CHAPTER V

CONCLUSIONS AND DISCUSSIONS

The aculeate insects in northern Thailand were surveyed and collected both in natural forests and cultivated areas during January 2006 to June 2007. The aculeate species found in this area were composed of 3 superfamilies; Apoidea, Chrysidoidea, and Vespoidea. So far a total of 120 specimens within 9 families were identified. There were 35 species in 16 genera of 10 subfamiles belonging to 5 families of Apoidea, 5 species in 3 genera of a single subfamily and family of Chrysidoidea, and 80 species in 45 genera of 12 subfamilies belonging to 3 families of Vespoidea. This is similar to the report of Finnamore (1997) that the 3 superfamilies: Apoidea, Chrysidoidea, and Vespoidea were found the Yokun in Canada. Also, Yamane, Ikudome and Terayama (1999) reported that those 3 superfamiles in the Nansei islands, Japan comprised of 26 families and 188 genera. A total number of species in our study is lower than that in Japan as these islands are complete natural forests (Suzuki, 1980). Moreover, the Nansei islands were created as a result of the Okinawa Trough formation and tectonic shifting some 15 million years ago (Rryu et al., 2006). In result of that, there are many endemic animals still living in Nansei Islands (Suzuki, 1980), including endemic species of aculeates species (Yamane, Ikudome and Terayama, 1999). This may be because geographic zone of these islands is divided into 2 regions; the northern islands limit of the Oriental region and the southern limit of the Palearctic region (Suzuki, 1980) while northern Thailand is classified in Oriental region (Maxwell, 2004). In addition, Suzuki (1980) concluded that this area has high species diversity because of ecotone which is a transition area between 2 adjacent ecological communities. In accordance with the study of Fernández (2001) reported that in the Neotropical region of South American, there were 3 superfamiles: Apoidea, Chrysidoidea, and Vespoidea which comprised of 25 families and 807 genera. This area is the most species diversity of these insects due to the most species diversity of plants in the world (Gurevitch, Scheiner and Fox, 2002) which leads to high diversity of the aculeate species (LaSalle and Gauld, 1993).

The family formicidae in the superfamily Vespoidea showed the highest species composition (50.83%). Compare to 247 known species in Thailand in 9 subfamilies (Jaitrong and Nabhitabhata, 2005), 61 species in 7 subfamilies were found in our study. It is, therefore, 24.67% of ants known in Thailand were recorded in the north of Thailand. The reasons that explain the highest number of this family may be due to the Formicidae are one of the large families of aculeates with a large number of members. They also have wide distribution and are found in all zoogeographic regions, including Thailand (Bolton, 1997). Ant species have successfully occupied several habitats including forests and urban environments. In accordance with the study of Watanasit, Noon-anant and Binnima (2005) which found 44 ant species belonging to 6 subfamilies (Dolichoderinae, Dorylinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae) in an open area at Prince of Songkla University in the south of Thailand. From the study of Sitthicharoenchai and Chantarasawat (2006) which worked in 3 habitat types; deciduous dipterocarp forest, mango plantation, and grassland in Nan province, they found 46 species of ants which belonging to 5 subfamilies; Dolichoderinae, Formicinae, Myrmicinae, Ponerinae and Pseudomyrmecinae. Apart from previous works, Bickel and Watanasit (2005) studied diversity of leaf litter ant in Ton Nga Chang Wildlife Sanctuary and in rubber plantations, 28 genera comprising 59 ant species from 5 subfamilies were found. All recorded species were from subfamily Cerapachyinae, Dolichoderinae, Formicinae, Myrmicinae and Ponerinae. This successful in adaptation is probably related to their feeding habits because they feed on variety of foods; i.e. natural food sources of honeydew, plant secretions, insects (Laakso and Setala, 1998; Kamura et al., 2007). Our result concluded that the ants distribute in all types of habitat, and seems well correlated with previous works.

