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Pollen diversity of *Apis dorsata* winter honeys of Nallamala Forest, Nagarkurnool District, Telangana, South India

S. Niranjan, R. Devender and H. Ramakrishna*

Department of Botany
University College of Science, Osmania University,
Hyderabad-500007, Telangana, India
* Corresponding author's email: hrkpalebot@gmail.com

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ABSTRACT

The present paper incorporates qualitative and quantitative melissopalynological analysis of thirty-three honey samples of *Apis dorsata* from Nallamala forest, Nagarkurnool District in Telangana state (south India) for the winter season from 2012 to 2014. Our palynological analysis of a total of thirty three samples, suggests predominance of unifloral pollen in sixteen samples that include *Ageratum conyzoides*, *Prosopis juliflora*, *Aegle marmelos*, *Albizia lebbeck*, *Andrographis echinoides*, *Grewia* sp., *Celosia argentea*, *Vicoa indica* and *Tridax procumbens*, while the remaining samples were observed to be multifloral. Overall, sixty-six palynotaxa, referable to thirty-one families, were identified in the present investigation. Further, we document that the palynotaxa recovered certainly authenticate abundant presence of bee forage plants as a nectar source in the Nallamala region, consequently, highlighting the need for future development of this region for the production of honey at a commercial scale.

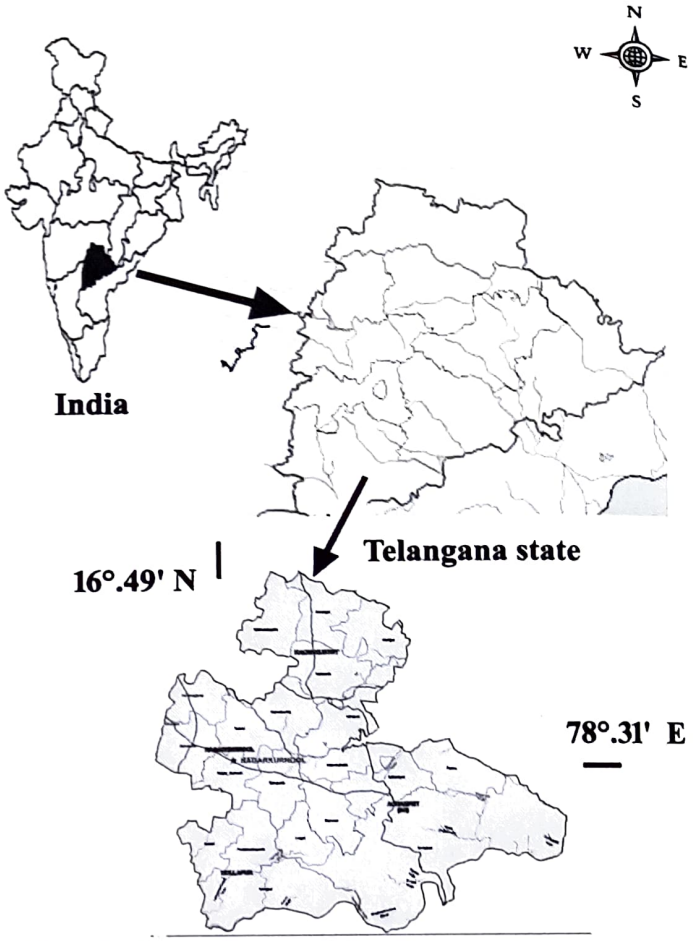
Key-words: *Apis dorsata*, Bee forage plants, Nagarkurnool District, Nallamala Forest, Telangana.

INTRODUCTION

Melissopalynology helps in the identification of source plants being foraged for honey by the honey bees (Seddly 1985). The honey produced is a source of carbohydrate and protein and required for the growth and development of the honey bees (Turner 1984; Lin et. al. 1993). Palynological analyses, as the one carried out in the present investigation, certainly help in our understanding of the honey bee foraging ecology, habitat, deciphering changes in the food sources for honey bees and also the geographical regions of the hive location (Maurizio 1951, 1975; Louveax et al. 1978; Lieux 1980; Agwu & Akanbi 1985; Moar 1985; Feller-Demalsy et. al. 1989; Terrab et al. 2004). In addition, pollen from the honey samples also provide reliable information on the floral resources of honeys along with the relative preferences of bees among the diverse assemblages of plant species flowering synchronously (Deodikar 1961; Garg 2006).

Melissopalynology is considered as an extremely useful tool in bee hive management that allows the identification of periods of production of unifloral honeys, which are commercially valuable (Oliveria et al. 2010; Costa et al. 2013). Consequently, pollen analysis provides a useful guide for beekeepers in their geographic region of honey cultivation (Song et al. 2012). Melissopalynology works have so far been executed on the above aspects within various provinces of India, in both the natural as well as apiaries habitats of honey bees (Mittre 1958; Nair 1964, 1985). Previous significant melissopalynological studies in various states of India include the works of within the

Telangana Sate (Ramanujam & Kalpana 1991; Ramanujam et al. 1992; Lakshmi & Suryanarayana 2004), in Karnataka State (Chauhan & Murthy 2010; Shivaram et al. 2012; Raghunandan & Basavarappa 2013), in Bihar (Suryanarayana et al. 1992), in Madhya Pradesh (Chauhan & Quamar 2010), in Maharastra (Deodikar & Thakar 1953), in Uttarakhand (Verma 1988; Gaur & Nanwani 1989; Tiwari et al. 2012; Dixit et al. 2013), in Uttar Pradesh (Sharma & Nair 1965; Chauhan & Trivedi 2011), in West Bengal (Mondal & Mitre 1980; Bhattacharya et al. 1983, Jana et al. 2000; Jana & Bera 2004). However, we still consider that the overall melissopalynological information from India is rather sporadic in nature and hints at the future scope in research in the field of melissopalynology. The qualitative and quantitative melissopalynological analyses from the east coast regions of India, demonstrate that these regions are quite rich in honey producing plants and presence of unifloral honey. In addition, due to an extended honey flow period, these regions can be commercially exploited in terms of moderate to large scale apiculture enterprises (Upadhyay et al. 2014). Palynological examinations of honeys procured from Uttar Pradesh and Uttarakhand have revealed that in addition to already known bee forage (*Brassica, Coriandrum* and Litchi), some other species including *Eucalyptus* and *Callistemon* that are planted for social forestry programs are also heavily utilized as pollen and nectar source by honey bees in urban and semi-urban areas (Datta et al. 2008). In a similar context, we have carried out a detailed melissopalynological study on honey samples of *A. dorsata* collected from the Nallamala Forest (having a rich source of dry deciduous vegetation), Nagarkurnool District, Telangana State.



Text-Figure 1. Map showing Nagarkurnool District, Telanagana, south India with localtions of the honey samples collected in the Nallamala Forest region.

