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Bee Diversity in Thailand and the Applications of Bee Products

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1. Introduction

This chapter provides information on honey bees (genus *Apis*) and their reasonably close relative group, the stingless bees within the Meliponini Tribe. Their taxonomic position, common morphology and behaviour are defined and explained. Also, a species identification of the four native Thai honey bee species, including the comb and nest structure, worker morphology, species distribution and description of each species behaviour, is summarized. Beyond their role as pollinators, honey bees and stingless bees have important economic, ecological and social values for many rural people in Asia. Especially, wild honey bees are hunted for their products (honey, brood and wax), providing many people with a useful component of household income. Therefore, the applications of bee products, which are important for many rural people in Asia including Thailand, are briefly outlined.

2. The genus *Apis*

Honey bees are classified in the Apini tribe within the subfamily Apinae and family Apidae (Ruttner, 1988). They are part of the large insect order Hymenoptera that includes bees, wasps, ants and sawflies (Gullan & Cranston, 2000). Apis is the only genus of true honey bees and is comprised of the ten Asian species and one Western species (Oldroyd & Wongsiri, 2006).

Some of the most discriminate morphological criteria for worker bees of the genus *Apis* are: the compound eyes covered with erect long hairs, a strongly convex scutellum, the pollen press on the hind leg, the greatly elongated marginal and submarginal cells of the forewing and the jugal lobe in the hind wing (Oldroyd & Wongsiri, 2006).

All honey bee species are highly social insects. Oldroyd & Wongsiri (2006) revealed at least three criteria for defining the eusociality form in honey bees that correspond with that of Wilson (1971). First, an individual larva is reared and cared for by a multitude of workers, and no one larva receives special attention compared to the others (of the same caste), except those going to be queens. Second, they have a pronounced reproductive division of labour, which is that one individual monopolizes reproduction (queen) while others are sterile (workers) for most or all of the time. Third, the form of eusociality in honey bees has overlapping generations. Therefore, during the short life span of workers they are surrounded by their sisters and brothers.

Usually, the social structure of a honey bee colony is composed of a single fertile female queen, several thousand sterile female workers, and, at certain times, a few hundred males (drones) (Fig. 1). The queen and workers both develop from fertilized eggs (diploid, 2n = 32) that are heterozygous at the sex locus. Their different and irreversible development trajectorie are thus not directly genetically predetermined but rather are determined solely epigenetically (environmentally) by their feeding and other treatments that they recieve as larvae. Unlike the queen and workers, drones or functional males are hemizygotes (haploid, n = 16) and develop from unfertilized eggs under the arrhenotous sex determination system. Note that fertilised eggs that are homozygous at the sex locus will develop as diploid males, but their functionality and fertility is limited.

Fig. 1. The size dimorphism between castes of the giant honey bee, *Apis dorsata* F. is less pronounced than other *Apis*. (A) A queen is surrounded by her workers. Her thorax is slightly longer and broader than workers'. (B) Drones have larger eyes (white arrow) but are slightly shorter than workers. Photo by S. Wongvirat.

Within a hive, the queen is the only fertile female so she is the mother of all diploid (queen and worker) members (Crane, 1990), whilst she is typically (under normal circumstances) the mother of all unfertilized eggs (functional drones) as well. Interestingly, a virgin queen can mate with many drones, and so limits the chances of a matched mating (homozygous at the sex locus) and diploid male production (Gould & Gould, 1988). Such high level of polyandry is especially the case for *A. dorsata* queens that have mating frequencies of up to 88.5 (Wattanachaiyingcharoen et al., 2003). Such polyandry, given sperm mixing, leads to asymmetrical levels of the genetic relatedness between workers within colonies and has a profound effect on the bee biology and on the evolution of sociality in bees (Oldroyd & Wongsiri, 2006). A queen can release twenty or more pheromones from her mandibular gland (Crane, 1990). These queen pheromones are volatile compounds, which are important in ensuring colony cohesion within the nest and the dominance of the single queen that heads the colony. The queen's mandibular gland pheromenes induce retinue physiology and behavior in workers (Slessor et al., 1988). For instance, they inhibit the worker's ovary development leading to non reproductive females, and stimulate workers to release pheromones (e.g. Nasonov pheromone) attracting other workers. They can stimulate workers to forage and regulate worker coherence in a swarm or abscorn (Crane, 1990).

Although workers are typically sterile, (in some circumstances some workers can lay unfertilized eggs which if left unattacked by other workers will develop as drones), they have many activities in a colony. For example, a very young adult worker cleans vacated brood cells. Then, at about five-days old, it can feed young larvae and a queen since its hypopharyngeal glands locating in its head are fully active to synthesize royal jelly. Later, these glands start to degenerate at 10-days-old (Crane, 1990). Next, the glands change to produce wax for comb building and to clean the colony. At about two weeks of age, the venom sac is full (Crane, 1990), and some worker bees become active as guards of the colony. As the workers develop from two to four weeks of age, their hypopharyngeal glands secrete increasing amounts of invertase and glucose oxidase, enzymes used in making honey from nectar (Gould & Gould, 1988). At the final stage, the workers will go out of a hive to forage food.

Drones are normally fertile (haploid) males. In all *Apis* spp. except *A. dorsata* and *A. laboriosa*, drones are reared in drone cells on the periphery of the brood nest (Oldroyd & Wongsiri, 2006). These cells are similar to the worker cells in shape and orientation, but the hexagous cells are about three times larger than those of workers (Gould & Gould, 1988). Drones do nothing except leave the colony and mate with a virgin queen. Then, they die. The morphology of the honey bee penis (genitalia) is unique to the genus (Michener, 2007) so it is one of the most useful species identification characters (Radloff et al., 2011).

3. Diversity and distribution of honey bees

From Oldroyd & Wongsiri (2006), three subgenera of honey bees are currently recognized (Table 1), and these differ in the location and structure of building their hive. The two dwarf honey bee species from the subgenera *Micrapis*, *A. florea* and *A. andreniformis*, build a single comb surrounding a twig, while the giant honey bees (subgenera *Megapis*), *A. dorsata* and *A. laboriosa* build a single massive comb under a branch or cliff overhanging or under the eves or roof of a building. Cavity-nesting honey bees (*Apis*), *A. mellifera, A. cerana, A. koschevnikovi, A. nuluensis* and *A. nigrocincta*, build multiple comb nest in cavities.

A recent molecular phylogeny (Lo et al., 2010) added two new taxa to the existing genus *Apis*, one each in the subgenera Megapis and Apis. Based on Bayesian and maximum parsimony phylogenetic trees, their analysis support recognition of *A. indica* (the plains honey bee of south India) as a separate group from the more broadly distributed *A. cerana.* In addition, it also supported classification of the giant Philippines honey bee, *A. breviligula*, as a separated species from the more broadly distributed lowland *A. dorsata*. Thus, three subgenera and 11 species of honey bee of genus *Apis* have been recognized. The distribution of these species is highly uneven (Fig. 2). Interestingly, nine of these 11 species of honey bee can be found in the South-east Asia region, and combined with molecular phylogentic estimates of diveregnce times within the genus, supports that Asia is the most likely birthplace of the *Apis* genus.

In Thailand, there are five *Apis* species which are *A. andreniformis*, *A. florea*, *A. dorsata*, *A. cerana* and *A. mellifera* (Rattanawannee et al., 2007). The first four species are native to Thailand but *A. mellifera* has been introduced by man (anthropogenic) into the country for the apicultural industry (Wongsiri et al., 1996). To recognize these four native species, Rattanawannee et al. (2010) revealed that geometric morphometric analysis of the single wing alone could be used to identify four Asian honeybee species in Thailand and that the sex of the individual does not impede identification. A description of each of the four native species in Thailand are provided below.

