Journal of Integrative Plant Biology 2006, **48** (11): 1266–1273

Nectar and Pollen Sources for Honeybee (*Apis cerana cerana* Fabr.) in Qinglan Mangrove Area, Hainan Island, China

Yi-Feng Yao[1, 3], Subir Bera[2], Yu-Fei Wang[1] and Cheng-Sen Li[1, 4*]

(1. *State Key Laboratory of Systematic and Evolutionary Botany*, *Institute of Botany*, *the Chinese Academy of Sciences*, Beijing 100093, China;
2. *Department of Botany*, *University of Calcutta*, Kolkata 700019, India;
3. *Graduate School*, *the Chinese Academy of Sciences*, Beijing 100039, China;
4. *Beijing Museum of Natural History*, Beijing 100050, China)

Abstract

In the present study, nectar and pollen sources for honeybee (*Apis cerana cerana* Fabr.) were studied in Qinglan mangrove area, Hainan Island, China, based on microscopic analysis of honey and pollen load (corbicular and gut contents) from honeybees collected in October and November 2004. Qualitative and quantitative melittopalynological analysis of the natural honey sample showed that the honey is of unifloral type with *Mimosa pudica* L. (Mimosaceae) as the predominant (89.14%) source of nectar and pollen for *A. cerana cerana* in October. Members of Araceae are an important minor (3%–15%) pollen type, whereas those of Arecaceae are a minor (<3%) pollen type. Pollen grains of *Nypa fruticans* Wurmb., *Rhizophora* spp., *Excoecaria agallocha* L., *Lumnitzera* spp., *Bruguiera* spp., *Kandelia candel* Druce, and *Ceriops tagal* (Perr.) C. B. Rob. are among the notable mangrove taxa growing in Qinglan mangrove area recorded as minor taxa in the honey. The absolute pollen count (i.e. the number of pollen grains/10 g honey sample) suggests that the honey belongs to Group V (>1 000 000). Pollen analysis from the corbicular and gut contents of *A. cerana cerana* revealed the highest representation (95.60%) of members of *Sonneratia* spp. (Sonneratiaceae), followed by *Bruguiera* spp. (Rhizophoraceae), Euphorbiaceae, Poaceae, Fabaceae, Arecaceae, Araceae, Anacardiaceae, and Rubiaceae. Of these plants, those belonging to *Sonneratia* plants are the most important nectar and pollen sources for *A. cerana cerana* and are frequently foraged and pollinated by these bees in November.

Key words: Hainan Island; honeybee; mangrove; nectar and pollen sources.

Yao YF, Bera S, Wang YF, Li CS (2006). Nectar and pollen sources for honeybee (*Apis cerana cerana* Fabr.) in Qinglan mangrove area, Hainan Island, China. *J Integr Plant Biol* **48**(11), 1266–1273.

doi: 10.1111/j.1672-9072.2006.00353.x, available online at www.blackwell-synergy.com; www.jipb.net

Nectar is an important source of the carbohydrate needed for the growth and development of honeybees, whereas pollen is the main protein source (Lin et al. 1993). Previous studies (Parker 1926; Chaturvedi 1973) have proved that the honeybee collects pollen of entomophilous and anemophilous plants. Analyzing the pollen taxa in the honey and the pollen load (including corbicular and gut contents) reveals information on nectar and pollen source plants foraged by the honeybee, the preference for each of these sources, and the biological and environmental factors affecting the pollen-gathering activity of the honeybee (Lin et al. 1993).

So far, some melittopalynological studies have been undertaken in mainland China (Zhang and Wang 1965, 1966; Liu 1994,

Received 19 Apr. 2006 Accepted 27 Jul. 2006

Supported by the National Natural Science Foundation of China (40342013).

*Author for correspondence. Tel: +86 (0)10 6283 6436; Fax: +86 (0)10 6259 3385; E-mail: <lics@ibcas.ac.cn>.