A total of 20 species, 4 genera within 3 subfamilies were identified in the family Apidae, known as honey bees, stingless bees and bumble bees. From our study, this number showed that Apidae was the second large group in number species in the infraorder Aculeata. This is also reported by Finnamore (1997) that the superfamily Apoidea is the second large group of the infraorder Aculeata. Michener (2007) explained that this group of insects distribute worldwide in all continents except Antarctica. The results of high species number of Apoidea in the north of Thailand may be due to natural forests and cultivated areas have plenty of species diversity of plants which supported the food sources and habitats for the bees. In this study, we found that nesting sites of *Trigona* species can be divided into 4 groups; 1) cavities in tree trunks, 2) cavities in termite mounds, 3) underground cavities, and 4) cavities in buildings. Jongjitvimol and Wattanachaiyingcharoen (2007) found that the trunks of 14 tree species: *Caesalpinia sappan, Eugenia cumini, Ficus annulata, F. locor, F. religiosa, Herea brasiliensis, Hopea odorata, Irvingia malayana, Knema globulalia, Parkia speciosa, Shorea curtisii, Strychnos nuxvomica, Syzygium cumini* and *Tamarindus indica* were used as the host plants of *T. collina*. In addition, Jongjitvimol and Wattanachaiyingcharoen (2006) reported that 29 plant species found in deciduous with bamboo forests were exploited by 3 *Trigona* species of stingless bees: *T. apicalis, T. collina* and *T. fimbriata* in Phitsanolok province. In accordance with the report of Kaewkaw et al. (2008) which found 91 flowering-plant species were visited by stingless bees in Queen Sirikit Botanic Garderden in Chiang Mai province. The stingless bees with 14 species found showed the highest species number of this family. Most samples were found in deciduous with bamboo forest at an altitude of less than 400 meters above sea level. All species have been reported in Thailand (Sakagami, Inoue and Salmah, 1990; Klakasikorn et al., 2005; Jongjitvimol and Wattanachaiyingcharoen, 2006). In this study, the stingless bee, *T. collina* showed the highest species composition (384 nests). They are among the most common flower-visiting insects in the canopy and the under-storey of forests in Thailand, and are most likely play role as crucial pollinators (Thapyai, 1996; Tasen, 2001; Jongjitvimol and Wattanachaiyingcharoen, 2006). Also, we found most *T. collina* nests (149 nests) in cavities within the mounds of *Macrotermes* spp. The benefits of colony aggregation are postulated to be increased opportunities for outbreeding by virgin queens (Cameron et al., 2004; Jongjitvimol et al., 2005).

From our study, the vespid wasps (Vespidae) are the third group in species number. Seventeen species in 10 genera were identified in 4 subfamilies; Eumeninae, Polistinae, Stenogastrinae and Vespinae. Most of them were found in subfamily Vespinae. There were 6 species in 2 genera; *Provespa* and *Vespa*. Of the 23 species of *Vespa* known in the world, 18 species have been recorded in Thailand (Archer, 1989). LaSalle and Gauld (1997) reported that social wasps were indicators of ecological importance in forests. In our study, 65 nests of *Vespa* were found in underground cavities, on trees and buildings. Most of them (45 nests) were found on buildings and tree in the city and cultivated area. This result showed that the number of their nests in forest areas were less than those in the city and cultivated areas. This may be because the increasing of the disturbance of forests in Thailand induced the vespid wasps into towns as previous report of Nakamura and Sonthichai (2004).

In general, altitude is an important factor influencing community structure, abundance, and diversity. The diversity of animals decreases with an increasing of altitude (Finnamore, 1997). Lower productivity of plants at higher elevations has been argued to cause such declines in abundance and diversity of insects (Romero-Alcaraz and Ávila, 2000). We surveyed the areas in northern Thailand at an average altitude of 622 meters above sea level. The highest area in the region reaches 2,572 meters above sea level (Chiangmai), while the lowest area is at 37 meters above sea level (Phichit). Hoffmann (2005) proposed that insect species richness was significantly affected by flowering plant species richness and flowering plant abundance. The difference in the number of aculeate species in each forest may be due to the difference in plant species, including the difference in food sources and host plants. Sanders, Moss, and Wagner (2003) and Zhu (2006) reported that values of species richness were shown in the higher level in the elevation range from 500 to 1,700 meters above sea level and species richness were decreased with an increasing elevation at 1,700 to 2,500 meters above sea level. At the level between 1,500 and 6,050 meters above sea level, Finnamore (1997) reported the negative relationship between the altitude and the species numbers of aculeate species. This negative relationship is that the latitudinal gradient increases, the species diversity decreases. In this study, the highest species number of aculeates was found in deciduous with bamboo forests (96 species), following by hill evergreen forest (70 species), mixed evergreen and deciduous forest (38 species), deciduous dipterocarp forest (29 species) and evergreen forest (21 species). In addition, the highest value of diversity index (J') of aculeates was found in hill evergreen forest (J' = 0.846), following by deciduous with bamboo forests (J' = 0.843), mixed evergreen and deciduous forest (J' = 0.691), deciduous dipterocarp forest (J' = 0.668) and evergreen forest (J' = 0.603). The grassland was the less in their species richness (J' = 0.369). This may be because this area is less abundant in plant species, hence, less food source and shelter providing to those insects. Moreover, we found that the value of species diversity index in deciduous with bamboo forest (J' = 0.843) had slightly lower than hill evergreen forest (J' = 0.846) while the highest species number (96 species) of aculeates was found in deciduous with bamboo forests. This might be because the number of individuals of each species or frequency found of each species in hill evergreen forest (286 specimens) is lower than that in deciduous with bamboo forest (1,264 specimens).