MATERIAL AND METHODS

A total of 33 *A. dorsata* honey samples were collected during the winter seasons (from 2012 to 2014) from various locations within the Nallamala Forest, Nagarkurnool District, Telangana State (refer Text-Figure 1). Later, the honey samples were processed for the recovery of pollen using Erdtman's (1960) acetolysis technique. Three slides were prepared for each sample and pollen types were identified with the help of reference pollen slides and relevant literature. Subsequently, the recorded pollen in the honey samples were classified based on their frequencies following Louveaux et al. 1978 as: a) predominant pollen type-P (> 45%), b) secondary pollen type-S (16-45%), c) important minor pollen type-I (3-15%), and d) minor pollen type-M (< 3%). It should be noted here that the honey samples containing more than 45% of a single type were considered as unifloral classes. A detailed list including sample number, locality, nature and type of honey, collection season and the frequency of pollen types recovered is provided in Table 1.

RESULTS AND DISCUSSION

In the present study, a total of sixty-six pollen types were recorded (refer Plate 1-4). The present investigation shows the presence of both unifloral and multifloral honeys in the samples collected. Of these, sixteen honey samples were characterized by the

Table 1. Pollen content in the honey samples of Nallamala Forest, Nagarkurnool District, Telangana, south India.

S. No	Sample code	Locality	Nature of honey	Type of honey	Season collected	Predominant pollen type (> 45%)	Secondary pollen types (16-45%)	Important minor pollen types (3-15%)	Minor pollen types (< 3%)
1	NBA Ad-12	Balmoor	Unifloral	Squeezed	Winter	*Ageratum conyzoides (48.38%)*	*Cajanus cajan (27.09%)*	*Prosopis juliflora (7.74%), Justicia procumbens (5.80%), Careya arborea (5.22%), Acacia nilotica (3.22%)*	*Tridax procombens (2.55%)*
2	NBA Ad-13	Balmoor	Multifloral	Squeezed	Winter	-	*Celosia argentea (25.56%), Gardenia lucida (24.66%), Terminalia arjuna (17.04%)*	*Lagerstroemia parviflora (12.55%), Ageratum conyzoides (6.72%), Alangium salviifolium (5.38%), Justicia procumbens (5.38%)*	*Blepharis maderaspatensis (2.71%)*
3	NBB Ad-14	Malmoor	Multifloral	Squeezed	Winter	-	*Ageratum conyzoides (30.84%)*, Grass pollen *(20.05%), Lagerstroemia parviflora (19.28%)*	*Albizia lebbeck (9.25%), Gardenia lucida (7.22%), Physalis minima (6.68%), Cassia auriculata (6.68%)*	-
4	NLA Ad-15	Lingal	Unifloral	Squeezed	Winter	*Ageratum conyzoides (79.22%)*	-	*Hyptis suaveolens (5.56%), Crateva manga (5.17%), Justicia procumbens (5.13%), Phoenix sylvestris (4.92%)*	-
5	NLB Ad-16	Lingal	Unifloral	Squeezed	Winter	*Ageratum conyzoides (46.53%)*	*Corchorus fascicularis (18.21%)*, Grass pollen *(17.27%)*	*Sapindus emarginatus (4.85%), Dillenia pentagyna (4.72%), Justicia procumbens (4.18%) Hyptis suaveolens (3.23%)*	*Impatiens balsamina (1.01%)*
6	NLL Ad-17	Lingal	Multifloral	Squeezed	Winter	-	*Borassus flabellifer (32.28%), Cucumis sativum (19.94%)*	*Ageratum conyzoides (13.86%), Cajanus cajan (9.49%), Cassia auriculata (6.45%), Echinops echinatus (5.31%), Syzygium cumini (4.93%)*	*Conyza stricta (1.99%), Erythrina variegata (1.97%), Centipeda minima (1.89%), Hygrophila auriculata (1.89%)*
7	NAM Ad-18	Amrabad	Unifloral	Squeezed	Winter	*Prosopis juliflora* (49.29%)	-	*Cocos nucifera (12.20%), Ageratum coyizoides (7.04%), Borassus flabellifer (7.04%), Ricinus communis (3.99%), Achyranthes aspera (3.28%)*	*Cyathocline purpurea (2.81%), Cucumis sativum (2.81%), Justicia procumbens (2.41%), Cardiospermum halicacabum (2.34%), Gangea maderaspatana (2.34%), Eucalyptus globulus (2.34%), Croton bonplandianus (2.11%)*
8	NAL Ad-19	Amrabad	Multifloral	Squeezed	Winter	-	*Ageratum conyzoides (31.87%), Prosopis juliflora (24.37%)*	*Celosia argentea (10.00%), Ocimum sanctum (5.00%), Cucumis sativum (5.00%), Sida acuta (4.37%), Blepharis maderaspatensis (3.75%), Justicia procumbens (3.75%), Leucas aspera (3.12%), Tridax procombens (3.12%)*	*Hyptis suaveolens (2.81%), Evolvulus alsinoides (2.84%)*

Table 1 continued...

9	NPN Ad-21	Peddakoth apally	Unifloral	Squeezed	Winter	*Prosopis juliflora (48.38%)*	*Ageratum conyzoides (19.35%), Borassus flabellifer (16.93%)*	*Tridax procombens (6.45%), Spinacia oleracea (3.22%), Echinops echinatus (3.22%),*	*Sesbania* sp. *(2.45%)*
10	NBA Ad-22	Balmoor	Unifloral	Squeezed	Winter	*Aegle marmelos (56.86%)*	-	*Ageratum conyzoides (9.44%), Celosia argentea (8.62%),* Unknown *(6.27%), Ocimum sanctum (5.49%), Alangium salviifolium (4.70%), Cucumis sativum (4.70%), Justicia procumbens (3.92%)*	-
11	NKN Ad-34	Kollapur	Unifloral	Squeezed	Winter	*Albizia lebbeck (67.16%)*	*Andrographis echioides (19.40%)*	*Ageratum conyzoides (13.44%)*	-
12	NKM Ad-35	Kollapur	Unifloral	Squeezed	Winter	*Andrograph is echioides (45.76%)*	*Croton bonplandianus (26.27%)*	*Albizia lebbeck (11.86%), Borassus flabellifer (10.18%), Ageratum conyzoides (5.93%)*	-
13	NPT Ad-36	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Vernonia cinerea (32.66%)*	*Celosia argentea (14.07%), Hyptis suaveolens (12.56%), Ocimum sanctum (9.04%), Hygrophila auriculata (8.04%), Ageratum conyzoides (6.53%), Vicoa indica (5.52%), Cajanus cajan (4.52%), Sida acuta (4.52%)*	*Brassica nigra (2.54%)*
14	NKP Ad-53	Kollapur	Unifloral	Squeezed	Winter	*Grewia* sp. *(62.98%)*	*Crateva magna (20.99%)*	*Lagerstroemia parviflora (12.43%), Albizia lebbeck (3.60%)*	-
15	NPP Ad-54	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Brassica nigra (38.55%), Ageratum conyzoides (31.31%)*	*Prosopis juliflora (8.82%), Ocimum sanctum (6.45%), Tridax procumbens (5.87%), Celosia argentea (4.50%), Tribulus terrestris (4.50%)*	-
16	NPP Ad-55	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Ageratum conyzoides (33.14%), Tridax procumbens (18.23%), Celosia argentea (15.46%)*	*Tribulus terrestris (11.60%), Terminalia catappa (11.04%), Alangium salviifolium (10.53%)*	-
17	NPL Ad-56	Peddakoth apally	Unifloral	Squeezed	Winter	*Ageratum conyzoides (73.28%)*	-	*Ricinus communis (10.94%), Celosia argentea (5.56%), Ziziphus* sp. *(4.26%), Ocimum sanctum (3.56%)*	*Hygrophila auriculata (2.40%)*
18	NPK Ad-57	Peddakoth apally	Unifloral	Squeezed	Winter	*Celosia argentea (89.18%)*	-	*Ageratum conyzoides (4.50%)*	*Spinacia oleracea (2.34%), Parkinsonia aculeata (2.34%), Ocimum sanctum (1.64%)*
19	NPB Ad-58	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Pongamia pinnata (33.94%), Ageratum conyzoides (21.55%), Borassus flabellifer (22.01%)*	*Celosia argentea (13.33%), Albizia lebbeck (9.17%),*	-

Table 1 continued...

