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# Pollen forage and storage pattern of *Apis dorsata* Fabricius in Bankura and Paschim Medinipur districts, West Bengal

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**ABSTRACT**

*Pollen cell frequencies within hive of Apis dorsata in Bankura and Paschim Medinipur districts of West Bengal remain maximum mean value of 8.74 during the month of April and minimum mean value of 3.47 in August. The pollen cell frequency of hive was very positively correlated to the pollen stack number with a correlation coefficient (r) value of 0.96. The stack number per pollen cell varied from mean value of 9.40 (during April) to 4.27 (in August). Each pollen stack was made up of an average of 9.88 pairs of pollen pellets. The number of pollen grains per pollen stack ranged from 572450 to 1052480 with an average value of 817370. Among the melissopalynologically analyzed 1336 pollen stacks, 865 (64.75%) were unifloral, 407 (30.46%) were bifloral and 64 (4.79%) were multifloral in pollen compositions. Though from each pollen cell 1 to 7 pollen types were obtained, but majority of the pollen cells contain 3 pollen types. A total of 84 pollen types belonging to 39 plant families were identified. Among them most frequently occurred pollen type was Eucalyptus globulus, followed by Borassus flabellifer, Brassica nigra, Acacia auriculiformis, Sesamum indicum, Terminalia arjuna, Lannea coromandelica, Alangium salvifolium, Shorea robusta and Phoenix sylvestris.*

***Key words:*** *Apis dorsata, melissopalynology, pollen cell frequency, pollen stack.*

## INTRODUCTION

Pollen is a source of proteins, free amino acids, lipids, minerals and vitamins which are essential to growth and development of honeybees[1, 2]. When honeybees were provided with insufficient pollen, brood rearing decreased[3] and workers lived shorter[4]. Forager honeybees collect pollen grains from the stamens of flowers. While visiting flowers, pollen grains adhere to the hairy body parts of the bees. Pollen grains are brushed off by the bee using front and middle leg and then are scrapped off and rakes on the special structure in the hind leg called the corbicula or pollen basket. The pollen grains are moistened with nectar and saliva, and are packed forming pasty pellets called pollen loads[5,6]. Pollen foragers carry the pollen loads back to the hive and unload by kicking the pollen loads off their legs into a pollen cell of the hive. Then the pollen loads are hammered into a paste-like consistency by other workers with their heads.

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In a pollen cell of the hive pollen grains are stored in the form of a series of stacks one above another. The stored pollen grains are mixed with honey to make bee bread which is fed to larvae and young bees. Melissopalynological analysis of stored pollen loads help to evaluate the botanical origin of the foodstuff, foraging preferences and pollen storage pattern of the honeybee species[7, 8]. Though some melissopalynological works on *A. dorsata* were previously done by Lakshmi and Suryanarayana[9], Tiwari *et al*[10], Padmavathy and Rehel[11] based on analyses of honey samples, but analysis of pollen loads of the bee species is still very rare in the country. Laxmikant and Devendra[12] analyzed pollen loads collected from Maharashtra during the month of May. In the state of West Bengal identification of polleniferous plants vis-à-vis stack wise pollen storage pattern within pollen cells for this bee species is yet to be determined.

Considering the importance of pollen grains in the colony development as well as egg laying behaviour of the queen bee in a hive, the present work was conducted to establish the pollen spectra of pollen stacks produced by worker bees of *A. dorsata*. The work will also help to determine the pollen storage pattern within the pollen cells of hives round the year.

