Nectar source for Honey Bees in a coastal district of Andhra Pradesh, India

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Microscopic analysis of the pollen contents of 80 extracted honeys of *Apis cerana* var. *indica*, collected during January to May 1992-1996, from the eastern part of Krishna district of Andhra Pradesh in southern India, has highlighted March to May as the major honey flow period with maximum honey production. June to December represents the floral dearth period. *Borassus flabellifer* the palmyra palm seen profusely in and around the agricultural tracts of this district constitutes the predominant nectar source for the honey bees during the summer season as evidenced by 30 (69.18%) of the 44 unifloral honeys, representing *Borassus* honeys. The other noterworthy unifloral honeys during this period were of *Phoenix sylvestris, Hygrophila* sp., and *Brassica nigra*. The period January-February showed limited production of honey from *Brassica nigra* and *Phoenix sylvestris*.

Borassus-Brassica-Phoenix-Cocos-Hygrophila complex represent regional indicators of honey from Krishna district. Based on the absolute pollen counts, the majority of the honey samples could be referable to Group II.

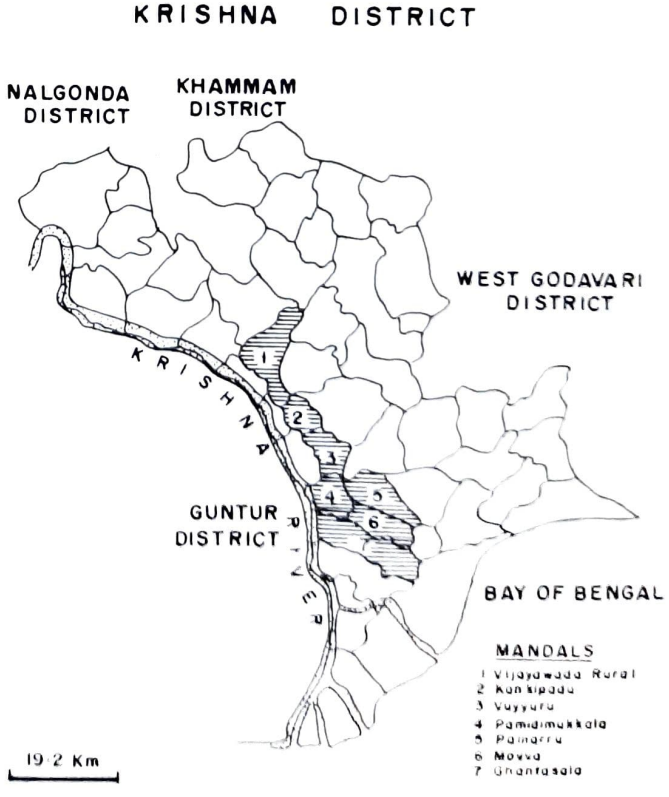
Key-words—Krishna district, honeys, chief nectar source, honey flow period.

INTRODUCTION

ONE of the prerequisites for a successful commercial bee-keeping enterprise is a thorough knowledge of the local nectar and pollen sources for the honey bees. Hence a critical screening of the bee plants supplying nectar and pollen during different seasons is essential to recognize areas suitable for apiary industry.

The pollen spectrum of a honey sample is a function of its floristic sources and concomitantly its geographic origin. Melittopalynological studies involving qualitative and quantitative analysis of the pollen contents of honeys and pollen loads play a significant role in providing information regarding the floral sources preferred by the bees during different seasons thereby helping the bee-keepers in the proper management of the bee colonies leading to enhanced honey production.

Melittopalynological studies have received only marginal attention in India, and particularly so in context of Andhra Pradesh, a major state in southern India. During the last decade, pollen analytical studies of honeys and pollen loads of various bee species viz., *Apis cerana, A. florea* and *A. dorsata* from different floristic regions of this state have been initiated on a large scale (Ramanujam & Khatija 1991, 1992, 1993; Ramanujam *et al.*, 1992a, 1992b; Ramanujam & Kalpana 1993, 1994, 1995a, 1995b; Jhansi *et al.* 1994; Kalpana & Ramanujam 1996; Ramanujam 1994a, 1994b).



Map 1. Location sites of honey samples

The present study deals with a critical microscopic analysis of the pollen contents of 80 apiary honeys collected from the agricultural tracts of the eastern part of Krishna district, one of the coastal districts of Andhra Pradesh. The study highlights the significant sources of nectar for the honey bees (*Apis cerana*) , unifloral (single source) honeys, the honey flow and dearth periods and also the regional indicators of honeys of this district. An advance report of part of this work was recently presented at the Melissopalynology Symposium of the IXth International Palynology Conference held at Houston, Texas, USA (Kalpana & Ramanujam, 1996b).

MATERIAL AND METHODS

80 apiary honey samples (200 grams each) of *Apis cerana* var. *indica,* the Indian hive bee were collected from the agricultural tracts of 7 mandals viz., Movva, Ghantasala, Pamidimukkala, Vijayawada Rural, Kankipadu, Vuyyuru and Pamarru of the eastern part of Krishna district during January-May of 1992-1996 (Map 1). Of these, 26 samples were obtained during January-February (winter) and 54 during March-May (summer). The bulk of the samples viz., 33 (14 winter, 19 summer) were from Movva mandal, followed by Pamidimukkala, 16 (6 winter, 10 summer) and Pamarru, 13 (1 winter, 22 summer). The inventory of the honey samples is provided in Table 1.

The methodology recommended by the International Commission for Bee Botany (Louveaux *et al.*, 1978) was employed for the recovery and analysis of the pollen contents from honey samples. The pollen types were placed under 4 frequency classes viz., predominant pollen type (> 45% of the total pollen complement of nectariferous taxa), secondary pollen types (16-45%), important minor pollen types (3-15%) and minor pollen types (< 3%). The honeys were designated as *Unifloral* if they contained a predominant pollen type and *Multifloral,* otherwise.

