adults (one male and one female), and 1 black small juvenile. In January 2004, the adult female (mother) expelled the black sub-adult female from the natal group. Following these expulsion four members remained in February. After that, in March the group consisted of three individuals, that is the black sub-adult male was missing. He might have left his natal group or died. In September 2004, there was one new member (1 black infant) that was clinging to its mother.

Table 1 Family structure of the gibbon family G1

Month\Member[1] (color)	AM (buff)	AF (black)	Sub-AM (black)	Sub-AF (black)	SJ (black)	Inf (black)
November 2003	✓	✓	✓	✓	✓	—
December 2003	✓	✓	✓	✓	✓	—
January 2004	✓	✓	✓	✓	✓	—
February 2004	✓	✓	✓	—	✓	—
March 2004	✓	✓	—	—	✓	—
April 2004	✓	✓	—	—	✓	—
May 2004	✓	✓	—	—	✓	—
June 2004	✓	✓	—	—	✓	—
July 2004	✓	✓	—	—	✓	—
August 2004	✓	✓	—	—	✓	—
September 2004	✓	✓	—	—	✓	✓
October 2004	✓	✓	—	—	✓	✓

[1] AM. adult male gibbon, AF. adult female gibbon, Sub-AM. sub-adult male gibbon, Sub-AF. sub-adult female gibbon, SJ. small juvenile gibbon and Inf. infant.

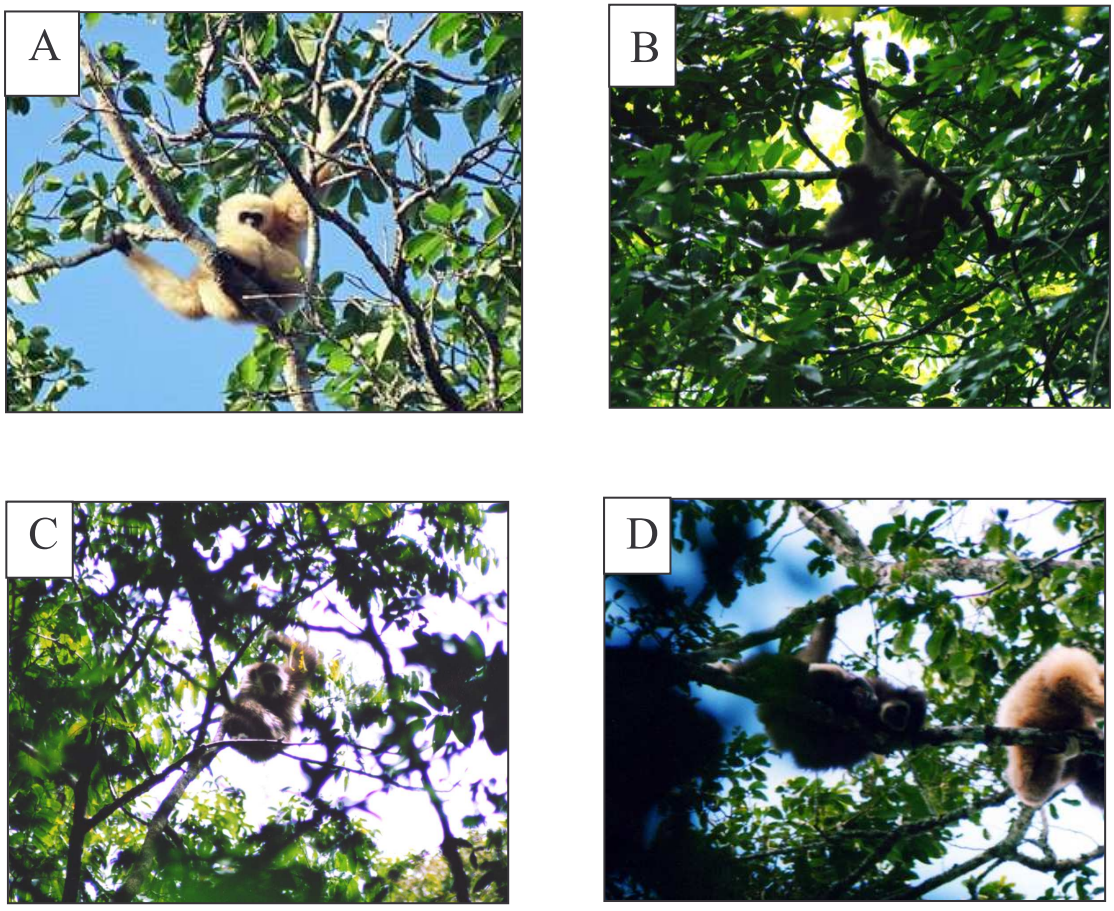

Figure 5 Members of study family (G1) (A. adult male, B. adult female, C. small juvenile and D. infant and adult female).