## MATERIALS AND METHODS

### Study area

In order to perform the study, samples collected from 16 different areas of Bankura and Paschim Medinipur districts, West Bengal (Figure 1, Table 1). These adjacent two districts are situated between 21°47'-23°38' north latitude and 86°36'-87°52' east longitude, with a total of 16177 km$^2$ area. The climate of these regions ranges from dry and hot summers with moderate monsoon and cold winter. Vegetation surrounding the selected areas is dominated by indigenous taxa like *Alangium salvifolium*, *Borassus flabellifer*, *Buchanania lanzan*, *Butea monosperma*, *Holoptelea integrifolia*, *Lannea coromandelica*, *Madhuca longifolia*, *Schleichera oleosa*, *Semecarpus anacardium*, *Shorea robusta*, *Tectona grandis* and *Terminalia arjuna*. Other introduced forest plants are *Acacia auriculiformis*, *Eucalyptus globulus* and *Peltophorum pterocarpum*. Agriculture is the main economic activity of the area. Most of the cultivated areas are planted with *Brassica nigra*, *Capsicum frutescens*, *Coccinia grandis*, *Coriandrum sativum*, *Helianthus annuus*, *Oryza sativa*, *Sesamum indicum* and *Solanum tuberosum*.

### Collection of hives and determination of pollen cell frequency

Thirty six wild hives and 1336 pollen stacks of *A. dorsata* were collected throughout the year during 2014-2015. Field survey was done to find out wild hives of *A. dorsata* in different areas. After finding them, the nests were harvested and the adult bees were smoked off from the combs[13]. Then the entire hives were taken for our study. After collection of hives, total comb cells and total pollen cells for each hive were counted. Then we determined the pollen cell frequency of a hive by the following formula:

$$\text{Pollen cell frequency} = \frac{\text{Number of pollen cells}}{\text{Total number of comb cells}} \times 100$$

### Collection and palynological analyses of pollen stacks

Five pollen cells from each hive were taken for these purposes. Each pollen cell was ruptured longitudinally to open out the pollen stacks (Figure 2). Then individual stacks from each pollen cell macroscopically separated with a sharp knife. Each stack was preserved separately in small glass vials containing FAA (Formalin Aceto Alcohol, 5:5:90) solution.

The numbers of pollen stacks per pollen cells were recorded. To determine the

number of pollen grains per pollen stack, each stack solution was diluted ten times and then counted the pollen grains with the help of compound light microscope. For determination of the number of corbicular pollen pellets per pollen stack, we also counted the number of pollen grains of 10 pairs of corbicular pollen pellets of the bee species.

To determine pollen spectra of the pollen stacks, first the stacks were suspended in 50 ml of 95% ethanol and thoroughly mixed[14]. This solution was then centrifuged at 4000 rpm for 5 minutes. After decanting supernatant, the sediment was analyzed both as non acetolyzed and acetolyzed pollen for better characterization[15]. Acetolysis of pollen grains were carried out through the method recommended by Erdtman[16]. Glycerine jelly was used as a mounting medium to prepare the samples for microscopic analysis[17]. Identification of pollen types was done with the help of reference slides prepared from the local flora as well as from published accounts. Photomicrographs of pollen types were taken by Leica DFC295 Digital camera. The number of pollen stacks for each pollen types were determined. In case of unifloral stack, given number is 1 for that pollen type in respect of that stack. Other cases (bifloral or multifloral stacks) the given number is 1/no. of pollen types in that stack.

## RESULTS

### Pollen storage pattern

The frequencies of pollen cells within each hive of *A. dorsata* varied from 3.09 to 9.03. The mean pollen cell frequencies were higher during the months of March (8.07), April (8.74) and May (8.27). The values were lower during August (3.47) and September (3.70). The mean frequency value again increased up to 7.83 during the month of December (Table 1). The number of pollen stacks within the pollen cells was also varied from 2 to 12 (Table 2). The month wise mean pollen stacks number per pollen cell was maximum of 9.40 during the month of April and minimum of 4.27 in August. The value of correlation coefficient (r) between these two variables, pollen cell frequency and pollen stack number was 0.96 (Table 3). The number of pollen grains per pollen stack ranged from 572450 to 1052480 with an average value of 817370. Each pair of corbicular pollen pellets contained pollen grains of 35410 to 96730 with mean value of 82710. Therefore each pollen stack was made up of an average of 9.88 pairs of corbicular pollen pellets (Table 4). Among the analyzed 1336 pollen stacks, 865 (64.75%) were unifloral, 407 (30.46%) were bifloral and 64 (4.79%) were multifloral in pollen compositions (Table 2). Each pollen cell contained 1 to 7 pollen types. Single pollen type containing pollen cell was 1; 2 pollen types were within 15 pollen cells; 3 pollen types in 66 pollen cells; 4 pollen types in 61 pollen cells; 5 pollen types in 22 pollen cells; 6 pollen types in 13 pollen cells and 7 pollen types containing pollen cells were 2 (Figure 3).

