# Pollen Sources of Stingless Bees (Hymenoptera: Meliponinae) in Nam Nao National Park, Thailand

Touchkanin Jongjitvimol* and Pisit Poolprasert

Faculty of Science and Technology, Pibulsongkram Rajabhat University, Phitsanulok 65000, Thailand
*Corresponding author. E-mail: touchkanin@psru.ac.th

## ABSTRACT

Stingless bees (Hymenoptera: Meliponinae) play an important ecological role as insect pollinators of many flowering plants in subtropical and tropical regions. This research aimed to investigate the species diversity and pollen sources of stingless bees in Nam Nao National Park, which covers the border between lower northern and upper northeastern Thailand, during January 2013 – June 2014. The sample collections of insects and plants were collected along 2 existing forest trails: bamboo-deciduous forest and deciduous dipterocarp-oak forest. Ten stingless bee species including *Homotrigona fimbriata* (Smith, 1857), *Lepidotrigona nitidiventris* (Smith, 1857), *L. terminata* (Smith, 1878), *L. ventralis* (Smith, 1857), *Lisotrigona cacciae* (Nurse, 1907), *Tetragonilla collina* (Smith, 1857), *Tetragonula laeviceps* (Smith, 1857), *Te. minor* (Sakagami, 1978), *Tetrigona apicalis* (Smith, 1857), and *Tet. melanoleuca* (Cockerell, 1929) were found from this study. All value indices, the species diversity index (*H'*), the species evenness index (*J'*) and species richness index (*D*) showed that bamboo-deciduous forest have higher species diversity than the deciduous dipterocarp-oak forest. The similarity coefficient ($S_s$) showed similar community structure of stingless bees in both types of forest. Moreover, their pollen grains were indentified in 70 plant species from 31 families. The family Asteraceae (Compositae) was the most diverse (12 species). The main pollen source of stingless bees found in both types of vegetation was *Synotis cappa* (Buch.-Ham. ex D.Don) C.Jeffrey & Y.L.Chen. The highest number of bee flora was found from pollen loads of *T. collina* (44 species), while *Te. laeviceps* ranked second (44 species), and *L. terminata* ranked third (38 species). These results suggest that the studied areas can provides food sources for stingless bees where is important for maintaining populations of them.

*Keywords: bee flora, native bees, Apidae, Meliponini, vegetation*

## INTRODUCTION

Stingless bees also known as meliponine bees (Hymenoptera: Apidae: Meliponinae) are abundant in both subtropical and tropical realms. Worldwide stingless bees are classified into over 600 species in 56 genera. A total of 60 species belonging to 14 genera have been reported in Southeast Asia. Currently, 35 species have been recorded in Thailand (Velthuis, 1997; Cortopassi-Laurino *et al*., 2006; Rasmussen, 2008). They constitute a diverse group, with many species building their nests in living or dead tree trunks. While others build nests above ground (Jongjitvimol and Wattanachaiyingcharoen, 2007). In ecosystems, stingless bees play a major role as pollinators of several flowering plants in tropical forests. They move pollens from 1 plant to another, ensuring seed set and gene flow between plants and plant populations (Venturieri, 2009). In return, the plants provide them with floral resources (pollen and/or nectar) that are vital to their own survival. They are, therefore, important for the balancing and

functioning of food webs of most ecosystems. For stingless bees, pollen is the main source of proteins, free amino acids, lipids, vitamins and minerals. Their adult females feed their larvae with pollen, or a mixture of pollen and nectar (Nicolson, 2011; da Silva *et al*., 2014).

The lower northern region of Thailand is characterized by a heterogeneous structure, dominated by tropical forests i.e. mixed deciduous and deciduous dipterocarp forests. The species number of pollen feeding insects is directly correlated with the number species of plants (Fontaine *et al*., 2006; Blüthgen and Klein, 2011). Over the past 5 decades, national parks and wildlife sanctuaries in this area have been deforested. This is one of the most serious threats to biodiversity. Winfree *et al*. (2007) proposed that these bees are sensitive to the change in habitat, thus, deforestation may reduce both populations and species diversity. Although some parts of this region have been deforested and converted for agricultural purposes, it is one of the most biologically diverse areas in Thailand. The Nam Nao National Park encompasses the border between the northern and northeastern parts of Thailand with an average elevation of 800 m. Nam Nao was established as a national park on the 4th May 1972 and was declared the 5th national park of Thailand. Total area of the park is about 966 sq km. The area is mountainous and its forests provide an essential watershed for the surrounding villages and farm lands (DNP, 2010). The aims of this study were to survey pollen sources and to determine species diversity of the stingless bees found in the Nam Nao National Park. The results obtained will provide useful knowledge on species diversity of stingless bees and their food sources. This knowledge, therefore, will be applied for further study in biology and sustainable conservation of those bees in Thailand and elsewhere.