Main group	Subgenus	Species	Author	Common name	Thai name
Dwarf honey bee	*Micrapis*	*A. andreniformis*	Smith (1858)	Small dwarf honey bee / Black dwarf honey bee	Pung mim sidam/Pung mim lek/ Pung marn
		A. florea	Fabricius (1787)	Dwarf honey bee / Red dwarf honey bee	Pung mim/ Pung vee
Giant honey bee	*Megapis*	*A. laboriosa*	Smith (1871)	Giant mountain honey bee	-
		A. dorsata	Fabricius (1793)	Giant honey bee / Common giant honey bee	Pung luang
		A. breviligula	Maa (1953)	giant Philippines honey bee	-
Cavity nesting honey bee	*Apis*	*A. cerana*	Fabricius (1793)	Eastern hive honey bee	Pung prong
		A. koschevnikovi	Enderlein (1906)	Red honey bee	-
		A. nigrocincta	Smith (1861)	Sulawesian honey bee	-
		A. nuluensis	Tingek, Koeniger and Koeniger (1996)	Mountain honey bee	-
		A. indica	Fabricius (1798)	Plains Honey Bee	-
		A. mellifera	Linnaeus (1758)	Western honey bee	Pung pun

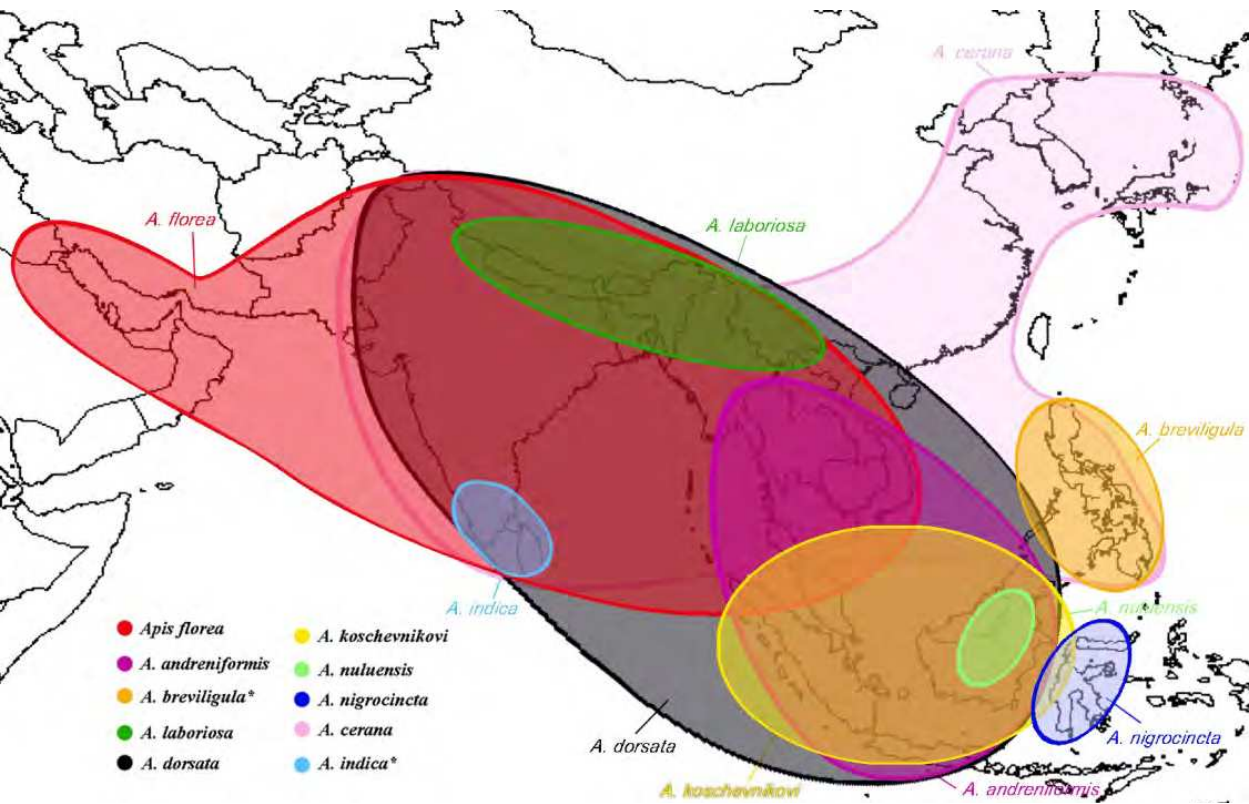Table 1. Three subgenera of the genus *Apis* Linnaeus.

Fig. 2. Approximate distribution of 10 Asian honey bee species of genus *Apis* (amended in accordance with Ruttner, 1988; Oldroyd & Wongsiri, 2006; Lo et al., 2010).

3.1 Dwarf honey bees, subgenus *Micrapis*

The existence of two dwarf honey bee species (*A. andreniformis* and *A. florea*) as valid biological species is well revealed (Radloff et al., 2011), although they are mostly similar in worker and nest sizes. Both build an exposed single comb colony and may utilize similar resources in similar habitats (Wongsiri et al., 1996). Considering species-specific mophological characters, *A. andreniformis* workers have black hairs on their hind tibia and the dorsolateral surface of the hind basitarsus whilst *A. florea* workers have white hairs instead (Wu & Kuang, 1987). In addition *A. andreniformis* workers also have black pigment all over which makes the bees look the darkest, while *A. florea* workers have less black pigment and so are mostly yellow bees (like red dwarf honey bees). The exception is the pigmentation of the scutellum, where in *A. andreniformis* it is yellowish, while that for *A. florea* tends to be black (Wongsiri et al., 1996). Furthermore, the abdominal segments of *A. andreniformis* queens and drones are all black, whilst in *A. florea,* queens present all orange-yellow abdominal segments while drones have grey abdominal segments with white hairs (Rinderer et al., 1995).

Although the endophalli of both species have a pair of bursal cornua, the morphology of the drone's endophallus is different in the two species. In *A. florea* the fimbriate has three protrusions with a strongly curved terminal whilst for *A. andreniformis* the fimbriate has six protrusions with thick and straight terminal. In addition, the thumb-like bifurcate basitasus of the hind leg of drones (Fig. 3) is comparatively longer in *A. florea* (Wu & Kuang, 1987), being just under a half and 2/3 that of the tibia length in *A. andreniformis* and *A. florea,* respectively (Wu & Kuang, 1987).

Fig. 3. Right hind leg of two dwarf honey bee drones showing the thumb-like bifurcate basitasus. Photo by A. Rattanawannee.

Although the nests of both species are very much alike (Figs. 4 and 5), some clear differences in the nest architecture are still observed. When viewed from the edge, cells in the honey storage area of *A. florea* nests are orientated inwards towards a supporting branch (Wongsiri et al., 1996). Considering a cross section of the crown of an *A. florea* nest, there are three levels of inter organization. The first level from the edge contains very long cells that extend to a supporting branch. The second level contains cells coming from the opposite side that have their base at the sides of cells coming from the other side. The third level contains cells

Fig. 4. A nest of *Apis andreniformis* in Thailand, showing the sticky resin around the supporting branches. Photo by S. Wongvirat.

Fig. 5. An *Apis florea* nest in Thailand, showing that the comb is built around a small branch. Photo by S. Wongvirat.

coming from the top of the honey storage area that have the same pattern as cells from the second level. However, some cells open to the top surface have their base well away from

the supporting cell's base (Rinderer et al., 1996). As a consequence of the comb building process, the crown of *A. florea* nests do not contain a midrib (Oldroyd & Wongsiri, 2006). These features contrast with the honey storage area in *A. andreniformis*'s nests, where a characteristic crest appearance is evident when viewed from the outside. A cross section of the honey storage area of an *A. andreniformis* nest reveals a clear midrib structure where the bases of opposing cells come into contact as found in the brood area (Rinderer et al., 1996).