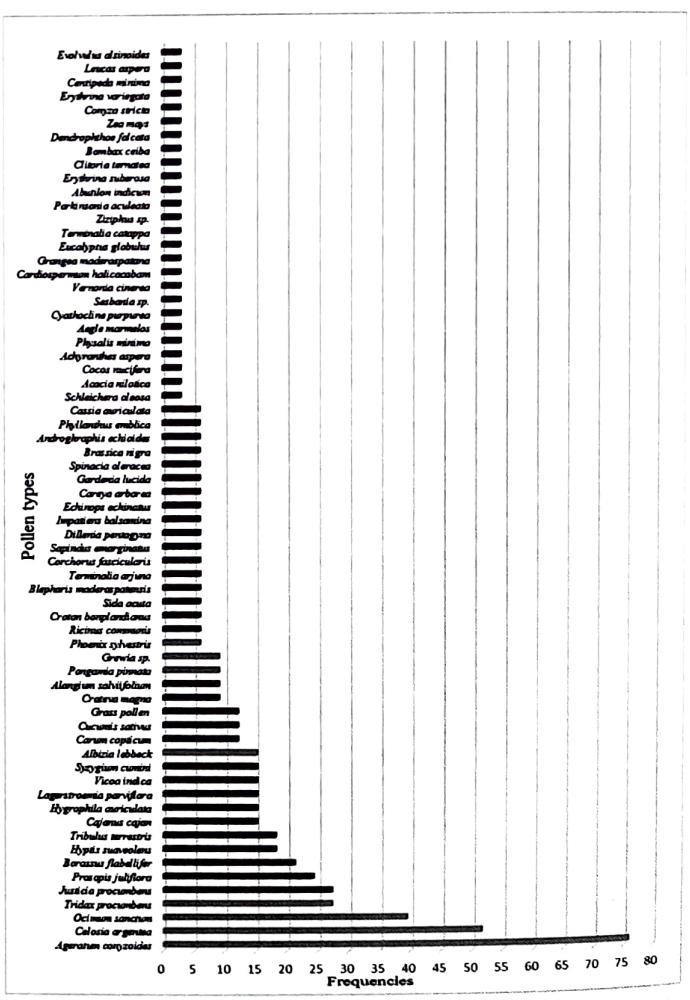
20	NPT Ad-59	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Celosia argentea (23.72%), Abutilon indicum (22.03%), Vicoa indica (19.77%), Ocimum sanctum (15.81%)*	*Erythrina suberosa (10.20%), Tribulus terrestris (8.47%)*	-
21	NPY Ad-60	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Ageratum conyzoides (36.77%), Celosia argentea (29.67%), Prosopis juliflora (23.22%)*	*Ocimum sanctum (10.34%)*	-
22	NPM Ad-61	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Celosia argentea (25.76%), Tridax procombens (25.55%), Syzygium cumini (24.74%)*	*Cajanus cajan (6.49%), Tribulus terrestris (6.49%), Ocimum sanctum (5.70%), Clitoria ternatea (5.27%)*	-
23	NPS Ad-62	Peddakoth apally	Multifloral	Squeezed	Winter	-	*Tridax procumbens (43.46%), Syzygium cumini (21.15%,) Prosopis juliflora (15.38%)*	*Bombax ceiba (10.84%), Tribulus terrestris (6.46%)*	*Dendrophthoe falcata (2.71%)*
24	NKS Ad-63	Kollapur	Unifloral	Squeezed	Winter	*Vicoa indica (46.54%)*	*Ageratum conyzoides (20.42%)*	*Borassus flabellifer (14.43%), Celosia argentea (14.41%), Hygrophila auriculata (4.20%)*	-
25	NKA Ad-64	Kollapur	Unifloral	Squeezed	Winter	*Vicoa indica (49.87%)*	*Ageratum conyzoides (18.67%), Borassus flabellifer (14.00%), Celosia argentea (13.49%)*	*Hygrophila auriculata (3.97%)*	
26	NKM Ad-65	Kollapur	Multifloral	Squeezed	Winter	-	*Ageratum conyzoides (29.66%), Zea mays (19.91%)*	*Lagerstroemia parviflora (13.98%), Celosia argentea (12.71%), Carum copticum (9.79%), Grewia* sp. *(8.47%), Ocimum sanctum (5.48%)*	-
27	NKN Ad-66	Kollapur	Unifloral	Squeezed	Winter	*Tridax procumbens (47.79%)*	*Pongamia pinnata (21.83%)*	*Syzygium cumini (12.74%), Ageratum conyzoides (8.82%), Carum copticum (4.41%), Ocimum sanctum (4.41%)*	-
28	NKM Ad-67	Kollapur	Multifloral	Squeezed	Winter	-	*Celosia argentea (38.38%), Phyllanthus emblica (30.18%)*	Grass pollen *(14.69%), Cajanus cajan (10.63%), Carum copticum (6.12%)*	-
29	NKB Ad-68	Kollapur	Multifloral	Squeezed	Winter	-	*Grewia* sp. *(36.62%), Tridax procumbens (21.81%), Pongamia pinnata (21.81%)*	*Prosopis juliflora (11.52%), Carum copticum (4.52%), Ocimum sanctum (3.72%)*	-
30	NKR Ad-69	Kollapur	Multifloral	Squeezed	Winter	-	*Phyllanthus emblica (34.15%), Vicoa indica (25.26%), Celosia argentea (15.45%)*	*Tribulus terrestris (15.80%), Ocimum sanctum (9.34%)*	-

Table 1 continued...

31	NAF Ad-71	Amrabad	Unifloral	Squeezed	Winter	*Ageratum conyzoides (46.22%)*	*Corchorus fascicularis (19.23%)*, Grass pollen *(11.78%)*	*Sapindus emarginatus (5.39%), Dillenia pentagyna (5.12%), Justicia procumbens (4.58%), Hyptis suaveolens (4.18%), Impatiens balsamina (3.50%)*	-
32	NLM Ad-72	Lingal	Unifloral	Squeezed	Winter	*Ageratum conyzoides (75.23%)*	-	*Hyptis suaveolens (6.80%), Justicia procumbens (6.42%), Crateva magna (5.99%), Phoenix sylvestris (5.56%)*	-
33	NLP Ad-73	Lingal	Multifloral	Squeezed	Winter	-	*Lagerstroemia parviflora (38.01%), Terminalia arjuna (23.29%), Syzygium cumini (11.84%)*	*Careya arborea (14.16%), Schleichera oleosa (12.70%)*	-

presence of predominant pollen taxa (i.e., unifloral), while the remaining samples are multifloral (Table 2).