## MATERIALS AND METHODS

### Study site

Species diversity of stingless bee and the pollen sources were conducted in Nam Nao National Park between January 2013 and June 2014. Two types of forest including bamboo-deciduous forest (BB/DF) and deciduous dipterocarp-oak forest (DOF) were set out to study. The park is conveniently accessible by Asian Highway 16 (AH16) for survey and sample collection. The park was divided into 3 trails in BB/DF and 3 trails in DOF (Figure 1). Each sampling area was 2,000 sq m (500 m long and 2 m wide on either side of the trail).

### Sample collection

The stingless bee species and the pollen sources were collected between 08.00 am and 04.00 pm at least once a month, depending on seasonal variations, during January 2013 – June 2014. The nature trails in each forest type were studied by random sampling and line transects (Krebs, 1999). The sampling techniques were sweep net sampling for stingless bees as well as hand collection for pollens and flowering plants. Pollen grains were taken from pollen baskets of forager stingless bees and flower buds. The stingless bee and pollen samples were kept in 70% (v/v) ethanol. Some parts of trees and plant specimens were collected for identification. Basic data obtained through observation were recorded in the form of handwritten field notes i.e. location, habitat and morphological details.

### Sample identification

A species list of stingless bee and flowering plant was made for each forest type. Each stingless bee species was divided into 2 groups. The first group was preserved in 70% ethanol solution for identification by using keys from Sakagami *et al*., (1990) and Rasmussen, (2008). The last group was collected as dried reference specimens (Hatch, 1926). All specimens of stingless bee were confirmed by comparing with the insects deposited in the Naresuan University (NU) museum. The insect specimens were collected and deposited in the Entomology Laboratory, Pibulsongkram Rajabhat University (PSRU).

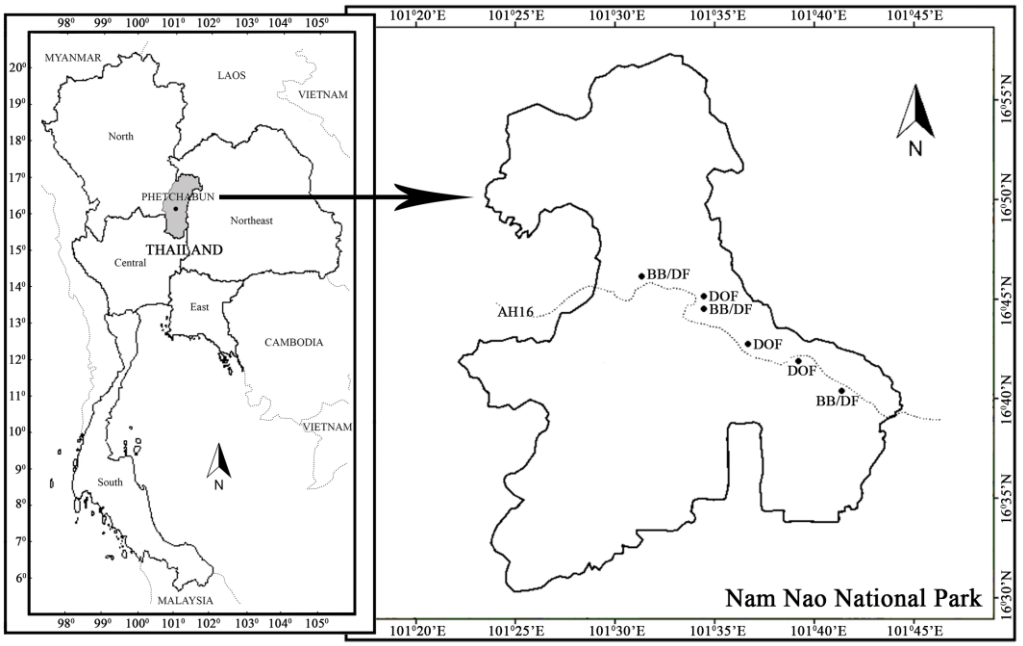


**Figure 1** Location and presentation of Nam Nao National Park, showing the sampling point.

Before taking scanning electron microscope images (SEM, Leo 1450VP) at PSRU, all samples of pollen grains were prepared according to the standard acetolysis method devised by Erdtman (1960). SEM photographs of pollen grains from flower buds were modified as the pollen key for the local flora of this national park. The pollen species carried by returning forager stingless bees were identified by comparing them with our reference collection. Flowering plants visited by stingless bees and other plants referenced were identified at Kasetsart University (KU), Kam Phaeng Saen Campus (KPS). In addition, identification of plant specimens was confirmed by comparing them with herbarium samples in the Chiang Mai University (CMU) Herbarium. The herbarium specimens and their pollens were collected and deposited in the Botany Laboratory, KU (KPS).