1998, 2001; Wang 1995; Yan et al. 2001; Shi and Yun 2005), as well as in different parts of Taiwan (Chen and Wu 1976; Chen 1979; Chen et al. 1984; Jeng et al. 1986; Lin et al. 1993). However, Hainan Island has good prospects for apiculture, with a favorable climate and flowering nectariforous plants available for honeybees (Zen 2004, 2005a, 2005b). In particular, the mangrove taxa of the nature reserve in Qinglan Harbor, Wenchang City (Figures 1, 2) include 28 species from 13 families that account for 90% of the total mangrove species in China (Mo et al. 1999); however, there are no melissopalynological studies reported for this area.

The aim of the present study was to determine the pollen spectrum from honey sample and pollen load (corbicular and gut contents) from the honeybees *Apis cerana cerana.* Fabr. in Qinglan mangrove area, as well as to provide some information regarding nectar and pollen sources in October and November for beekeepers because they are dependent on the production of honey and pollen loads for their income. The other major aim is to recognize the local vegetation through microscopic analysis of honey and bee pollen load.

Results

Honey sample

Twenty pollen types (Figures 3, 4) belonging to 15 families were identified in the 2 837 pollen grains counted from six prepared slides, made from 0.1 mL sediments. *Mimosa pudica* L. (Mimosaceae) was found to be the predominant pollen type. The relative frequency of *M. pudica* reached 89.14% of total pollen (Figure 3). Araceae pollen ranked as the second-most frequent pollen type, representing 6.87%. Arecaceae pollen accounted for 2.08%. Other pollen types, namely *Cocos* spp.,

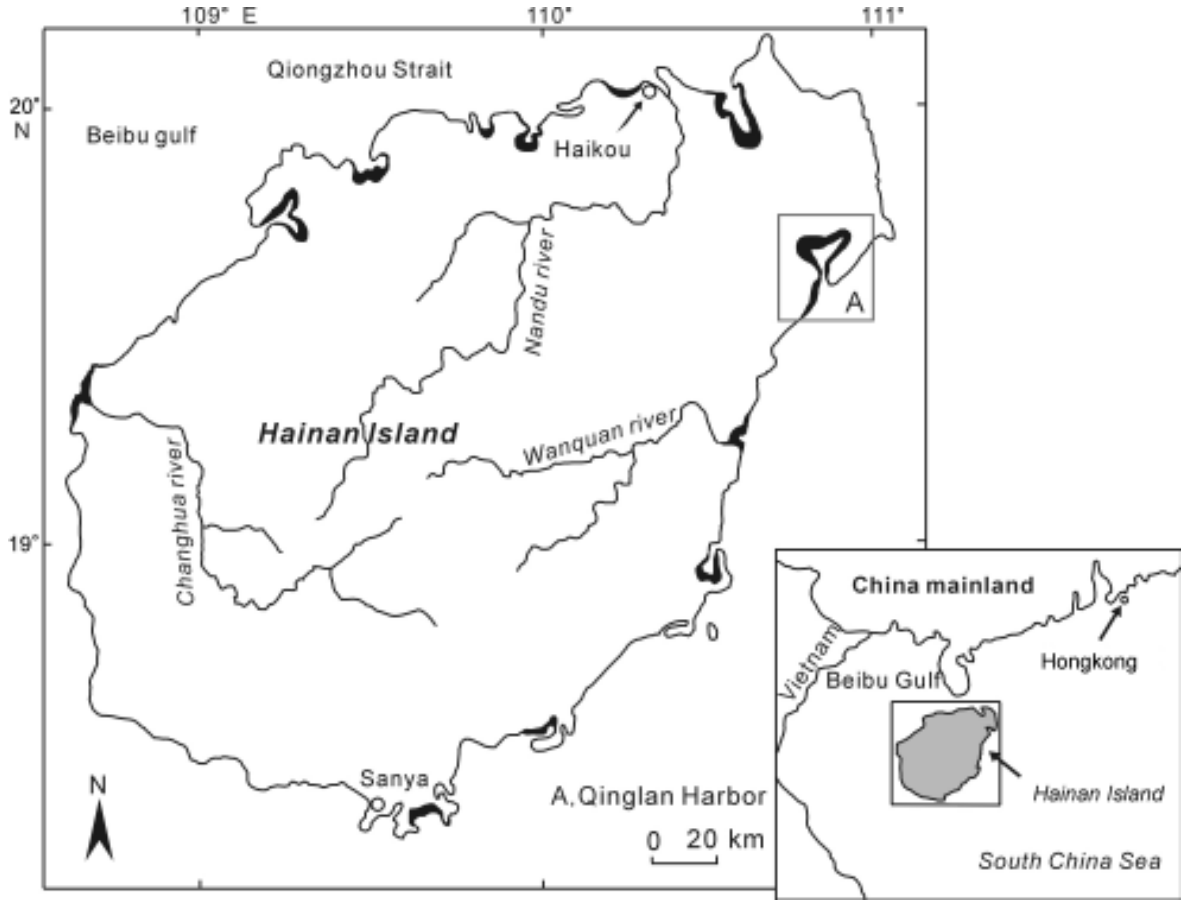
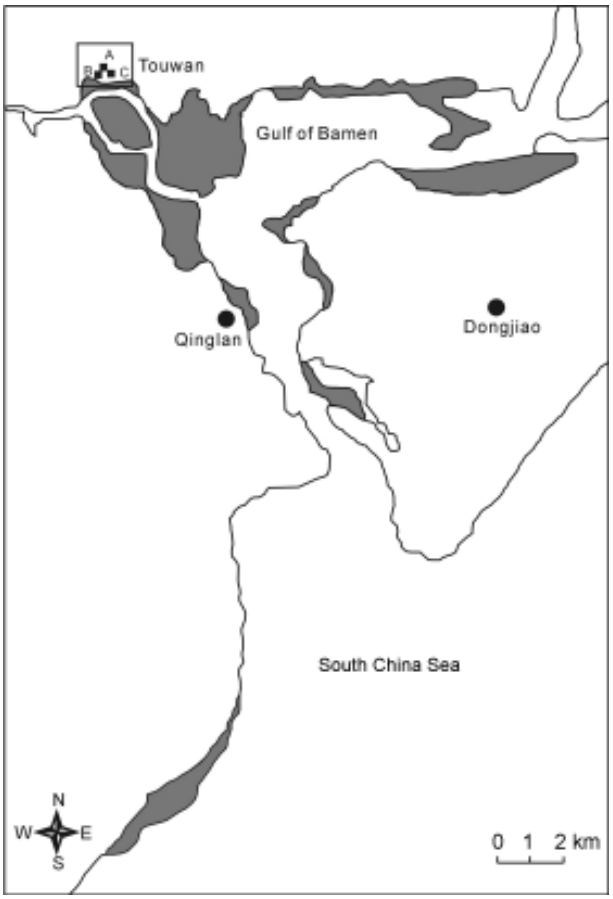


