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Studies on pollen sources for *Apis cerana* Fabr and *Apis mellifera* L bees at Muzaffarpur, Bihar, India

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Summary — At Muzaffarpur, Bihar, in northern India, a total of 40 and 48 plant species served as pollen sources to *Apis cerana* Fabr and *A mellifera* L respectively. The major, medium and minor pollen sources were identified. The peak in pollen availability was observed from January to May and again in November. The dearth period was July–August in this area. The main differences in pollen foraging between 2 honey bee species were noted. Each of the species had 13 anemophilous plant species as sources of pollen.

***Apis mellifera* / *Apis cerana* / pollen plant / foraging / India**

INTRODUCTION

Microscopic analysis of pollen loads collected by foragers of a honey bee colony has been an established melittopalynological method to determine the sources of pollen for bee colonies. As early as 1908, Betts (1935) initiated investigations of pollen loads from *Apis mellifera* L bee colonies in England, to determine the pollen plants and to identify factors affecting bee constancy towards flowers. Particularly in Europe, this aspect was subsequently examined in several studies, among which mention may be made of those by Synge (1947) and Percival (1947) on pollen loads collected from *A mellifera* bee colonies in the UK; Louveaux (1954, 1958) from France; Maurizio (1949) from Switzerland; Knee and Moeller (1967), and O'Neal and Waller (1984) from the USA. A classic example of the study of pollen loads is that of Hodges (1955), who presented a comprehensive and practical guide to identifying pollen sources in the UK.

Melittopalynological studies on the sources of pollen in Asia have been very few. Systematic investigations have been made of the pollen sources on the Mahabaleshwar plateau in Maharashtra in western India by Deodikar *et al* (Deodikar, 1965). Routine laboratory studies using melittopalynological methods have been

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made at the Central Bee Research and Training Institute, Pune, India, to evaluate sources of pollen and nectar for *A cerana* Fabr bees in different parts of India (Chandran and Suryanarayana, 1970; Suryanarayana, 1975, 1978; Chaudhari, 1977; Singh *et al,* 1987; Suryanarayana and Singh, 1989). Sharma (1970 a,b) analysed pollen loads collected from Kangra, Himachal Pradesh; and Chaturvedi (1973, 1977) investigated the pollen sources at Banthra (Lucknow), Uttar Pradesh.

Muzaffarpur (26°07' N, 85°24' E) is an important area for honey production in Bihar, northern India. Many beekeepers from distant areas migrate their bee colonies to Muzaffarpur for the honey harvest. In spite of its importance for beekeeping, very little information is available on bee foraging sources in this area. The Central Bee Research and Training Institute, Khadi and Village Industries Commission, Pune, established a Field Observation Station at Muzaffarpur during 1976 for studies on various aspects of beekeeping. The results of melittopalynological investigations on the sources of pollen are presented here.

MATERIALS AND METHODS

About 40 colonies of *A cerana* and 30 colonies of *A mellifera* have been maintained at the Field Observation Station, Muzaffarpur. The 2 bee species were kept in 2 separate apiaries 2 km apart during 1987–1988, while during 1988–1989, they were kept in the same apiary about 5 km away from the 2 previous apiaries (fig 1). Botanical surveys of the areas around these apiaries have been made and observations were made on the component flowering species, as well as visits of bees to these flowers. Samples of pollen (anthers, flowers and inflorescences) of the flowering species were collected. Refer-

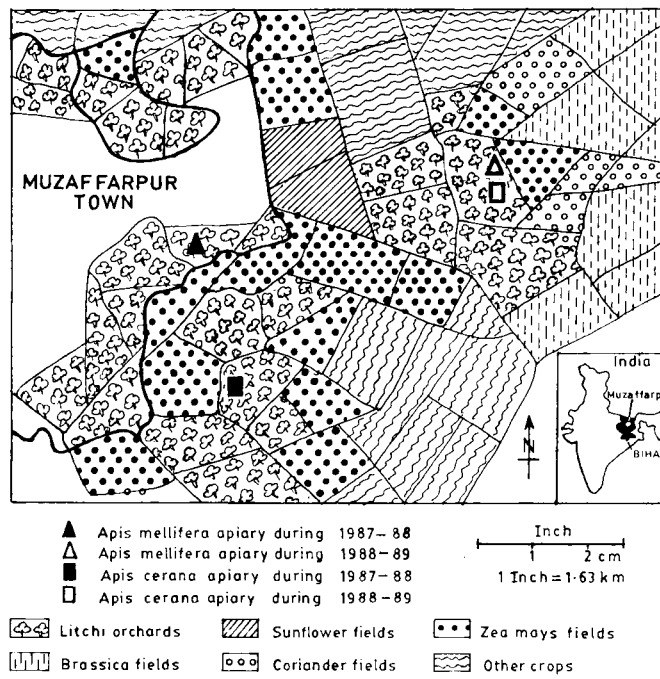


Fig 1. Map of Muzaffarpur area indicating location of apiaries.

ence slides of pollen were prepared following the methods of Wodehouse (1935) and Erdtman (1952).

Samples of pollen loads brought by forager bees into the colonies were collected throughout the day at hourly intervals. The incoming pollen foragers were caught by hand by holding their wings. The 2 loads on the 2 hind legs were gently removed onto a slip of clean paper; the forager was then let off to resume its activity. The 2 loads were then packed in 2 separate paper packets. Each packet was labelled with data on the colony number, bee species, time and date of collection, colour of the load and number of incoming forager bees per minute with similar type of pollen. This was done at 1–2-hour intervals throughout the day. Sampling was performed once a week. A total of 810 pollen loads from *A cerana* colonies and 1 260 from *A mellifera* colonies was collected over more than 2 years of study from January 1987 to March 1989. To identify the pollen sources, small amounts of pollen from different parts of each pollen load sample were transferred on to a glass slide by a needle and a temporary mount was made. The mount was examined microscopically for pollen contents. Identification of the pollen species was confirmed by comparing these with the pollen in the reference pollen slides.

