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Original article

Tamarindus indica L : an important forage plant for *Apis florea* F in south central India

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Summary — The paper reports pollen analyses of six honey samples and 300 pollen loads of *Apis florea*, collected in June, 1990 from three small administrative areas of Ranga Reddy district, Andhra Pradesh, India. Five honey samples were found to be of unifloral origin and one was multifloral. *Tamarindus indica* was the predominant pollen type in three samples, while *Ageratum conyzoides* and *Punica granatum* predominated in the other two unifloral samples. The other significant pollen types recorded include *Dodonaea viscosa*, *Tridax procumbens*, *Acacia nilotica* and *Casearia elliptica*. Two hundred and thirty-four (78%) pollen loads were found to be unifloral, 40 (13.3%) bifloral and 26 (8.7%) multifloral. One hundred and ninety-nine (85%) of the unifloral loads were from *T indica*. Further, the pollen of *Tamarindus* was present in 260 (86.7%) of the total pollen loads examined, which reflects the importance of *T indica* as a chief source of both nectar and pollen for *A florea*.

***Apis florea* / *Tamarindus indica* / nectar plant / pollen plant / honey pollen analysis**

INTRODUCTION

The dwarf honey bee, *Apis florea* Fabr contributes substantially to the overall production of honey in the agricultural tracts of Ranga Reddy district of Andhra Pradesh in south central India. The chief honey flow season in this district is October to January, with *Prosopis juliflora*, *Carum copticum* and *Guizotia abyssinica* comprising the major bee plants (Kalpana and Ramanujam, 1989, 1991; Ramanujam and Kalpana, 1990). Earlier workers have recognized *Tamarindus indica* L as an important summer nectar source to the Indian hive bee, *Apis cerana* Fabr (Sardar Singh, 1962; Chaubal, 1982; Seethalakshmi, 1983). *T indica*, originally a native of central Africa, was introduced into India long ago and has now become naturalised in regions where little frost is experienced. It is an evergreen tree that can reach a height of over 15 m and has a lifespan exceeding 200 yr. When the plant is in full bloom (May–July), it produces large numbers of medium-sized yellow flowers which provide copious nectar and pollen avidly sought after by

all the three species of Indian bees, *viz Apis florea*, *A cerana* and *A dorsata* Fabr. This paper reports pollen analyses of six honey samples and 300 pollen loads of *A florea*, collected from three mandals (small administrative areas) of Ranga Reddy district, during summer (June) of 1990.

MATERIAL AND METHODS

Honey samples (100 g each) from six different nests of *Apis florea* were collected from three mandals of Ranga Reddy district, Andhra Pradesh in June, 1990. Of these, three samples (16f, 16g and 16h) were obtained from Chinnareddyguda village of Shankerpally mandal, two (39e and 39f) from Cheemaladari village of Mominpet mandal and one (18j) from Janwada village of Serilingampally mandal (fig 1). All these samples represent squeezed honey. Only the honey-storing portion of the combs was pressed for the removal of honey.

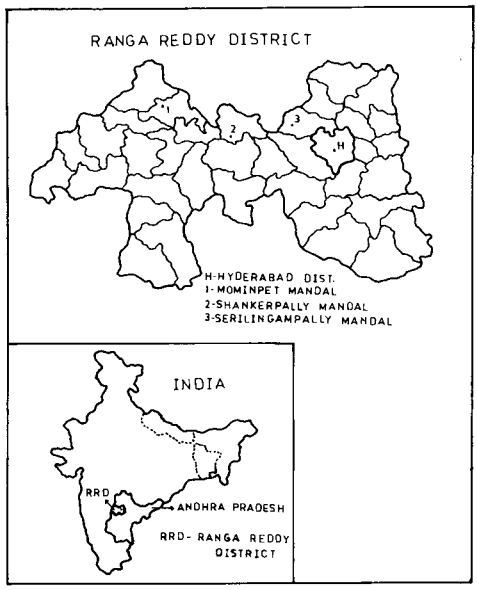


Fig 1. Location sites of honey samples.