Figure 1. Location of Qinglan Harbor in Hainan Island, China (Modified from Mao et al. 2003).



■ Sampling location
A, Honey sample and honeybees from the beehives
B, Honeybees from the foraging plant of *Sonneratia ovata*
C, Honeybees from the foraging plant of *Bruguiera gymnorhiza*

Figure 2. Mangrove distribution in Qinglan Harbor (Modified from Mao et al. 2003).

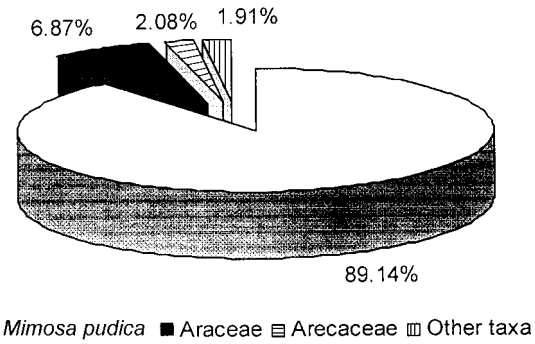


Figure 3. Percentage of pollen grains in the honey sample from Hainan Island.

Note, other taxa found in the honey sample include *Cocos* spp., *Nypa fruticans*, *Sonneratia* spp., *Rhizophora* spp., *Excoecaria agallocha*, *Lumnitzera* spp., *Bruguiera* spp., *Kandelia candel*, *Ceriops tagal*, *Pandanus* spp., *Acacia* spp., Apocynaceae, Plantaginaceae, Sapindaceae, Rutaceae, Poaceae, and Chenopodiaceae.