From the result of the diversity index showed that the diversity of aculeate species in each forest; bamboo forests, hill evergreen forest, mixed evergreen and deciduous forest, deciduous dipterocarp forest and evergreen forest was higher than 0.5 which indicated the high species diversity. This result differed from of the dominant index (Simpson's index: *C*). The highest dominant index (0.202) of aculeates was found in grassland, following by evergreen forest (0.061), deciduous dipterocarp forest (0.051), mixed evergreen and deciduous forest (0.047), cultivated areas (0.044), hill evergreen forest (0.035), forest area (0.027) and mixed evergreen and deciduous forest (0.020). Although grassland has the highest dominant index of aculeates, they have less plant and aculeate diversity. Therefore, some dominant species can occur, even at lower than 0.5. The Simpson's index of other areas is lower than 0.5 which means that all areas do not have dominant species. This is may be due to the abundance of forest resources, and also the complex community. Floral abundance might support species diversity of aculeates leading to less competition among creatures. Gathmann, Greiler and Tscharntke (1994) proposed that diverse vegetation- obviously supplied a greater amount of nutritious pollen, thereby supporting more bee species and therefore, plant diversity through bee pollinations. This is a plausible explanation for the species richness and the diversity index of all forests (120 species, J' = 0.880) which were higher than that of cultivated areas (54 species, J' = 0.663).

In addition to altitude changes, food sources and host plants influenced the aculeate species richness. From the Sorensen's similarity coefficient: S_s showed that natural forests and cultivated areas (S_s = 0.621) were similar in relation of species presence-absence. This may be because 54 species found in cultivated areas were presented in natural forests. In addition, food sources and host plants in continuously agricultural process enhance the survival and reproduction of these aculeate species. Similar result was found in natural forests. This may be because deforestation, slash and burn for agriculture, and forest fire in natural forests affected on tree growth, and survival of insects by destroying flora and fauna (Hoamuangkaew, 2007). Therefore, they lead to migration of aculeates from natural forests to cultivated areas and human dwellings.

From the calculated 3 ecological indices: species diversity index (J'), dominant index (C) and similarity index (S_s) in each type of habitats, we found that the species diversity indices in each habitat were higher than 0.5 (Table 8) which mean that those areas are high species diversity, except grassland. Also dominant species in each habitat were lower than 0.5 (Table 8) which means that all areas do not have dominant species. From the diversity index and dominant index showed that those areas are more abundant in plant diversity leading to resource partitioning in foods and shelters of aculeate species (LaSalle and Gauld, 1993). Finally, the comparison of each type of habitats showed that the similarity index in each habitat were higher than 0.5 (Table 9) which means that those areas were more similar in species structure of aculeates. This may be because each type of habitats is similar in plant community structures, including food plants and host plants (Maxwell et al., 1995; Maxell, 1996; Maxwell et al., 1997; Maxwell, 1998; Maxwell, 2004) which are niche of aculeate species (O'Toole and Raw, 1999).

According to the identification handbooks (Chapter III), we were unable to identify 32 specimens to species level. They were classified in 24 genera: *Bembix*, *Bombus*, *Camponotus*, *Campsomeris*, *Chalybion*, *Chrysis*, *Coelioxys*, *Delta*, *Halictus*, *Hyoptrigona*, *Lepisiota*, *Megachile*, *Philidris*, *Polites*, *Polybioides*, *Polyrhachis*, *Praestochrysis*, *Rhynchium*, *Ropalidia*, *Sceliphron*, *Scolia*, *Sphex*, *Thyreus* and *Trichrysis* (Table 5).

Our report is the first study of species diversity and taxonomy of the insects in the infraorder Aculeata in Thailand. Even though some parts of forests in the north of Thailand have been deforested and converted for agricultural purposes, they are high in biological diversity. The forests are important natural resources for people and insects because they are rich in floral, fauna and water resources. Thus, the more aculeate insects mean the more complete forest due to these insects play role as pollinators of plants. We proposed that the areas are important for the maintenance of the aculeate species.