RESULTS AND DISCUSSION

Muzaffarpur is a predominantly agricultural area. The important annual crops during 1987–1989 were *Zea mays* L, *Hordeum vulgare* L, *Brassica* spp, *Helianthus annuus* L, *Sesamum indicum* L, *Coriandrum sativum* L, *Trigonella corniculata* L, *Cajanus cajan* (L) Millsp, *Pisum sativum* L var *arvense* (L) Poir, *Vigna* sp and different cucurbit species. These contribute to the seasonal bee forage. *Nephelium litchi* Camb and *Mangifera indica* L were important fruit crops. Other horticultural crops of minor importance were *Psidium guajava* L, *Citrus* spp, *Spondias pinnata* (Lf) Kurz and *Emblica officinalis* Gaertn. All these plants provided both nectar and pollen, excepting *Emblica officinalis*, which is exclusively a source of pollen.

Other pollen and nectar sources were: a), the following arboreal species cultivated or growing wild: *Borassus flabellifer* L, *Bombax ceiba* L, *Cocos nucifera* L, *Dalbergia sissoo* Roxb, *Delonix regia* (Boj) Raf, *Moringa oleifera* Lamk, *Tamarindus indica* L, *Wendlandia exserta* (Roxb) DC; b), the most important weeds: *Cannabis sativa* L, *Cleome* sp, *Cyanotis* sp, *Cosmos bipinnatus* Cav, *Cyperus* sp, and *Parthenium hysterophorus* L.

From the results it appeared that a total number of 40 species served as pollen sources to *A cerana* and 48 to *A mellifera* (table I). The major pollen sources for *A cerana* were, in order of importance, *Zea mays*, *Brassica* spp, *Phoenix sylvestris* (L) Roxb and *Borassus flabellifer*. *Zea mays* provided 34% of the total pollen loads and was a dominant source providing pollen almost every month. *Cyanotis* sp, *Cosmos bipinnatus*, Fabaceae, Cucurbitaceae and *Cocos nucifera* were sources of medium importance, providing a significant quantity of pollen.

The major pollen sources for *A mellifera* were, in order of importance, *Zea mays*, *Parthenium hysterophorus*, *Brassica* spp, *Phoenix sylvestris*, *Borassus flabellifer*, Fabaceae, Cucurbitaceae, *Cajanus cajan*, *Pisum sativum* var *arvense* and *Cosmos bipinnatus*. However, only *Zea mays*, Fabaceae, Cucurbitaceae and *Parthenium hysterophorus* provided forage for a major part of the year and the others served as forage sources only for a few months. Other sources which contributed significantly to the total pollen availability, in order of importance, were *Coriandrum sativum*, *Cocos nucifera*, *Cyanotis* sp, *Helianthus annuus* and Asteraceae.

In table II a floral calendar is provided of plants of significance to beekeeping in Muzaffarpur. Although pollen is available

Table I. Pollen sources of *Apis cerana* Fabr and *A mellifera* L at Muzaffarpur, Bihar, India.

TAXON	MONTHS											
	J	F	M	A	M	J	J	A	S	O	N	D
AMARANTHACEAE												
Amaranthus sp.			○●		○	○	○					
APIACEAE												
Coriandrum sativum Linn.	○▲	○▲	▲									
ARECACEAE												
Borassus flabellifer Linn.				□■	□■	□■		■	■	□	□	
Cocos nucifera Linn.				Δ▲	Δ	Δ	Δ▲	▲	Δ▲	▲	Δ▲	▲
Phoenix sylvestris (Linn.) Roxb.	□■	□■	■							□	□	□
ASTERACEAE												
Ageratum sp.					●							
Cosmos bipinnatus Cav.	■									Δ■	Δ■	Δ■
Dahlia pinnata Cav.			●		●					●	●	
Helianthus annuus Linn.					▲	▲	▲	▲				
Lagascea mollis Cav.											○●	
Parthenium hysterophorus Linn.			■	■	■	■	■	■			■	
Taraxacum sp.			●	○	○							
BALSAMINACEAE												
Impatiens balsamina Linn.											●	
BOMBACACEAE												
Bombax ceiba Linn.		○	●○	●								
BRASSICACEAE												
Brassica spp.	□■	□■	■								□■	□■
Raphanus sativus Linn.	○											
CAESALPINIACEAE												
Delonix regia (Boj.) Rafin.				○	○●	●						
Tamarindus indica Linn.				●								
CANNABACEAE												
Cannabis sativa Linn.	●	●	○●	○●	○							●
CAPPARACEAE												
Cleome sp.							●	●	●			
COMMELINACEAE												
Commelina sp.						●		●	○●	○●	○	
Cyanotis sp.										Δ▲	Δ▲	
CUCURBITACEAE												
Cucumis sp.					○●	●		●		○		
Cucumis melo Linn.				●	●							
Cucumis sativus Linn.			●		●					●		●
Cucurbita spp.	■	■	■	Δ■	Δ■	Δ	Δ■	■	Δ■	Δ■	Δ■	Δ
Luffa sp.			○●		●				●			
Momordica charantia Linn.					○							
CYPERACEAE												
Cyperus sp.					○		●○		○			

year-round in the area studied, the peak pollen availability was during January–May and in November. During July, August and September it was poor. A maximum number of sources was visited by *A cerana* in May and in November, while in July and August the number was the lowest. For *A mellifera* the maximum number was in March, May and November and the lowest was in July and August. Photomicrographs of some pollen sources are given in figure 2.