Table 1. Flowering calendar in October and November of major plants near the study area in Qinglan mangrove area, Hainan Island (from Chun et al. 1964, 1965, 1974, 1977)

Plant name	Flowering period
Acacia pennata	Mar.–Oct.
Bauhinia purpurea L.	Sept.–Nov.
Bruguiera gymnorhiza	Jan.–Dec.
B. sexangula Poir.	Sept.–May
Carica papaya	Jan.–Dec.
Cerbera manghas L.	Mar.–Oct.
Ceriops tagal	Sept.–Feb.
Cocos nucifera	Jan.–Dec.
Kandelia candel	Jan.–Dec.
Mimosa pudica	Mar.–Oct.
Rhizophora stylosa Griff.	Sept.–Feb.
R. apiculata Blume	Jan.–Dec.
Sonneratia spp.	Jan.–Dec.
Thespesia lampas Dalzell ex Dalzell & Gibs.	Sept.–Jan.
Xylocarpus granatum	Apr.–Nov.

Nypa fruticans Wurmb., *Sonneratia* spp., *Rhizophora* spp., *Excoecaria agallocha* L., *Lumnitzera* spp., *Bruguiera* spp., *Kandelia candel* Druce, *Ceriops tagal* (Perr.) C. B. Rob., *Pandanus* spp., *Acacia* spp., Apocynaceae, Chenopodiaceae, Plantaginaceae, Sapindaceae, Rutaceae, and Poaceae, accounted for 1.91% of the total pollen count (Figure 3).

Poaceae and Chenopodiaceae pollens were subtracted from the total number of pollen grains prior to calculating the frequency of pollen from nectar-producing plants. Poaceae is a wind-pollinated plant. Chenopodiaceae is known to be nectarless but is entomophilous (Louveaux et al. 1978). The frequency of pollen grains of anemophilous and nectarless plants, including Poaceae and Chenopodiaceae, was sporadic in the honey examined in the present study, reaching only 0.1%.

The absolute pollen count of the honey was found to be 2 956 000/10 g honey and, therefore, placed the honey examined in the present study into Group V (including only pressed

Figure 4. Major pollen types from the honey sample and corbicular and gut contents of honeybees.

(A, B, C, D) *Excoecaria agallocha*;
(E, F) *Lumnitzera* sp.;
(G, H) *Cocos* sp.;
(I) Combretaceae;
(J, K) *Sonneratia* sp.;
(L) *Acacia* sp.;
(M) *Mimosa pudica*;
(N) *Nypa fruticans*;
(O) Poaceae;
(P) Spindaceae;
(Q) *Rhizophora* sp.;
(R) *Ceriops tagal*;
(S) *Brugueria* sp.
All pollen micrographs are magnified ×1 000 except 7, 8 and 12 (×600).

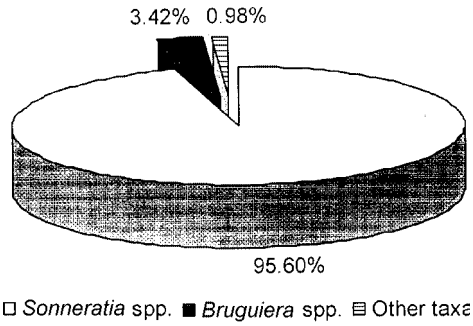


Figure 5. Percentage of pollen grains recovered from the corbicular and gut contents of honeybees.

Note, other taxa found include Anacardiaceae, Arecaceae, Araceae, Euphorbiaceae, Fabaceae, Poaceae, and Rubiaceae.

honey rich in pollen).

Pollen load (corbicular and gut contents)

Due to poor pollen content of corbicular and gut of honeybees collected from the beehives, contents from all the honeybees collected from beehives and foraged plants (*Sonneratia ovata* Backer and *Bruguiera gymnorhiza* (L.) Lam.) were mixed together and regarded them as one sample.

The analysis of the corbicular and gut contents of *A. cerana cerana* showed nine pollen types belonging to nine families (Figure 5) of a total of 2 135 pollen grains counted from one prepared slide. This analytical data reveals the highest representation (with a relative frequency of 95.60%) of members of *Sonneratia* spp. (Sonneratiaceae), followed by *Bruguiera* spp. (Rhizophoraceae), Euphorbiaceae, Poaceae, Fabaceae, Arecaceae, Araceae, Anacardiaceae, and Rubiaceae. Of these plants, those belonging to *Sonneratia* are the most important nectar and pollen sources for *A. cerana cerana*, and these plants are frequently foraged and pollinated by the honeybees in November.

