CHAPTER 2

LITERATURE REVIEW

2.1 General History

In 1793, Fabricius named the honey bee that was found in China as Apis cerana. It was found later that this bee natives to almost all over Asia and represents the honey bee in Eastern hemisphere. The name "Eastern Honey Bee" was named after the Eastern hemisphere, land that the bee was originated (Ruttner, 1988).

A colony of A. cerana composed of a queen, several thousands of workers which may reach 20,000, and a few hundred drones which emerged only in the mating season (Okada, 1985; Wongsiri, 1988).

The queen is, normally, the only fertile female in the colony. The queen is the most important bee in the colony as she lays eggs and acts as a chemical source to control the activities in the colony. Each queen can lay several hundreds to a thousand eggs in a day for 1-2 years (Wongsiri et al., 1990). Okada (1985) reported his observation that the number of ovarioles in A. cerana japonica is approximately half of that of A. mellifera which resulted in the smaller colony in the former. Potichot (1988) reported her study on artificial insemination and natural mating of A. cerana in Thailand. Her study showed the possibility of selecting the suitable strain by means of artificial insemination required to improve the efficiency in the building up of the colony and the productivity of this species.

The nest of A. cerana is the multiple comb nest which normally bulit in the sheltered cavities like the hollow of the rock or the tree trunks. The cavity nest is very helpful in protection from the predators and controlling the temperature in the nest. Comparing to the open air nest honey bee, A. dorsata and A. florea that are restricted only in the tropics and subtropics, A. cerana can colonize in the cool temperature zone with the same ability as it does in tropical climate. The nesting site of A. cerana was considered to be a succesful stratergy for survivalship throughout long periods of its evolution.

Generally, A. cerana and A. mellifera look very similarly in morphology and behaviour except for a few qualitative characteristics that are used to discriminate between the two species eg. a radial vein on the hind wing, different shape of endophallus, fourth and sixth tomentum, inverse position of workers while fanning, lack of propolis in the hive and a pore in the capping drone cells. (Ruttner, 1988)

The body size of A. cerana worker is absolutely distinguished from A. dorsata and A. florea but overlapped with A. mellifera. The size of the bees in this genus evidently resulted from their ecological adaptation and is currently used as taxonomical characteristics in the interspecific level (Ruttner,1988)

Misidentification between these two species can be made because of the similarity and the overlapping of the variability in the size of both species. The truth is that the bees occurring in the plains are smaller in both species than those of the mountains; the same is true for the bees in the tropics and the temperate zones in the two species. The comparisons are generally made between large European races of A. mellifera and the relatively small southern A. cerana type, instead of comparing races of the same geographic lattitude. Small southern races of A. mellifera are smaller than medium-sized A. cerana races and there is no significant difference between the smallest races of both species. However, the big races of A. mellifera exceed the biggest A.cerana races in size. The overall mean values for body dimensions in the species A. cerana are smaller than in A. mellifera (Ruttner, 1988).

A. cerana and A. mellifera show a very close line of the phylogenic evolution. They may be separated sometimes before or during the Pleistocene as the fossils of A. mellifera were firstly found in this epoch (Ruttner, 1988). Both species seem to be in the immature stage of speciation as they have the same mating behaviour and the successful in hybrid instrumental insemination and hybrid egg fertilization. This is to indicate the immediate splitting between these two species. The subunits of these two species are in an initial phase of speciation as they are isolated during the last glaciation. Their recent distribution in the temperate zone shows a post glacial pattern which have existed only for at most 50,000 years. It is evident that the process of speciation is not yet finished since no pre-mating barrier has been established (Ruttner, 1985; 1988).

A. cerana is capable of coexisting, without serious damage, with an exoparasitic bee mite Varroa jacobsoni. This mite is the most serious pest of the western honey bee, A. mellifera, but is originated from A. cerana. Another bee mite pest, Tropilaelaps clareae, the mite pest which cause serious problems to A. mellifera beekeeping in the tropics, was never recorded on infestation in the hive of A. cerana. The resistance behaviour of this bee is investigated in order to get the resistance strain for the commercial beekeeping and to use A. cerana as the biological control agent to control the bee mites in A.

mellifera (Wongsiri and Tangkanasing, 1989). A. cerana is reported to resist Nosema apis similarly to the observation that has been made at Bee Biology Research Unit, Chulalongkorn University, Thailand, A. cerana was infested by Nosema apis as 22 % of adult bees was positively checked but no mortality was observed. The susceptibility to the imported diseases such as Acarapis and European foulbrood were also reported (Wongsiri, 1988). A. cerana showed a very effective defensive behaviour against native predators like Vespa spp. (Ruttner, 1985; 1988).