**Data analyses**

Data were analysed using the equations of species diversity index (Shannon-Wiener index, ***H'***) (Margurran, 1988), species evenness index (Pielou's index, *J'*) (Ludwig and Reynolds, 1988), species richness index (Simpson's index, *D*) (Simpson, 1949), and similarity index (Sorensen's similarity coefficient, $S_s$) (Sorensen, 1948). All ecological indices were used to explain the diversity of stingless bees in each habitat.

## RESULTS

In total, 10 species of stingless bees were recorded in this area; *Homotrigona fimbriata* (Smith, 1857), *Lepidotrigona nitidiventris* (Smith, 1857), *L. terminata* (Smith, 1857), *L. ventralis* (Smith, 1857), *Lisotrigona cacciae* (Nurse, 1907), *Tetragonilla collina* (Smith, 1857), *Tetragonula laeviceps* (Smith, 1857), *Te. minor* (Sakagami, 1978), *Tetrigona apicalis* (Smith, 1857), and *Tet. melanoleuca* (Cockerell, 1929). The greater number of species of stingless bees was recorded in the BB/DF (9 species) and the DOF had 5 species. The detail of stingless bee species was listed in Table 1.

**Table 1** List and distribution of stingless bee found in bamboo-deciduous forest (BB/DF) and deciduous dipterocarp-oak forest (DOF).

| No. | Stingless bee species | Forest type | |
|---|---|---|---|
| | | BB/DF | DOF |
| 1. | *Homotrigona fimbriata* (Smith, 1857) | / | |
| 2. | *Lepidotrigona nitidiventris* (Smith, 1857) | / | |
| 3. | *Lepidotrigona terminata* (Smith, 1857) | / | / |
| 4. | *Lepidotrigona ventralis* (Smith, 1857) | / | / |
| 5. | *Lisotrigona cacciae* (Nurse, 1907) | / | |
| 6. | *Tetragonilla collina* (Smith, 1857) | / | / |
| 7. | *Tetragonula laeviceps* (Smith, 1857) | / | |
| 8. | *Tetragonula minor* (Sakagami, 1978) | / | |
| 9. | *Tetrigona apicalis* (Smith, 1857) | | / |
| 10. | *Tetrigona melanoleuca* (Cockerell, 1929) | / | / |
| | **Total** | 9 | 5 |

The diversity of stingless bees estimated using the Shannon-Wiener's index and Simpson's index indicated that BB/DF had the highest species diversity and the most complex community while DOF had the lowest species diversity and the simplest community. Moreover, Pielou's evenness index was 0.998 in bamboo-deciduous forest, followed closely by DOF (0.266). This index indicated that species of stingless bees in BB/DF were the most abundant. Sorensen's similarity coefficient ($S_s$) was moderately high (0.571) between BB/DF and DOF (4 species shared), indicating that there was no difference of bee species in both types of forest. The detail of stingless bee species structure index values from both habitat types was shown in Table 2.

**Table 2.** Ecological indices of stingless bees in bamboo-deciduous forest (BB/DF), and deciduous dipterocarp-oak forest (DOF).

| Forest type | Ecological index | | | |
|---|---|---|---|---|
| | **Shannon-Wiener index (*H'*)** | **Pielou's index (*J'*)** | **Simpson's index (*D*)** | **Sorensen's similarity coefficient ($S_s$)** |
| BB/DF | 2.194 | 0.998 | 0.136 | 0.571 |
| DOF | 1.328 | 0.266 | 0.114 | |

The pollen loads taken directly from the corbiculae of forager bees were identified into 70 plant species of 31 families (Table 3). Of these, 58 plant species from 28 families were recorded in BB/DF, and 31 plant species from 18 families were found in DOF. Of the remaining 19 pollen species of families, 12 were collected from both locations. The Asteraceae (Compositae) was the largest family of flowering plant (12 species).