The ratio of honeydew elements (fungal spores and hyphae, algae and wax particles) versus total number of pollen grains of nectariferous taxa in each sample (HDE/P) was obtained by the study of unacetolysed honeys. The absolute pollen counts (APC) of the honey samples (i.e., the number of pollen grains per 10g) were calculated using haemocytometer (Suryanarayana *et al.*, 1981) and the samples were categorized under various groups in conformity with the universally followed grading parameters viz., 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 (Louveaux *et al.*, 1978).

The frequency distribution (frequency of occurrence) of pollen types was determined from the total complement of honey samples and 4 discrete classes were recognized viz., very frequent (present in more than 50% of the samples), frequent (20-50%), infrequent (10%-20%), and rare (less than 10%) (Feller-Demalsy *et al.* 1987).

OBSERVATIONS

Of the 26 samples collected during January-February, 20 (76.92%) were found to be unifloral and 6 (23.07%) multifloral. *Brassica nigra* (53.83-79.0%) in 7 samples, *Phoenix sylvestris* (49.33-68.67%) in 6 samples. *Hygrophila* sp. (52.5-70.17%) in 3 samples, *Cleome gynandra* (49.65-69.83%) in 2 samples and *Prosopis juliflora* (76.17%) and *Ziziphus mauritiana* (63.33%) in 1 sample each, represent the predominant pollen types. *Sapindus emarginatus, Cleome gynandra, Brassica nigra, Phoenix sylvestris, Hygrophila* sp. and *Celastraceae* type constitute secondary pollen types in the multifloral honeys. Other pollen types recorded upto important minor category include *Borassus flabellifer, Polygonum plebieum, Cuscuta hyalina, Crataeva magna, Cucumis* sp., *Cocos*

PLATE 1 →

(All Figures x 750)

1, 2. *Borassus flabellifer*, 3. *Cocos nucifera*, 4, 5. *Phoenix sylvestris*, 6, 7. *Brassica nigra*, 8, 9. *Sapindus emarginatus*, 10. *Leucaena leucocephala*, 11. *Sesbania* sp., 12. *Eucalyptus* sp., 13. *Syzygium cumini*, 14, 15. *Cleome gynandra*, 16. *Ziziphus mauritiana*, 17. *Sphaeranthus indicus*, 18, 19. *Sesamum indicum* 20, 21. *Feronia elephantum*, 22. *Tridax procumbens*, 23, 24. *Coccinia grandis*, 25, 26. *Prosopis juliflora*, 27, 28. *Phyllanthus emblica*