3.1.1 *Apis andreniformis* Smith, 1858

The black dwarf honey bee or small dwarf honey bee, *A. andreniformis*, is the smallest species in the genus *Apis*. It is widely distributed in the tropical and sub tropical regions of Asia, especially in the southern part of China, India, Burma, Laos, Vietnam, Malaysia, Indonesia and the Philippines (Fig. 2). It is always found at coastal flats and near foothill areas (1 - 100 m above sea level) to high mountain and forest areas at about 1600 m attitude (Wongsiri et al., 1996). The economic value of *A. andreniformis* has not been documented. However, the importance of the naturally occurring flora in the range of *A. andreniformis* probably depends on this bee species for pollination (Rinderer et al., 1995).

Since *A. andreniformis* is a rare and patchily distributed species, very little work has been reported. For example, intraspecific variation of *A. andreniformis* was reported by Rattanawannee et al. (2007). They sampled from 27 colonies (for morphometric analysis) and 32 colonies (for genetic analysis) of *A. andreniformis* throughout Thailand. In addition, three colonies for morphometric analysis and five colonies for DNA polymorphism were taken from Tenom in Sabah, Malaysia. For morphometry, 20 informative morphometric characters were used to assess the variation. Principle component analysis (PCA) yielded four factor scores. Within PCA plots, *A. andreniformis* from across Thailand and Tenom (Malaysia) formed a single group, a notion further supported by a hierarchical cluster analysis generated dendrogram. However, linear regression analysis showed clinal patterns of morphometric characters, where the body size of bees increased from the South to the North, associated with increasing altitude, but decreased from the West to the East, associated with decreasing altitude. For genetic variation, based on the sequence analysis of the mitochondrial *cytochrome oxidase subunit b* (*Cyt-b*) gene fragment, two groups of *A. andreniformis* populations from Thailand were found. However, these results are tentative, pending more extensive analyses of samples across the distribution areas of *A. andreniformis*.

3.1.2 *Apis florea* Fabricius, 1787

The red dwarf honeybee, *A. florea,* is extremly widespread in Asia, extending from Vietnam and southeastern China, across mainland Asia along and below the southern Himalayas, westwards to the Plateau of Iran and southern into Oman (Fig. 2) (Hepburn & Hepburn, 2005). However, the main habitat of this bee species is Pakistan, India, Sri Lanka, Thailand, Indochina, Malaysia, part of Indonesia and Palawan at altitudes below 1000 m (Ruttner, 1988).

Multivariate morphometric analysis of *A. florea* using 20 morphometric characters to investigate the intraspecific morphometric variation of 18 samples of *A. florea* (360 bees) from Sri Lanka, Thailand, Pakistan, Iran and Oman revealed three morphocluster groups of *A. florea* (Ruttner, 1988); (i) Sri Lanka and south India, (ii) Thailand and Oman and (iii) Pakistan and Iran. In addition, the body size of *A. florea* was observed to increase across the study range from the South to the North. Subsequent analysis using 12 morphometric

characters of *A. florea* from 26 localities in southern Iran revealed two morphoclusters of *A. florea*; a larger bee group at high latitudes (29° - 34°) and a smaller bee group at lower latitudes (<29°) (Tahmasebi et al., 2002). After combining their data with that of Ruttner (1988) and Mogga & Ruttner (1988), they also identified three morphoclusters for all *A. florea* samples. However, information on the geographical contiguity of this honey bee species was still missing (Radloff et al., 2011).

To fill the geographical contiguity of *A. florea*, Hepburn et al. (2005) performed multivariate morphometric analysis of 184 colonies (2,923 individual workers) of *A. florea* collected from 103 localities across the full distributional area from Vietnam and southeastern China to Iran and Oman. They concluded that *A. florea* was a panmictic species comprised of three morphoclusters; northwestern, southeastern and an intermediate form. They suggested that the seasonality of reproductive swarming was temporary continuous allowing gene flow throughout this panmictic species.

In Thailand, Chaiyawong et al. (2004) performed multivariate morphometric analysis of 50 *A. florea* colonies (750 worker bees) from different locations throughout Thailand. From a PCA and cluster analysis of 22 morphometric characters, they revealed only a single group of *A. florea* in Thailand. Then, after reducing the number of characters, a degree of isolation from the mainland group was obtained for Samui Island and Pha-ngan Island, but the bees from these locations were correctly regarded simply as variants. This single morphocluster for Thailand of *A. florea* was in close agreement to the report of Nanork (2001), who found no variation among sympatric *A. florea*, in Thailand using PCR-RFLP analysis of the *Cyt-bI-tRNA* coding gene region of the mtDNA.

3.2 *Apis dorsata* Fabricius, 1793

The common giant honeybee, *Apis dorsata,* is one of three species of the subgenus *Megapis*. Neither Ruttner (1988) nor Engels (1999) separated *A. dorsata* from the closely related species, *A. laboriosa*. However, various evidences have demonstrated the difference between the two giant honey bee species. For example, Underwood (1990) reported the mating flight of Nepalese *A. laboriosa* drones was during 12:30 - 14:30 h whereas *A. dorsata* drone mating flight occured just after dusk, during 18:15 - 18:50 h (Koeniger et al., 1988), suggesting a prezygotic reproductive barrier. Also, the vocal communication dance performed by *A. dorsata* workers is different from that of the silent *A. laboriosa* workers (Oldroyd & Wongsiri, 2006; Kirchner et al., 1996). Furthermore, Arias & Sheppard (2005) revealed that the ND2 and EF-1a gene nucleotide DNA sequence divergence between *A. dorsata* and *A. laboriosa* is 10.6 - 11.5%, which strongly supports seperate species status. Indeed, Raffiudian & Crozier (2007) showed that 100% of Bayesian consensus trees support the grouping of *A. dorsata* distinct from *A. laboriosa*, and supporting recognition of *A. laboriosa* as a valid species.

Other than *A. dorsata* and *A. laboriosa*, another species of giant honey bees has been reported by Lo et al. (2010). Based on Bayesian and maximum parsimony phylogenetic trees, their analysis supports recognition of the giant Philippines honey bee, *A. breviligula* Maa, 1953, as a separate species from the more broadly distributed lowland *A. dorsata*. *A. breviligula* is found northwest of the Merrill line in Luzon in the Philippines (Oldroyd & Wongsiri, 2006). This giant honey bee is strikingly distinguished from *A. dorsata* owing to black rather than yellow coloration of the abdomen and that it never forms colony aggregations as *A. laboriosa* and *A. dorsata* do (Lo et al., 2010). Therefore, three species of giant honey bee in the subgenus *Megapis* of the genus *Apis* have now been recognized.

The distribution of *A. dorsata* is over a vast geographic area in the South and Southeast Asia (Fig. 2). To the West, *A. dorsata* occurs not farther than the Indus river, and to the East, *A. dorsata* are throughout the Philippines and even cross the Wallace line. The giant honey bee is reported to present at altitudes up to 1000 - 1700 m, or even up to 2000 m during migration (Ruttner, 1988).

In Thailand, *A. dorsata* is the only species of the subgenus *Megapis* that can be found. Among honey bee spp., individual workers of *A. dorsata* are relatively large, being about 17 mm long. Thus, the giant honey bees are distinguished from the other four honey bee species in Thailand by their much larger body size and that their wings that are fuscous, and quite hairy (Oldroyd & Wongsiri, 2006). The fore and hind wings of *A. dorsata* workers are 12.96 and 8.91 mm long, respectively (Tan, 2007). The body color of *A. dorsata* workers is yellow, with tergites 2 and 3 being reddish-brown (Crane, 1990). Unlike the comb of the dwarf honey bees (*A. florea* and *A. andreniformis*), in which the crown of the comb always encircles the support, the massive single comb colony of *A. dorsata* is always attached under the surface of a stout tree branch or an overhang of a rock face, and nowadays also sometimes to the eves of buildings or other urban structures (Fig. 6) (Paar et al., 2004).

Fig. 6. A masive single comb nest of *Apis dorsata* attached under the eves of buildings at Mae Fah Luang University, Chiang Rai, Thailand. Photo by A. Rattanawannee.