**Table 3.** List and distribution of pollen source found in bamboo-deciduous forest (BB/DF), and deciduous dipterocarp-oak forest (DOF).

| Family | Plant species | Habit | Forest type | |
|---|---|---|---|---|
| | | | BB/DF | DOF |
| 1. Acanthaceae | 1. *Asystasia salicifolia* Craib | Herb | / | |
| | 2. *Eranthemum tetragonum* Wall. ex Nees | Herb | / | |
| | 3. *Thunbergia grandiflora* (Roxb. ex Rottl.) Roxb. | Climber | / | |
| 2. Amaranthaceae | 4. *Gomphrena celosioides* Mart. | Herb | / | / |
| 3. Amaryllidaceae | 5. *Hippeastrum puniceum* (Lam.) Voss | Herb | / | |
| 4. Apocynaceae | 6. *Rauvolfia serpentina* (L.) Benth. ex Kurz | Shrub | / | |
| 5. Asteraceae | 7. *Acmella paniculata* (Wall. ex DC.) R.K.Jansen | Herb | / | / |
| (Compositae) | 8. *Ageratum conyzoides* (L.) L. | Herb | / | / |
| | 9. *Bidens pilosa* L. | Herb | / | |
| | 10. *Blumea lacera* (Burm.f.) DC. | Herb | | / |
| | 11. *Crassocephalum crepidioides* (Benth.) S.Moore | Herb | / | |
| | 12. *Crotalaria alata* D.Don | Herb | / | |
| | 13. *Cyanthillium cinereum* (L.) H.Rob. | Herb | | / |
| | 14. *Erigeron floribundus* (Kunth) Sch.Bip.* | Herb | / | |
| | 15. *Synotis cappa* (Buch.-Ham. ex D.Don) C.Jeffrey & Y.L.Chen | Herb | / | / |
| | 16. *Tridax procumbens* (L.) L. | Herb | / | |
| | 17. *Vernonia gratiosa* Hance* | Climber | / | |
| | 18. *Youngia japonica* (L.) DC.* | Herb | / | |
| 6. Begoniaceae | 19. *Begonia palmata* D.Don | Herb | | / |
| | 20. *Stereospermum neuranthum* Kurz | Tree | | / |
| 7. Buddlejaceae | 21. *Buddleja asiatica* Lour. | Shrub | / | |
| 8. Commelinaceae | 22. *Murdannia edulis* (Stokes) Faden | Herb | | / |
| | 23. *Murdannia spectabilis* (Kurz) Faden | Herb | / | |
| 9. Convolvulaceae | 24. *Merremia vitifolia* (Burm. f.) Hallier f. | Climber | / | |
| 10. Cyperaceae | 25. *Scleria terrestris* (L.) Fassett | Herb | | / |
| 11. Ericaceae | 26. *Vaccinium sprengelii* (G. Don) Sleumer | Tree | / | / |
| 12. Euphorbiaceae | 27. *Antidesma ghaesembilla* Gaertn. | Tree | | / |
| | 28. *Croton decalvatus* Esser | Shrub | / | |
| | 29. *Croton persimilis* Müll.Arg. | Tree | / | / |
| | 30. *Homonoia riparia* Lour. | Shrub | / | |
| 13. Fabaceae | 31. *Afzelia xylocarpa* (Kurz) Craib | Tree | / | |
| (Leguminosae) | 32. *Cassia bakeriana* Craib | Tree | / | |
| | 33. *Cassia fistula* L. | Tree | / | |
| | 34. *Entada glandulosa* Gagnep. | Climber | / | |
| | 35. *Leucaena leucocephala* (Lam.) de Wit | Shrub | / | |
| | 36. *Melilotus suaveolens* Ledeb.* | Herb | / | |
| | 37. *Millettia brandisiana* Kurz | Tree | / | |
| | 38. *Mimosa pudica* L. | Climber | / | |
| 14. Lamiaceae | 39. *Gmelina arborea* Roxb. | Tree | / | / |
| (Labiatae) | 40. *Vitex peduncularis* Wall. ex Schauer | Tree | / | |
| 15. Malvaceae | 41. *Helicteres elongata* Wall. ex Bojer | Shrub | | / |
| 16. Melastomataceae | 42. *Melastoma malabathricum* L. | Shrub | / | / |
| 17. Meliaceae | 43. *Azadirachta indica* A.Juss. | Tree | / | |
| 18. Moraceae | 44. *Ficus ischnopoda* Miq. | Shrub | / | |
| 19. Oleaceae | 45. *Jasminum siamense* Craib | Climber | / | |

**Table 3.** List and distribution of pollen source found in bamboo-deciduous forest (BB/DF), and deciduous dipterocarp-oak forest (DOF) (Cont.).