The pollen of *Ageratum conyzoides* and *Celosia argentea* are recorded as very frequent class, *Ocimum sanctum, Tridax procumbens, Justicia procumbens, Prosopis juliflora, Borassus flabellifer* pollen were recorded under the frequent class, the pollen of *Hyptis suaveolens, Tribulus terrestris, Cajanus cajan, Hygrophila auriculata, Lagerstroemia parviflora, Vicoa indica, Syzygium cumini, Albizia lebbeck, Carum copticum, Cucumis sativus,* Grass pollen were placed under the infrequent class and the pollen of *Crateva magna, Alangium salviifolium, Pongamia pinnata, Grewia sp., Phoenix sylvestris, Ricinus communis, Croton bonplandianus, Sida acuta, Blepharis maderaspatensis, Terminalia arjuna, Corchorus fascicularis, Sapindus emarginatus, Dillenia pentagyna, Impatiens balsamina, Echinops echinatus, Careya arborea, Gardenia lucida, Spinacia oleracea, Brassica nigra, Androghraphis echioides, Phyllanthus emblica, Cassia auriculata, Schleichera oleosa, Acacia nilotica, Cocos nucifera, Achyranthes aspera, Physalis minima, Aegle marmelos, Cyathocline purpurea, Sesbania sp., Vernonia cinerea, Cardiospermum halicacabum, Grangea maderaspatana, Eucalyptus globulus, Terminalia catappa, Ziziphus sp., Parkinsonia aculeate, Abutilon indicum, Erythrina suberosa, Clitoria ternatea, Bombax ceiba, Dendrophthoe falcata, Zea mays, Conyza stricta, Erythrina variegata, Centipeda minima, Leucas aspera* and *Evolvulus alsinoides* were recorded under the rare class (Text-Figure 2). Thus, overall, sixty-six pollen taxa belonging to thirty-one families were identified from



Text-Figure 2. Pollen frequency distribution for the honey samples of *Apis dorsata* collected from the Nallamala Forest, Nagarkurnool District, Telangana, south India.

Table 2. Representation of the pollen types (in various families) in the winter honeys of *Apis dorsata* collected from Nallamala Forest, Nagarkurnool District, Telangana, south India.

S. No	Name of the Family	Name of the Pollen Taxa
1.	Asteraceae	*Ageratum conyzoides, Justicia procumbens, Tridax procumbens, Echinops echinatus, Conyza stricta, Centipeda minima, Cyathocline purpurea, Grangea maderaspatana, Vernonia cinerea, Vicoa indica*
2.	Fabaceae	*Cajanus cajan, Cassia auriculata, Erythrina variegata, E. suberosa Sesbania sp., Parkinsonia aculeate, Pongamia pinnata, Clitoria ternatea*
3.	Mimosaceae	*Prosopis juliflora, Acacia nilotica, Albizia lebbeck*
4.	Lecythidaceae	*Careya arborea*
5.	Amaranthaceae	*Celosia argentea, Achyranthes aspera, Spinacia oleracea*
6.	Rubiaceae	*Gardenia lucida*
7.	Combretaceae	*Terminalia arjuna, T. catappa*
8.	Lythraceae	*Lagerstroemia parviflora*
9.	Cornaceae	*Alangium salviifolium*
10.	Acanthaceae	*Blepharis maderaspatensis, Hygrophila auriculata, Andrographis echioides*
11.	Poaceae	Grass pollen, *Zea mays*
12.	Solanaceae	*Physalis minima*
13.	Lamiaceae	*Hyptis suaveolens, Ocimum sanctum, Leucas aspera*
14.	Capparaceae	*Crateva magna*
15.	Arecaceae	*Phoenix sylvestris, Borassus flabellifer, Cocos nucifera*
16.	Malvaceae	*Sida acuta, Abutilon indicum*
17.	Sapindaceae	*Sapindus emarginatus, Cardiospermum halicacabum, Schleichera oleosa*
18.	Dilleniaceae	*Dillenia pentagyna*
19.	Balsaminaceae	*Impatiens balsamina*
20.	Cucurbitaceae	*Cucumis sativus*
21.	Myrtaceae	*Syzygium cumini, Eucalyptus globulus*
22.	Euphorbiaceae	*Ricinus communis, Croton bonplandianus, Phyllanthus emblica*
23.	Convolvulaceae	*Evolvulus alsinoides*
24.	Rutaceae	*Aegle marmelos*
25.	Brassicaceae	*Brassica nigra*
26.	Tiliaceae	*Grewia sp., Corchorus fascicularis*
27.	Zygophyllaceae	*Tribulus terrestris*
28.	Rhamnaceae	*Ziziphus*
29.	Bombacaceae	*Bombax ceiba*
30.	Loranthaceae	*Dendrophthoe falcata*
31.	Apiaceae	*Carum copticum*

the *Apis dorsata* winter honeys from the Nallamala Forest, Nagarkarnool District, Telangana, south India. Of these, ten pollen taxa belong to the family Asteraceae, eight represent the family Fabaceae, three each represent the families Mimosaceae, Amaranthaceae, Acanthaceae, Lamiaceae, Arecaceae, Sapindaceae and Euphorbiaceae, two each represent the families Combretaceae, Poaceae, Malvaceae, Myrtaceae and Tiliaceae, while each of the families Lecythidaceae, Rubiaceae, Lythraceae, Cornaceae, Solanaceae, Capparaceae, Dilleniaceae, Balsaminaceae, Cucurbitaceae, Convolvulaceae, Rutaceae, Brassicaceae, Zygophyllaceae, Rhamnaceae, Bombacaceae, Loranthaceae and Apiaceae are represented by one pollen taxa (Table 2).

Comparison of the present investigation with the melissopalynological studies carried out previously on honey samples of *A. dorsata* in the different regions of India reveals few similarities and dissimilarities. For instance, recovery of *Acacia* sp., *Syzygium cumini, Schleichera oleosa, Cocos nucifera, Terminalia* sp., Asteraceae and Apiaceae pollen in the honey of *Apis*