2.2 Systematical Background

In 1793, Fabricius named the honeybee he found in China as Apis cerana. Unfortunately, the type specimens have no exact locality that can indicate the specific collecting area. All of them are workers and kept at Copenhagen Museum, Denmark. Five years later, he described the bees he collected in India and named them as Apis indica. Type specimens of A. indica were all workers, two of them were kept in Kiel Museum, Western Germany and the another three were kept in Copenhagen Museum, Denmark (Maa,1953).

In 1804, Latreille named the bees he collected from India as Apis socialis, all of them were workers and kept in Oxford Museum, England. This name was not used as it was reidentified later as A.indica (Maa,1953).

In 1861, Smith described the bees found in Celebes, the Island of Indonesia, as Apis nigrocincta, type specimens was kept in Oxford Museum, England. In 1865, he named the bees he found in China as Apis sinensis, type specimens were kept in British Museum, England

(Maa,1953).

In 1904, Ashmead classified the bees in the genus Apis to three genus : Megapis, Apis, and Micrapis ,

Megapis constituted the group of the giant honey bee eg. Megapis dorsata.

Apis comprised the western honey bee eg. Apis mellifera and the eastern honey bee eg. Apis cerana.

Micrapis represented the group of the dwarf honey bee eg. Micrapis florea.(Maa,1953)

Enderlein (1906) proposed the name Apis indica variety javana for the bees he found in South East Asia (Maa,1953). The adding variety name indicated the difference at ultraspecific level that was discussed later by several authors. The type specimens of A. indica variety javana were kept at Stettin Museum. (Maa, 1953)

Buttel - Reepen named the bees found in Kamerun as Apis koschevnikovi but by that time no other specimens to support his work and this name was considered to be invalid.(Maa,1953)

In 1929, Skorikovi identified the bees he collected in the Philippines as A. indica philipina. Type specimens were kept in Lehningard Museum, U.S.S.R. (Maa,1953).

Maa (1953) put all the eastern honey bee into subgenus Sigmatapis in his latest revision and added three new species and two new subspecies as:

Apis (Sigmatapis) lieftincki from South Sumatra, the type specimen were kept in the Bogor Museum, Indonesia.

Apis (Sigmatapis) vechti vechti from East Borneo. The specimen were primarily examined as Apis mellifera var. koschevnikovi. Maa (1953) suggested that typical koschevnikovi was found only in

Kamerun. 1 holotype and 2 paratypes was kept in the Maa's collection and the other paratypes are in the Bogor Museum, Indonesia; Taiwan Agriculture Research Institute and Dr. J. van der Vecht's collection (Maa, 1953).

Apis (Sigmatapis) vechti linda from North Borneo. The holotype and 1 paratype are kept in the Leiden Museum, Netherland and other paratypes in Maa's collection. Maa recognized this new subspecies that its wings were a little paler and its tongue was much shorter than the typical subspecies.

Apis (Sigmatapis) nigrocincta marginella from Central Celebes. 2 holotypes were kept in Leiden Museum and 1 paratype was in Maa's collection.

Apis (Sigmatapis) samarensis from Samar, Phillipine. 4 holotypes and 1 paratype were kept in the California Acad. Sci.,and 2 further paratypes in Maa's collection.

Ruttner (1985,1988) concluded the results on systematical studies comparing with his morphometrical surveying on the eastern honey bee and proposed its geographical distribution as

Group 1. including all populations of small size, which known as plain variety of India and the populations of the south Asian Island, corresponds to A. cerana indica Fabricius 1798. The samples were collected from South India, Sri Lanka, Bangladesh, Burma, Malaysia, Thailand, Indonesia and Philippines. The samples of Sri Lanka are the smallest bees, followed by the samples of the Philippines and by some of Java. By discriminant analysis, the bees of the Philippines should be recognized as the separated subspecies, A. cerana philippina Skorikov 1929, which can be decided by a more thorough knowledge of their variation.

Group 2. the northern population of A. cerana including all the samples from North China, can be assumed to equal A. cerana cerana Fabricius 1793. The populations of the western mountains part of the cerana area (Afghanistan, Pakistan and North India) are not discriminated morphometrically from the bee of North China (Ruttner, 1988). The samples of this group were collected from Afghanistan, Pakistan, North India, China and North Vietnam. The discriminant analysis showed that the bees in this group formed a very compact group in spite of the great geographical distances and a highly disjunct area of distribution. The results from discriminant analysis of Ruttner (1988) confirmed the classical taxonomic identification done by Maa (1953).