This direct observation of the focal family over the long term showed a change in family structure. In one year of this study, there were several changes caused by emigration or death and birth.

The observation of the expulsion of the sub-adult female by the mother is a rather rare case. In the population of Khao Yai NP expulsions have not been observed often (Brockelman *et al.*, 1998). Even though more recent observations indicate that such cases occasionally occur (Savini, personal communication), the situation at Khao Yai NP is considerably different, because of the high density of gibbons. While at Khao Yai almost all space is occupied and possibly parents tolerate their maturing offspring in the family, at Phu Khieo Wildlife Sanctuary more space may be available (see below) and parents force their offspring to leave earlier.

At present it is not clear what happened to the two sub-adults. They might have formed new pairs elsewhere or died. Phu Khieo Wildlife Sanctuary is a rather undisturbed forest and has many predators (Horata and Kreetiyutanont, 1997) such as Asian wild dog (*Cuon alpinus* (Pallas 1811)), tiger (*Panthera tigris* (Linnaeus 1758)), and clouded leopards (*Pardofelis marmorata* (Martin 1837)). From direct observation (Lloyd *et al.*, in press) it is known that clouded leopards (*Pardofelis marmorata* (Martin 1837)) regularly occur in the study area. So, it is possible that the two sub-adults were predated by clouded leopards, even though a recent study in Phu Khieo Wildlife Sanctuary did not indicate gibbon hair in the scats of clouded leopards (Grassman *et al.*, 2005).

The final change in the composition of the gibbon group was due to the birth of an infant in September. Similarly, Muangkhum (2001) encountered an adult female before and after she delivered an infant at Huai Kha Khaeng Wildlife Sanctuary. When observations are carried out over many years, one can study the reproduction, natal dispersal and pair formation of gibbon families, which has been extensively documented in the study of white-handed gibbons at Khao Yai NP by Brockelman *et al.* (1998). Here, gibbons usually give birth from July to January, which is the second part of the wet season and the early dry season (Savini *et al.*, in revision). Thus, the observation in this study matches quite well the birth season in Khao Yai, however, in order to know the overall pattern for Phu Khieo Wildlife Sanctuary more data are required.

1.2 Behavior: Throughout the study period, the adult white-handed gibbons showed the following characteristics in their activities: Locomotion 28.53%, Feeding 25.32%, Grooming 16.71%, Resting 9.64%, Vocalization 9.00%, Sleeping 2.96%, Play 1.67%, Aggression 1.54% and Other 4.63%. The activities of the juvenile gibbons were distributed as follows: Locomotion 35.04%, Feeding 33.96%, Play 8.63%, Grooming 7.55%, Resting 7.28%, Sleeping 3.23%, Vocalization 0.81%, Aggression 0.27% and Other 3.23% (Figure 6).