Discussion

Nectar and pollen source plants

The honeybee collects many different types of pollen to achieve a nutritional balance (Barbier 1970). It has been found that if the honeybee confines its nourishment to a single species of pollen, its growth, development, and reproductive activity will stop (Lin et al. 1993). The present study has identified 20 pollen taxa from honey sample and nine pollen taxa from the corbicular load and gut contents of *A. cerana cerana*, revealing that *Mimosa pudica* and *Sonneratia* spp., respectively, are the chief nectar and pollen sources for *A. cerana cerana* during October and November, in Qinglan mangrove area of Hainan Island.

The honey sample is characterized by the absence of any secondary pollen types and only one important minor pollen type (Araceae). All other pollen types were minor pollen types, including some mangrove taxa growing in this area (i.e. *N. fruticans*, *Rhizophora* spp., *E. agallocha*, *Lumnitzera* spp., *Bruguiera* spp., *K. candel*, *C. tagal* etc.).

Records of foraging of mangrove taxa by honeybees as source of nectar and pollen in India have been reported mostly during April and May (Mondal and Mitra 1980; Chaubal and Kotmire 1986; Malakar et al. 1995; Jana and Bera 2004). Species of *Sonneratia*, *Ceriops*, *Bruguiera*, *Acanthus*, *Aegiceras*, *Excoecaria*, *Phoenix and Nypa* are the principal pollen types recovered from unifloral honeys collected during March-June from the Sunderbans Mangrove Reserve Forest area, West Bangal, India (Jana 2005). Similar to the present study, analysis of mangrove honeys from Brazil (Barth and Luz 1998; Luz and Barth 2001; Barth 2004) revealed the predominance of different species of *Mimosa*, including *M. bimucronata* Kuntze, *M. caesalpiniaefolia* Benth., and *M. pudica*. In addition, mangrove taxa were also poorly represented in the honey sample in the present study. While examining the pollen content of honeybee loads in Taiwan over a 1-year period, Lin et al. (1993) found that *M. pudica* was an important minor source (6.85%). These authors suggested that wild plants such as *Mimosa*, *Ageratum*, and *Humulus*, may become a dominant source of pollen for honeybees when some of the cultivated plants are not in full bloom.

Mangrove plants are recognized as good honey plants (Jana and Bera 2004; Naskar 2004). Only a few mangrove taxa flower during October in Hainan Island (Table 1). Thus, the honeybees cannot forage on them and are compelled to forage on plants such as *M. pudica* and members of the Chenopodiaceae and Plantaginaceae. The absence of fungal elements, the lack of pollen grains from toxic plants, and the high absolute pollen count of Group V suggests that the local flora in the present study area may be used as a source of good-quality honey.

Factors affecting pollen frequency

Pollen productivity, length of the flowering period, and the area of distribution of vegetation can affect pollen frequency in honey and pollen loads (Lin et al. 1993). *Mimosa pudica* is distributed widely and has a long flowering period from March to October in the mangrove area investigated in the present study. As a result, *M. pudica* pollen had the highest frequency (89.14%) in our honey sample. Terrab et al. (2004) mentioned that some

other factors influence the under- or over-representation of pollen in honey, including the size of the pollen grains, monoecious or dioecious plants, insufficiency or lack of pollen, and dominant pollen of nectarless species. In the present study, over-representation of *M. pudica* may also be due to its small size (diameter approximately 10 μm; Figure 4M) compared with the pollen of other plants.

The distribution area of *Sonneratia* plants, including *S. caseolaris* (L.) Engl., *S. ovata*, *S. hainanensis* W. C. Ko, E. Y. Chen & W. Y. Chen, and *S. alba* Sm., is also very large in the mangrove area investigated in the present study and the flowering period lasts year round (Table 1). In addition, the mostly open perianths of *Sonneratia* spp. make it easier for the honeybee to gather pollen. Consequently, *Sonneratia* spp. (95.60%) dominated in the total pollen count from the corbicular load and gut contents in November.