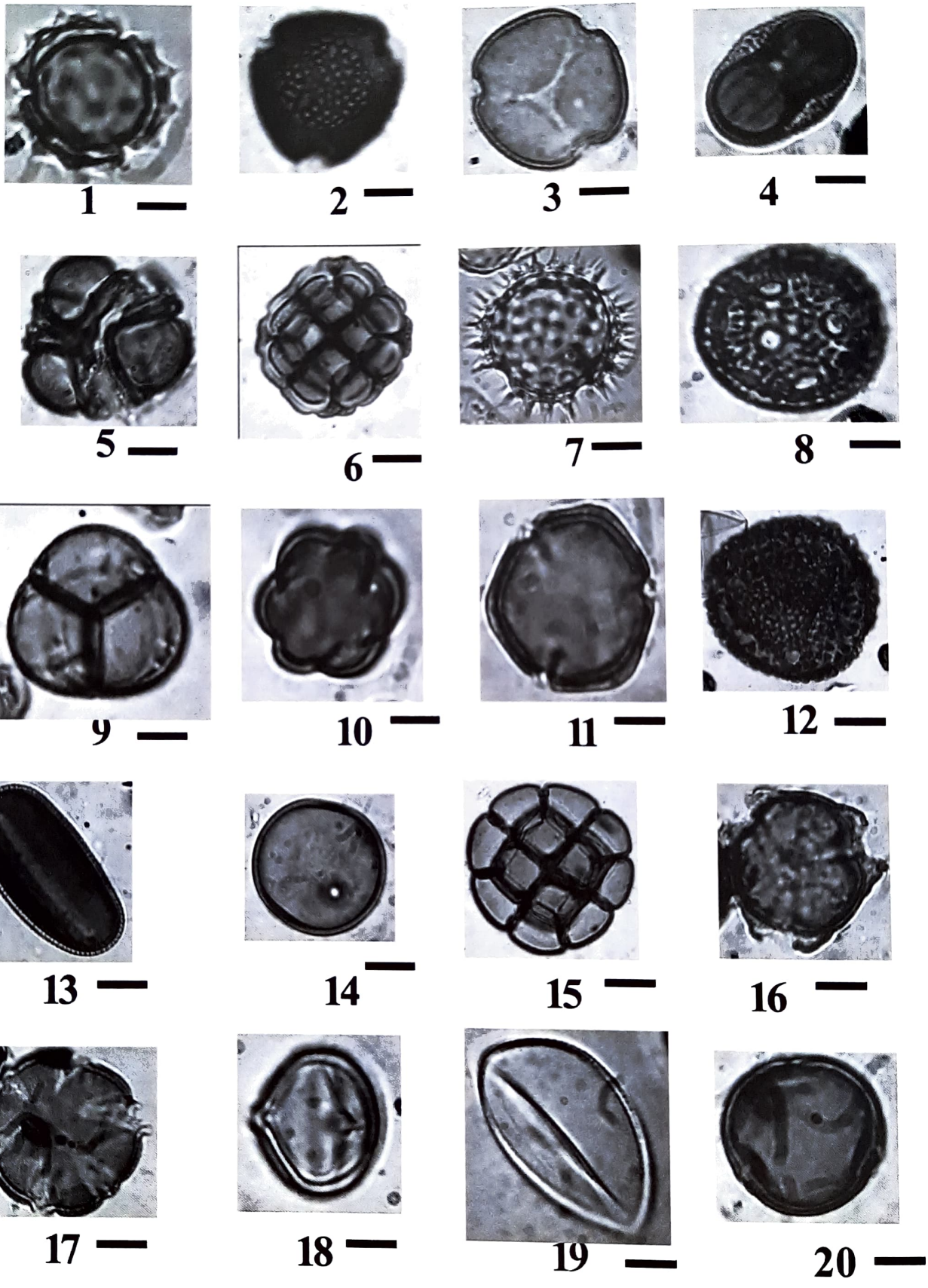


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PLATE 1

1. *Ageratum conyzoides*, **2.** *Cajanus cajan*, **3.** *Prosopis juliflora*, **4.** *Justicia procumbens*, **5.** *Careya arborea*, **6.** *Acacia nilotica*, **7.** *Tridax procumbens*, **8.** *Celosia argentea*, **9.** *Gardenia lucida*, **10.** *Terminalia arjuna*, **11.** *Lagerstroemia parviflora*, **12.** *Alangium salviifolium*, **13.** *Blepharis maderaspatensis*, **14.** Grass pollen, **15.** *Albizia lebbeck*, **16.** *Physalis minima*, **17.** *Hyptis suaveolens*, **18.** *Crateva magna*, **19.** *Phoenix sylvestris*, **20.** *Corchorus fascicularis*