An analysis of the contribution of anemophilous plant species to pollen availability is given in table III. Out of the 40 sources of pollen for *A cerana* bees, 13 sources can be considered as anemophilous, and contributed 495 (61.7%) pollen loads. Of these 381 (70.7%) loads were contributed by 3 major sources, viz, *Borassus flabelli-*

TAXON	MONTHS											
	J	F	M	A	M	J	J	A	S	O	N	D
EUPHORBIACEAE												
Croton bonplandianum Baill.			●			○ ●	○		○	○		
FABACEAE												
Cajanus cajan (Linn.) Millsp.	○ ■	○ ■		○	○							○ ■
Pisum sativum Linn. var. arvense (Linn.) Poir.	○ ■	○ ■	■									
Trigonella corniculata Linn.	○ ●											●
Vigna sp.				●	○ ●							
LORANTHACEAE												
Dendrophthoe falcata (Linn. F.) Ettingsh.										○	○	
MIMOSACEAE												
Mimosa sp.						○						
MORINGACEAE												
Moringa oleifera Lamk.						○					○	○
MYRTACEAE												
Psidium guajava Linn.				○	○		●				●	
PEDALIACEAE												
Sesamum indicum Linn.										●		
POACEAE												
Hordeum sp.										○ ●	○ ●	
Jowar type			○								○ ●	
Zea mays Linn.	□	□ ■	□ ■	□ ■	□ ■	□ ■	□ ■	□ ■	□ ■	□ ■	□	□
SAPINDACEAE												
Nephelium litchi Cambess.			○ ●									
AMARYLLIDACEAE (Unidentified)						●	○ ●			○		
ARECACEAE (Unidentified)											○	
ASTERACEAE (Unidentified)		▲	▲							▲	○ ▲	○ ▲
CAESALPINIACEAE (Unidentified)			●						●	●		
CUCURBITACEAE (Unidentified)		●	●			●		●		●		
EUPHORBIACEAE (Unidentified)					○ ●							
FABACEAE (Unidentified)	△ ■	△ ■	△ ■	△ ■		■		■	■	△ ■	△ ■	△ ■
MALVACEAE (Unidentified)									●			
POACEAE (Unidentified)			○ ●		○ ●						○ ●	
RUTACEAE (Unidentified)		●	○ ●		●	●	●	●	○			
SAPINDACEAE (Unidenfified)										●	●	●
TILIACEAE			●					●			○	

A. cerana
○ = Minor
△ = Medium
□ = Major

A. mellifera
● = Minor
▲ = Medium
■ = Major

No. of loads
1-20 Minor
21-50 Medium
> 50 Major

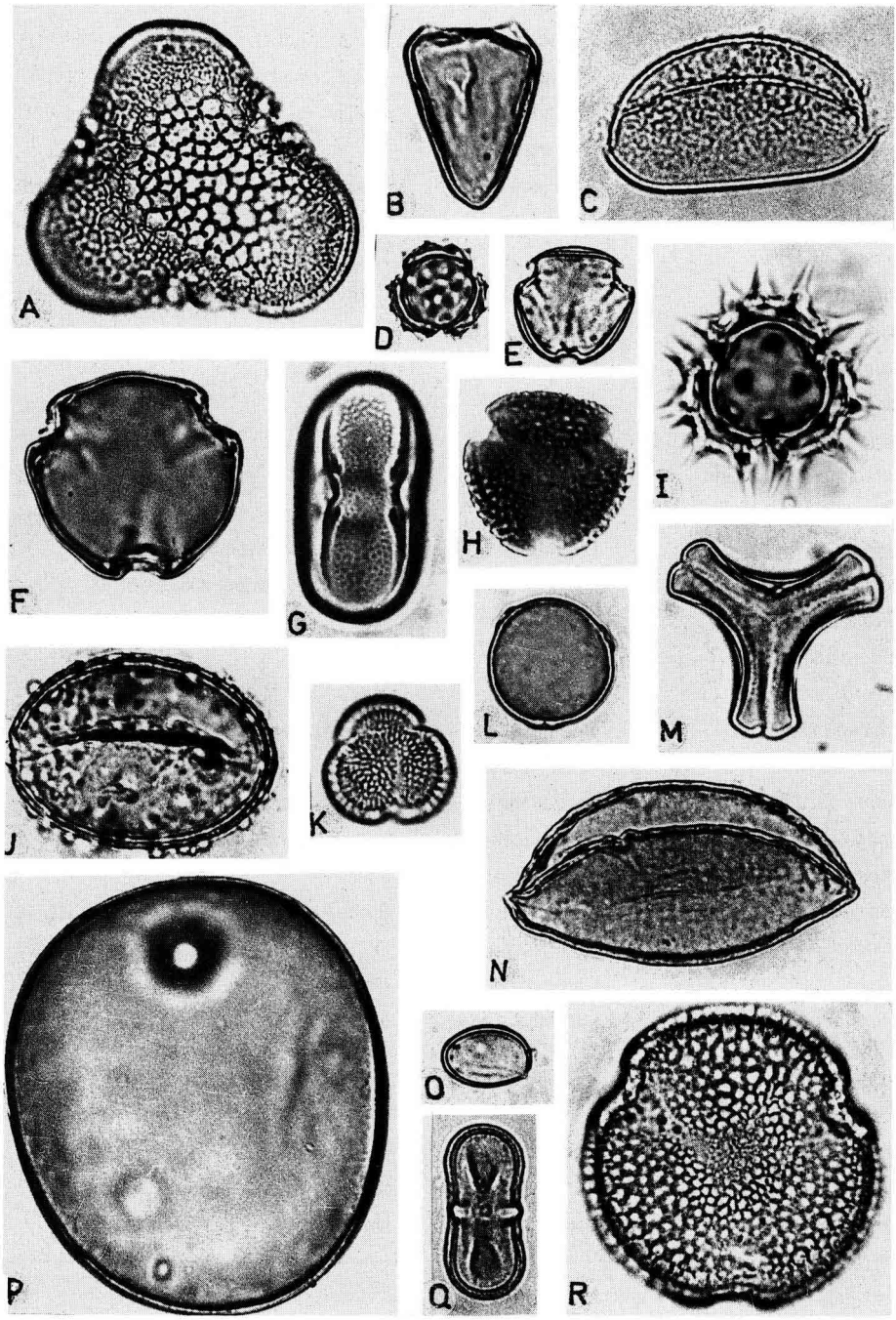
fer, *Phoenix sylvestris* and *Zea mays*. In the case of *A mellifera* also, 13 anemophilous species, out of the total number of 48 pollen sources contributed 569 (45.2%) pollen loads. Of these, 4 major sources of pollen, viz, *Borassus flabellifer*, *Phoenix sylvestris*, *Parthenium hysterophorus* and *Zea mays*, contributed 481 (84.5%) loads. For both honey bee species, anemophilous plant species constituted important pollen sources at Muzaffarpur. Sharma (1970a) reported a similar predominance of anemophilous sources of pollen in Kangra, Himachal Pradesh, while in the Shimla hills of the same state, Sharma (1983) recorded only one (*Artemisia* sp) important pollen source, which was anemophilous. *Zea mays* was recorded as the most important source in southern Wisconsin, USA, by Knee and Moeller (1967), while