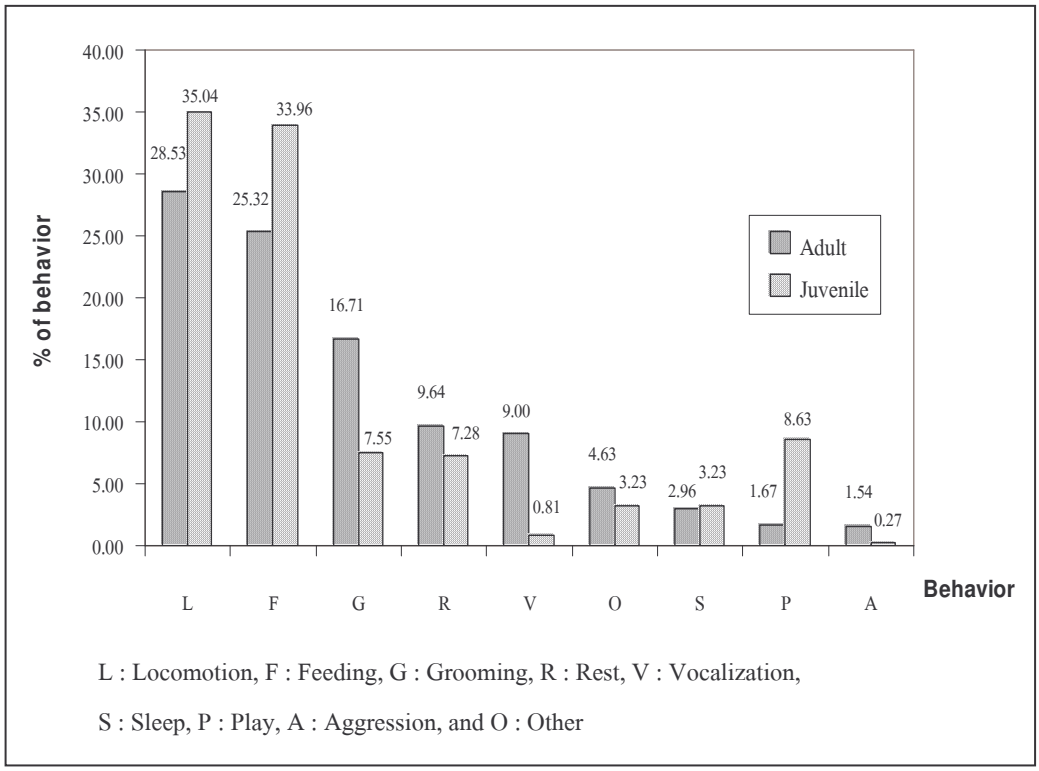

Figure 6 Percentage of the white-handed gibbon's daily activities.

When comparing the same activities especially of the adults' behaviors in this study and other investigations, there were some interesting differences in the percentages of the behaviors. In this study, the highest percentage of white-handed gibbon's behavior was locomotion (28.53%). However, the highest percentage of white-handed gibbon's behavior at the Khao Pra Theaw Non-hunting Area (Punnadee and Damiana, 2004) and Khao Yai NP (Bartlett, 1999) was feeding behavior. Locomotion had only the third highest percentage of behavior in both areas. Similarly, in the rainforests of the Gunung Leuser NP, Sumatra, resting was most common (45%)

followed by feeding & foraging (34%; Palombit, 1997). Locomotion was third with 16%. The only study with similar locomotion activity (32%), but a much longer feeding time (42%) has been conducted on the white-handed gibbons at Kuala Lompat, Malaysia (Raemaekers, 1979).

One explanation for these differences could be due to the different observation methods or differences in the definition of activities. This study divided several types of gibbons' behaviors (9 behaviors), which was for example different from the study by Palombit (1997) with 5 behaviors (sing, rest, travel, feed/forage, intergroup interaction). However, the differences in the activities could also be explained by the different habitats. Especially, Khao Yai NP and Gunung Leuser NP are evergreen forest, whereas Phu Khieo Wildlife Sanctuary is more seasonal. Possibly at Phu Khieo Wildlife Sanctuary the feeding trees are more spaced apart and the gibbons have to travel more (see below).

The figures 7 and 8 show 9 types of behaviors of the adult and juvenile gibbons. Each type of behavior had a different percentage overall, across age classes and period of time observed. For example, the vocalization behavior of the adults had a much higher percentage (9.00%) than the juveniles (0.81%). Vocalization behavior was usually heard in the early morning and continued until noon. But in the afternoon until evening the gibbons' three main activities were resting, grooming and sleeping. *Locomotion* includes brachiation, leaping and walking on large branches. Locomotion was the most common of the adult's and juvenile's activities. When the gibbons woke up in the early morning, they moved to foraging site and to defend their territory. Later on during the day, the gibbons moved to other food sources. Locomotion data was observed and compiled to produce day range data via the GIS technique. Day range data was then used to determine the home range of the white-handed gibbons. Details of home range are explained in the next topic Home Range.