Where *A. dorsata* nests are found in trees, the diameter of the supporting branches varies from 12 - 30 cm (Morse & Laigo, 1969) or much larger (Oldroyd & Wongsiri, 2006). A

slightly sloping branch is preferred (Tan et al., 1997). The width of *A. dorsata* combs varies from 43 – 162 cm, and the height from 23 – 90 cm (Tan, 2007). Honey is stored in one corner of the comb nearest the uppermost section of the comb in an area about 10 - 20 cm in a large nest (Oldroyd & Wongsiri, 2006). In the large colonies, the number of individual workers can be over 50,000 (Morse & Laigo, 1969). About 3 - 4 weeks after nesting, a colony of *A. dorsata* typically has about 4 kg of stored honey in the comb, but the highest recorded amount is 15.7 kg (Tan, 2007).
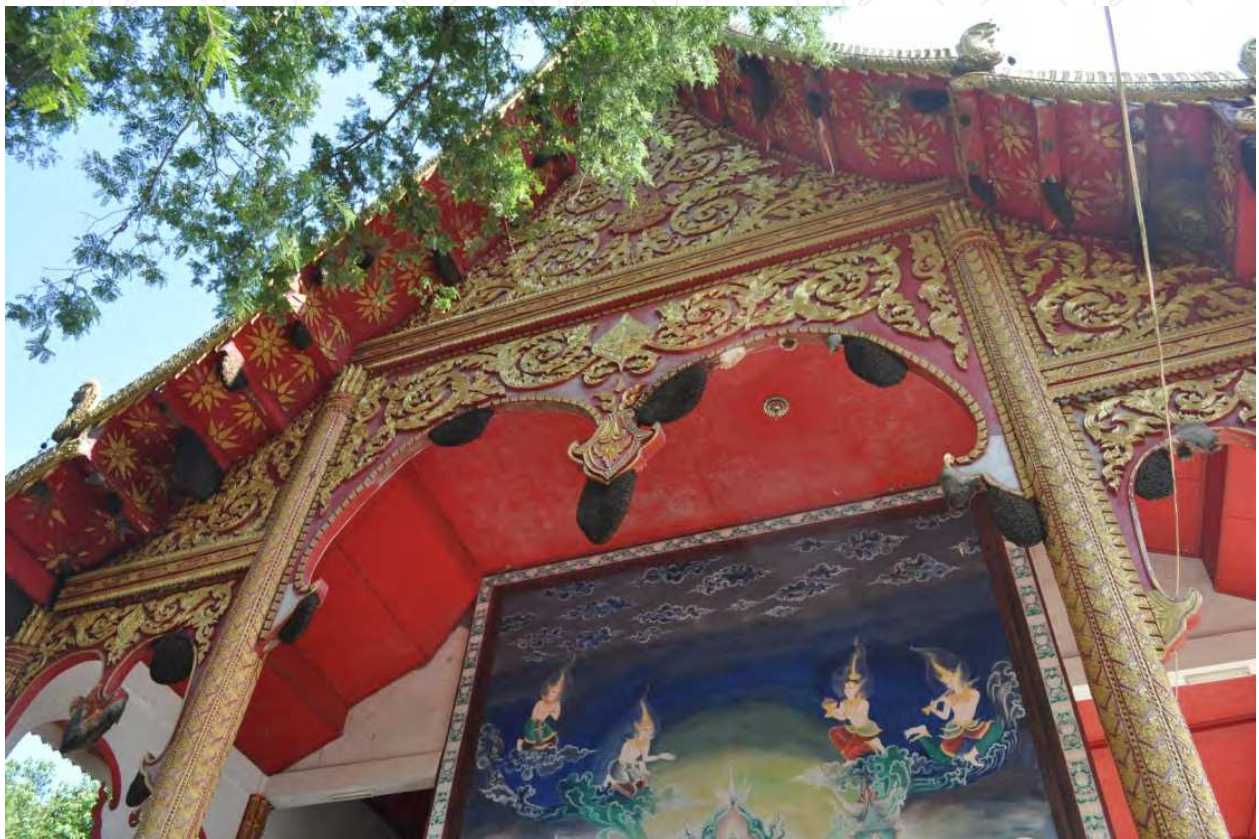

Fig. 7. An aggregation of *Apis dorsata* colonies under the roof of a temple in Chaing Rai, Thailand. Photo by A. Rattanawanee.

Three further typical characters of *A. dorsata* are as follows. First, colonies are unusual in terms of that nests often occur in dense aggregations of up to 100 or even 200 colonies on a single tree or building (Koeniger & Koeniger, 1980), and these colonies are often separated by only a few centimeters (Figs. 7 and 8). Secondly, the nest sites are occupied seasonally year after year. Interestingly, queens often return to the same nest site even after an absence of up to 18 months (Paar et al., 2000). In Thailand, aggregations of nests are formed by swarms that arrive at the onset of the dry season. Finally, colonies usually display seasonal migration between alternate nesting sites. Nest sites of these bee populations tend to be occupied for 3 - 4 months (Paar et al., 2004). Towards the end of this period, colonies abscond, leaving an empty comb (Fig. 8). The swarms leave the nest site to a new site up to 200 km away (Koeniger & Koeniger, 1980), and most like spending the wet season as combless swarms in mountainous regions (Ruttner, 1988). The proximate cause of migration may be related to available flowers. Abscornding *A. dorsata* have been observed to travel among habitats with different blooming seasons (Crane et al., 1993). The migration of

colonies may also contribute to control infections with the parasitic mite *Tropilaelaps clareae*, since it needs bee brood in order to reproduce (Paar et al., 2004). Therefore, colonies may reduce infestation levels by this parasitic mite with a period of broodless migration (Rinderer et al., 1994).

Fig. 8. Absconding nests within a colony aggregation of *A. dorsata* on a single tree in Sakonnakorn, Thailand. Photo by A. Rattanawannee.

3.3 *Apis cerana* Fabricius, 1793

A. cerana can be found throughout Asia, including in the great mountain ranges and deserts (Ruttner, 1988), except that there is no evidence of *A. cerana* occurrence in the northern Japanese island of Hokkaido. In contrast, it is widely distributed over the other islands in Japan. In Southeast Asia, *A. cerana* is restricted to the Malayan region, the West of the Wallace line (Ruttner, 1988, as shown in Fig. 2).

A. cerana is a medium sized bee (in body length) with a fore wing length of 7 - 10 mm (Oldroyd & Wongsiri, 2006). Feral colonies of *A. cerana* are found in a similar location as *A. mellifera* colonies, such as tree hollows, clefts in rocks and walls (Fig. 9) (Ruttner, 1988). They usually build three or more parallel combs attached to the roof of tree hollows (Fig. 10). Among the native Thai honey bee species, only *A. cerana* can be maintained in hives like *A. mellifera* (Wongsiri et al., 1986). However, traditional hives for *A. cerana* are substantially smaller than those constructed for *A. mellifera* (Ruttner, 1988).

Fig. 9. A feral colony of *Apis cerana* in a coconut tree hollow in Samut Songkham, Thailand. Photo by J. Kaewmuangmoon.

Fig. 10. Multiple combs withinan *A. cerana* nest. Photo by P. Nanork.

The first morphometric analysis of *A. cerana* was reported in Ruttner (1988), where the results of a PCA using 40 morphometric characters on 93 samples (18 Asian countries) revealed four main groups. Group I consisted of *A. cerana* collected from South India, Sri Lanka, Bangladesh, Burma, Malaysia, Thailand, Indonesia and the Philippines, whereas *A. cerana* from Afghanistan, Pakistan, North India, China and Vietnam were classified in Group II. *A. cerana* samples from central and east Himalaya belonged to Group III whilst Group IV contained *A. cerana* from Japan.