Table II. Floral calendar of sources of bee forage to honey bees in the Muzaffarpur area (Bihar, India).

Taxon	*Family*	*Flowering period*	*Bee forage value* *
Zea mays Linn	Poaceae	January to December	P3
Cucurbita sp	Cucurbitaceae	January to December	P3
Fabaceae	Fabaceae	January to April, June, August to December	P3
Cannabis sativa Linn	Cannabaceae	January to May, December	P1
Phoenix sylvestris (Linn) Roxb	Arecaeae	January to March, October to December	P3
Cucurbitaceae	Cucurbitaceae	January, March, June August, October	P1
Brassica sp	Brassicaceae	January to March, November, December	P3 N3
Cajanus cajan (Linn) Millsp	Fabaceae	January, February, April, May, December	P2 N1
Asteraceae	Asteraceae	January, March, October to December	P1
Cosmos bipinnatus Cav	Asteraceae	January, October to December	P2
Pisum sativum Linn var *arvense* (Linn) Poir	Fabaceae	January to March	P2
Coriandrum sativum Linn	Apiaceae	January to March	P2 N2
Trigonella corniculata Linn	Fabaceae	January, December	P1 N1
Rutaceae	Rutaceae	February, March, May to September	P1
Bombax ceiba Linn	Bombacaceae	February, March	P1 N1
Mangifera indica Linn	Anacardiaceae	February, March	N1
Parthenium hysterophorus Linn	Asteraceae	March to August, November	P3
Croton bonplandianum Baill	Euphorbiaceae	March, June, July, September, October	P1
Amaranthus sp	Amaranthaceae	March, May to July	P1
Dahlia pinnata Cav	Asteraceae	March, May, October, November	P1
Cucumis sativus Linn	Cucurbitaceae	March, May, October, December	P1
Taraxacum sp	Asteraceae	March to May	P1
Luffa sp	Cucurbitaceae	March, May, September	P1
Poaceae	Poaceae	March, May, November	P1

Caesalpiniaceae	Caesalpiniaceae	March, September, October	P1
Dalbergia sissoo Roxb	Fabaceae	March, April	N1
Sorghum type	Poaceae	March, November	P1
Nephelium litchi Camb	Sapindaceae	March	P1 N3
Emblica officinalis Gaertn	Euphorbiaceae	March	P2
Spondias pinnata (Linn f) Kurz	Anacardiaceae	March	N2
Cccos nucifera Linn	Arecaceae	April to December	P2
Borassus flabellifer Linn	Arecaceae	August to November	
Psidium guajava Linn	Myrtaceae	April, May, July, November	P1 N1
Delonix regia (Boj) Rafin	Caesalpiniaceae	April to June	P1
Cucumis melo Linn	Cucurbitaceae	April to June	P1
Vigna sp	Fabaceae	April, May	N2
Wendlandia exserta (Roxb) DC	Rubiaceae	April, May	N2
Tamarindus indica Linn	Caesalpiniaceae	April, May	P1 N1
Helianthus annuus Linn	Asteraceae	May to August	P2 N1
Cyperus sp	Cyperaceae	May, July to September	P1
Cucumis sp	Cucurbitaceae	May, June, August, October	P1
Ageratum sp	Asteraceae	May	P1
Euphorbiaceae	Euphorbiaceae	May	P1
Momordica charantia Linn	Cucurbitaceae	May	P1
Commelina sp	Commelinaceae	June, August to November	P1
Amaryllidaceae	Amaryllidaceae	June, July, October	P1
Cleome sp	Capparaceae	July to September	P1
Moringa oleifera Lamk	Moringaceae	June, November, December	P1 N1
Mimosa sp	Mimosaceae	June	P1
Malvaceae	Malvaceae	September	P1
Sapindaceae	Sapindaceae	October to December	P1 N1
Cyanotis sp	Commelinaceae	October, November	P2
Dendrophthoe falcata (Linn f) Ettingsh	Loranthaceae	October, November	P1
Hordeum sp	Poaceae	October, November	P1
Sesamum indicum Linn	Pedaliaceae	October	P1 N1
Impatiens balsamina Linn	Balsaminaceae	November	P1 N1
Arecaceae	Arecaceae	November	P1
Lagascea mollis Cav	Asteraceae	November	P1