| Family | Plant species | Habit | Forest type | |
|---|---|---|---|---|
| | | | BB/DF | DOF |
| 20. Orchidaceae | 46. *Dendrobium draconis* Rchb.f. | Epiphyte | / | / |
| | 47. *Eulophia spectabilis* (Dennst.) Suresh | Herb | | / |
| | 48. *Geodorum attenuatum* Griff. | Herb | / | |
| | 49. *Hetaeria oblongifolia* Blume | Herb | / | / |
| | 50. *Nervilia concolor* (Blume) Schltr. | Herb | / | |
| 21. Plantaginaceae | 51. *Plantago major* L. | Herb | / | / |
| 22. Polygonaceae | 52. *Persicaria barbata* (L.) H.Hara | Herb | / | |
| 23. Rosaceae | 53. *Prunus cerasoides* Buch.-Ham. ex D. Don | Tree | / | |
| | 54. *Rubus alceifolius* Poir. | Shrub | | / |
| 24. Rubiaceae | 55. *Gardenia sootepensis* Hutch. | Tree | / | / |
| | 56. *Ixora cibdela* Craib | Shrub | / | / |
| | 57. *Melicope viticina* (Wall. ex Kurtz) T.G. Hartley | Shrub | | / |
| | 58. *Prismatomeris tetrandra* (Roxb.) K.Schum. | Shrub | / | |
| | 59. *Spermacoce remota* Lam. | Herb | | / |
| 25. Smilacaceae | 60. *Wendlandia tinctoria* (Roxb.) DC. | Tree | / | / |
| 26. Solanaceae | 61. *Smilax verticalis* Gagnep. | Climber | / | |
| 27. Theaceae | 62. *Solanum torvum* Sw. | Shrub | / | |
| 28. Tiliaceae | 63. *Anneslea fragrans* Wall. | Tree | / | / |
| | 64. *Grewia abutilifolia* Vent. ex Juss. | Shrub | / | / |
| | 65. *Grewia eriocarpa* Juss. | Tree | / | |
| 29. Verbenaceae | 66. *Muntingia calabura* L. | Tree | / | |
| 30. Xanthorrhoeaceae | 67. *Stachytarpheta indica* (L.) Vahl* | Herb | / | / |
| 31. Zingiberaceae | 68. *Alpinia malaccensis* (Burm.f.) Roscoe | Herb | / | / |
| | 69. *Gagnepainia godefroyi* (Baill.) K.Schum. | Herb | / | |
| | 70. *Kaempferia rotunda* L. | Herb | / | / |
| | **Total** | | **58** | **31** |

note: *non-native plant species of Thailand

The second largest number of species (8 species) was recorded for the family Fabaceae (Leguminosae), while the families Amaranthaceae, Amaryllidaceae, Apocynaceae, Buddlejaceae, Convolvulaceae, Cyperaceae, Ericaceae, Malvaceae, Melastomataceae, Meliaceae, Moraceae, Oleaceae, Plantaginaceae, Polygonaceae, Smilacaceae, Solanaceae, Theaceae, Verbenaceae and Xanthorrhoeaceae were ranked last, because each family had only 1 species. Five of the plant species (*Erigeron floribundus* (Kunth) Sch. Bip., *Vernonia gratiosa* Hance, *Youngia japonica* (L.) DC., *Melilotus suaveolens* Ledeb, *Stachytarpheta indica* (L.) Vahl) were non-native species. The highest number of bee flora species was found in pollen loads of *T. collina* (44 species), while there were the lowest with *Li. cacciae* (9 species). The most abundant pollen source of all stingless bee species was *Synotis cappa* (Buch.-Ham. ex D.Don) C.Jeffrey & Y.L.Chen in family Asteraceae (Compositae). The consolidated list of pollen source and its stingless bee pollinator is given in Table 4.