One ml of the honey sample was dissolved in 10 ml of distilled water and centrifuged. The pollen sediment obtained was then subjected to the acetolysis technique proposed by Erdtman (1960). Three pollen slides prepared for each sample were studied critically for their pollen contents. The pollen types recovered were identified to generic and specific level with the help of reference slide collection of local flora and relevant literature. However, a few types which could not be identified even to family level were placed under the category, "unknown". The frequency classes and frequencies of the pollen types of each sample were determined in accordance with Louveaux *et al* (1978). Pollen spectra of the honey samples were constructed based on the frequencies of the pollen types.

Unacetolysed honey samples were used for obtaining the ratio between the honeydew elements (fungal spores, hyphal shreds in the present study) and pollen grains (Louveaux *et al*, 1978).

The pollen productivity of *Tamarindus indica* was computed by using a haemocytometer (Subba Reddy, 1976). Ten samples with three anthers each (there are only three fertile anthers in each flower of *T indica*) were used for determining the pollen productivity. Matured but undehisced anthers were taken into 10 stoppered tubes and were allowed to dehisce. After complete dehiscence, one ml of 50% glycerine with safranin was added to each tube, and the tube was thoroughly shaken to obtain a uniform suspension of pollen grains. A drop of this suspension was pipetted out and placed on the 1-mm squares of the haemocytometer (counting chamber) and the pollen grains present in 1 mm square were counted at a magnification of 100x. The depth of the chamber was 0.1 mm and the area of the square 1 mm^2. The total volume of the square was 0.1 mm^3 or 0.000 1 cm^3. If the number of pollen grains counted in 1 mm^2 is *N*, the number of pollen grains per ml of suspension is 10^4 x *N*. The counting was repeated three times for each of the suspensions, the average of which permitted estimation of the number of pollen grains liberated by the three anthers. Similar pollen counts were made with the remaining nine samples, and the overall mean from the ten samples was used to establish the pollen count of the three anthers.

Discrete pollen loads were observed neatly stacked one above the other in the pollen-

storing chambers of the combs. A total of 300 such pollen loads (which may even be called comb loads) were directly recovered with fine needles and forceps from the pollen-storing chambers of the six honey-combs, *viz* 16f (80 pollen loads), 16g (35), 16h (50), 39e (60), 39f (50) and 18j (25). Each pollen load (comb load) was dispersed in 5 ml of glacial acetic acid. After centrifuging, the acid was decanted and the sediment was subjected to the acetolysis technique of Erdtman (1960). One slide was prepared for each pollen load. The pollen loads were designated as unifloral (exclusively with pollen grains of one taxon), bifloral (with pollen grains of two taxa) and multifloral or mixed (with pollen grains of more than two taxa) (Mithilesh Sharma, 1970).

RESULTS

Analysis of honey

Five of the six honey samples were found to be unifloral and one multifloral. *Tamarindus indica* (50.7–88%) constituted the predominant pollen type in the three samples from Shankerpally mandal *ie* 16f, 16g and 16h. One of the two samples (39e) from Mominpet mandal had *Ageratum conyzoides* L (57.3%) as the predominant pollen type and the other (39f) had no predominant pollen, although *A conyzoides* (26.7%), *T indica* (25.7%) and *Dodonaea viscosa* (L) Jacq (25%) occurred as secondary pollen types. The Serilingampally mandal sample (18 j) had *Punica granatum* L (74.7%) as the predominant pollen type. The other significant pollen types (up to important minor category) included *Tridax procumbens* L, *Acacia nilotica* L and *Casearia elliptica* Willd. Table I provides information on the frequency classes and frequencies (in %) of the pollen types of each sample. Figures 2–7 present the pollen spectra of the honey samples.

Altogether, 18 pollen types (15 melliferous and three non-melliferous) referable to 13 families (11 melliferous and two non-melliferous) were recorded. The sample 16g had the maximum number of pollen types, *ie* ten (referable to seven families) and the samples 39e the minimum number, *ie* four (three families). Figures 8–28 are the photomicrographs of the significant pollen types.