* Bee forage value: P = Pollen; N = Nectar. Relative importance as assessed visually and palynologically: 1 = Minor; 2 = Medium; 3 = Major.


A
B
C
D
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Q
R

Table III. Details of the pollen loads from anemophilous plant species collected by honey bees in Muzaffarpur, Bihar, during 1987–1989.

Plant species or family	*No of pollen loads* *					
	Apis cerana			Apis mellifera		
	Major	*Medium*	*Minor*	*Major*	*Medium*	*Minor*
Ageratum sp	–	–	–	–	–	1 (0.18)
Amaranthus sp	–	–	17 (3.43)	–	–	1 (0.18)
Borassus flabellifer	51 (10.30)	–	–	71 (12.48)	–	–
Cannabis sativa	–	–	12 (2.42)	–	–	13 (2.29)
Cocos nucifera	–	21 (4.24)	–	–	29 (5.10)	–
Croton bonplandianum	–	–	12 (2.42)	–	–	3 (0.53)
Cyperus sp	–	–	9 (1.82)	–	–	1 (0.18)
Hordeum sp	–	–	20 (4.04)	–	–	14 (2.46)
Mimosa sp	–	–	1 (0.20)	–	–	–
Parthenium hysterophorus	–	–	–	122 (21.44)	–	–
Phoenix sylvestris	55 (11.11)	–	–	73 (12.83)	–	–
Sorghum type	–	–	7 (1.41)	–	–	6 (1.05)
Zea mays	275 (55.56)	–	–	215 (37.79)	–	–
Arecaceae	–	–	1 (0.20)	–	–	–
Poaceae	–	–	14 (2.83)	–	–	20 (3.52)
Total	381 (76.97)	21 (4.24)	93 (18.79)	481 (84.53)	29 (5.10)	59 (10.37)

* Figures in parentheses are percentages of total anemophilous pollen (*ie*, 495 loads of *Apis cerana* and 569 loads of *Apis mellifera*).

Fig 2. A-R. Photomicrographs of pollen grains (x 650) of some bee plants at Muzaffarpur, Bihar, India. (A) *Bombax ceiba* Linn. (B) *Cyperus* sp. (C) *Cyanotis* sp. (D) *Parthenium hysterophorus* Linn. (E) *Nephelium litchi* Camb. (F) *Moringa oleifera* Lamk. (G) *Pisum* sp. (H) *Cajanus cajan* (Linn) Millsp. (I) *Cosmos* sp. (J) *Borassus flabellifer* Linn. (K) *Brassica* sp. (L) *Cannabis sativa* Linn. (M) *Dendrophthoe* sp. (N) *Cocos nucifera* Linn. (O) *Phoenix sylvestris* (Linn) Roxb. (P) *Zea mays* Linn. (Q) *Coriandrum sativum* Linn. (R) *Cucurbita maxima* Duchesne.

wind-pollinated species contributed to an unexpectedly large amount of pollen in the LaCrosse county, Wisconsin, USA (Severson and Parry, 1981). Todd and Bretherick (1942), while giving the chemical composition of pollen in 32 plant species, observed that pollen from anemophilous plants was not greatly different from pollens of entomophilous plants in their protein value. Maurizio (1960) classified corn pollen under the group of highly nutritive pollens. Dietz (1975) mentioned that the difference between insect-pollinated and wind-pollinated plants in protein content of pollen was non-significant. It is generally observed that brood rearing activity in the colonies is vigorous during the period when maize pollen is available (personal observations). It therefore appears that anemophily as a concept of pollination ecology is not relevant in the case of social insects like honey bees, whose foraging behaviour is controlled by a different set of factors.

The period and abundance of the main pollen sources of *A cerana* and *A mellifera* have been shown in figures 3 and 4 respectively.

Important differences were found in the pollen sources between *A cerana* and *A mellifera*. These are given below: a) pollen load samples of *A cerana* did not have even a single load of *Parthenium hysterophorus*. This was noted as the second most important pollen source for *A mellifera*. Suryanarayana and Singh (1989) recorded earlier that *A cerana* did not forage on *P hysterophorus*, although this was a common weed in the area. b) Samples of *A mellifera* pollen loads did not represent *Dendrophthoe falcata* (Lf) Ettingsh and *Moringa oleifera*, which were sources for *A cerana*. This might be due to competition among the floral sources and their relative unattractiveness to *A mellifera*. c) *Cajanus cajan* and *Pisum sativum* var *arvense* were important forage sources for *A mellifera*, whereas these were only of minor importance for *A cerana*. This difference in foraging behaviour is significant from the point of view of pollination of these crops. d) *Helianthus annuus* was an important