Generally, environmental factors, such as temperature, light intensity, humidity, and windspeed, also affect the collection activity of the honeybee. In high humidity, the honeybee becomes sluggish and is less likely to venture out to collect pollen (Lin et al. 1993). In the present study, honeybees were collected from the beehives, as well as from foraging plants of *S. ovata* (approximately 20 m away from the beehives) and *B. gymnorhiza* (approximately 40 m away from the beehives) on a drizzly and humid day in November 2004. Most honeybees did not go out to gather pollen, so little pollen was found in the corbicular load and gut contents of the honeybees collected from beehives. In the meantime, honeybees often gather pollen from plants that are located close to the hive rather than venturing too far away (Moezeal et al. 1987), which also contributes to the higher frequency of *Sonneratia* spp. in the corbicular and gut content of honeybees compared with that of other pollen types.

Preference of *A. cerana cerana* for certain types of plants

The honeybee will not gather the pollen of certain plants (Moezeal et al. 1987). For instance, *Hibbertia* species generally have numerous exposed stamens but appear to present little pollen and no nectar for collection by bees (Keighery 1975). In the present study, honey and pollen load analysis indicated that none or only very little pollen of certain species of plants in Qinglan mangrove area, namely *Acacia pennata* Willd., *Carica papaya* L., *Cocos nucifera* L., *Xylocarpus granatum* Koen. etc, was present, even though these plants grow in the area and bloom in October and November (Table 1). Of all nectar and pollen source plants recovered from the pollen analysis, *A. cerana cerana* seems to prefer to gather the pollen of *M. pudica* and *Sonneratia* spp. during this season. *Mimosa pudica* is the plant of "first choice" for *A. cerana cerana* in October. When the flowering period of *M. pudica* ends in November, *Sonneratia* spp. become the plant of "first choice" for the honeybees.

Conclusions

The present study suggests that *M. pudica* and *Sonneratia* spp. are the most important nectar and pollen sources for *A. cerana cerana* during October and November in Qinglan mangrove area of Hainan Island. The mangrove forest area has considerable potential for medium- to large-scale bee-keeping ventures for the production of good-quality honey. The development of apiaries in the region may result in increased crop production owing to frequent foraging by the honeybees and may improve the socioeconomic situation of the people of Hainan Island, China.

Materials and Methods

Natural honey sample produced by *A. cerana cerana* was collected directly from a professional beekeeper in October 2004 in Qinglan mangrove area, Touwan Town (19°37' N, 110°47' E), Wenchang City, Hainan Island, China (Figures 1, 2). Twenty-five honeybees were collected from three spots (Figure 2): beehives and foraging plants of *S. ovata* (approximately 20 m away from the beehives) and *B. gymnorhiza* (approximately 40 m away from the beehives) in November 2004 in this mangrove area. Immediately after capture, honeybees were preserved in vials containing 70% alcohol and the vials were labeled with the names of the foraging plants (Bera et al. 2004). Preserved honeybees were dissected carefully to isolate the gut. The gut and corbicular load of 10 honeybees foraging on different plants, as well as those from honeybees from the beehives, were opened and micro-slides were prepared following the acetolysis technique (Edrtman 1960).

For pollen analysis of the honey sample, the method recommended by the International Commission for Bee Botany (Louveaux et al. 1978) was adopted. Honey (10 g) was dissolved in 20 mL warm (40 °C) water. The solution was centrifuged for 10 min at 2 500 r/min, the supernatant solution was decanted, and the sediments were collected into a conical tube and treated with the acetolysis mixture (Erdtman 1960) for approximately 30 min at room temperature. After treatment with the acetolysis mixture, the sediments were rinsed with distilled water, centrifuged for 5 min at 2 500 r/min, and preserved for study.

The absolute pollen count of the honey sample (i.e. the number of pollen grains/10 g honey) was made determined according to the methods of Maurizio (1939). Accordingly, the sample was categorized under various groups in accord with the universally followed grading parameters provided by Louveaux et al.(1978) as follows: Group I, <20 000; Group II, 20 000–

100 000; Group III, 100 000–500 000; Group IV, 500 000–1 000 000; and Group V, >1 000 000. The types of pollen were allocated to one of four frequency classes: (i) predominant pollen types (>45% of the total pollen complement of nectariferous taxa); (ii) secondary pollen types (16%–45%); (iii) important minor pollen types (3%–15%); and (iv) minor pollen types (<3%). The honey sample is unifloral if it contains a predominant pollen type, otherwise it is considered to be multifloral honey.