In Thailand, Limbipichai (1990) successfully used standard morphometrics to verify a geographic subpopulation of *A. cerana* split by the Isthmus of Kra, a biogeographic transition area (12° N latitude). This morphometric result was supported by Deowanish et al. (1996) who used PCR-RFLP analysis of the tRNA^leu – COII region mitochondrial DNA sequence based analysis and found variation in the PCR-RFLP banding patterns among Thai samples when using *Bgl*II, *Eco*RV, *Hae*III, *Hin*fI and *Nde*I. In addition, *A. cerana* from the South of Thailand (Hatyai and Samui) could be clearly separated from the mainland population when the tRNA^leu – COII region containing amplicon was digested by *Eco*RV and *Hin*dIII. In some support of this, Sihanuntavong et al. (1999) also reported that the *A. cerana* population from the Samui islands (South of Thailand) was distinct from the mainland populations, as determined using PCR-RFLP anlaysis using *Dra*I restriction of the PCR amplicons of the *srRNA* and *lrRNA* gene and *COI-COII* coding regions. Likewise, Songram et al. (2006) revealed eight distinct RFLP patterns of the *ATPase6-ATPase8* gene region when the DNA was digested by *Vsp*I. Overall, a strong biogeographic pattern between the northern and southern latitude bee populations in Thailand was revealed.

4. Stingless bees

Meliponini is one of the 19 tribes in the subfamily Apinae, including Apini, Euglossini and Bombini (Michener 1974, 2000). Apini and Meliponini are the two tribes that contain members that display a high level of social behavior (Arias et al., 2006). Meliponines are groups of stingless bees whose size, body color and appearance vary greatly. For example, stingless bees in some species have a slender body while those in other species have a wide body. Some appear shiny and others as hairy somewhat like small bumble bees. Also, stingless bees in some species look metallic (Crane, 1990). The number of stingless bee species of Meliponini is still controversial, but it is estimated to be about 50 times more species than *Apis* spp. (Roubik, 2006). Currently, over 600 species in 56 named genera have been recorded in the tropical and subtropical regions of the world. Of these, 400 known species exist in the Neotropical regions and at least 45 species were described in Southeast Asia (Cortopassi-Laurino et al., 2006).

Stingless bees and honey bees are both classified as highly eusocial insects (Michener, 2000), with large perennial colonies, morphologically distinct worker and queen castes and an intricate division of labour and recruitment to food sources (Peter et al., 1999). They normally have a single egg-laying queen and reproduce by division of a colony between the mother queen and a daughter, which is called reproductive swarming (Roubik, 1989).

Meliponines differ from honey bees of the genus *Apis* in many biologically significant ways. For example, they generally have no sting, do not use water to cool their nest and pure wax to build it, and the males feed at flowers while the gravid queens cannot fly (Roubik, 2006). Moreover, Peter et al. (1999) showed that single mating is the rule in stingless bees; in contrast to the well-known multiple mating of honeybee queens (Oldroyd et al., 1997), since

diploid males (from sex allele matched matings) are not tolerated and lead to the queen bee being usurped.

Stingless bees nest in cavities, which differ in locality between species and may be underground, in tree or other enclosed spaces, such as buildings and termite nests (Crane, 1990). Stingless bee species are recognizable from the characteristic nest entrances and often their particular site (Roubik, 2006). Nests are made of wax secreted from the metasomal terga mixed with resins and gums collected by stingless bee workers. Some species add mud, feces or other materials to certain parts of the construct. In all Meliponine species, the composition and texture differ in different parts of the nest (Michener, 2000). Unlike honey bees, they produce brood in the manner of a solitary bee with an egg placed on top of a food mass in a sealed cell (Michener, 2000). Inside the nest of stingless bees, there are different shapes and arrangements of brood cells and food storages (Fig. 11). Brood cells in many stingless bee species are spherical to ovoid, while food storage containers are small to large spheres, or are egg-shaped, or even conical or cylindrical (Roubik, 2006). Honey and pollen are usually stored in separated containers called "storage pots". Usually, pots are constructed together in conglomerates, as are the brood cells. Interestingly, the horizontal brood cells of stingless bees open upwards and are closed after an egg is laid. The egg is positioned on the semi-liquid mix of honey, hypopharyngeal-gland secretion and pollen. All brood cells are destroyed by workers after use and cannot be reused as they are in honey bees (Michener, 2007).
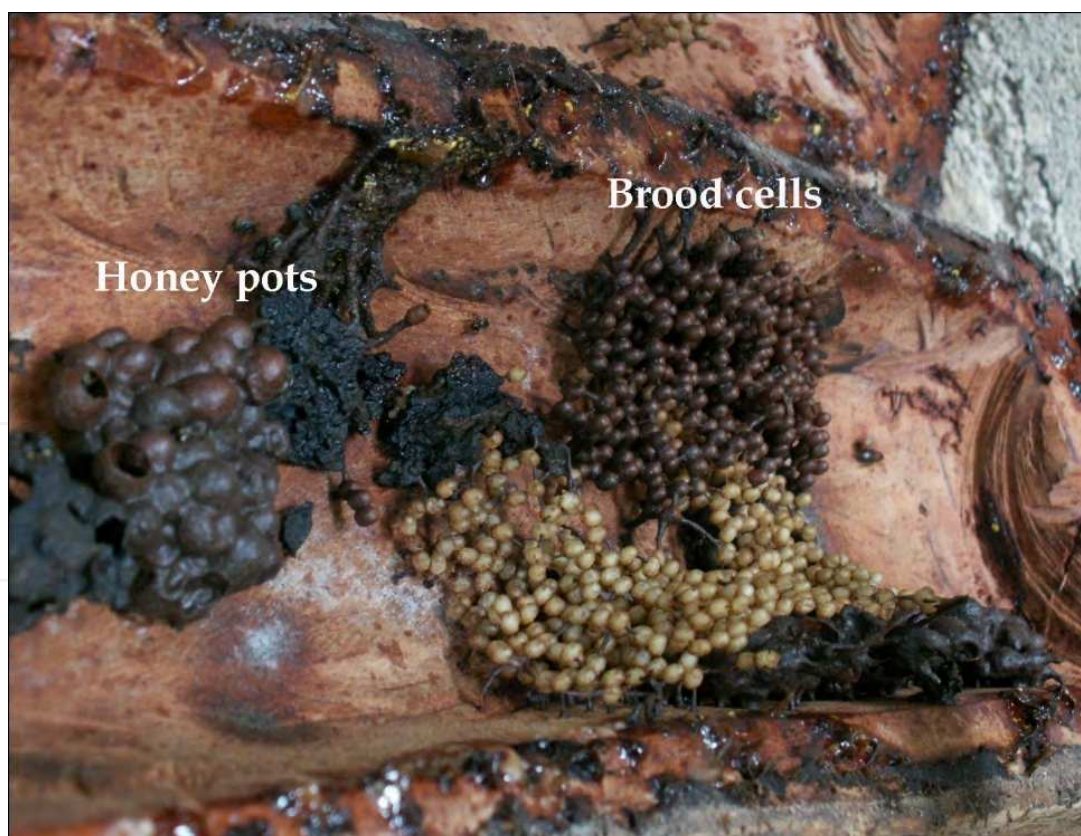

Fig. 11. Ovoid brood cells and honey pots within a *Trigona laeviceps* nest are separated.

More than 50 genera of Meliponines have been reported (Arias et al., 2006). In Thailand, only one genus, *Trigona*, is recognized as endemic with 32 species currently reported

(Klakasikorn et al., 2005). However, this genus is found extensively in tropical regions. In the Neotropics it ranges from Mexico to Argentina, in the Indo-Australian region it extends from India and Sri Lanka to Taiwan, the Solomon islands, South Indonesia, New Guinea and Australia (Michener, 2000). The Thai name for stingless bees varies across the regions, and are Channa Rong (Central), Kheetung Nee (North), Khee Suit (Northeast), and Oong (South).