The similarity index between any two samples may be quantified by using the formula $2c / a + b$ where a and b represent the number of pollen types in each of the samples and c, the number of pollen types common to both the samples (Kalpana and Ramanujam, 1889). Table II provides similarity index values between the 15 possible pairs of honeys. In as many as 10 samples, the index values were found to be > 0.5, which could be due to essentially similar floristic elements within the foraging range of the bees.

The anemophilous pollen grains, *Amaranthus spinosus* L, *Zea mays* L and the Poaceae type were rarely encountered (table I) and could result from contamination of *Apis florea* combs by wind-borne grains. The honeydew elements recorded are the spores of *Drechslera*, *Bispora* and *Nigrospora*, and hyphal shreds of fungi. The ratio of honeydew elements to the pollen grains (HDE/P) ranged from 0.01–0.02 (table I) and hence were referable to the group "practically none" (Louveaux *et al,* 1978). The honey samples with *Tamarindus* as the predominant pollen type were golden yellow and the rest of the samples were amber-coloured.

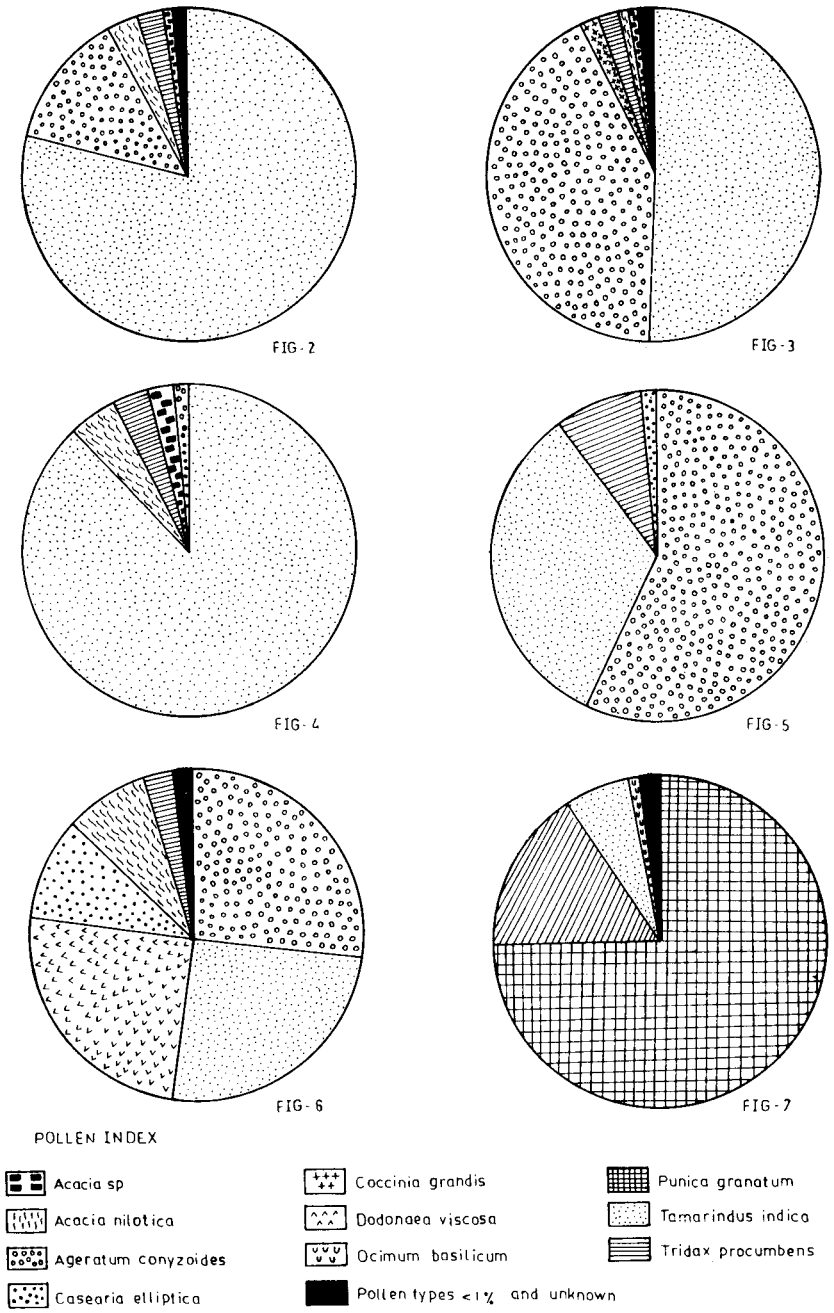
Analysis of pollen loads

An analysis of 300 pollen loads obtained from six honeycombs revealed that 234 (78%) loads were unifloral, 40 (13.3%) bi-

Table I. Pollen analyses of honey samples.

Pollen types	*Sample No*					
	16f	*16g*	*16h*	*39e*	*39f*	*18j*
Melliferous pollen						
Asteraceae						