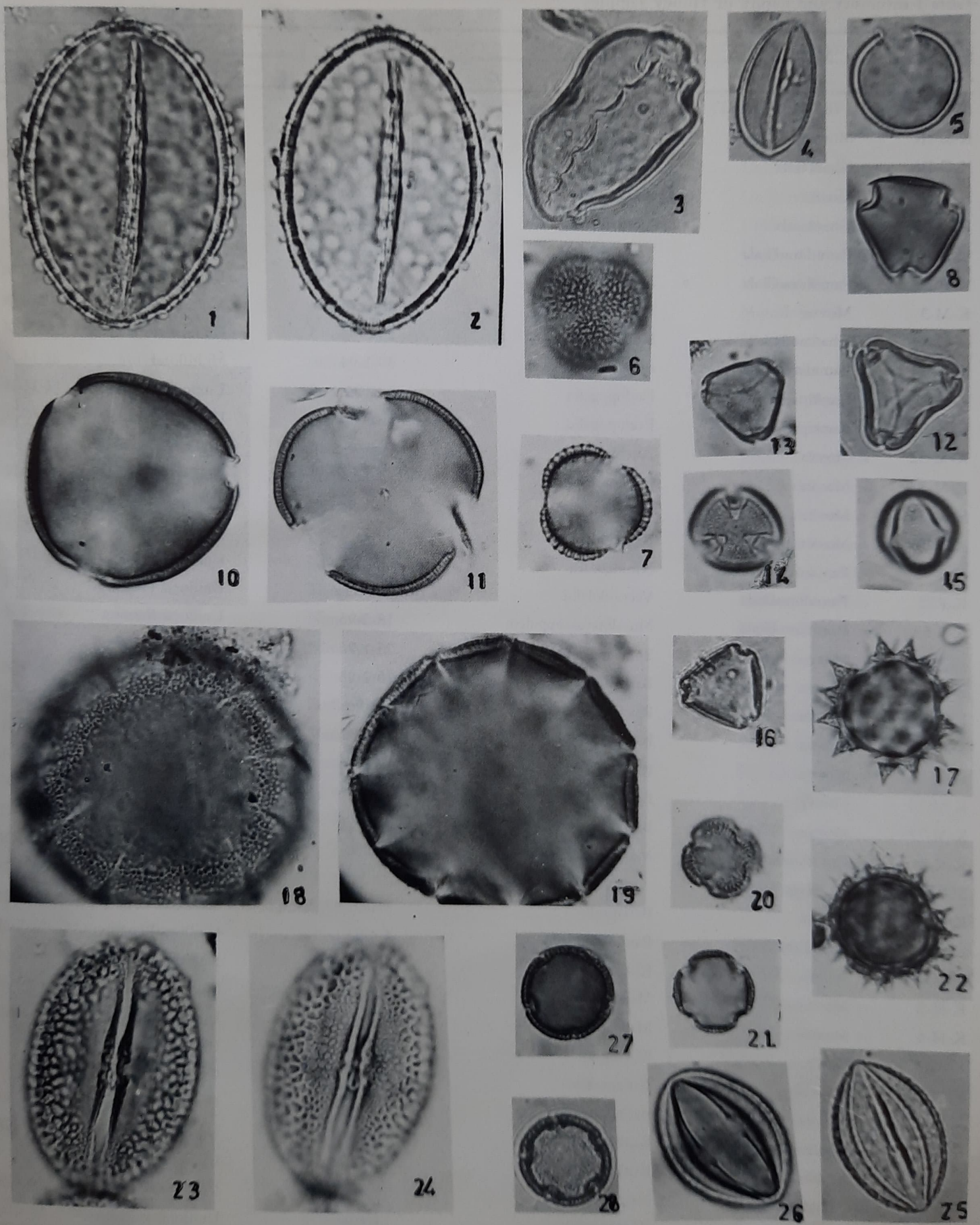


PLATE 1

Table 1-Inventory and nature of Honey samples

Sample No.	Mandal	Village	Date of Collection	Nature of Honey
WINTER (JANUARY-FEBRUARY)				
K-M-III	Movva	Barlapudi	26-1-93	Multifloral
K-G-IV	Ghantasala	Challapalli	15-1-93	Unifloral Cleome
K-M-VI	Movva	Barlapudi	21-2-93	Unifloral Hygrophila
K-M-VII	Ghantasala	Ramudupalem	22-2-93	Unifloral Phoenix
K-P-1	Pamidimukkala	Veerankilaku	1-2-94	Multifloral
K-P-2	Pamidimukkala	Narayanapuram	22-2-94	Unifloral Phoenix
K-M-3	Movva	Barlapudi	22-2-94	Multifloral
K-G-10	Ghantasala	Kodala	25-2-94	Unifloral Phoenix
K-P-13	Pamidimukkala	Alinakipalem	30-1-94	Multifloral
K-K-17	Kankipadu	Eudupugallu	Jan. 94	Unifloral Brassica
K-K-18	Kankipadu	Eudupugallu	Jan. 94	Unifloral Brassica
K-M-32	Movva	Kuchipudi	Jan. 95	Unifloral Prosopis
K-M-33	Movva	Barlapudi	14-1-95	Unifloral Brassica
K-M-34	Movva	Pedapudi	16-1-95	Unifloral Ziziphus
K-M-35	Movva	Barlapudi	30-1-95	Unifloral Brassica
K-P-46	Pamarru	Nimmakuru	Jan. 94	Unifloral Phoenix
K-P52	Pamidimukkala	Veerankilaku	Jan. 95	Unifloral Phoenix
K-P-53	Pamidimukkala	Musalinayakunipalem	18-2-95	Unifloral Brassica
K-M-71	Movva	Turakapalem	25-1-96	Multifloral
K-M-72	Movva	Barlapudi	28-1-96	Uuifloral Hygrophila
K-M-73	Movva	Kuchipudi	1-2-96	Unifloral Brassica
K-M-74	Movva	Barlapudi	Feb. 96	Unifloral Hygrophila
K-M-75	Movva	Barlapudi	13-2-96	Multifloral
K-M-76	Movva	Barlapudi	20-2-96	Unifloral Cleome
K-M-77	Movva	Barlapudi	21-2-96	Unifloral Phoenix
K-K-81	Pamidimukkala	Musalinayakunipalem	4-2-96	Unifloral Brassica
SUMMER (March - May)				
K-M-I	Movva	Barlapudi	March 92	Unifloral Hygrophila
K-P-V	Pamidimukkala	Pamidimukkala	4-4-93	Uniflora Phoenix
K-M-4	Movva	Kosuru	March 94	Unifloral Hygrophila
K-M-5	Movva	Mangankhanpalem	10-3-94	Multifloral
K-M-6	Movva	Mangankhanpalem	April 94	Unifloral Borassus
K-M-7	Movva	Kuchipudi	4-4-94	Unifloral Borassus
K-M-8	Movva	Barlapudi	4-4-94	Unifloral Borassus
K-M-9	Movva	Barlapudi	11-4-94	Unifloral Borassus
K-G-11	Ghantasala	Kothapalli	4-3-94	Unifloral Phoenix
K-G-12	Ghantasala	Kothapalli	13-4-94	Unifloral Phoenix
K-P-14	Pamidimukkala	Nayakunipalem	March 94	Unifloral Phoenix
K-P-15	Pamidimukkala	Agniparru	13-4-94	Unifloral Brassica
K-V-16	Vijayawada rural	Mangalapuram	14-4-94	Unifloral Borassus