5. Value of bees

5.1 Pollination value

Up to a third of the food we eat is derived from plants that are either dependent on or benefit from insect pollination (Oldroyd & Nanork, 2009), especially by honey bees (Richards, 2001). The European honey bee, *Apis mellifera*, is the most economically valuable pollinator of agricultural crops worldwide (Conte & Navajas, 2008). However, in most areas of Southeast Asia, there is no significant pollination industry. Insect pollinated crops are, therefore, completely reliant on wild bees, particularly honey bees and stingless bees, for their pollination (Rahman & Rahman, 2000).

Because of their dance language and broad foraging length, honey bees can rapidly identify and exploit the available flowers for nectar and or pollen or plant sap for propolis over a wide range (Dornhaus et al., 2006). Therefore, honey bees are better at long-distance dispersal of pollen than solitary arthropods (Oldroyd & Wongsiri, 2006). Circumstantially, honey bees may partially compensate for fragmentation by bridging the gaps between isolated plant communities (Johnson & Steiner, 2000). Corlett (2001) reported that 86% of plant species in an extremely disturbed area in Hong Kong were visited by *A. cerana*. Thus, although *A. cerena* is probably not a pollinator of all these plants, it does appears to maintain Hong Kong's diverse flora.

Lychees, *Litchi chinensis* Sonn., is one of the important commercially grown economic fruit plants in Thailand. Field trials suggested that the reduction of fruit yield by as much as 11.2% occurs in the absence of pollinators (Oldroyd & Wongsiri, 2006, as cited in Sihag, 1995), and that the majority of pollinators are honey bees and stingless bees. Wongsiri et al. (1996) reported that *A. florea* and *A. andreniformis* are excellent orchard and field crop pollinators, including for longan (*Dimocarpus longan* Lour.) and mango (*Mangifera indica* L.). Since *A. florea* is easy to maintain in orchards and is abundant throughout Thailand, this dwarf honey bee is an excellent pollinator for economic crops and wild plants (Ruttner, 1988).

The lowland forests of Asia are dominated by trees in the family Dipterocarpaceae. Since an individual tree of each species tends to be over the long distances required for efficient effective fertilization and gene flow (Itioka et al., 2001). This requires an animal vector that has species fidelity while foraging, a large foraging range, and the tendency to visit multiple trees, either as individual foragers, or via transfer of pollen among foragers in the nest. The giant honeybee has all these characteristics (Oldroyd & Nanork, 2009). In addition, Momose et al. (1998) reported that *A. dorsata* is one of the major pollinators of several dominant components of the forest canopy in Southeast Asian lowland Dipterocarp forests, one of the richest terrestrial ecosystems in the world. It was reported that *A. dorsata* pollinated at least 15 species of emergent and canopy trees at Lambir (Momose et al., 1998) and was the dominant pollinator of the upper strata in rainforests in peninsular Malaysia (Appanah, 1993), and for canopy dipterocarps in Sri Lanka (Dayanandan et al., 1990).

5.2 Products value

Bee products (honey, royal jelly, propolis, bee pollen, wax and bee venom) are of increasing economic importance. Honey is always consumed as food while royal jelly, propolis and bee pollen are useful in nutrient supplements and applied in cosmetics and traditional medicine. Furthermore, bee venom has long been used in Apitherapy. Among the different bee products in Thailand during 2008 - 2010, honey seems to be the only world trade product according to the statistical record of Thai Custom Department, Ministry of Finance of Thailand (Tables 2 and 3).

It is obvious that China's market is the biggest, both in terms of importation and exportation. Interestingly, the US exports the highest quantity of honey while relatively only a small quantity is consumed in the country. Although China exports a high quantity of honey, a much higher quantity of imported honey is observed. In contrast, Germany is the leading exporter of honey overseas. In addition, although there are many bee farms in countries such as Thailand, Myanmar and Australia, large quantities of honey still have to be imported. This suggests that a promotion program in bee apiary should be arranged and supported.

Country	2008 A.D.		2009 A.D.		2010 A.D.	
	Quantity (ton)	CIF value (million baht)	Quantity (ton)	CIF value (million baht)	Quantity (ton)	CIF value (million baht)
Australia	150.26	17.39	112.44	14.48	119.64	18.75
China	35.96	0.61	431.38	14.00	1,222.11	57.11
France	14.58	3.83	11.24	3.17	14.99	3.54
Germany	23.68	6.16	23.96	6.89	24.04	6.12
Japan	14.03	2.12	14.12	2.67	9.7	1.92
Laos	0.03	0.00	ND	ND	18.60	1.36
Malaysia	ND	ND	0.28	0.01	0.86	0.18
Myanmar	0.2	0.00	0.08	0.00	1,094.68	31.13
Switzerland	3.29	1.08	1.00	0.36	3.00	1.04
Thailand	1.79	0.41	1.79	0.31	251.40	8.57
UK	3.15	0.94	2.53	0.72	8.16	2.10
USA	0.00	0.00	0.00	0.00	0.14	0.02

Table 2. Honey imports (2008 - 2010). The data was obtained from Thai Custom Department, Finance Ministry, Thailand. ND represents no data.

Country	2008 A.D.		2009 A.D.		2010 A.D.	
	Quantity (ton)	FOB value (million baht)	Quantity (ton)	FOB value (million baht)	Quantity (ton)	FOB value (million baht)
Australia	ND	ND	ND	ND	0.00	0.00
China	400.53	38.58	174.16	12.33	447.32	32.02
France	4.00	0.83	8.54	0.96	637.93	49.82
Germany	140.10	10.29	169.22	11.96	658.20	44.48
Japan	2.68	0.29	5.76	0.60	2.56	0.33
Laos	ND	ND	0.11	0.02	0.04	0.00
Malaysia	272.34	14.69	252.90	16.20	269.11	32.22
Myanmar	ND	ND	ND	ND	ND	ND
Switzerland	ND	ND	ND	ND	0.00	0.00
Thailand	ND	ND	ND	ND	ND	ND
UK	1.79	0.35	1.79	0.26	79.03	4.67
USA	186.09	10.18	1,954.86	95.51	1,815.79	92.75

Table 3. Honey exports (2008 - 2010). The data was obtained from Thai Custom Department, Finance Ministry, Thailand. ND represents no data.

6. Application of bee products

Not only are bee products consumed as food, as mentioned earlier, but they also have long been used in medical aspects, especially in traditional medicine. Bee products are derived from plants. For example, honey is the modified form of plant nectar by alpha-glucosidase (Kubo et al., 1996). Propolis is collected from plant buds and barks (Castaldo & Capasso, 2002). Since it is hard to control the consistency of bioactivities from natural products, both in their original form and crude extract, it is important to obtain a chemical structure of the active compounds for subsequent chemical synthesis or (bio) assay of the active contents. Many purification steps were used in order to obtain a pure compound. To this end, spectroscopic techniques, such as Infrared spectroscopy (IR) and Nuclear Magnetic Resonance (NMR), have been broadly applied. Once the structures of the bioactive compounds are known, it can lead into their chemical synthesis and or serve as templates for modifications for subsequent drug development. Currently, the bioactive chemical compounds found in propolis and honey, which mainly belong to the groups of flavonoids and phenolic compounds, seem to be similar to those found in the pollen or sap of the foraged plants (Katircioglu & Mercan, 2006), as expected. Some of the bioactivities from bee products are briefly outlined below.