Pollen types were identified by comparison with reference slides of pollen collected directly from the plants in the present study area. In addition, some monographs and references (Institute of Botany and South China Institute of Botany, Chinese Academy of Sciences 1982; Liu and Tang 1989; Wang et al. 1995; Mao et al. 2003) were also used.

Acknowledgements

The authors are grateful to Professor Nai-Qiu Du and Dr Xiao-Yan Song (Institute of Botany, the Chinese Academy of Sciences) and Professors Jian-Hua Jin and Wen-Bo Liao (*Sun Yat-sen* University, Guangzhou, China) for their support for this work.

References

Barbier M (1970). Chemistry and biochemistry of pollens. *Prog Phytochem* **2**, 1–34.

Barth OM (2004). Melissopalynology in Brazil: A review of pollen analysis of honeys, propolis and pollen loads of bees. *Sci Agr* (*Piracicaba Braz*) **61**, 342–350.

Barth OM, Luz CFP (1998). Melissopalynological data obtained from a mangrove area near to Rio de Janeiro, Brazil. *J Apicult Res* **37,** 155–163.

Bera S, Ghorai N, Mandal KC, Bera SK, Trivedi A (2004). Role of *Syrphus serarius* Wied. as a pollinator in Darjeeling Hills, West Bengal: Palynological assessment. *Geophytology* **34,** 115–119.

Chaturvedi M (1973). An analysis of honey bee pollen loads from Banthra, Lucknow, India. *Grana* **13**, 139–144.

Chaubal PD, Kotmire SY (1985).Melissopalynological aspects of mangroves. I. Honey analysis. In: Bhosale LJ, ed. *The Mangroves: Proceedings of National Symposium on Biology, Utilization and Conservation of Mangroves*. Shivaji Univ., Kolhapur. India. pp. 398–400.

Chen LT, Wu TY (1976). Pollen grain in honey. I.The relationship between the kinds and number of pollen with its flavor. *Food Sci* **3,** 54–61 (in Chinese).

Chen SC (1979). *The Study of Honey Pollen in Taiwan*. Cin-Yen Book Co., Tainan, China. pp. 48 (in Chinese).

Chen SH, Tsai JT, An K, Jeng YC (1984). Melittopalynological study in Taiwan (1). *Taiwania* **29,** 121–140.

Chun WY, Chang CC, Chen FH (1964). Flora Hainanica, Tome I. Science Press, Beijing (in Chinese).

Chun WY, Chang CC, Chen FH (1965). Flora Hainanica, Tome II. Science Press, Beijing (in Chinese).

Chun WY, Chang CC, Chen FH (1974). Flora Hainanica, Tome III. Science Press, Beijing (in Chinese).

Chun WY, Chang CC, Chen FH (1977). Flora Hainanica, Tome IV. Science Press, Beijing (in Chinese).

Erdtman G (1960). The acetolysis method: A revised description. *Seven Bot Tidskr* **54,** 561–564.

Institute of Botany and South China Institute of Botany, Chinese Academy of Sciences (1982). *Angiosperm pollen Flora of Tropic and Sub-tropic China*. Science Press, Beijing (in Chinese).

Jana D (2005). *Melittopalynology and Recognition of Nectar and Pollen Sources for Honey Bees in the Lower Gangetic Plains, India*. Unpublished Ph.D thesis. University of Calcutta.

Jana D, Bera S (2004). *Sonneratia apetala* Buch-Ham. as major nectar source for honey bees during mid-summer days in Sunderbans, West Bengal, India. *Phytomorphology* **54**, 51–57.

Jeng YC, Tsai JT, An K (1986). Studies on the honey plants in Taiwan. *Annu Taiwan Museum* **29,** 117–155 (in Chinese).

Keighery GJ (1975). Pollination of Hibbertia hypericoides (Dilleniaceae) and its evolutionary significance. *J Nat Hist* **9,** 681–684.