### Polleniferous flora

Form melissopalynological analysis of the pollen stacks 84 pollen types belonging to 39 plant families were identified (Table 5). Photomicrographs of some pollen types were given in Figures 4 and 5. Maximum number of pollen stacks were came from the family Myrtaceae, followed by Arecaceae and Fabaceae. The family represented by maximum number of pollen types was Fabaceae (11 pollen types), afterward Asteraceae (10 pollen types) and Myrtaceae (6 pollen types). Large numbers of pollen stacks were of *Eucalyptus globulus*, followed by *Borassus flabellifer*, *Brassica nigra*, *Acacia auriculiformis*, *Sesamum indicum*, *Terminalia arjuna*, *Lannea coromandelica*, *Alangium*

*salvifolium*, *Shorea robusta* and *Phoenix sylvestris* (Table 5).

**Table 1: Characteristics of pollen cells within the hives of *A. dorsata* in Bankura and Paschim Medinipur districts, West Bengal**

| Hive no. | Date of collection | Locality | Total no. of comb cells | No. of pollen cells | Pollen cell frequency | Mean frequency | No. of pollen stacks | Pollen stacks/ pollen cell |
|---|---|---|---|---|---|---|---|---|
| **January** | | | | | | | | |
| 01 | 17.01.14 | Balikhun | 7862 | 534 | 6.79 | 6.76 | 38 | 7.87 |
| 13 | 08.01.15 | Jenadihi | 7638 | 497 | 6.51 | | 39 | |
| 14 | 28.01.15 | Amarda | 8759 | 611 | 6.98 | | 41 | |
| **February** | | | | | | | | |
| 02 | 16.02.14 | Piardoba | 8683 | 542 | 6.24 | 6.65 | 40 | 8.13 |
| 15 | 06.02.15 | Anandapur | 9256 | 627 | 6.77 | | 40 | |
| 16 | 25.02.15 | Bansol | 8524 | 591 | 6.93 | | 42 | |
| **March** | | | | | | | | |
| 03 | 13.03.14 | Jenadihi | 8195 | 658 | 8.03 | 8.07 | 43 | 8.53 |
| 17 | 07.03.15 | Piardoba | 8671 | 675 | 7.78 | | 41 | |
| 18 | 29.03.15 | Daspur | 10336 | 868 | 8.40 | | 44 | |
| **April** | | | | | | | | |
| 04 | 14.04.14 | Suabasha | 12772 | 1153 | 9.03 | 8.74 | 48 | 9.40 |
| 19 | 06.04.15 | Amlasuli | 8807 | 731 | 8.30 | | 44 | |
| 20 | 30.04.15 | Deshra | 9314 | 827 | 8.88 | | 49 | |
| **May** | | | | | | | | |
| 05 | 12.05.14 | Daspur | 8627 | 684 | 7.93 | 8.27 | 47 | 9.07 |
| 21 | 06.05.15 | Korui | 7348 | 646 | 8.79 | | 45 | |
| 22 | 27.05.15 | Seulibona | 9193 | 745 | 8.10 | | 44 | |
| **June** | | | | | | | | |
| 06 | 18.06.14 | Bansol | 6875 | 349 | 5.08 | 5.03 | 35 | 6.93 |
| 23 | 05.06.15 | Balikhun | 8216 | 427 | 5.20 | | 36 | |
| 24 | 26.06.15 | Anandapur | 8522 | 409 | 4.80 | | 33 | |
| **July** | | | | | | | | |
| 07 | 16.07.14 | Amarda | 7891 | 273 | 3.46 | 3.88 | 28 | 5.67 |
| 25 | 07.07.15 | Gauripur | 9234 | 388 | 4.20 | | 30 | |
| 26 | 28.07.15 | Amlasuli | 6918 | 276 | 3.99 | | 27 | |
| **August** | | | | | | | | |
| 08 | 13.08.14 | Gauripur | 8117 | 276 | 3.40 | 3.47 | 21 | 4.27 |
| 27 | 06.08.15 | Rangamati | 6239 | 245 | 3.93 | | 22 | |
| 28 | 29.08.15 | Deshra | 7382 | 228 | 3.09 | | 21 | |
| **September** | | | | | | | | |
| 09 | 12.09.14 | Rangamati | 8276 | 314 | 3.79 | 3.70 | 25 | 5.07 |
| 29 | 08.09.15 | Gauripur | 7981 | 255 | 3.20 | | 23 | |
| 30 | 30.09.15 | Balikhun | 7614 | 312 | 4.10 | | 28 | |
| **October** | | | | | | | | |
| 10 | 15.10.14 | Garhbeta | 7497 | 457 | 6.10 | 6.07 | 37 | 7.53 |
| 31 | 07.10.15 | Jenadihi | 8125 | 448 | 5.51 | | 35 | |
| 32 | 27.10.15 | Piardoba | 8419 | 556 | 6.60 | | 41 | |
| **November** | | | | | | | | |
| 11 | 17.11.14 | Anandapur | 9263 | 642 | 6.93 | 6.68 | 42 | 8.07 |
| 33 | 06.11.15 | Ramsagar | 7842 | 486 | 6.20 | | 38 | |
| 34 | 28.11.15 | Suabasha | 8717 | 603 | 6.92 | | 41 | |
| **December** | | | | | | | | |
| 12 | 14.12.14 | Garhbeta | 9448 | 812 | 8.59 | 7.83 | 45 | 8.53 |
| 35 | 05.12.15 | Seulibona | 9926 | 752 | 7.58 | | 42 | |
| 36 | 29.12.15 | Suabasha | 8583 | 627 | 7.31 | | 41 | |