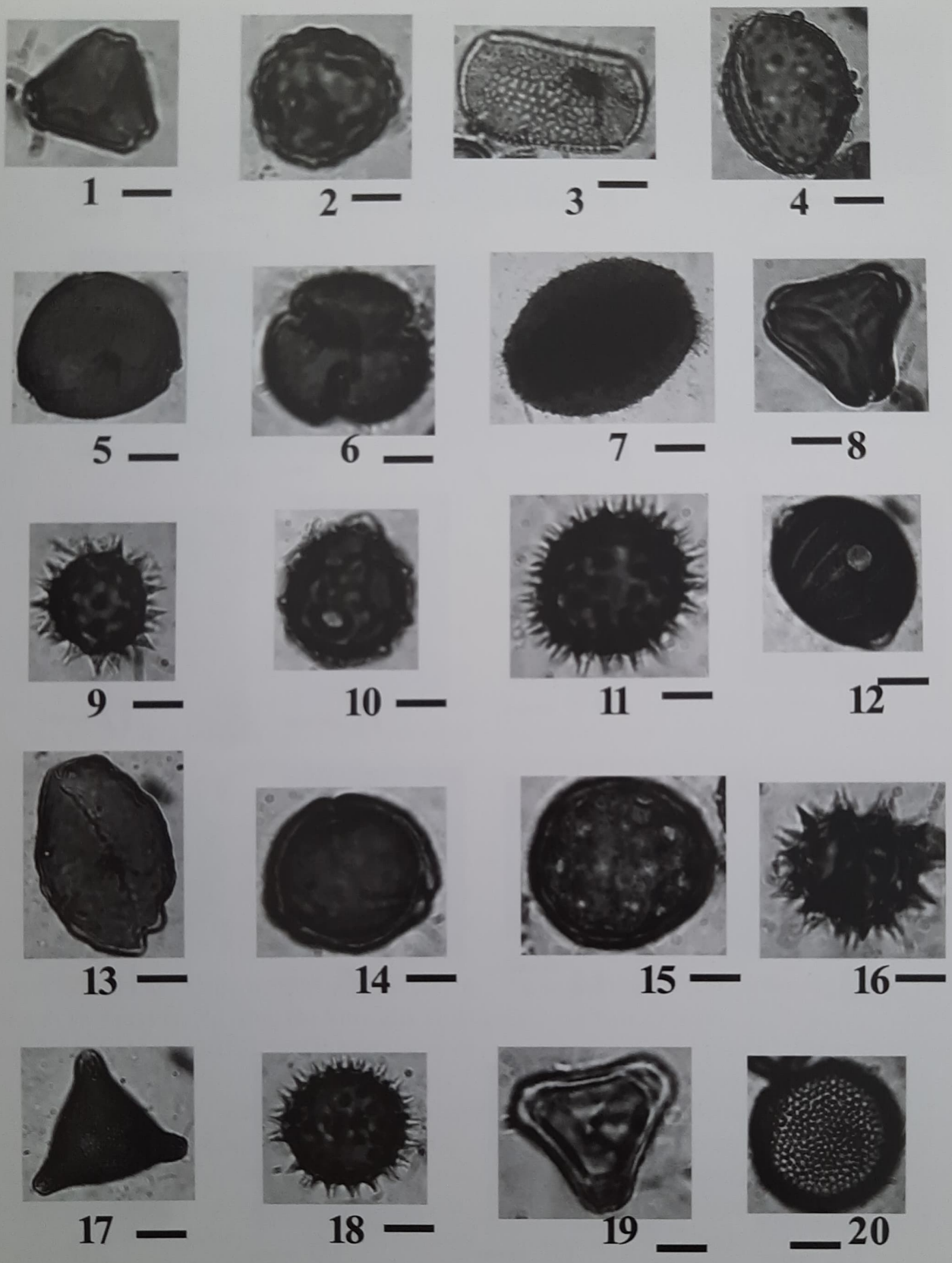

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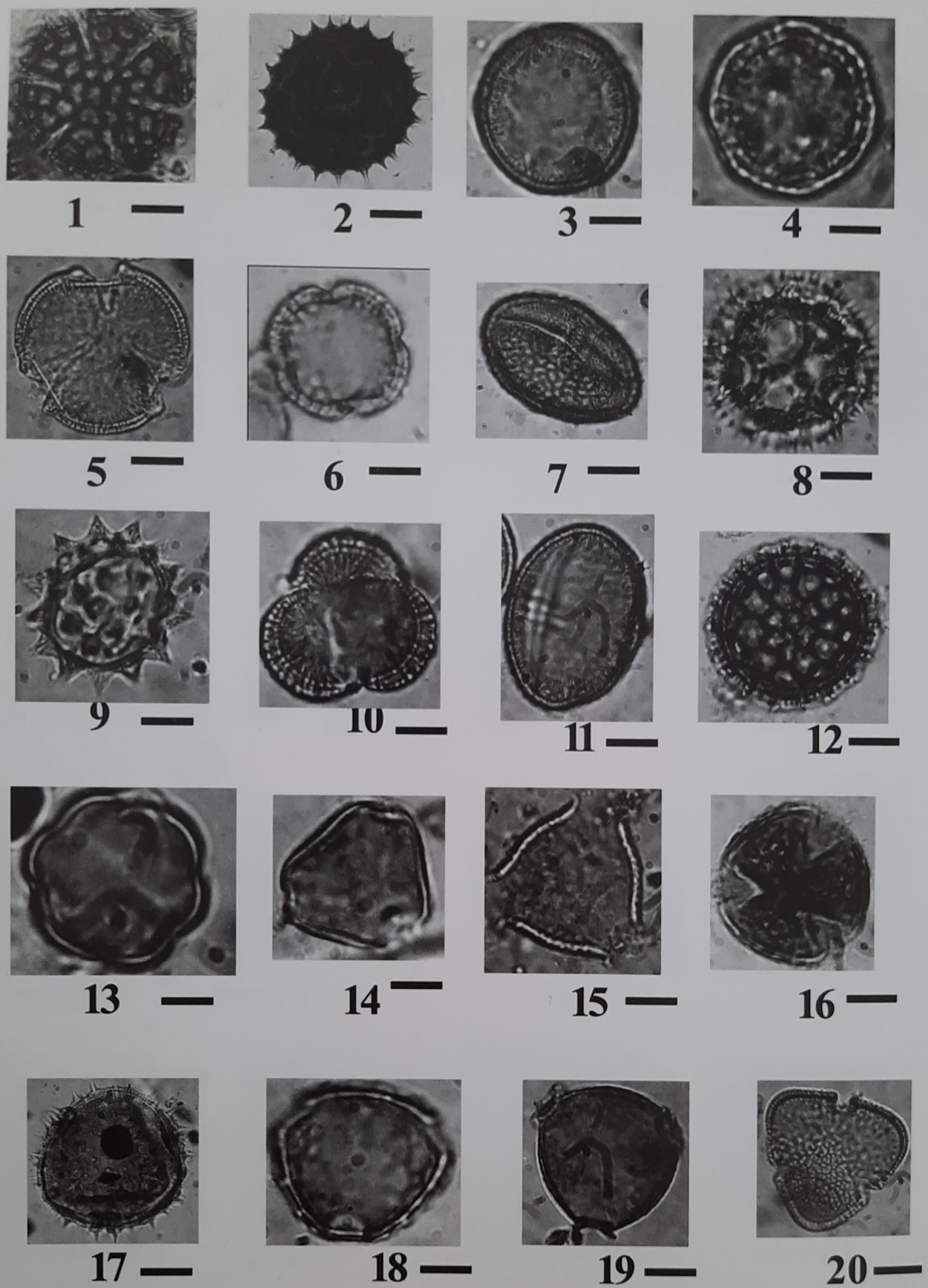
PLATE 2

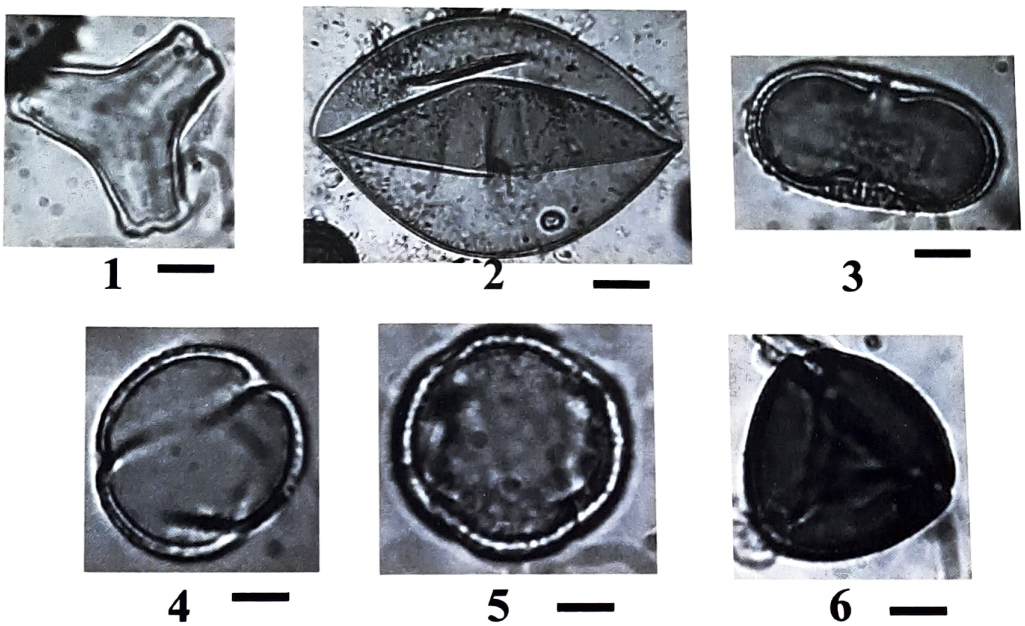
1. *Sapindus emarginatus*, **2.** *Dillenia pentagyna*, **3.** *Impatiens balsamina*, **4.** *Borassus flabellifer*, **5.** *Cucumis sativus*, **6.** *Cassia auriculata*, **7.** *Echinops echinatus*, **8.** *Syzygium cumini*, **9.** *Conyza stricta*, **10.** *Erythrina variegata*, **11.** *Centipeda minima*, **12.** *Hygrophila auriculata*, **13.** *Cocos nucifera*, **14.** *Ricinus communis*, **15.** *Achyranthes aspera*, **16.** *Cyathocline purpurea*, **17.** *Cardiospermum halicacabum*, **18.** *Grangea maderaspatana*, **19.** *Eucalyptus globulus*, **20.** *Croton bonplandianus*