Lin SH, Chang SY, Chen SH (1993). The study of bee-collected pollen loads in Nantou, Taiwan. *Taiwania* **38,** 117–133.

Liu BL (1994). Pollen morphology of nectar plants in China and the methods of pollen analysis from honey. *Apicult Sci Technol*, (5), 10–12 (in Chinese).

Liu BL (1998). Pollen morphology of major spring nectar plants in China and the methods of pollen analysis from honey. *Apicult Sci Technol*, (2), 4–7 (in Chinese).

Liu BL (2001). Pollen morphology of 44 nectar plants during spring, summer, autumn and winter in China *Apicult Sci Technol,* (4), 4–6 (in Chinese).

Liu LF, Tang SQ (1989). Pollen morphology of the mangrove plants in China. *Guihaia* **9**, 221–232 (in Chinese with an English abstract).

Louveaux J, Maurizio A, Vorwohl G (1978). Methods of melissopalynology. *Bee World* **59,** 139–157.

Luz CFP, Barth OM (2001). Melissopalynological observations in a mangrove area next to Rio de Janeiro, Brazil. In: Palynological Congress, 9, Houston, 1996. Proceedings Houston: American Association of Stratigraphic Palynologists Foundation. pp. 489–

492.

Malakar A, Chattopadhay G, Ghosh A, Chanda S (1995). Pollen and chemical analysis of three selected honey samples, *J Natl Bot Soc* **49,** 155–160.

Mao LM, Wang KF, Bi H (2003). A palynological study for coastal mangrove swamps in northern Hainan Island, China: Relationship between surface pollen and mangrove vegetation. *The Quaternary Res* **42**, 247–264.

Maurizio A (1939). Untersuchungen zur quantitativen Pollenanalyse des Honigs. *Mitt Geb Lebensmittelunters U Hyg* **30,** 27–69.

Mo YN, Geng ZZ, Su WB (1999). Mangrove investigation in Hainan Island. *Trop For* **27**, 19–22 (in Chinese).

Moezeal PG, Delfs JC, Pate JS, Loneragan WA, Bell DT (1987). Pollen selection by shrublands of the Northern Sandplains of Western Australia. *J Apicult Res* **26**, 224–232.

Mondal M, Mitra K (1980). Pollen analysis of honey from Sunderbans. *Geophytology* **10**, 137–139.

Naskar KR (2004). *Manual of India Mangroves*. Daya Publishing House, Delhi. pp. 1–220.

Parker RL (1926). The collection and utilization of pollen by the honeybee. *Mem Cornell Agr Exp Sta* **98**, 1–55.

Shi QY, Yun JM (2005). A study on the method of testing pollen in honey. *Apicult China* **56**, 9–11. (in Chinese with an English abstract).

Terrab A, Pontes A, Heredia FJ, Diez MJ (2004). Palynological and geographical characterization of avocado honeys in Spain. *Grana* **43,** 116–121.

Wang FH, Chien NF, Zhang YL, Yang HQ (1995). *Pollen Flora of China* (2nd ed). Science Press, Beijing (in Chinese).

Wang XZ (1995). Quality distinguish of honey and pollen grains from honey. *J Bee,* (3), 7 (in Chinese).

Yan WY, Li L, Zhou LH (2001). Using the pollen in honey for distinguishing the quality of honey. *Apicult Sci Technol* (3), 4–5 (in Chinese with an English abstract).

Zen CY (2004). A good future prospect of apiculture in Hainan, China. *Apicult China* **55**, 36–36 (in Chinese).

Zen CY (2005a). Apiculture calendar in Hainan, China. *Apicult China* **56**, 11–12 (in Chinese).

Zen CY (2005b). Apiculture calendar in Hainan, China. *Apicult China* **56**, 14–14 (in Chinese).

Zhang JT, Wang JL (1965). A study on pollen morphology of nectar plants in China. *Acta Bot Sin* **13,** 339–374 (in Chinese with a Russian abstract).

Zhang JT, Wang JL (1966). Pollen analysis of honey. *Acta Bot Sin* **14**, 186–190 (in Chinese with a Russian abstract).

(Managing editor: Ya-Qin Han)