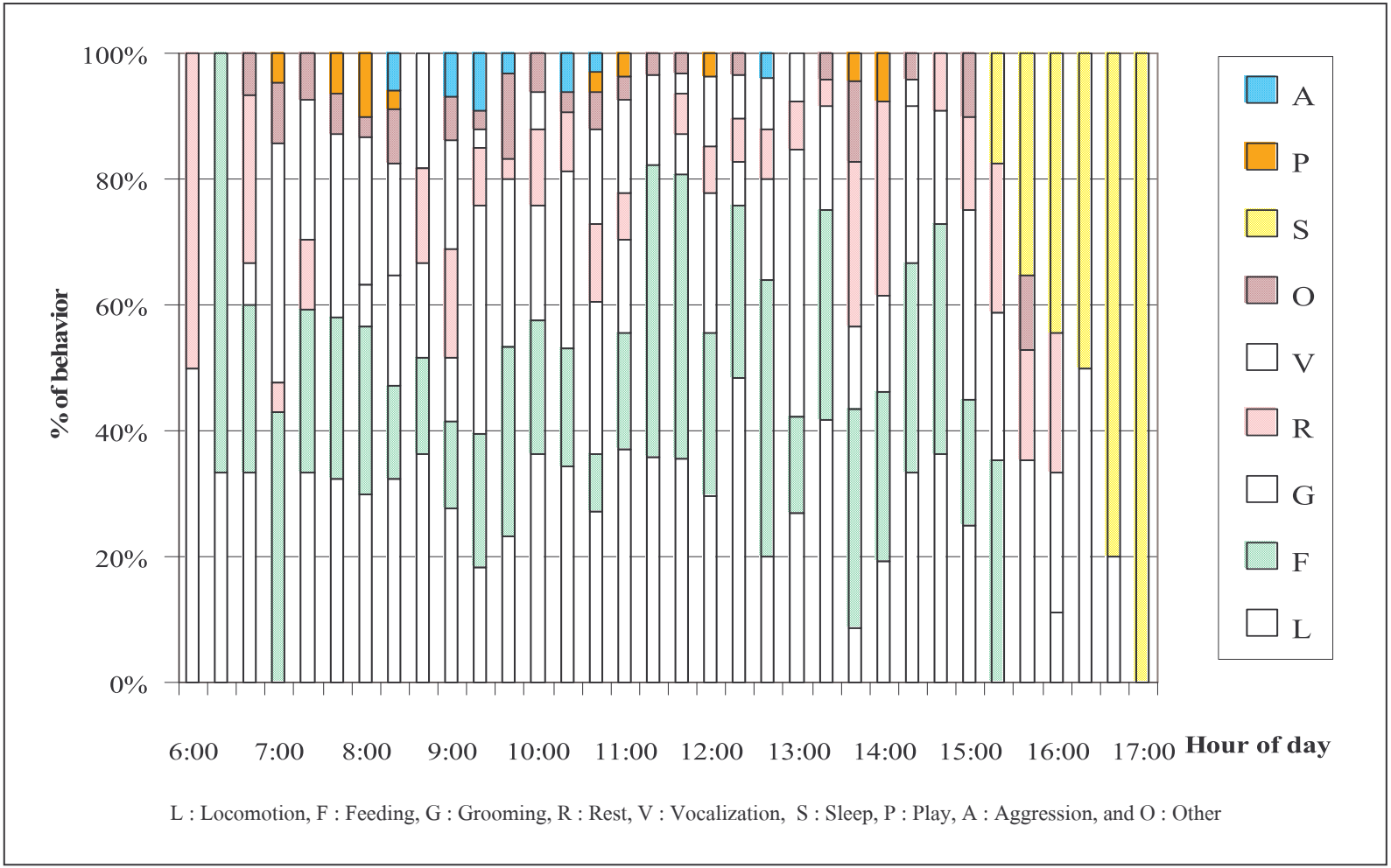

Figure 7 Percentage of adult white-handed gibbon's behavior during the cause of the study.