Scale bar: ▬▬ 10μm

PLATE 3

1. *Ocimum sanctum*, **2.** *Sida acuta*, **3.** *Evolvulus alsinoides*, **4.** *Spinacia oleracea*, **5.** *Sesbania sp.*, **6.** *Aegle marmelos*, **7.** *Andrographis echioides*, **8.** *Vernonia cinerea*, **9.** *Vicoa indica*, **10.** *Brassica nigra*, **11.** *Grewia sp.*, **12.** *Tribulus terrestris*, **13.** *Terminalia catappa*, **14.** *Ziziphus sp.*, **15.** *Parkinsonia aculeate*, **16.** *Pongamia pinnata*, **17.** *Abutilon indicum*, **18.** *Erythrina suberosa*, **19.** *Clitoria ternatea*, **20.** *Bombax ceiba*



Scale bar: ▬ 10µm

PLATE 4

1. *Dendrophthoe falcata,* **2.** *Zea mays,* **3.** *Carum copticum,* **4.** *Leucas aspera,* **5.** *Phyllanthus emblica,* **6.** *Schleichera oleosa*

dorsata from the Nilgiris, Tamil Nadu (Padmavathi & Shiny Mariam Rehel 2014), and presence of *Ageratum conyzoids, Bombax ceiba, Cocos nucifera, Cucumis sativus, Gardenia* sp., *Justicia* sp., *Lagerstroemia* sp., *Rcinus communis, Syzygium cumini, Ziziphus* sp., *Brassica* sp., *Acacia* sp., *Cassia* sp., *Clitorea ternatea, Eucalyptus globulus, Vernonia cinerea* pollen in the honey samples from Assam (Sarma & Sahari 2011; Sahari & Sarma 2016). Further, presence of *Bombax* sp., *Brassica* sp., *Phoenix* sp., *Acacia* sp., *Eucalyptus* sp., Cucurbitaceae, Asteraceae, Lamiaceae, Malvaceae, Apiaceae, Sapindaceae pollen in the honey of *Apis cerana* from the Shiwalik Hills (Avinash Kaur & Mattu 2016), and the recovery of *Acacia* sp., *Ageratum conyzoides, Cocos nucifera, Croton bonplandianus, Eucalyptus globulus, Justicia procumbens, Prosopis juliflora, Ocimum* sp., *Ricinus communis, Schleichera oleosa, Syzygium cumini, Terminalia* sp., *Tridax procumbens, Sida* sp., *Ziziphus* sp., pollen in the honey samples collected from Western Ghats, Tamil Nadu (Mahendran et al. 2015). In addition, presence of *Ageratum conyzoides, Bombax ceiba, Cajanus cajan, Cassis* sp., *Eucalyptus globulus, Justicia procumbens, Phoenix* sp., *Phyllanthus emblica, Ziziphus* sp., and Poaceae pollen in the honey samples from Varanasi District, Uttar Pradesh (Sahney et al. 2016), recovery of *Hyptis suaveolens, Brassica* sp., *Syzygium cumini, Terminalia* sp., *Tridax procumbens, Mimosa* sp., *Careya arborea, Albizzia lebbeck* pollen in the honeys of *Apis dorsata* from Wardha, Maharashtra (Cherian 2010), presence of *Ageratum conyzoides, Tridax procumbens, Vicoa* sp., *Cyathocline purpurea, Corchorus fascicularis, Blepharis maderaspatensis, Erythrina* sp., *Acacia* sp., *Albizia lebbeck, Schleichera oleosa, Sapindus emarginatus, Dendrophthoe falcata, Terminalia arjuna, Cassia* sp., *Careya arborea, Ocimum sanctum, Dillenia pentagyna, Eucalyptus globulus, Syzygium cumini, Vernonia cinerea, Prosopis juliflora, Cocos nucifera, Borassus flabellifer and Lagerstroemia parviflora* pollen within the honey samples from Visakhapatnam, southeast India (Devender et al. 2014; Devender & Ramakrishna 2015), and the presence of *Hygrophila auriculata, Justicia procumbens, Coocs nucifera, Phoenix sylvestris, Borassus flabellifer, Ageratum conyzoides, Vernonia cinerea, Tridax procumbens, Bombax ceiba, Terminalia arjuna, Cucumis* sp., *Lagerstroeia parviflora, Prosopis juliflora, Albizia lebbeck, Syzygium cumini, Eucalyptus globulus*

pollen in the honey samples collected from the Guntur District, south India (Mamatha et al. 2017).

The recovery of abundant pollen taxa from the honey samples of *A. dorsata* collected from the Nallamala Forest, Nagarkurnool District, South India, in the present investigation certainly provides evidence for the presence of honey bee (*A. dorsata*) forage plants as an essential nectar source in the region. Thus, we emphasize development of apiaries for honey production for commercial use in the Nallamala region, south India.

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REFERENCES

Agwu C.O.C. & Aknabi T.O. 1985. A palynological study of honey from four vegetation zones in Nigeria. Pollen et Spores 27: 335-348.

Avinash Kaur & Mattu K.V. 2016. Pollen Spectrum of honey samples of *Apis cerana* F. collected from different areas of Shiwalik hills. International Journal of Scientific Research and Education 4(6): 5434-5440.

Bhattacharya K., Chanda S., Gupta S. & Ganguly P. 1983. Analysis of the pollen load from a honey sample from Salt Lake City, Clcutta. Science & Culture 49: 222-224.

Chauhan M.S. & Murthy S. 2010. Melittopalynological investigation of honeys from Chamaraj Nagar District, Southern Karnataka. Geophytology 39: 41-47.

Chauhan M.S. & Quamar M.F. 2010. Melissopalynological studies of honeys from Harda District, Madhya Pradesh. Phytomorphology 69: 122-127.

Chauhan M.S. & Trivedi A. 2011. Pollen analysis of honeys from Lucknow District, Uttar Pradesh. Journal of Applied Bioscience 37: 48-51.

Cherian K.J. 2010. Pollen analysis of *Apis dorsata* honey collected from the Wardha, Maharashtra. International Journal for Environmental Rehabilitation and Conservation. I (2):77-80.

Costa M.C., Vergara-Roing V.A. & Kivatinitz S.C. 2013. A melissopalyological study of artisanal honey procured in Catanarca (Argentina). Grana 52: 229-237.

Datta K., Verma P.C. & Chatterjee A. 2008. Mapping of key bee flora of upper Gangetic region of India- a palynological assessment through regional honeys. Grana 47: 159-170.

Deodikar G.B. & Thakar C.V 1953. A pollen study of honey yielding plants of Mahabaleshwar hills. Apicultural Lab. Bulletin 1: 1-6.

Deodikar G.B. 1961. Some aspects of bee botany. Indian Bee Journal 23: 60-61.