Ageratum conyzoides L	I (13.3)	S (42)	M (1.3)	P (57.3)	S (26.7)	M (0.3)
Tridax procumbens L	M (2.3)	M (2)	I (3.3)	I (8.7)	M (3)	S (16)
Vernonia cinerea (L) Less	–	M (0.3)	–	–	–	–
Caesalpiniaceae						
Peltophorum ferrugineum Benth	M (0.3)	–	–	–	–	–
Tamarindus indica L	P (79)	P (50.7)	P (88)	S (32.7)	S (25.7)	I (6.3)
Cucurbitaceae						
Coccinia grandis (L) Voigt	–	M (2)	–	–	–	–
Flacourtiaceae						
Casearia elliptica Willd	–	–	–	M (1.3)	I (10)	M (0.7)
Lamiaceae						
Ocimum basilicum L	–	–	–	–	–	M (1)
Mimosaceae						
Acacia nilotica (L) Willd ex Del	I (3)	M (1)	I (4.7)	–	I (8)	–
Acacia sp	M (1)	M (1)	M (2.7)	–	–	M (0.3)
Punicaceae						
Punica granatum L	–	–	-	–	–	P (74.7)
Rutaceae						
Citrus limon (L) Burm	–	M (0.3)	–	–	–	–
Rubiaceae						
Randia malabarica Lam	M (0.7)	M (0.7)	–	–	–	–
Sapindaceae						
Dodonaea viscosa (L) Jacq	M (0.3)	–	–	–	S (25)	–
Tiliaceae						
Grewia tiliaefolia Vahl	–	-	–	–	M (0.7)	–
Non-melliferous pollen						
Amaranthaceae						
Amaranthus spinosus L	M (1.3)	M (0.7)	–	–	–	–
Poaceae						
Grass type	–	–	–	–	M (0.3)	M (0.3)
Zea mays L	–	–	–	–	M (0.3)	–
Unknown	–	–	–	–	1	0.7
Ratio of honeydew elements to pollen grains (HDE/P)	N (0.02)	N (001)	N (0.01)	N (0.01)	N (0.02)	N (0.02)

P: predominant pollen type (> 45%); S: secondary pollen type (16–45%); I: important minor pollen type (3–15%); M: minor pollen type (<3%); N: practically none.



Figs 2–7. Pollen spectra of honey samples. **2.** Sample 16f. **3.** Sample 16g. **4.** Sample 16h. **5.** Sample 39e. **6.** Sample 39f. **7.** Sample 18j.