**Table 4.** List of pollen sources associated of stingless bee species

| | Plant species | Insect species | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *H. fimbriata* | *L. nitidiventris* | *L. terminata* | *L. ventralis* | *Li. cacciae* | *T. collina* | *Te. laeviceps* | *Te. minor* | *Tet. apicalis* | *Tet. melanoleuca* | |
| 1. | *Asystasia salicifolia* | / | / | | | | / | | | | / | **4** |
| 2. | *Eranthemum tetragonum* | | | / | | / | / | | | | | **3** |
| 3. | *Thunbergia grandiflora* | / | / | | / | / | / | / | / | | / | **8** |
| 4. | *Gomphrena celosioides* | | | / | | | / | | | / | | **3** |
| 5. | *Hippeastrum puniceum* | / | / | / | | | / | | / | | | **5** |
| 6. | *Rauvolfia serpentina* | | / | / | | | | | / | | / | **4** |
| 7. | *Acmella paniculata* | | / | / | / | | / | / | / | / | / | **8** |
| 8. | *Ageratum conyzoides* | | / | | | | / | / | / | / | | **5** |
| 9. | *Bidens pilosa* | | / | / | | | / | / | | | | **4** |
| 10. | *Blumea lacera* | / | | | / | / | / | / | | / | | **6** |
| 11. | *Crassocephalum crepidioides* | | / | / | | | | / | | | / | **4** |
| 12. | *Crotalaria alata* | / | / | / | / | | / | | | | | **5** |
| 13. | *Cyanthillium cinereum* | | / | / | | | | | | / | / | **4** |
| 14. | *Erigeron floribundus* | | | / | / | | | | | | | **2** |
| 15. | *Synotis cappa* | / | / | / | / | | / | / | / | / | / | **9** |
| 16. | *Tridax procumbens* | | / | / | / | | / | | | | | **4** |
| 17. | *Vernonia gratiosa* | | | / | / | / | | | | | / | **4** |
| 18. | *Youngia japonica* | | | | | / | | / | / | | | **3** |
| 19. | *Begonia palmata* | | | / | / | | / | | | / | | **4** |
| 20. | *Stereospermum neuranthum* | | | / | / | | / | | | / | / | **5** |
| 21. | *Buddleja asiatica* | | / | | | | | / | / | | | **3** |
| 22. | *Murdannia edulis* | | | | / | | | | | / | / | **3** |
| 23. | *Murdannia spectabilis* | | | | / | | | / | / | | | **3** |
| 24. | *Merremia vitifolia* | / | / | / | | | / | | | | / | **5** |
| 25. | *Scleria terrestris* | | | | | | / | | | / | / | **3** |
| 26. | *Vaccinium sprengelii* | | / | | | | | | / | / | / | **4** |
| 27. | *Antidesma ghaesembilla* | | | / | / | | / | | | / | / | **5** |
| 28. | *Croton decalvatus* | / | / | / | / | | / | / | / | | | **7** |
| 29. | *Croton persimilis* | | / | | / | | / | / | / | / | | **6** |
| 30. | *Homonoia riparia* | | | / | / | | | / | / | | | **4** |
| 31. | *Afzelia xylocarpa* | / | | / | / | | / | | | | | **4** |
| 32. | *Cassia bakeriana* | / | / | / | / | | / | / | | | | **6** |
| 33. | *Cassia fistula* | | / | / | / | | | / | | | | **4** |
| 34. | *Entada glandulosa* | | / | | / | | | / | / | | / | **5** |
| 35. | *Leucaena leucocephala* | | | | | | / | / | / | | | **3** |
| 36. | *Melilotus suaveolens* | | | | / | | | / | / | | / | **4** |
| 37. | *Millettia brandisiana* | / | | / | / | | | / | | | / | **5** |
| 38. | *Mimosa pudica* | / | | | / | | / | / | / | | | **5** |
| 39. | *Gmelina arborea* | | / | | | | | / | | / | / | **4** |
| 40. | *Vitex peduncularis* | | | | / | / | | / | / | | | **4** |
| 41. | *Helicteres elongata* | | | | / | | / | | | / | / | **4** |
| 42. | *Melastoma malabathricum* | / | | | / | / | | / | | / | / | **6** |
| 43. | *Azadirachta indica* | / | / | | | | / | | | | / | **4** |

**Table 4.** List of pollen sources associated of stingless bee species (Cont.).

| | Plant species | Insect species | | | | | | | | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | *H. fimbriata* | *L. nitidiventris* | *L. terminata* | *L. ventralis* | *Li. cacciae* | *T. collina* | *Te. laeviceps* | *Te. minor* | *Tet. apicalis* | *Tet. melanoleuca* | |
| 44. | *Ficus ischnopoda* | / | | / | | | / | / | | | | **4** |
| 45. | *Jasminum siamense* | | | | | | / | / | | | | **2** |
| 46. | *Dendrobium draconis* | / | | / | / | | | / | | / | / | **6** |
| 47. | *Eulophia spectabilis* | | / | | / | | / | / | / | / | | **6** |
| 48. | *Geodorum attenuatum* | | | | | | / | / | / | | | **3** |
| 49. | *Hetaeria oblongifolia* | | | | | | | / | / | | / | **3** |
| 50. | *Nervilia concolor* | | / | / | | | / | | | | / | **4** |
| 51. | *Plantago major* | / | | | | | | / | | / | / | **4** |
| 52. | *Persicaria barbata* | | | / | | / | / | / | / | | | **5** |
| 53. | *Prunus cerasoides* | / | / | / | / | | / | / | | | / | **7** |
| 54. | *Rubus alceifolius* | | | / | / | | / | | | / | / | **5** |
| 55. | *Gardenia sootepensis* | | / | | / | | | | | / | / | **4** |
| 56. | *Ixora cibdela* | | | | | | / | | | / | / | **3** |
| 57. | *Melicope viticina* | | | / | | | / | / | | / | | **4** |
| 58. | *Prismatomeris tetrandra* | | | / | / | | | / | | | | **3** |
| 59. | *Spermacoce remota* | | | / | | | / | | | / | / | **4** |
| 60. | *Wendlandia tinctoria* | | / | / | / | | / | / | / | | | **6** |
| 61. | *Smilax verticalis* | | / | | | | / | | | | / | **3** |
| 62. | *Solanum torvum* | / | | | / | / | | / | | | | **4** |
| 63. | *Anneslea fragrans* | / | | | | | | | / | / | / | **4** |
| 64. | *Grewia abutilifolia* | | | / | | | / | / | | / | / | **5** |
| 65. | *Grewia eriocarpa* | | / | / | | | / | / | / | | | **5** |
| 66. | *Muntingia calabura* | / | / | | / | | | / | | | / | **5** |
| 67. | *Stachytarpheta indica* | | | | / | | / | / | | | | **3** |
| 68. | *Alpinia malaccensis* | / | | / | / | | / | | | / | / | **6** |
| 69. | *Gagnepainia godefroyi* | | | / | | | / | / | | | | **3** |
| 70. | *Kaempferia rotunda* | | | / | | | / | / | | | | **3** |
| | **Total** | **22** | **30** | **38** | **37** | **9** | **44** | **42** | **25** | **27** | **35** | |