6.1 Antimicrobial activity
Anti-bacterial activity has been reported against pathogenic bacteria for bee products, and especially propolis and honey (Boorn et al., 2010). Overall, Gram positive bacteria are more

sensitive to the bee products than Gram negative bacteria (Marcucci et al., 2001). Active compounds may act on the inhibition of bacterial RNA polymerase (Takaisi & Schilcher, 1994), degrade the cytoplasmic membrane of bacteria (Cushnie & Lamb, 2005) or cause bacteria to lose their capacity to synthesize ATP, membrane transport and mobility (Mirzoeva et al., 1997). For example, the proliferation of *Staphylococcus aureus* (Gram[+ve] bacteria) and *Escherichia coli* (Gram[-ve] bacteria) is inhibited by the propolis of *Melipona compressipes* (Kujumgiev et al., 1999). Furthermore, propolis collected from the same bee species but in different regions, or different bee species in the same region show marked differences in bioactivity levels as well as susceptible microbes, as expected given the different flora available or utilized by the different bee species in different regions. For example, propolis collected from Spain yielded a higher antimicrobial activity than that collected from Mongolia (Kujumgiev et al., 1999).

However, such geographical and likely seasonal variations in the bioactivity of bee products necessitates some form of standardization of their bioactivity. There has been some progress in the improvement of the standard and acceptance in using bee products in medicine, especially medical-grade honey (Kwakman et al., 2011). Manuka honey, is one such medical-grade honey with antibacterial bioactivity (Lin et al., 2011). Given the severe problem of bacterial resistance to antibiotics, such as methicillin-resistant *S. aureus*, there is a growing need to find new antimicrobial agents. Interestingly, honey from *A. mellifera* in Ireland (Maeda et al., 2008) and from *T. laeviceps* in Thailand (Jirakanwisal, 2010) can inhibit the growth of methicillin-resistant *S. aureus in vitro* better than the currently used antibiotics. In addition, other antibiotic-resistant bacteria, such as gentamicin-resistant *E. coli*, methicillin-resistant *S. epidermidis*, vancomycin-resistant *Enterococcus faecium*, could be killed by medical-grade honey (Kwakman et al., 2008).

Other than pathogenic bacteria, antifungal activity has been reported for bee products, such as the *in vitro* inhibition of *Candida albicans* growth by propolis from Brazil (Kujumgiev et al., 1999). Interestingly the antifungal activity of the propolis extract from *A. mellifera* against *Phomopsis* spp., *Fusarium* spp. *Trichoderma* spp. and *Penicillium notatum* was greater than that seen with ketoconazole, an antifungal drug (Quiroga et al, 2006).

In addition to bacterial and fungal pathogens are severe human diseases caused by viruses. Due to their high rate of mutation, the development of new antiviral agents is always required. With respect to bee products, in 1999, Kujumgiev et al. presented that the aromatic acids and flavonoid aglycone compounds in the propolis from *M. compressipes* in Brazil could inhibit the growth of avian influenza virus *in vitro*. Furthermore, the *in vitro* replication of herpes simplex virus was also inhibited by propolis (Erukhimovitch et al., 2006) and honey (Banerjee, 2006).

6.2 Anti-inflammatory activity

Inflammation is part of the immune and general tissue damage defense response of the vascular tissues, such as for aiding removal of invading pathogens, intruders, which can be microbes, wounds, allergenic proteins, auto-immune, some chemicals, and removing damaged or necrosing tissues Although required for the healing process and part of the immune response, as outlined above, inappropriate or chronic inflammation is deleterious and can lead to, for example, asthma, atherosclerosis and rheumatoid arthritis as well as pain and poor healing. Each individual is differently susceptible to the anti-inflammatory agents or drug. It is still necessary to find out a new anti-inflammatory agent. However, this response can be inappropriate or too extreme and detrimental, driving the requirement for

topical, specific and systemic agents to control the anti-inflammatory responses. With respect to bee products, Paulino et al. (2003) reported an anti-inflammatory activity in the ethanolic extract of propolis from *A. mellifera* in Bulgaria, which had a similar anti-inflammatory activity level to that provided by indomethacin, a recent anti-inflammatory drug. Subsequentially, Hu et al. (2005) reported that the water and ethanolic extracts of propolis from *A. mellifera* in China could significantly decrease the swollen symptoms within two hours of treatment.

Other than propolis, an anti-inflammatory activity can be provided by bee pollen, such as that reported in the ethanol extract of pollen from *A. mellifera* in Brazil (Medeiros et al., 2008). The main active compounds were found to be phenolic compounds and furthermore these were similar to those found in various plants, such as berry ,vegetables, fruits and tea leaves. Moreover, it was reported that the flavanol derivatives from propolis could reduce the allergenic symptom of paw edema, inhibit the synthesis of immunoglobulin E (IgE) and immunoglobulin G_1, reduce the activity of eosinophil peroxidase and reduce the mobility of pulmonary cells. Thus, it is promising that we may be successful in finding new anti-inflammatory agent in propolis.

6.3 Free radical scavenging activity

Free radicals are oxygen-centered molecules that contain a single electron at the outermost orbit. Although they play an important role in biological processes such as in immunity (intracellular killing of bacteria) and certain redox signaling pathways, their inappropriate expression in terms of level or cellular location can lead to serious cell damage as they can bind to low-density lipoprotein (LDL) and some other compounds including proteins and DNA causing irreversible changes. The bound or modified compounds can be toxic to cells leading to premature or inappropriate cell death, and can cause mutations in the genetic materials transforming normal cells to cancer cells (Campos et al., 2003). Other than cancer, excess free radicals are linked to a diverse array of disorders, such as atherosclerosis, cerebral ischemia, cardiac ischemia, Parkinson's disease, gastrointestinal disturbance and aging (Ames et al., 1993). It has long been challenging to find new free radical scavenging agents. However, with respect to bee products, Choi et al. (2006) reported that *A. mellifera* propolis from different regions in Korea (Yangpyeong, Boryung, Cheorwon and Yeosu) contained free-radical scavenging activity, but that they differed in their ED_{50} values between regions. Indeed, propolis from the same bee species collected in Portugal showed the same free radical-scavenging affect (Moreira et al., 2008). Both works also support the idea that natural products from different regions provide an interesting bioactivity at different efficiencies.

Other than propolis, Silva et al. (2005) reported the presence of a free radical scavenging activity in bee pollen from the stingless bee, *Melipona* subnitida, in Brazil. Analysis of the bee pollen revealed that they were from *Mimosa gemmulata*, a plant in the *Mimosaceae* family, and from plants in the *Fabaceae* family. The efficiency of the free radical scavenging activity obtained mainly depended on the organic solvents used in the extraction process. Ethyl acetate was the most efficient extraction solvent for recovery of this bioactivity, followed by ethanol and hexane, respectively. Active compounds were analyzed to be naringenin, isorhamnetin, D-mannitol, *β*-sitosterol, tricetin, selagin and 8-methoxinerbacetin.

6.4 Antiproliferative activity

Although cancer research has long been established, cancer is still the leading cause of death and sickness to people worldwide. Due to the high cost of cancer treatment and the

limitation of recent therapy, including the evolution and spread of resistance to current chemotherapy agents, alternative and complementary medicines are becoming of increasing interest and potential importance, especially those with a different mechanism of action. Indeed, a significant proportion of cancer research has been focused upon finding new anti-cancer agents. With respect to bee products, Awale et al. (2008) reported that the methanolic extract of red propolis in Brazil contained an antiproliferation activity against human pancreatic cancer cells (PANC-1) in tissue culture (*in vitro*). From this extract, forty-three active chemical compounds were analyzed. Among those, three new compounds, 6)a*S*,11 a*S*)-6a-ethoxymedicarpan, 2)-2',4 '-dihydroxyphenyl)--3methyl--6 methoxybenzofuran and 2, 6-dihydroxy-2-[(4-hydroxy-phenyl) methyl]-3-benzo-furanone, were found. In addition, Umthong et al. (2009) reported that the propolis from *T. laeviceps* in Thailand had an antiproliferative activity against the colon cancer (SW620) cell line in tissue culture. The concentration of the methanolic extract of this propolis showed a linear correlation to the anti-proliferative affect, whereas the water extract revealed a biphasic effect.