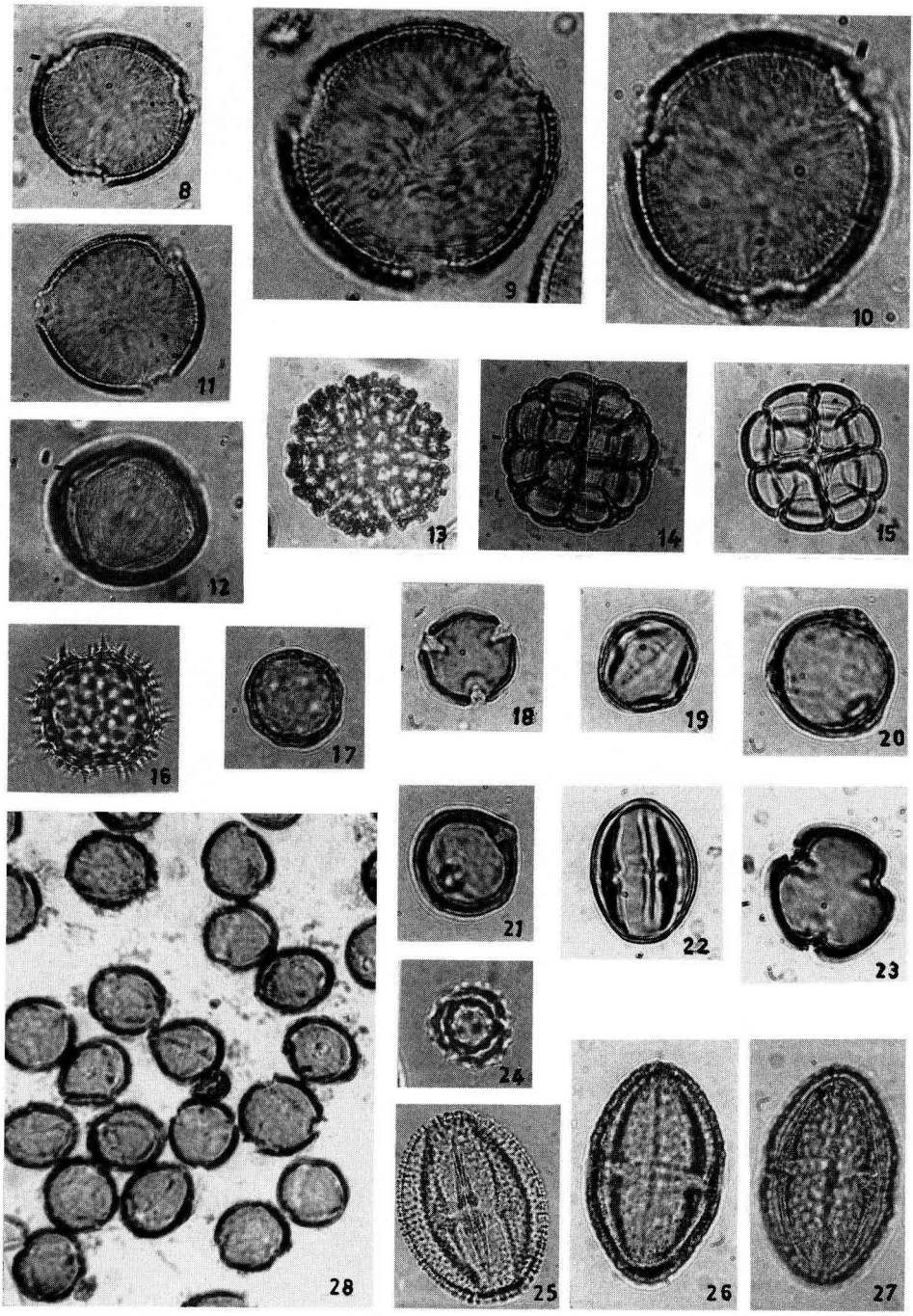

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Table II. Similarity indexes between 15 pairs of honeys.

	16f	*16g*	*16h*	*39e*	*39f*	*18j*
16f	–					
16g	0.74	–				
16h	0.71	0.67	–			
39e	0.46	0.43	0.67	–		
39f	0.56	0.42	0.57	0.62	–	
18j	0.47	0.44	0.62	0.67	0.56	–

floral, and 26 (8.7%) multifloral. Pollen from *Tamarindus indica*, *Ageratum conyzoides*, *Dodonaea viscosa*, *Acacia nilotica*, *Tridax procumbens*, *Casearia elliptica*, *Punica granatum* and *Grewia tiliaefolia* Vahl were recorded from the pollen loads. Table III gives the details of the pollen load analysis. The column *'No'* in the table contains the number of uni-, bi- and multifloral loads, whereas the column "composition" provides the breakup of the pollen types within this number.