## CONCLUSIONS AND DISCUSSION

Large numbers of stingless bee species have been reported in tropical areas, of which 35 species have been found in Thailand (Yamane *et al.*, 1999; Rasmussen, 2008). In this study, we found 10 species in Nam Nao National Park. All of them were the same species which have been reported in Thailand. The highest species number of stingless bees was found in BB/DF (9 species), following by DOF (5 species). *T. collina* was the most abundance in BB/DF while *Tet. melanoleuca* was the most abundance in DOF. In accordance with the studies of Rajitparinya (2000), Klakasikorn *et al.* (2005) and Jongjitvimol (2008) reported that they are the main pollinator in the BB/DF and DOF of northern Thailand. Moreover, *Tet. apicalis* was only captured in DOF. It is probable that *Tet. apicalis* is less adaptive to find food than other species in this area. Geslin *et al*. (2014) proposed that interspecific competition had effect on species richness and distribution of bees.

Herein, BB/DF had the highest value on the Shannon-Wiener index, Pielou's index, and Simpson diversity index while the lowest was in the DOF. It was plausible that BB/DF provided food sources and host plants for stingless bees. Moreover, this might be due to the fact that the microclimate was more proper for successful foraging or nesting, because either there were more nesting trees, or food resources were well-supplied (Boontop *et al.*, 2008). The results obtained from the present studies are also in agreement with Nkoba (2012) who found that the diversity of stingless bee species did vary within different habitats in forests especially in the indigenous forest that had more species diversity than the other habitats. Additionally, stingless bees might be strongly related to natural native forest habitats for nesting and food (Roubik, 1989; Ricketts, 2004; Brosi *et al*., 2007; Boontop *et al.*, 2008; Brosi *et al*. 2008).

From these results, we concluded species diversity of the stingless bees and their pollen sources were higher in BB/DF than in DOF. In accordance with their pollen food sources found that the highest number of plant species (58 species) was found in BB/DF while the less in their species number (31 species) was found in DOF.

## ACKNOWLEDGEMENTS

This work was supported by the Higher Education Research Promotion–National Research Universities (HERP–NRU) budget under the biodiversity project (2556A14262002). The authors are grateful to Dr. Tracey Stead form British Council in United Kingdom for her critical comments and helpful suggestions.

## REFERENCES

Blüthgen, N. and Klein, A.M. (2011). Functional complementarily and specialisation: the role of biodiversity in plant-pollinator interactions. *Basic and Applied Ecology*, *12*(4), 282-291.

Boontop, Y., S. Malaipan, K. Chareansom and D. Wiwatwittaya. (2008). Diversity of Stingless Bees (Apidae: Meliponini) in Thong Pha Phum District, Kanchanaburi Province, Thailand. *Kasetsart Journal: Natural Science*, *42*(3), 444-456.

Brosi, B.J., Daily, G.C. and Ehrlich, P. (2007). Bee community shifts with landscape context in a tropical countryside. *Ecological Applications*, *17*(2), 418-430.

Brosi, B.J., Daily, G.C., Shih, T.M., Oviedo, F. and Duran, G. (2008). The effects of forest fragmentation on bee communities in tropical countryside. *Journal of Applied Ecology*, *45*(3), 773-783.