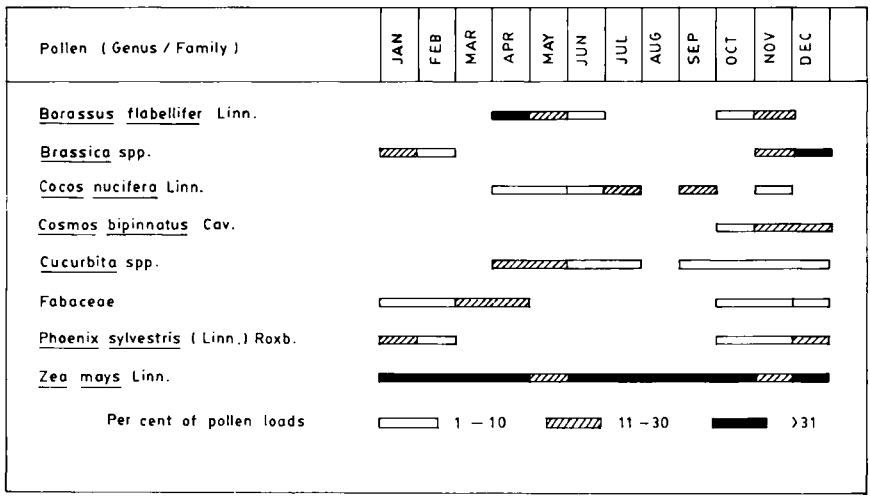

Fig 3. Monthly distribution of major sources of pollen to *Apis cerana* Fabr at Muzaffarpur, Bihar, India, during 1987–1988.

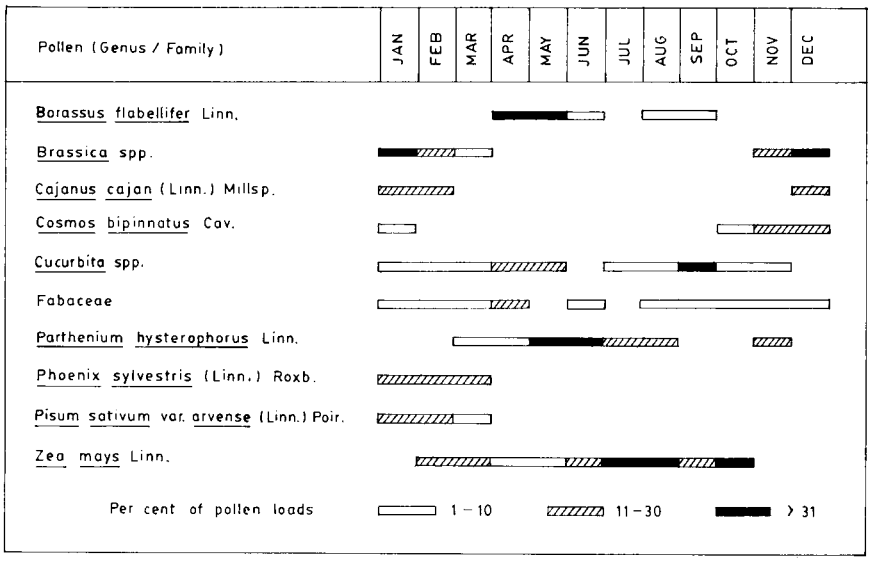

Fig 4. Monthly distribution of major sources of pollen to *Apis mellifera* L at Muzaffarpur, Bihar, India, during 1987-1988.

source for *A mellifera*, but it was not represented in the loads brought by *A cerana*. This might be due to non-availability of sunflower within the flight range of *A cerana*, which has been reported as 700 to 900 m (Naim and Phadke, 1972; Darade *et al*, 1989). Suryanarayana *et al* (1987) showed that *A cerana* was one of the important pollinators of sunflower in Maharashtra.

It is interesting to note that *Zea mays* was an important pollen source for both *A cerana* and *A mellifera* in agricultural areas such as Muzaffarpur, as has been observed in several parts of the world (for example, Sladen (1911) in England; Casteel (1912), Knee and Moeller (1967), and Severson and Parry (1981) in the USA and Maurizio (1953) in Switzerland). In India maize has been found to be a source of pollen for *A cerana* bees in the Punjab (Chaudhari, 1977) and in Andhra Pradesh (Singh *et al*, 1987).

Though *Nephelium litchi* is an important nectar source (Phadke and Naim, 1974; Suryanarayana *et al*, 1981; Rao, 1983), it was found to be a poor pollen source. Likewise, *Mangifera indica* and *Wendlandia exserta*, which were reported to be nectar sources (Rao and Nair, 1985; and personal observations), were not pollen sources.

Out of the 810 pollen loads of *A cerana* examined, only one pollen load had a bifloral source and all the rest were unifloral. The bifloral load was collected in November from *Phoenix sylvestris* and *Zea mays*. *A mellifera* also collected one bifloral pollen load in November from Cucurbitaceae and *Cocos nucifera*. Bifloral loads were likewise found to be rare in the pollen

loads collected by *A cerana* in Vijayarai, Andhra Pradesh (Singh *et al,* 1987). However, Sharma (1970a,b) found that 8 pollen loads out of 19 collected during 1st June to 9th July, 1968 at Kangra, Himachal Pradesh, were mixed; one had 4 pollen species, 2 had 3 pollen species and 5 were bifloral, while only one out of 27 collected during September, 1968 was mixed with 3 pollen species. She therefore concluded that June-July was the dearth period in Kangra and that bees were therefore forced to collect pollen from more than one source on several of their foraging trips. On the other hand, at Banthra (Lucknow), Uttar Pradesh, she found that 3 out of 49 loads collected in February, 1970 and 3 out of 44 loads collected in April, 1970 were bifloral (Chaturvedi, 1973).

The almost exclusive occurrence of unifloral loads in the present investigations is indicative of the richness of the local pollen resources to the honey bees.