Devender R. & Ramakrishna H. 2015. Palynodiversity in *Trigona* honeys from Paderu forest division of Visakhapatnam district, Andhra Pradesh, India. *Geophytology* 45 (2): 221-226.

Devender R., Ramakrishna H. & Padal S.B. 2014. Pollen diversity in *Apis* honeys of Narsipatna forest Visakhapatnam district, Andhra Pradesh, India. Geophytology 44(2): 181-187.

Dixit S., Basumatary S.K., Singh H. & Bera S.K. 2013 Melissopalynological studies of western part of Almora District, Uttarakhand. The Paleobotanist 62: 39-46.

Erdtman G. 1960. The acetolysis method-a revised description. Sv.Bot. Tidskr. 54: 561-564.

Feller-Demalsy M. J., Parent J. & Strachan A. 1989.Microscopic analysis of honeys from Manitoba, Canada. Journal of Apicutureal Research 28: 41-48.

Garg A. 2006. Bee botany of Bhimtal in western Himalayas: Melissopalynological analysis. 1st ed. Dehra Dun: Bishen Singh & Mahendra Pal Singh.

Gaur R. D. & Nanwani P. 1989. A Melittopalynological analysis of apiary honeys from Pauri Garhwal, U.P., India. Indian Bee Journal 51:12-14.

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.

Jana D., Bandyopadhyay A. & Bera S. 2000. Pollen analysis of winter honey samples from Murshidabad District, West Bengal. Geophytology 30: 91-97.

Lakshmi K. & Suryanarayana M.C. 2004. Melittopalynological investigation of *Apis dorsata* honeys from forest areas of Cuddapha District, Andhra Pradesh. Journal of Palynology 40: 189-198.

Lieux M.H. 1980. Acetolysis applied to microscopical honey analysis. Grana 19: 57-61.

Lin S.H., Chang S.Y. & Chen S.H. 1993. Nectar and Pollen sources for Honeybee (*Apis cerana* Fabr.) in Qinglan Mangrove area, Hainan Island, China. Journal of Integrative Plant Biology 48: 1266-1273.

Louveaux J., Mourizio A. & Vorwohl G. 1978. Methods of melissopalynology. Bee World 59: 139-157.

Mahendran S., Kumara Samy D. & Saravana Kumar K. 2015. Pollen analysis of honey samples from Western Ghats, Tamil Nadu, India International Journal of Current Research and Development 3(1): 29-35.

Mamatha K., Devender R., Ganga Kailas J., Niranjan S. & Ramakrishna H. 2017. Melissopalynological analysis of apiary *(Apis mellifera)* honey from Guntur District, Andhra Pradesh. Geophytology 47(1): 59-67.

Maurizio A. 1951. Pollen analysis of honey. Bee World 32: 1-5.

Maurizio A. 1975. Microscopy of honey. In: Crane E, editor. Honey, a comprehensive survey. New York: Crane, Russak and Co; p. 240-257.

Mittre V. 1958. Pollen analysis of Indian honeys. Journal of Scientific and Industrial Research 17C: 123-124.

Moar N.T. 1985. Pollen analysis of New Zealand honey. New Zealand Journal of Agricultural Research 28: 39-70.

Mondal M. & Mitra K. 1980. Pollen analysis of honey from Sunderban (W. Bengal). Geophytology 10: 137-139.

Nair P.K.K. 1964. A pollen analytical study of Indian honeys. Journal of Indian Botanical Society 43: 179-191.

Nair P.K.K. 1985. Melittopalynology. In: Essentials of Palynology. New Delhi: Today and Tomorrow's Publishers; p. 59-64.

Oliviera P.P., Van den Berg C. & Santos F. 2010. Pollen analysis of honeys from Caatinga vegetation of the state of Bahia, Brazil. Grana 49: 66-75.

Padmavathy P. & Rehel S.M. 2014. Bee Plants of *Apis dorsata* during Winter Season from Coonoor Region, Nilgiris, Tamil Nadu, India. Journal of Academia and Industrial Research 2(10): 570-572.

Raghunandan K.S. & Basavarajappa S. 2013. Analysis of multifloral honey of the giant honey bee, *Apis dorsata* F., for pesticide residues in southern Karnataka, India. European Journal of Zoological Research 2: 22-28.

Ramanujam C.G.K. & Kalpana T.P. 1991. Pollen analysis of *Prosopis juliflora* honeys from Ranga Reddy district, A.P. and its relevance to apiculture and social forestry. Journal of Palynology 27: 345-368.

Ramanujam C.G.K., Reddy P.R. & Kalpana T.P. 1992. Pollen analysis of apiary honeys from East Godavari District, A.P. Journal of Indian Institute of Sciences 72: 289-299.

Saharia D. & Sarma, G.C. 2016. Melissopalynological studies in the Darrang district of Assam, India. Pleione 10(1):116-122.

Sahney M., Kumar A. & Rahi S. 2016. Pollen Analysis of Honeys from Varanasi District, Uttar Pradesh, India. Biological Forum – An International Journal 8(2): 126-133.

Sarma, G.C. & Saharia. D. 2011. Important Winter Bee Plant of Sonapur Area, Kamrup District, Assam Indian. Journal of Fundamental and Applied Life Sciences. 1(3): 166-171.

Seedley T.D. 1985. Honeybee ecology. Princeton, New Jersey: Princeton University Press.

Sharma M. & Nair P.K.K. 1965. Pollen analysis of some honeys from Uttar Pradesh. Indian Journal of Horticulture 22: 46-51.

Sivaram V., Roopa P., Shubharani R. & Suwannapong G. 2012. Pollen analysis in Honeys collected from Karnataka region of Nilgiri Biosphere, South India. Journal of Apiculture 27: 223-231.

Song X.Y., Yao Y.F., & Yang W.D. 2012. Pollen analysis of natural honeys from the Central Region of Shanxi, North China. PLoS ONE 7: e49545.doi:10.1371/journal.pone.0049545

Suryanarayana M.C., Rao G.M. & Singh T.S.M.S. 1992. Studies on pollen sources for *Apis cerana* Fabr. and *Apis mellifera* L. bees at Muzaffarpur, Bihar, India. Apidologie 23: 33-48.

Terrab A., Pontes A., Heredia F.J. & Diez M.J. 2004. Palynological and geographical characterization of avocado honeys in Spain. Grana 43: 116-121.

Tiwari J.K., Gairola A., Tiwari P. & Ballabha R. 2012. Pollen analysis of some honey samples from Kamad area of district Uttarkashi in Garhwal Himalaya, India. Asian Journal of Experimental Biological Sciences 3: 778-784.

Turner V. 1984. Banksia pollen as a source of protein in the diet of two Australian marsupials *Cercartetus nanus* and *Tarsipus rostratus*. Oikos 43: 53-61.

Upadayay D., Bhattacharya S., Ferguson D.K. & Bera S. 2014. Prospects of Apicultural Entrepreneurship in coastal district of eastern India: A Melissopalynological evaluation. PLOS one 9: 1-15.

Verma S.K. 1988. Foraging behaviour of *Apis cerana* indica Fabr. in Jeolekote (Nainital), India. Indian Bee Journal 45: 5-7.