Cortopassi-Laurino, M., Imperatriz-Fonseca, V.L., Roubik, D.W., Dollin, A., Heard, T., Aguilar, I., Venturieri, G.C., Eardley, C., Nogueira-Neto, P. (2006). Global meliponiculture: challenges and opportunities. *Apidologie*, *37*(2), 275-292.

da Silva, G.R., da Natividade, T.B., Camara, C.A., da Silva, E.M.S., de Assis Ribeiro dos Santos, F. and Silva, T.M.S. (2014). Identification of sugar, amino acids and minerals from the pollen of Jandaíra stingless bees (*Melipona subnitida*). *Food and Nutrition Sciences*, *5*(11), 1015-1021.

DNP (Department of National Parks, Wildlife and Plant Conservation). (2010). *National Parks in Thailand* (2nd ed.). Bangkok: Department of National Parks, Wildlife and Plant Conservation.

Erdtman, G. (1960). The acetolysis method, a revised description. *Svensk Botanisk Tidskrift*, *54*, 561-564.

Fontaine, C., Dajoz, I., Meriguet, J. and Loreau, M. (2006). Functional diversity of plant pollinator interaction webs enhances the persistance of plant communities. *PLoS Biology*, *4*(1), 129-135.

Geslin, B., Baude, M., Mallard, F. and Dajoz, I. (2014). Effect of local spatial plant distribution and conspecific density on bumble bee foraging behaviour. Ecological Entomology, *39* (3), 334-342.

Hatch, M. (1926). Concerning the insect collection. *Entomological News*, *37*(12), 329-332.

Jongjitvimol, T. (2008). *Species diversity and taxonomy of infraorder Aculeata (Hymenoptera: Apocrita) in the north of Thailand*. Ph.D. thesis, Naresuan University, Thailand.

Jongjitvimol, T. and Wattanachaiyingcharoen, W. (2007). Distribution, nesting sites and nest structures of the sthingless bee species, *Trigona collina* Smith, 1857 (Apidae, Meliponinae) in Thailand. *Tropical Natural History*, *7*(1), 25-34.

Klakasikorn, A., Wongsiri, S., Deowanish, S. and Duangphakdee, O. (2005). New record of stingless bees (Meliponini: *Trigona*) in Thailand. *Tropical Natural History*, *5*(1), 1-7.

Krebs, C.J. (1999). *Ecology Methodology* (2nd ed.). New York: A Wesley Longman.

Ludwig, J.A. and Reynolds, J.F. (1988). *Statistical Ecology*. New York: John Wiley and Sons.

Magurran, A.E. (1988). *Ecological Diversity and Its Measurement.* New Jersey: Princeton University Press.

Nicolson, S.W. (2011). Bee food: the chemistry and nutritional value of nectar, pollen and mixtures of the two. *African Zoology*, *46*(2), 197-204.

Nkoba, K. (2012). *Distribution, behavioural biology, rearing and pollination efficiency of five stingless bee species (Apidae: Meliponinae) in Kakamega forest, Kenya*. Ph.D. thesis, Kenyatta University, Kenya.

Rajitparinya, T. (2000). Ecology and Diversity of Stingless Bees (Hymenoptera: Apidae) in Chiang Mai. M.Sc. thesis, Chiang Mai University, Thailand.

Rasmussen, C. (2008). Catalog of the Indo-Malayan/Australasian stingless bees (Hymenoptera: Apidae: Meliponini). *Zootaxa*, *1935*, 1-80.

Ricketts, T. H. (2004). Tropical forest fragments enhance pollinator activity in nearby coffee crops. *Conservation Biology*, *18*(5), 1262-1271.

Roubik, W. D. (1989). *Ecology and Natural History of Tropical Bees*. New York: Cambridge University Press.

Sakagami, S.F., Inoue, T. and Salmah, S. (1990). Stingless bees of central Sumatra. In R. Ohgushi, R.F. Sakagami and D.W. Roubik (Eds.). *Natural History of Social Wasps and Bees in Equatorial Sumatra*. Sapporo: Hokkaido University Press, 125-137.

Simpson, E.H. (1949). Measurement of diversity. *Nature*, *163*, 688.

Sorensen, T.A. (1948). A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analyses of the vegetation on Danish commons. *Kongelige Danske Videnskabernes Selskab, Biologiske Skrifter*, *5*(4), 1-34.

Velthuis, H.H.W. (1997). The Biology of Stingless Bees. Netherlands: Utrecht University.

Venturieri, G.C. (2009). The impact of forest exploitation on Amazonian stingless bees (Apidae, Meliponini). *Genetics and Molecular Research*, *8*(2), 684-689.

Winfree, R., Griswold, T. and Kremen, C. (2007). Effect of human disturbance on bee communities in a forested ecosystem. *Conservation Biology*, *21*(1), 213-223.

Yamane, S.k., Ikudome, S. and Terayama, M. (1999). *Identification Guide to the Aculeata of the Nansei Islands, Japan*. Sapporo: Hokkaido University Press.