Sample No.	Mandal	Village	Date of Collection	Nature of Honey
K-K-19	Kankipadu	Eudupugallu	14-4-94	Multifloral
K-K-20	Kankipadu	Eudupugallu	14-4-94	Multifloral
K-K-21	Kankipadu	Kankipadu	30-3-94	Multifloral
K-K-22	Kankipadu	Kankipadu	14-4-94	Unifloral Borassus
K-K-25	Vuyyuru	Anandapuram	March 94	Unifloral Borassus
K-V-26	Vuyyuru	Anandapuram	13-4-94	Unifloral Borassus
K-V-27	Vuyyuru	Kalavapamula	9-4-94	Unifloral Phoenix
K-P-28	Pamarru	Perisepalli	4-3-94	Unifloral Borassus
K-P-29	Pamarru	Konduparru	12-4-94	Multifloral
K-P-30	Pamarru	Konduparru	12-4-94	Multifloral
K-M-36	Movva	Barlapudi	28-3-95	Multifloral
K-M-37	Movva	Barlapudi	31-3-95	Unifloral Borassus
K-M-38	Movva	Mangankhanpalem	1-4-95	Unifloral Borassus
K-M-39	Movva	Barlapudi	4-4-95	Unifloral Borassus
K-M-40	Movva	Barlapudi	4-4-95	Unifloral Borassus
K-M-41	Movva	Barlapudi	9-4-95	Unifloral Borassus
K-M-43	Movva	Kosuru	12-4-95	Unifloral Borassus
K-M-44	Movva	Kuchipudi	13-4-95	Unifloral Borassus
K-M-45	Movva	Mangankhanpalem	13-4-95	Unifloral Borassus
K-P-48a	Pamarru	Nimmakuru	6-4-95	Uniflroal Sachharum
K-P-48b	Pamarru	Nimmakuru	6-4-95	Unifloral Sachharum
K-P-49	Pamarru	Konduparru	14-4-95	Unifloral Borassus
K-K-51	Kankipadu	Eudupugallu	1-4-95	Unifloral Borassus
K-P-54	Pamidimukkala	Musalinayakunipalem	21-3-95	Multifloral
K-P-55	Pamidimukkala	Agniparru	13-4-95	Unifloral Borassus
K-P-56	Pamidimukkala	Agniparru	13-4-95	Unifloral Borassus
K-P-57	Pamidimukkala	Narayanapuram	14-4-95	Unifloral Borassus
K-G-58	Ghantasala	Kothapalli	11-4-95	Unifloral Borassus
K-V-60	Vuyyuru	Anandapuram	9-4-95	Unifloral Phoenix
K-P-61	Pamidimukkala	Musalinayakunipalem	13-3-95	Unifloral Borassus
K-P-62	Pamidimukkala	Musalinayakunipalem	28-3-95	Unifloral Borassus
K-P-63	Pamidimukkala	Alinakipalem	13-4-95	Multifloral
K-P-64	Movva	Kuchipudi	May 95	Unifloral Borassus
K-P-47	Pamarru	Perisepalli	3-4-95	Unifloral Borassus
K-M-78	Movva	Barlapudi	25-3-96	Unifloral Borassus
K-M-79	Movva	Barlapudi	14-4-96	Unifloral Borassus
K-P-85	Pamarru	Perisepalli	March 96	Unifloral Borassus
K-P-86	Pamarru	Konduparru	March 96	Unifloral Phoenix
K-P-87	Pamarru	Konduparru	March 96	Unifloral Phoenix
K-P-88	Pamarru	Konduparru	March 96	Multifloral
K-P-89	Pamarru	Bollirepalli	12-4-96	Unifloral Borassus

Table 2-Significant Pollen Types recorded in Krishna District Honeys

January - February

Predominant Pollen Types (>45%)	Secondary Pollen Types (16- 45%)	Important Minor Pollen Types (3-15%)
Brassica nigra	*Phoenix sylvestris*	*Cleome gynandra*
Phoenix sylvestris	*Cleome gynandra*	*Hygrophila* sp.
Cleome gynandra	*Brassica nigra*	*Phoenix sylvestris*
Prosopis juliflora	*Hygrophila* sp.	*Prosopis juliflora*
Ziziphus maurtitiana	*Sapindus emarginatus*	*Sapindus emarginatus*
Hygrophila sp.	Celastraceae type	*Brassica nigra*
		Borassus flabellifer
		Cocos nucifera
		Ploygonum plebieum
		Cucumis sp.
		Momordica charantia
		Eucalyptus sp.
		Cuscuta hyalina
		Crataeva magna

nucifera, Momordica charantia and *Eucalyptus* sp. Table 2 provides detailed information on the predominant, secondary and important minor pollen types encountered during January - February period.

44 (81.44%) of the 54 honey samples collected during March-May were found to be unifloral and 10 (18.51%) multifloral. *Borassus flabellifer* (47.5-96.33%) in 30 samples, *Phoenix sylvestris* (50.83-72.0%) in 8 samples, *Hygrophila* sp. (49.17%, 54.17%), *Brassica nigra* (47.33%, 51.33%) and *Saccharum officinarum,* (64.83%, 68.17%) in 2 samples each constitute the predominant pollen types. *Borassus flabellifer, Syzygium cumini, Cocos nucifera, Cleome gynandra, Phoenix sylvestris, Hygrophila* sp., *Feronia elephantum, Crataeva magna, Cucumis* sp., and *Brassica nigra* represent the secondary pollen types in the multifloral honeys. Other pollen types recorded upto important minor category include *Sapindus emarginatus* (in a few March samples), *Eucalyputs* sp., *Prosopis juliflora, Tridax procumbens, Cuscuta hyalina, Sesbania* sp., *Sesamum indicum, Phyllanthus emblica, Ceiba pentandra, Leucaena leucocephala, Capparis* sp., *Coccinia grandis* and Solanaceae type. Predominant, secondary and important minor pollen types recorded in the honeys of March-May period are given in Table 3.

Table 3-Significant Pollen Types recorded in Krishna District Honeys

March-May

Predominant Pollen Types (> 45%)	Secondary Pollen Types (16-45%)	Important Minor Pollen Types (3-15%)
Borassus flabellifer	*Borassus flabellifer*	*Cocos nucifera*
Phoenix sylvestris	*Cocos nucifera*	*Phoenix sylvestris*
Hygrophila sp.	*Phoenix sylvestris*	*Brassica nigra*
Brassica nigra	*Cleome gynandra*	*Hygrophila* sp.
	Feronia elephantum	*Cucumis* sp.
	Syzygium cumini	*Syzygium cumini*
	Brassica nigra	*Cleome gynandra*
	Cucumis sp.	*Prosopis juliflora*
	Hygrophila sp.	*Borassus flabellifer*
	Crataeva magna	*Phyllanthus emblica*
	Prosopis juliflora	*Feronia elephantum*
	Sphaeranthus indicus	*Crataeva magna*
		Sapindus emarginatus
		Sesamum indicum
		Tridax procumbens
		Eucalyptus sp.
		Cuscuta hyalina
		Sesbania sp.
		Ceiba pentandra
		Leucaena leucocephala
		Capparis sp.
		Coccinia grandis
		Solanaceae type

48 pollen types were encountered only as minor types in the total contingent of honey samples studied and most of them were represented by less than 1% (Table 4). The significant and characteristic pollen types of the bee plants encountered in Krishna district are illustrated in Plates 1&2.