The 234 unifloral pollen loads included 199 (85%) of *T indica*, 15 of *T procumbens*, 10 of *P granatum*, four of *A conyzoides* and three each of *A nilotica* and *D viscosa*. *T indica* was present in 35 (87.5%) of the 40 bifloral loads and in all the 26 multifloral loads. Two hundred and sixty (86.7%) of the 300 pollen loads showed the pollen of *T indica* (table III). The pollen productivity of *T indica* per flower was as follows: mean 29 000; standard deviation ± 5 676; standard error 598.

The pollen loads of *A conyzoides* were greyish white, those of *T indica* yellowish brown, and those of *A nilotica* orange. The rest of the unifloral loads were of various shades of yellow.

T indica, *A conyzoides*, *T procumbens*, *A nilotica*, *C elliptica*, *D viscosa*, *G tiliaefolia* and *P granatum* serve as both nectar and pollen sources to honey bees during summer. *Randia malabarica*, *Peltophorum ferrugineum*, *Citrus limon*, *Vernonia cinerea*, *Coccinia grandis* and *Ocimum basilicum* represent only minor sources of nectar.

DISCUSSION

Analyses of six honey samples and 300 pollen loads of *Apis florea* from Ranga Reddy district indicate that *Tamarindus indica*, *Ageratum conyzoides*, *Tridax procumbens*, *Acacia nilotica*, *Casearia elliptica*, *Dodonaea viscosa* and *Punica granatum* are important bee plants, providing both nectar and pollen during summer. However, the presence of pollen of *T indica* as predominant (in 3 samples) and secondary (in two samples) type in the honeys, and its presence in 85% of the unifloral and 86.7% of the total pollen loads clearly show this plant to be a chief nectar and pollen source to *A florea*.

A florea bees cover a range of 400 m during their foraging activity (Lindauer, 1957). All the pollen types recovered in the present study were from plants situated within 400 m from the combs of these bees, *ie* within their foraging range. At

Figs 8–28. Significant pollen types recorded in the present study (unless otherwise mentioned, all figures x 500). **8, 11, 12.** *Tamarindus indica*. **9, 10.** *T indica* x 1 000. **13.** *Ocimum basilicum*. **14.** *Acacia nilotica*. **15.** *Acacia* sp. **16.** *Tridax procumbens*. **17.** *Amaranthus spinosus*. **18, 19.** *Punica granatum*. **20, 21.** *Dodonaea viscosa*. **22, 23.** *Casearia elliptica*. **24.** *Ageratum conyzoides*. **25.** *Coccinia grandis*. **26, 27.** *Grewia tiliaefolia*. **28.** *T indica* in a unifloral pollen load x250.

Table III. Analyses of pollen loads from honey combs.