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Résumé — Étude sur les sources de pollen pour *Apis cerana* Fabr et *Apis mellifera* L à Muzaffarpur, Bihar (Inde). Muzaffarpur, dans le Bihar (Inde du Nord), est une région principalement agricole. Les cultures constituent les principales sources de pollen et de nectar pour les abeilles. Au laboratoire de terrain du Central Bee Research and Training Institute à Muzaffarpur, les pelotes de pollen rapportées par les butineuses en 1987-1988 ont été étudiées afin de déterminer l'origine des pollens. Les pelotes ont été échantillonnées toutes les heures durant une journée entière, une fois par semaine. On a récolté environ 810 pelotes de pollen provenant de 40 colonies d'*A cerana* et 1 260 venant de 30 colonies d'*A mellifera*. En 1987-1988, les colonies des 2 espèces étaient réparties en 2 ruchers distants de 2 km, en 1988-1989 elles étaient regroupées en un même rucher (fig 1).

Au total, 40 espèces de plantes ont fourni du pollen à *A mellifera* et 48 à *A cerana*. Les sources polliniques les plus importantes pour *A cerana* sont : *Zea mays* L, *Brassica* spp, *Phoenix sylvestris* (L) Roxb et *Borassus flabellifer* L. À celles-ci il faut ajouter, pour *A mellifera*, les espèces suivantes : *Parthenium hysterophorus* L, *Cajanus cajan* (L) Millsp, *Pisum sativum* L var *arvense* (L) Poir et les Cucurbitacées (tableau I). Dans la région de Muzaffarpur, du pollen est disponible toute l'année. C'est de janvier à mai et en novembre qu'il est le plus abondant; de juillet à septembre, la disponibilité est faible (tableau II). Treize plantes anémophiles (61,7% des pelotes d'*A cerana* et 45,2% des pelotes d'*A mellifera*) constituent des sources de pollen importantes pour les 2 espèces d'abeilles (tableau III). *Parthenium hysterophorus* représente la 2e source de pollen pour *A mellifera*, tandis qu'*A cerana* n'en a pas récolté une seule pelote. Les grains de pollen de *Dendrophthoe falcata* (Lf) Ettingsh et de *Moringa oleifera* Lamk, présents dans les pelotes d'*A cerana*, n'ont pas été trouvés dans celles d'*A mellifera*. *Nephelium litchi* Camb, principale source de nectar à Muzaffarpur, fournit peu de pollen aux abeilles. Il n'a été trouvé qu'une seule pelote mixte (2 espèces) dans les échantillons des 2 espèces d'abeilles. Ceci prouve la richesse des plantes locales quant à la fourniture de pollen pour ces insectes.

***Apis mellifera* / *Apis cerana* / plante pollinifère / Inde / butinage**

Zusammenfassung — Studien über die Pollenquellen von *Apis cerana* Fabr und *Apis mellifera* L in Muzaffarpur, Bihar (Indien). Muzaffarpur, Bihar, in Nordindien ist überwiegend ein landwirtschaftlich genutztes Gebiet. Kultivierte Nutzpflanzen sind die Hautpollenpflanzen und Nektarpflanzen für die Bienen. An den Völkern von *Apis cerana* und *A mellifera* der Feldstation des Zentralen Bienenforschungsinstitutes in Muzaffarpur wurden an den Pollenladungen der heimkehrenden Bienen 1987–1988 Untersuchungen über die Herkunft des Pollens vorgenommen. Ein Mal wöchentlich wurden den ganzen Tag über in stündlichen Abständen Pollenproben gesammelt. Etwa von 40 Völkern von *A cerana* und von 30 Völkern von *A mellifera* wurden insgesamt 810 Pollenhöschen von ersterer und 1260 Pollenhöschen von letzterer entnommen. 1987–1988 wurden die beiden Bienenarten auf zwei getrennten Bienenständen 2 km voneinander entfernt gehalten, 1988–1989 aber gemeinsam auf einem Bienenstand (Abb 1). Insgesamt 40 Pflanzenarten lieferten Pollen für *A cerana* und 48 Arten für *A mellifera*. Die wichtigsten Pollenpflanzen für *A cerana* waren *Zea mais* L, *Brassica* spp, *Phoenix silvestris* L und *Borassus flabellifer* L. Zusätzlich zu diesen dienten für *Apis mellifera* noch *Parthenium hysterophorus* L, *Cajanus cajan* L, *Pisum sativum* L var *arvense* L Poir und Cucurbitaceen als wichtige Pollenquellen (Tab I). In Muzaffarpur ist für die Bienen Pollen das ganze Jahr über vorhanden. Das Hauptangebot an Pollen lag zwischen Januar und Mai und im November. Von Juli bis September ist das Pollenangebot knapp (Tab II). Dreizehn windblütige Pflanzenarten (61.7% der Pollenladungen von *A cerana* und 45.2% von *A mellifera*) bildeten für beide Arten wichtige Pollenspender (Tab III). *Parthenium hysterophorus* war der zweitwichtigste Pollenspender für *A mellifera*; aber *A cerana* sammelte von dieser Art nicht einmal eine einzige Ladung. Die Pollenkörner von *Dendrophthoe falcata* (Lf) Ettingsh und von *Moringa oleifera* Lamk, die in den Proben von *A cerana*-Völkern vorhanden waren, wurden in den Proben von *A mellifera*-Völkern nicht gefunden. *Nephelium litchi* Camb, die Hauptnektarquelle in Muzaffarpur, erwies sich als wenig ergiebige Pollenquelle. Es wurde bei jeder der beiden Bienenarten nur je ein einziges gemischtes Pollenhöschen (von zwei Pflanzenarten) gefunden. Das beweist die Reichhaltigkeit der lokalen Pollenpflanzen für die Versorgung der Bienenvölker.