On the whole 76 pollen types of nectariferous taxa referable to 40 families could be recognized in the 80 honey samples investigated (Table 5). A critical analysis of the number of pollen types in each honey sample indicating the plants visited by bees for nectar collection has brought to light interesting results. The bulk of these samples (35) showed

PLATE 2 →

(All Figures x 750)

1-3 *Chrozophora* sp., 4-7 *Hygrophila* sp., 8,9. *Cucumis* sp., 10,11. *Ceiba pentandra*, 12,13. *Saccharum officinarum*, 14,15. *Alangium salvifolium*, 16. *Albizia lebbek*

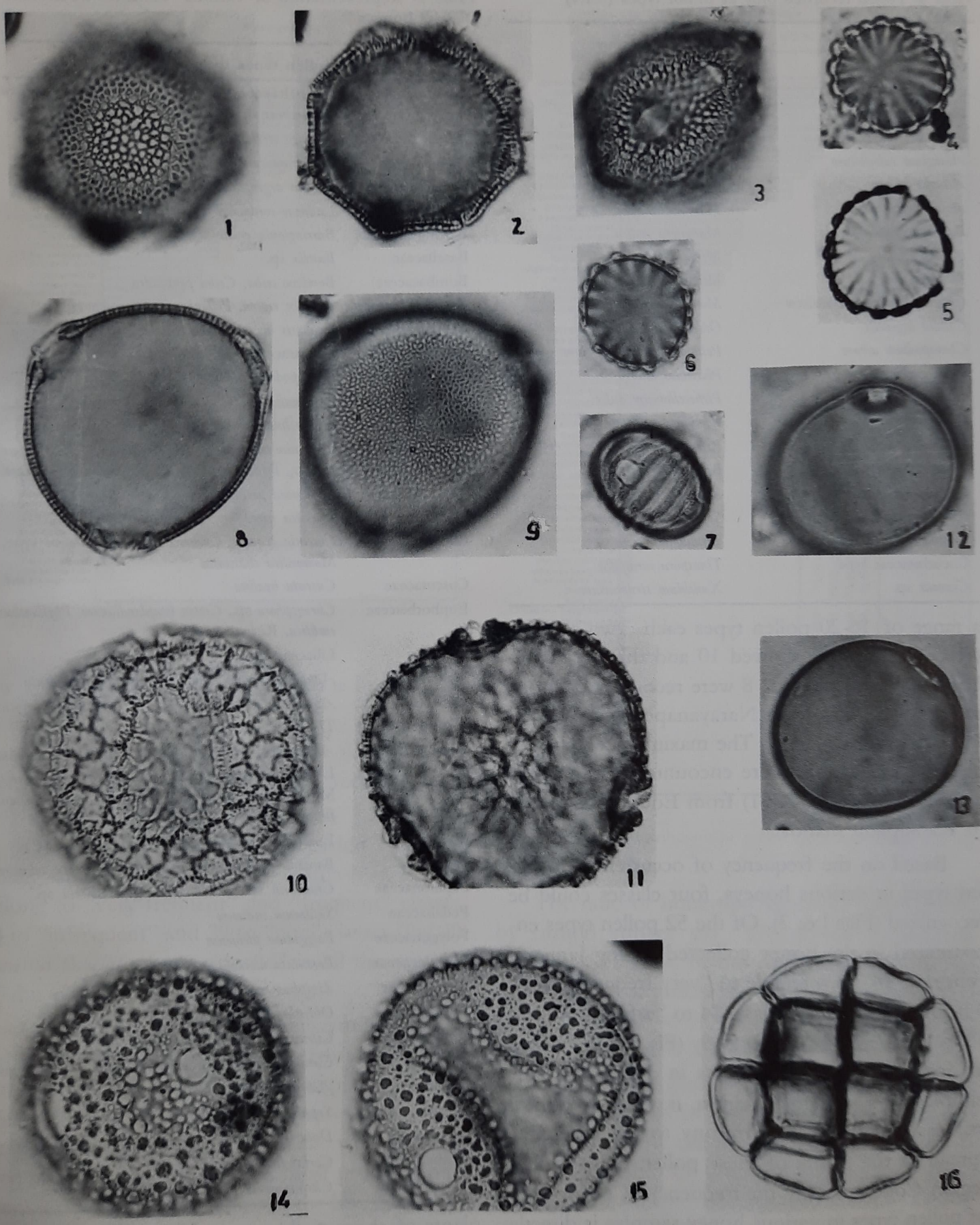


PLATE 2

Table 4- Pollen recorded only as minor types (<3%)

Abutilon indicum	*Datura strumarium*
Acacia sp.	*Delonix regia*
Acanthaceae type	*Enterlobium saman*
Achras japota	*Ipomoea pescaprae*
Ageratum conyzoides	*Justicia procumbens*
Alangium salvifolium	*Lannea coromandelica*
Albizia lebbek	Liliaceae type
Azadirachta indica	Malvaceae type
Barringtonia acutangula	*Mangifera indica*
Basella sp.	*Mimosa rubicaulis*
Bombax ceiba	Mimosoideae type
Cardiospermum halicacabum	*Mollugo cerviana*
Celosia argentea	*Oldenlandia umbellata*
Chenopodium album	*Peltophorum pterocarpum*
Chrozophora sp.	*Phaseolus mungo*
Citrus sp.	*Pithecellobium dulce*
Clerodendrum sp.	*Portulaca oleracea*
Commelina benghalensis	*Ricinus communis*
Compositae type	*Rungia repens*
Coriandrum sativum	*Sida acuta*
Cortalaria sp.	*Sopubia delphinifolia*
Croton bonplandianum	*Terminalia* sp.
Cucurbitaceae type	*Tinospora cordifolia*
Cyanotis sp.	*Xanthium strumarium*

a range of 16-20 pollen types each. Two samples (K-G-10, K-P-89) showed 10 and the least number of pollen types viz., 8 were recording only one sample (K-P-57) from Narayanapuram village of Pamidimukkala mandal. The maximum number of pollen types i.e., 27 were encountered in a single summer sample (K-K-51) from Edupugallu village of Kankipadu mandal.