Comb No	Total No of pollen loads	Unifloral		Bifloral		Multifloral	
		No	Composition	No	Composition (%)	No	Composition (%)
16f	80	75 (93.8%)	75 *T indica*	4 (5%)	2 *T indica* (36,28), *Ageratum conyzoides* (64,72) 2 *T indica* (76,75) *Acacia nilotica* (24, 25)	1 (1.3%)	*T indica* (36), *A conyzoides* (53), *A nilotica* (11)
16 g	35	24 (68.6%)	20 *T indica* 4 *A conyzoides*	3 (8.6%)	3 *T indica* (25–73), *A conyzoides* (27–75)	8 (22.9%)	5 *T indica* (41–67) *A conyzoides* (25–36), *A nilotica* (8–14) 3 *T indica* (26–66) *A conyzoides* (10–64) *Tridax procumbens* (10–24)
16 h	50	46 (92%)	42 *T indica* 4 *T procumbens*	2 (4%)	2 *T indica* (73,65), *A nilotica* (27,35)	2 (4%)	2 *T indica* (12,15) *A nilotica* (18,30) *T procumbens* (70, 55)
39e	60	47 (78.3%)	43 *T indica* 3 *A nilotica* 1 *T procumbens*	8 (13.3%)	6 *T indica* (30–75) *A conyzoides* (25–70) 2 *T indica* (79,61) *A nilotica* (21,39)	5 (8.3%)	2 *T indica* (26,59) *T procumbens* (12,30) *A conyzoides* (62,11) 1 *T indica* (59) *T procumbens* (16) *A nilotica* (25) 1 *T indica* (23) *A conyzoides* (60) *A nilotica* (17) 1 *T indica* (50) *Casearia elliptica* (35), *A nilotica* (15)
39f	50	18 (36%)	15 *T indica* 3 *Dodonaea viscosa*	23 (46%)	18 *D viscosa* (25–77) *T indica* (23–75) 3 *C elliptica* (67–79), *Grewia tiliaefolia* (21–33) 2 *C elliptica* (71,64) *A nilotica* (29,36)	9 (18%)	5 *T indica* (10–30) *D viscosa* (25–50) *C elliptica* (10–35) *G tiliaefolia* (15–25) 4 *T indica* (30–50) *D viscosa* (33–55) A nilotica (15–20)
18 j	25	24 (96%)	10 *Punica granatum* 10 *T procumbens* 4 *T indica*	Nil	–	1 (4%)	*P granatum* (68) *T indica* (21) *T procumbens* (11)

hankerpally (samples 16f, 16g and 16h) and Mominpet (samples 39e and 39f) mandals, where *T indica* was encountered either as the predominant or secondary pollen type in the honeys, a good number of large trees of this taxon were noted.

Sardar Singh (1962) Seethalakshmi (1983) considered *T indica* to be a good nectar source in summer to the honey bee, *A cerana* in parts of south India. Chaubal (1982) also reported *Tamarindus* to be a good nectar and pollen source to *A cerana* bees during summer in Maharashtra state. The present study shows that *T indica* is an important nectar and pollen source for *A florea* in the Ranga Reddy district.

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Résumé — *Tamarindus indica* L, plante importante pour *Apis florea* F dans le Sud de l'Inde Centrale. L'étude porte sur l'analyse pollinique de 6 échantillons de miel et de 300 pelotes de pollen prélevés directement sur 6 rayons d'une colonie d'*Apis florea* en juin 1990 dans 3 régions du district de Ranga Reddy, Andhra Pradesh, Inde (fig 1). Les échantillons ont été analysés selon la méthode de Louveaux *et al* (1978). Cinq échantillons de miel étaient monofloraux, un seul toutes fleurs. Les types de pollens prédominants sont *Tamarindus indica* L dans 3 échantillons et *Ageratum conyzoides* L et *Punica granatum* L dans chacun des 2 autres miels monofloraux. Les autres types de pollens significatifs (jusqu'à la catégorie pollen mineur) incluent *Tridax procumbens* L, *Dodonaea viscosa* (L) Jacq, *Acacia nilotica* L et Burn et *Casearia elliptica* Willd. Les classes de fréquences et les fréquences (en %) des types de pollen, ainsi que le rapport HDE/P (éléments de miellat/grains de pollen) sont données dans le tableau I. Les figures 2-7 représentent les spectres polliniques des échantillons de miel. Au total 18 types de pollen (15 de plantes mellifères et 3 de non mellifères) appartenant à 13 familles botaniques (11 mellifères et 2 non méllifères) ont été recensés. Les pollens anémophiles, *Amaranthus spinosus* L, *Zea mays* L et Les Poaceae, se rencontrent peu et représentent probablement une contamination atmosphérique. Les figures 8–28 sont des microphotographies des types de pollen significatifs. Le tableau II fournit les valeurs de l'index de similarité pour 15 paires possibles d'échantillons de miel. Les valeurs très élevées de l'index (> 0,5) pour 10 paires d'échantillons, sont probablement dues à la présence d'éléments floristiques similaires dans le champ de butinage des abeilles. Deux cent trente quatre (78%) pelotes de pollen sont monflorales, 40 (33%) biflorales et 26 (8,7%) multiflorales. *T indica*, *A conyzoides*, *D viscosa*, *A nilotica*, *T procumbens*, *C elliptica*, *P granatum* et *Grewia tiliaefolia* Vahl sont les types de pollen trouvés dans les pelotes (tableau III). Le pollen de *T indica* a été trouvé dans 85% des pelotes uniflorables, 87,5% des pelotes biblorales et dans toutes les pelotes multiflorales. L'étude montre l'importance de *T indica* comme source de nectar et de pollen pour *A florea* dans l'Inde Centrale du Sud.