Group 3. The bees from the eastern South Asian mountains, from Nepal to Thailand and probably South-West China. The samples were collected from Central and East Himalaya and an undefined region east of it : Nepal, North East India (Darjeeling and Manipur) and from the mountains in North Thailand (Chiangmai). The bees in this group constituted a well-separated cluster in discriminant analysis and was also recorded by Verma et al. (1984) as a morphometrically different type. This group occupied the newly named A. cerana himalayana and was supposed to represent the bee of the tropical mountain region (Ruttner, 1988).

Group 4. The bee of this group is completely isolated from the other groups. The samples were collected from Japan, hence the bee was named as A. cerana japonica Radoszkowski 1877 not to include the Japanese bee in A. cerana cerana as Maa (1953) did. The bee from Korea formed a seperated cluster between group 2 and group 4 with a little closer to group 4. Whether the Korean bee should be associated with japonica or whether they belong to a separate, continental subspecies needs more knowledge to be decided (Ruttner, 1988).

The four major groups of *A. cerana* are resulted from the geographical change before or during the Pleistocene (after the seperation of Japanese Islands from the continent) and the minor groups, which are only slightly different, after the Pleistocene. The islands of South-East Asia have been separated from the continent for only 8,000 - 10,000 years (Ruttner, 1988).

The area of distribution of *A. cerana* is from Ussuria in the north to the Southeast Asia in the south and from Afghanistan in the west to the Philipines in the east. Because of the widely distribution of the species, a large number of samples have been described and categorized by many authors in the way of Linnean taxonomy. New species were described again and again mainly on morphological appearance that was judged to be the insufficient diagnostic characterization and several attempts were made in a number of reviews to amend the nomenclature. Maa(1953) did the last revision of tribus Apini and categorized the specimens obtained from several locations into eleven species and four subspecies and put all the Eastern honey bee into subgenus Sigmatapis, Maa's "species" replace one another geographically but his system was not widely accepted because it contained too many categories while some of them were classified upon a few individuals. Ruttner (1988) argued that the descriptive method based on a single or a few specimens was considered to be inappropriate as intra-colonial variations were ignored. A number of samples with a number of individuals are required for the measurement that the results are analyzed by the appropriate statistical methods, this procedure is known as morphometrical method.

2.3 Morphometry and Honey Bee

Morphometrical method has been introduced in studying honey bee by Cochlov, the Russian Scientist, since 1916, beginning with measurement of tongue length. Slowly, more and more characters were tested as to their suitability for the purposes and incorporated into current rountine technique. (Ruttner, 1987)

The characters that were used for morphometrical analysis should have certain qualities : (Ruttner, 1988)

1. Distinct geographic variability as measured by the relation of intra - colony and intra - subspecies variation to the total variation with in the species.
2. Precision in measuring, with reasonable investment of labor.
3. Normal distribution in the population, at least when the character is used for discriminant analysis.
4. Distribution across different catagories of characters : size of body and various appendages, wing venation.

Alpatov (1928) proposed to measure fore wing length and fore wing width that these two characters can indicate the size of the flying apparatus.

Alpatov (1929) proposed several more characters in morphometrical measurement. He introduced the measurement of hind leg: femur, tibia and metatarsus, as the representative of the bee appendages. The longitudinal length of tergite 3, 4 and stenite 3 were measured as these characters could indicate the length of the body. The wax plate was also measured. This has been used until now.

Almost the characters that were introduced by Alpatov (1928, 1929) were used as discriminant characters.

Goetze (1964) introduced the measurement on the cover hair length of tergite 5. These characters were the important traits to discriminate the European races of A. mellifera.

The width of tomentum on tergite 4 and the width of stripe posterior of tomentum namely tomentum A and tomentum B were measured to indicate the races of the bees.

The Goetze's characters was done mostly on the characters that used to discriminate the European races of A. mellifera.

Ruttner et al. (1978) introduced the measurement of the distance between wax plates of sternite 3 and the measurement of the longitudinal and transversal length of sternite 6.

The pigmentation of scutellums Sc, B, K and tergites 2, 3, 4 was considered to be the discriminant characters in European honey bee.

SAS® (Statistics Analytical Software) is the statistical program used in this thesis. This program is provided with the other programs written for analyze the morphometrical variables of A. cerana which will be discussed in the next chapter.