Based on the frequency of occurrence of pollen types in various honeys, four classes could be recognized (Figs 1 & 2). Of the 52 pollen types encountered in the honey collected during January-February, 14 are referable to "very frequent class", 9 belong to "frequent class, 14 to "infrequent" and 15 to "rare" classes respectively (Fig. 1.). Frequency of occurrence of pollen types in different honey samples of a particular region, is verily a faithful expression of and a testimony to the extensive spread of the plants of these pollen types in that region. Concomitantly, the frequency of occurrence of pollen types in various honey samples is directly proportional to the extent of distribution of the plants of those pollen types. Using this parameter, one can unravel the index taxa of the honeys of

Table 5- Representation of various Families in Krishna District honeys

Family	Pollen types in honey samples
Acanthaceae	Acanthaceae type, *Hygrophila* sp., *Justicia procumbens, Rungia repens*
Aizoaceae	*Mollugo cerviana*
Alangiaceae	*Alangium salvifolium*
Amaranthaceae	*Celosia argentea*
Anacardiaceae	*Lanneae coromandelica, Mangifera indica*
Barringtoniaceae	*Barringtonia acutangula*
Basellaceae	*Basella* sp.
Bombacaceae	*Bombax ceiba, Ceiba pentandra*
Caesalpiniaceae	*Delonix regina, Peltophorum ptreocarpum*
Capparidaceae	*Capparis* sp., *Cleome gynandra, Crataeva mangna*
Celastraceae	Celastraceae type
Chenopodiaceae	*Chenopodium album*
Combretaceae	*Terminalia* sp.
Commelinaceae	*Commelina benghalensis, Cyantois* sp.
Compositae	*Ageratum conyzoides,* Compositae type, *Sphaeranthus indicus, Tridax procumbens, Xanthium strumarium*
Convolvulaceae	*Impomoea pescaprae*
Cruciferae	*Brassica nigra*
Cucurbitaceae	*Coccinia grandis, Cucumis* sp., *Cucurbitaceae* type, *Momordica charantia*
Cuscutaceae	*Cuscuta hyalina*
Euphorbiaceae	*Chrozophora* sp., *Croton bonplandianum, Phyllanthus emblica, Ricinus communis*
Liliaceae	Liliaceae type
Malvaceae	*Abutilon indicum,* Malvaceae type, *Sida acuta*
Meliaceae	*Azadirachta indica*
Menispermaceae	*Tinospora cordifolia*
Mimosoideae	*Acacia* sp., *Albizia lebbek, Enterlobium saman, Leucaena leucocephala, Mimosa rubicaulis,* Mimosoideae type, *Pithecellobium dulce, Prosopis juliflora*
Myrtaceae	*Eucalyputs* sp., *Syzygium cumini*
Palmae	*Borassus flabellifer, Cocos nucifera, Phoenix sylvestris*
Papilionaceae	*Crotalaria* sp., *Phaseolus mungo, Sesbania* sp.
Pedaliaceae	*Sesamum indicum*
Polygonaceae	*Polygonum plebieum*
Portulacaceae	*Portulaca oleracea*
Rhamnaceae	*Ziziphus mauritiana*
Rubiacea	*Oldenlandia umbellata*
Rutaceae	*Citrus* sp., *Feronia elephantum*
Sapindaceae	*Cardiospermum halicacabum,Sapindus emarginatus*
Sapotaceae	*Achras japota*
Scrophulariaceae	*Sopubia delphinifolia*
Solanaceae	*Datura strumarium,* Solanaceae type
Umbelliferae	*Coriandrum sativum*
Verbenaceae	*Clerodendrum* sp.

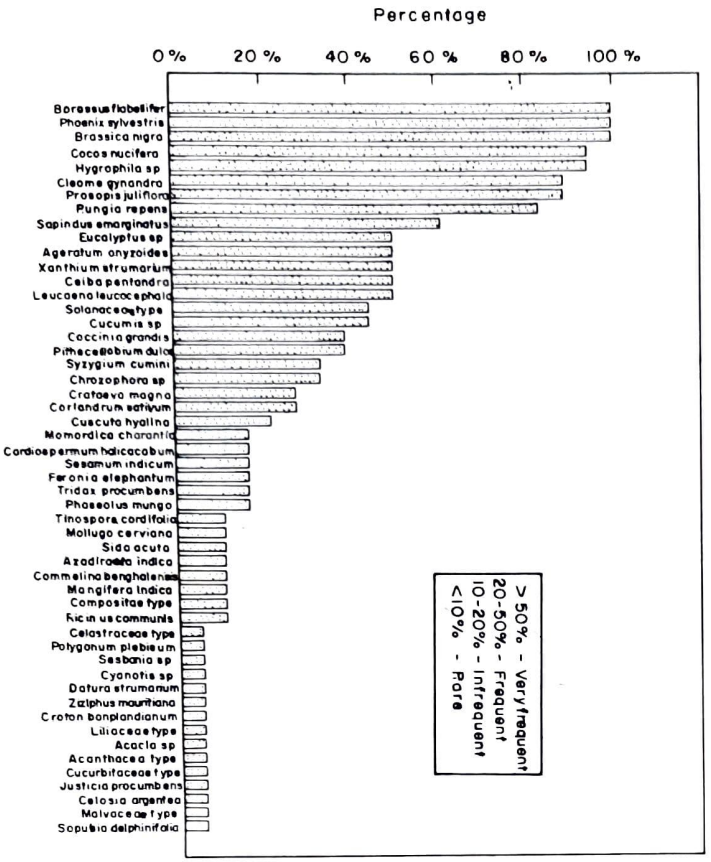


Fig. 1. Frequency distribution of pollen types in Krishna District honeys (Jan.-Feb.)

particular region. Pollen of *Borassus flabellifer, Phoenix sylestris* and *Brassica nigra* were recorded in all the honeys of January-February (Fig. 1).