Apis florea* / plante mellifère / plante pollinifère / miel / analyse pollinique / *Tamarindus indica

Zusammenfassung — *Tamarindus indica* : eine wichtige Trachtpflanze für *Apis florea* F in Zentral-Südindien. Diese Arbeit befaßt sich mit der Pollenanalyse von 6 Honigproben und 300 Pollenladun-

gen (direkt aus 6 Waben entnommen) von *Apis florea*, die im Juni 1990 in drei Mandalen (kleinen Verwaltungsgebieten) im Distrikt Ranga Reddy, Andhra Pradesh, Indien, gesammelt wurden. Die drei Mandalen, aus denen die Proben stammen, umfassen Shankerpally (3 Proben), Mominpet (2 Proben) und Serilingampally (1 Probe) (Abbildung 1).

Die Proben wurden nach der Methode von Louveaux *et al* (1978) analysiert. Fünf Honigprobe waren unifloral (= nur von einer einzigen Blütenart stammend) und eine multifloral. Die vorherrschende Pollenform war in drei Proben *Tamarindus indica* L und in jeder der anderen unifloralen Honige *Ageratum conyzoides* L und *Punica granatum* L vorhanden. Die anderen bedeutenden Pollentypen (bis zur Kategorie von weniger wichtigen Pollen) umfaßten *Tridax procumbens* (L) Burm, *Dodonaea viscosa* L (Jacq), *Acacia nilotica* L, und *Casearia elliptica* Willd. Die Häufigkeitsklassen und die Häufigkeiten (in %) von Pollentypen und die Verhältnisse von HDE/p werden in Tabelle I gegeben. Abbildungen 2–7 zeigen die Pollenspektra der Honigproben.

Insgesamt wurden 18 Pollentypen (15 von Nektarpflanzen und 3 von nektarlosen Pflanzen), aus 13 Pflanzenfamilien (11 Nektarpflanzen und 2 nektarlose) gefunden. Pollen von windblütigen Planzen wie *Amaranthus spinosus* L, *Zea mays* und *Poaceae-Type* wurden nur selten gefunden, sie waren wahrscheinlich eine Übertragung durch den Wind. Abbildungen sind Mikroaufnahmen der wichtigen Pollentypen.

Die Werte des Ähnlichkeitsindex von 15 môoglichen Paaren von Honigproben werden in Tabelle II gegeben. Die recht hohen Indexwerte (über 0,5) von 10 Paaren der Honigproben sind wahrscheinlich auf ähnliche Florenelemente im Trachtbereich der Bienen zurückzuführen.

234 (78%) der Pollenladungen waren unifloral, 40 (13,3%) bifloral und 26 (8,7%) multifloral. Die Pollentypen, die in den Pollenladungen bestimmt werden konnten, waren *T indica*, *A conyzoides*, *D viscosa*, *A nilotica*, *T procumbens*, *C elliptica*, *P granatum* und *Grewia tiliaefolia* Vahl (Tabelle III). Pollen von *T indica* wurde in 85% der unifloralen, in 87,5% der bifloralen und in allen multifloralen Ladungen gefunden.

Diese Untersuchung zeigt die Bedeutung von *T indica* als wichtige Nektar- und Pollenquelle für *A florea* im Süden von Zentralindien. Außerdem deutet sie auf einen wesentlich geringeren Grad der Blütenstetigkeit von *A florea* gegenüber *A mellifera* hin.

***Apis florea* / *Tamarindus indica* / Honig / Pollenpflanze / Nektarpflanze / Pollenanalyse**

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