***Apis mellifera* / *Apis cerana* / Pollenpflanze / Indien / Trachtverhalten**

REFERENCES

Betts AD (1935) The constancy of the pollen-collecting bee. *Bee World* 16, 111-113

Casteel DB (1912) The behavior of the honey bee in pollen collecting. *US Bur Entomol Bull* No 21

Chandran K, Suryanarayana MC (1970) A note on entomophily in *Dendrophthoe falcata*, and its usefulness to the Indian honeybee. *J Apic Res* 9, 45-47

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

Chaturvedi M (1977) Further investigation on the pollen analysis of bees loads from Banthra, India. *New Bot* 4, 41-47

Chaudhari RK (1977) Forage in Punjab plains (India). Pathankot and adjacent villages. *Indian Bee J* 39, 15-20

Darade MN, Singh BP, Chakrawarty P (1989) Flight range of *Apis cerana*. *Indian Bee J* 51, 59-61

Deodikar GB (1965) Melitto-palynology. *Indian Bee J* 27, 59-72

Dietz A (1975) Nutrition of the adult honey bee. *In: The Hive and the Honey Bee*. Dadant and Sons, Hamilton, IL

Erdtman G (1952) *Pollen Morphology and Plant Taxonomy–Angiosperms.* Almquist and Wiksells, Uppsala

Hodges D (1955) Pollen loads, the way the worker bee gathers, packs and stores them for use. *Am Bee J* 95, 475-482

Knee WJ, Moeller FE (1967) Comparative study of pollen sources of honeybees and bumble bees. *J Apic Res* 6, 133-138

Louveaux J (1954) Études sur la récolte du pollen par les abeilles. XV Int Beekeep Congr, Copenhagen

Louveaux J (1958) Recherches sur la récolte du pollen par les abeilles (*Apis mellifica* L). *Ann Abeille* 1, 113-188, 197-221

Maurizio A (1949) Pollenanalytische Untersuchungen an Honig und Pollenhöschen. *Beih Schweiz Bienenztg* 2, 320-455

Maurizio A (1953) Weitere Untersuchungen an Pollenhöschen. *Beih Schweiz Bienenztg* 2, 486-556

Maurizio A (1960) Bienenbotanik. *In: Biene und Bienenzucht* (Büdel A, Herold E, eds) Ehrenwirth Verlag, Munich

Naim M, Phadke KG (1972) Flight range of *Apis cerana indica* when enticed to a feeding dish. *J Apic Res* 11, 167-169

O'Neal RJ, Waller GD (1984) On the pollen harvest by the honey bee (*Apis mellifera* L) near Tucson, Arizona (1976–1981). *Desert Plants* 6, 81-94, 99-109 *(AA 558/1986)*

Percival M (1947) Pollen collection by *Apis mellifera. New Phytol* 46, 142-173

Phadke KG, Naim M (1974) Observations on the honeybee visitation to the litchi *(Nephelium litchi)* blossoms at Pusa (Bihar, India). *Indian Bee J* 36, 9-12

Rao GM (1983) Litchi and bee-keeping. *Indian Hortic* 28 (2), 19-20

Rao GM, Nair KS (1985) Mango tree – a source of bee forage. *Indian Bee J* 47, 49-50

Severson DW, Parry JE (1981) A chronology of pollen collection by honeybees. *J Apic Res* 20, 97-103

Sharma M (1970a) An analysis of pollen loads of honey bees from Kangra, India. *Grana* 10, 35-42

Sharma M (1970b) Studies on the pollen loads of honeybees from Kangra, India. *J Palynol* 6, 104-110

Sharma N (1983) Melissopalynology and survey of honey plants in Simla Hills (Himachal Pradesh). MPhil Project Report, Himachal Pradesh University, India (AA 1245/85)

Singh TSMS, Joshi MA, Suryanarayana MC (1987) Evaluation of sources of pollen to honey bees at Vijayarai (Andhra Pradesh). Proc 5th All India Symp Palynol, Nagpur, India, 65-71

Sladen FWL (1911) How pollen is collected by the social bees and the part played in the process by the auricle. *Br Bee J* 39, 491-506

Suryanarayana MC (1975) Studies on bee botany and palynology of the flora and coorg and adjacent parts of the Mysore State. Ph D thesis, Poona University

Suryanarayana MC (1978) Bee plants of India. 1. *Carvia callosa* (Nees) Brem. *Indian Bee J* 40, 7-10

Suryanarayana MC, Singh TSMS (1989) *Parthenium hysterophorus* – a pollen source to *Apis mellifera. Bee World* 70, 127-129

Suryanarayana MC, Rao GM, Phadke RP (1987) Higher yields of sunflower through honey bees. *Indian Fmg* 37 (2), 5-7, 19

Suryanarayana MC, Seethalakshmi TS, Phadke RP (1981) Pollen analysis of Indian honeys – 1. Honeys from litchi *(Nephelium litchi)* and Jamun *(Syzygium cumini). Proc IV Int Palynol Conf, Lucknow 1976–1977*, 3, 491-498

Synge AD (1947) Pollen collection by honey bees. *J Anim Ecol* 16, 122-138

Todd FE, Bretherick O (1942) The composition of pollens. *J Econ Entomol* 35, 312-317

Wodehouse RP (1935) *Pollen Grains.* McGraw Hill, New York