Of the 67 pollen types recorded from the honey samples obtained during March-May, 12 each belong to "very frequent" and "frequent" classes, 14 to "infrequent" and 29 to "rare" classes (Fig. 2). *Borassus flabellifer* was recorded in all the samples of this period (Fig. 2).

In the majority of the honeys studied, a few pollen types of non-nectariferous taxa viz., Amaranthaceae/Chenopodiaceae complex, *Sorghum vulgare, Zea mays,* Grass type, *Casuarina equisetifolia, Cyperus rotundus* and *Typha angustata* were encountered in minor percentages and most probably represent accidental contaminants in the hives, brought by the bees themselves.

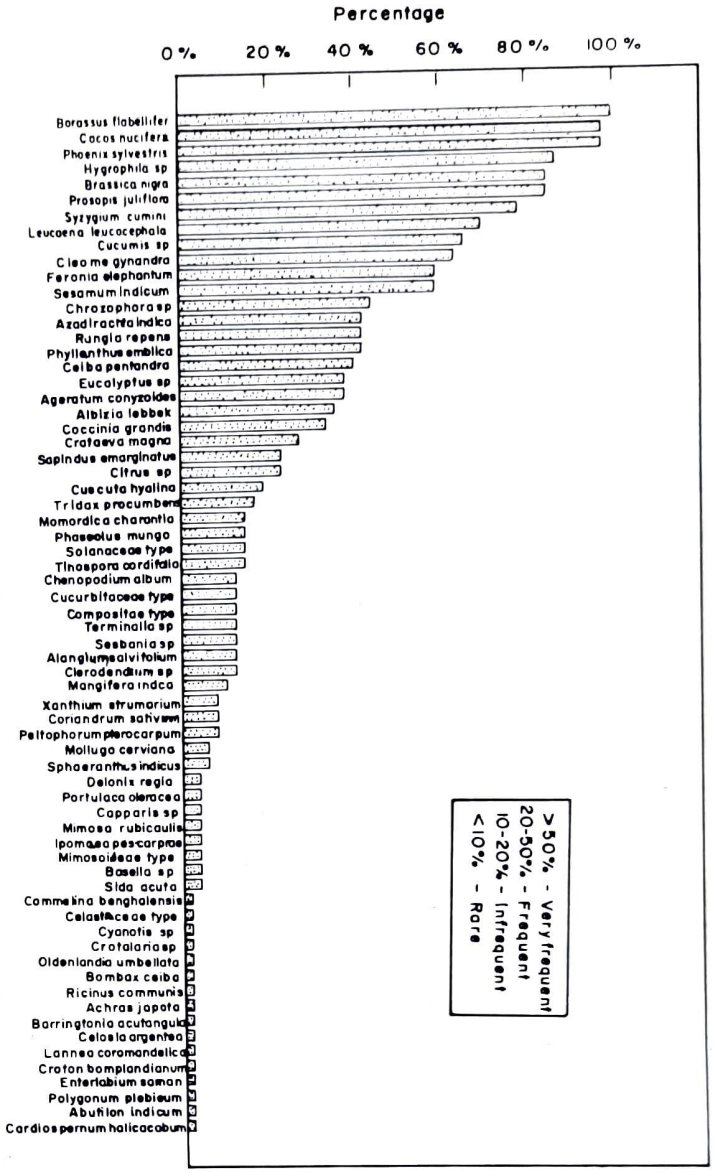


Fig. 2. Frequency distribution of pollen types in Krishna District honeys (March-May)

The ratio of honeydew elements (represented by fungal spores viz., *Drechslera, Curvularia, Nigrospora, Tetraploa, Bispora* and fungal hyphae) to total number of pollen grains of nectariferous taxa ranged from 0.01 to 0.04 and hence referable to the category "practically none".

Based on the absolute pollen counts, an overwhelming majority of the honeys of Krishna district (57 i.e., 70%) could be referable to Group II with the number of pollen grains ranging from 50,000 to 90, 000 per 10 grams, followed by Group III honeys (Table 6).

Table 6-APC Groupings of Krishna District Honeys

Group	Number and % of honey samples	Observed APC range
Group II (20,000 - 100,000)	56 (70%)	50,000 - 90,000
Group III (100,000 - 500,000	19 (23.75%)	110,000 - 330,000
Group IV (500,00 - 1,000,000)	4 (5%)	610,000 - 960,000
Group V (>1,000,000)	1 (1.25%)	1,080,000

The honey samples are yellow to dark amber in color by visual observation. The *Borassus* honeys are generally dark amber and the *Brassica* honeys are light amber.

DISCUSSION

Majority of the honey samples i.e., 64 (80%) collected from the agricultural tracts of the eastern part of Krishna district were found to be single source (unifloral) honeys. The various unifloral honeys obtained during the period January-May were viz., *Borassus flabellifer* (30), *Phoenix sylvestris* (14), *Brassica nigra* (9), *Hygrophila* sp. (5), *Saccharum officinarum* and *Cleome gynandra* (2 each), *Ziziphus mauritiana,* and *Prosopis juliflora* (1 each). Other important nectar suppliers (represented by 10% or above in the pollen spectrum of each sample) were viz., *Sapindus emarginatus, Crataeva magna, Cucumis* sp., *Cocos nucifera, Syzygium cumini, Feronia elephantum, Sphaeranthus indicus* and *Phyllanthus emblica.*