Bee pollen has also been reported to have an antiproliferative activity upon cancer cell lines in tissue culture, and this has been linked to the flavonoid composition (Rice-Evans et al., 1997). The antiproliferative activity from *A. mellifera* bee pollens collected from *Cystus incanus* L. in Croatia were found to be mediated by phenolic compounds, such as flavonol (pinocembrin), flavanol (quercetin, kaempferol, galangin and isohamnetin), flavones (chrysin) and phenylpropanoid (caffeic acid).

Overall, it is evident that the active chemical compounds and bioactivities depend mainly on the bee species, collecting sites, biogeography and other external factors.

7. Threats to and conservation of wild bees in Southeast Asia

7.1 Deforestation and destruction of nesting sites

Flint (1994) reported that between 1880 and 1980 Southeast Asia showed an average loss of forest cover area of 0.3%, which was primarily caused from agricultural expansion and commercial logging. Subsequent to 1985, deforestation has remained particulary severe in Southeast Asia (Achard et al., 2002).

Little is known about how deforestation will affect honey bees, especially the giant honey bee. Liow et al. (2001) revealed that the proportion of stingless bees and honey bees (Hymenoptera: Apidae) was very low in oil palm plantation areas and very high in undisturbed areas, which implies that oil palm plantations are not suitable in terms of either fulfilling the preferences of honey bees or the ability to support them. Palm trees do not produce nectar and their dense leaves render them unsuitable for nest building by *A. dorsata* (Oldroyd & Nanork, 2009).

The removal of nesting trees of *A. dorsata* is of great concern in their conservation (Oldroyd & Nanork, 2009). Giant honey bees tend to build their nests in aggregations, sometimes with more than 100 colonies on a single tree (Oldroyd et al., 2000). In addition, *A. dorsata* colonies often migrate long distances, but return to their previous nesting site every year (Koeniger & Koeniger, 1980). Thus, the felling of major bee trees may cause a significant decline in the *A. dorsata* populations. Although the effects of agricultural landscapes and industrialization have significantly increased in Thailand, deforestation could represent as a main threat to wild honey bee and stingless bee populations and their nesting sites should be protected (Dietemann et al., 2009).

7.2 Brood and honey hunting

Honey hunting is the general term given to the collection of honey from wild honey bee colonies. Traditional honey hunting is an important role in the life of Asian people. They have been hunting wild honey bees for more than 40,000 years (Crane, 1999) and honey bee hunting remains a widespread practice throughout the region (Oldroyd & Nanork, 2009). The existing method of honey hunting in giant honey bees is the same across Asia. Hunting *A. dorsata* and *A. laboliosa* is more ruthless, and often burning the bees with a smoldering torch of tightly-bound brush (Lahjie & Seibert, 1990). In traditional honey hunting, night time is preferred by many hunters. The smoking is considered crucial to disorientate the bees and so to reduce the number of stings received. After smoking off the bees from the comb, most honey hunters cut down the whole combs destroying all the brood and food stores. A large number of larva and young bees, some hundreds of adult bees and drones are also killed while hunting honey (Tsing, 2003). Many queens must be lost during these harvest methods, and their colonies perish along with them (Oldroyd & Nanork, 2009). Therefore, these methods of hunting may kill many colonies of *A. dorasata* within colony aggregations in one night.

7.3 Honey bee diseases and parasites

Honey bee colonies can be infected by numerous pathogens (viruses, bacteria, fungi and protozoa), and can be infested by various parasitic insects and mites (Morse & Nowogrodzki, 1990). Normally, feral honey bee populations are not threatened by the parasites and pathogens with which they have co-evolved (Oldroyd and Nanork, 2009). However, Allen et al. (1990) reported that *A. laboriosa* populations in Nepal were infected by European foulbrood (*Mellisococcus pluton*), which they attributed to environmental stress by deforestation. Moreover, *A. mellifera* colonies have been introduced into many countries in Southeast Asia. Thus, the anthropogenic movement of honey bee populations between countries increasingly exposes wild populations to novel pathogens and parasites that they have no or reduced resistance to the pathogen alone or after subsequent stress (Oldroyd & Nanork, 2009).

The *Tropilaelaps* mite is a serious external parasite of the honey bee. Its primary host was subsequently recognized as the giant honeybee, *A. dorsata* (Laigo & Morse, 1968) and it has now been reported throughout the entire distribution range of *A. dorsata* (Matheson, 1996). It is also associated with other Asian honey bees, including *A. laboriosa*, *A. cerana* and *A. florea* (Delfinado-Baker et al., 1985).

The greater wax moth, *Galleria mellonella*, is the most serious pest in honey bee colonies worldwide. Its larvae cause considerable damage to bee colonies by feeding on the wax combs and cells containing broods, honey and pollens. The wax moth larvae also destroy the comb structure by forming tunnels inside the comb (Jyothi et al., 1990). Furthermore, Tingek et al. (2004) reported that a Conopid fly, *Physocephala parralleliventris* Kröber (Diptera: Conopidae) parasitizes *A. dorsata*, *A. cerana*, and *A. koschevnikovi* in Borneo. This fly grasps foraging bees in flight and deposits a larva on the integument. Then, the larva penetrates the bee cuticle and consumes the bee from the inside.

7.4 Pesticides

Some commercial fruit orchards, particularly longan (*Dimocarpus longan*), litchi (*Litchi chinensis*) and citrus are major nectar producers which are highly attractive to honey bees

(Crane et al., 1984). Commercial sun flower (*Helianthus annuus*) plantations are one of the most important sources of pollen and nectar for bees in Thailand. However, these commercial crops are regularly sprayed with insecticides, especially in the flowering period. Oil palm (*Elaeis* spp.) orchards are also regularly exposed to insecticides, and this may contribute to the observed low number of honey bees within oil palm crops (Oldroyd & Nanork, 2009). Colonies of all bee species may lose field bees when foraging on crops that are exposed to insecticides. The regulation of pesticide use is lax in some Southeast Asia countries, and can increase the possibility of honey bees exposure to pesticides (Oldroyd & Wongsiri, 2006).

7.5 Impact of climate change

Climate influences flower development and nectar and pollen production, which are directly linked with the colonies' foraging activity and development (Winston, 1987). A major effect of climate change on honey bees stems from changes in the distribution of the flower species (Thuiller et al., 2005) on which the bees depend for food. Rain can impact on honey harvesting. For example, when acacia (*Acacia* spp.) flowers are washed by rain, they are no longer attractive to honey bees as it dilutes their nectar too much (Conte & Navajas, 2008). Likewise, an overly dry climate can reduce the production of flower nectar for honey bees to harvest, since many plant flowers produce no nectar when the weather is too dry, which makes harvesting by bees a largely hypothetical matter. In these situations, honey bees can die of starvation.

8. Conclusion

In Southeast Asia, the bee diversity is very high, especially for honey bees (*Apis* spp.). In Thailand, there are four native honey bees; *A. cerana, A. florea, A. dorsata* and *A. andreniformis*, plus the anthropogenically imported *A. mellifera*. Other than *Apis* spp., stingless bees can produce honey as well. In Thailand, there are more than 50 species of stingless bees, of which the most common is *T. laeviceps*. Besides the biology, diversity and ecology of the bees, variation, both morphometric and genetic variations have been evaluated. In addition, although the gender of bees can be distinguished easily by their morphology, geometric morphometric analysis of their wings alone could successfully distinguish the genders. Bees are classified as eusocial insects since there are three distinct castes within a hive; that is the queen, drones and workers. Not only are bees are very useful as pollinators, but their bee products, especially honey, are economically important. Other than being consumed as food, bee products, especially honey, propolis and bee pollens, have long been used in traditional medicine. They provide many bioactivities, such as antimicrobial, anti-inflammatory, free radical scavenging and antiproliferation activities amongst others. Although they are important in agriculture, at present, it is obvious that there is a decrease in the number of hives of these bees. This may be due to a combination of deforestation, hunting, diseases, pesticide and other factors. Thus, it is very important to consider the conservation of bees and promote the bee management in each country.

9. Acknowledgments

10. References

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