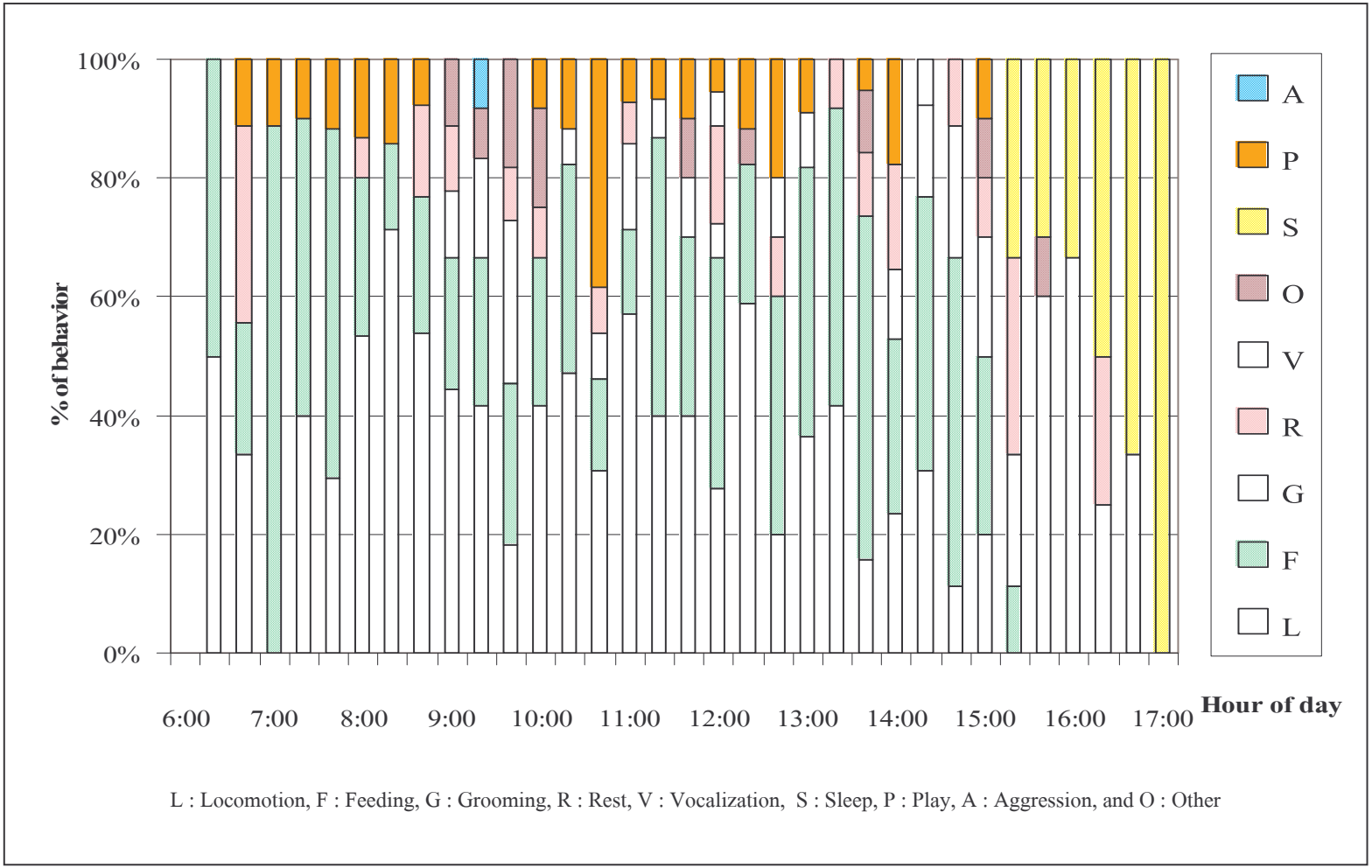

Figure 8 Percentage of juvenile white-handed gibbon's during the course of the study.

Feeding behavior comprised of foraging and drinking. It was the second most common behavior. Feeding behavior was the most common in the morning, but continued until ca. 15:00. The gibbons were feeding on various types of food. They used fingers and hands to pick leaves and fruits. They had different styles to put different food types into their mouths. When drinking, gibbon dipped its hand into crotches of water from large trees and quickly raised its hand to the mouth by flexing and supinating the wrist and elbow. When fig trees (*Ficus* spp.) had ripe fruits, gibbons came to feed on figs for very long periods of time. Besides, the sometimes gibbon rested on that fig tree.

Next in the series of adult's behavioral percentage was *Grooming* behavior; however, this behavior was only the fourth series of the juvenile's behavioral percentage. Grooming behavior consists of autogrooming and allogrooming. Usually, the juvenile gibbon was groomed by an adult gibbon. In addition, the adult male often groomed the adult female. Grooming was most common near the center of home range and near feeding sites. Gibbons usually groomed in the late morning after the morning feeding and during the afternoon before they went to sleep. On a sunny day, gibbons preferred to groom in shady trees. Sometimes they sat or lay down during grooming. While gibbons rested they either sat or laid down. Adult individuals rested more than the juvenile. Characteristics of the trees selected by gibbons for resting were tall 25-40 m, with big branches and were located close to their feeding site.

The most well-known behavior of gibbons is *Vocalization* behavior. Vocalization was the main behavior of adult gibbons, both single and pairs. Gibbons vocalized in the morning until approximately mid-day. Two to three times, the sub-adult female called following the adult female. Gibbons could be hanging and vocalizing at the same time. In general, gibbons often vocalized near the boundary of their territory, however, occasionally they also called near a feeding site. Neighbors vocalized frequently at the same time. Gibbons called to announce their territory, and in addition when they heard other groups calling, the two groups called together. In the winter, gibbons started to call later than during the summer time. In the rainy season, whenever it rained in the morning, the gibbons hardly ever vocalized.