Two honey samples (K-P-48a, 48b) obtained during early part of April 1995, from a private apiary at Nimmakuru village of Pamarru mandal deserve special mentioning as they showed a high percentage of pollen of *Saccharum officinarum* (64.83% and 68.17%) and accordingly represent unifloral honeys of sugarcane plant. *Saccharum* is an anemophilous taxon with neither floral nor extra floral nectaries and hence these honeys do not represent byproducts of nectariferous secretions. These honeys were derived from the sugary juice oozing out from the cut ends of the sugarcane stumps which the honey bees avidly collect and subsequently convert into honey in the hives. Pollen grains produced in enormous quantities by the sugarcane plants and air-borne for a fairly long duration get ultimately lodged in the sugary juice foraged upon by the bees and this explains the presence of *Saccharum* pollen in high numbers in honey collected from apiaries maintained around sugarcane fields. As the freshly harvested sugarcane fields provide a fair source of forage in the form of sugary sap for the honey bees, the possibility of utilizing this situation in bee keeping enterprises merits serious consideration. The bee forage value of sugarcane juice has been reported earlier from Ghana, Columbia, Trinidad, Tobago and Florida (see Kalpana & Ramanujam 1996a).

With regard to *Phoenix* honeys, it is worth mentioning that partly they could have been derived from the sweet sap either oozing out from the cut surface of spadix or collected in the pots tied to spadices by 'neera' tappers.

The importance of a taxon as a geographical or regional indicator is a function of the frequency of the occurrence of its pollen in the total contingent of honey samples. *Borassus-Brassica-Phoenix-Cocos-Hygrophila* complex, the pollen grains of which were encountered in 90% of the honeys studied, represent regional indicators of honeys obtained from Krishna district. Palmae, Cruciferae and Acanthaceae considered together merit the status of principal sources of nectar for honey production in Krishna district. This clearly highlights the overwhelming preference of the members of these three families by the honey bees, for their nectar supply.

The absolute pollen counts indicate that Group II honeys constituting 70% of the honey samples investigated are characteristic of Krishna district.

Microscopic pollen analytical studies coupled with field observations help in providing data regarding the bee plants of an area and also the favourable period of honey production in commercial quantities. All such taxa constituting predominant pollen types in the unifloral honeys were considered as their sources (local or regional) of nectar and those represented by at least 10% in the

pollen spectrum of each honey sample, as medium sources of nectar. The months January-February represent the minor honey flow period with *Phoenix sylvestirs, Brassica nigra, Cleome gynandra, Prosopis juliflora, Ziziphus mauritiana* and *Hygrophila* sp. serving as chief nectar sources. The majority of unifloral honeys obtained during this period, however, were derived from the floral sources of *Brassica* and *Phoenix,* which may then be considered as characteristic of this period. *Brassica* (Mustard) is one of the important crops grown on a moderate scale and *Phoenix* is seen in wild and gregarious condition in the agricultural tracts and waste lands of Krishna district. The bulk of honey, however, is consistently obtained during the summer months and the period March-May represents the major honey flow period. Unifloral honeys mostly of *Borassus flabellifer, Phoenix sylvestirs,* and occasionally those of *Brassica nigra* and *Hygrophila* sp. were obtained during this period. An overwhelming majority of summer honeys, however, were generated from the nectar of *Borassus flabellifer.* Further, in a number of summer honeys *Borassus* was also found as a significant secondary pollen type. *B. flabellifer,* commonly known as Palmyra palm, is encountered in wild condition extensively, often in pure strands in Krishna district. This palm is known to yield several products of commercial importance such as toddy, neera, palm-jaggery, edible fruits and fibre. *Borassus* is dioecious and each spadix of the male plants has a number of stout cylindrical branches bearing numerous small whitish-green or cream coloured flowers. Each male flower with a centrally placed pistillode around the base of which nectar is secreted, has 6 stamens and each stamen produces on the average 9700 pollen grains. The male plants are repeatedly visited by honey bees for the collection of both nectar and pollen especially during the early and late hours of the day.

Sapindus emarginatus during winter and *Syzygium cumini, Sapindus emarginatus* (in a few March samples), *Prosopis juliflora, Cleome gynandra, Feronia elephantum, Cocos nucifera, Phyllanthus emblica, Sphaerathus indicus, Crataeva magna,* and *Cucumis* sp., during summer constitute medium nectar sources.

We consider June to December as the floral dearth period and within this we recognize "*Acute dearth period*" coinciding with the bulk of monsoon from June to August and "*Dearth period*" from September to December. The "*Acute dearth period*" straddling the rainy months is more severe to the bees highly restricting their forays for forage collection. The limited and essentially weedy and herbaceous ground flora available during the "*Dearth period*" provides patenly inadequate quantities of nectar and pollen, hardly sufficient for the survival and rapid multiplication of the bee colonies, and therefore, necessitating artificial feeding of the bees for their carbohydrate and proteinaceous requirements.

Earlier studies on pollen analysis of honeys from nearby East Godavari and Guntur districts reveal a slightly different picture regarding the major bee plants and honey producing periods. In the agricultural tracts of Guntur district December to June represent the honey flow period with the production of unifloral honeys mostly of *Sapindus emarginatus, Capsicum frutescence* and *Prosopis juliflora,* during winter and *Borassus flabellifer* and *Hygrophila* sp. during summer. (Ramanujam *et al.* 1992b). In the east Godavari district the honey flow period spans November to June. Unifloral honeys of *Sapindus emarginatus* and *Eucalyputs* sp. are chiefly produced during the winter months and those of *Borassus flabellifer* followed by *Cocos nucifera, Syzygium cumini, Anacardium occidentale* and *Phoenix sylvestris* during the summer months (Ramanujam & Kalpana, 1993, 1995a, 1995b).

The present study highlights that though January to May may be considered as the overall honey flow period, it is indeed the summer period March-May that constitutes the chief honey flow period in the agricultural tracts of the eastern part of Krishna district with copious production of *Borassus* honeys, which are characteristic of this region.

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