**Table 2: Stack wise pollen content of some pollen cells of *A. dorsata* hives given from basal pollen stack (individual pollen stacks are separated by semicolon)**

| Hive no. | Pollen cell no. | Pollen contents |
|---|---|---|
| **March** | | |
| 03 | 1 | *Ceiba pentandra*; *C. pentandra*, *Madhuca longifolia*; *Borassus flabellifer*; *B. flabellifer*; *B. flabellifer*; *B. flabellifer*; *B. flabellifer*; *B. flabellifer*, *Shorea robusta*; *B. flabellifer*, *S. robusta*; *S. robusta*; *S. robusta* |
| **April** | | |
| 04 | 1 | *Lannea coromandelica*; *L. coromandelica*; *B. flabellifer*, *L. coromandelica*; *B. flabellifer*, *L. coromandelica*; *B. flabellifer*; *S. robusta*; *S. robusta*; *S. robusta*; *S. robusta* |
| 19 | 1 | *Eucalyptus globulus*; *E. globulus*; *Brassica nigra*, *E. globulus*; *B. nigra*; *B. flabellifer*; *B. flabellifer*; *B. flabellifer*; *Albizia lebbeck*, *B. flabellifer*; *B. flabellifer*, *Foeniculum vulgare*; *B. flabellifer* |
| 20 | 2 | *B. flabellifer*; *B. flabellifer*; *M. longifolia*; *B. flabellifer*, *M. longifolia*, *Mimosa pudica*; *A. lebbeck*, *B. flabellifer*, *Spinacia oleracea*; *A. lebbeck*; *B. flabellifer*; *B. flabellifer*; *Sesamum indicum*, *Terminalia arjuna*; *S. indicum*, *T. arjuna*; *T. arjuna*; *T. arjuna* |
| | 5 | *L. coromandelica*; *L. coromandelica*; *L. coromandelica*; *L. coromandelica*, *S. robusta*; *L. coromandelica*, *S. robusta*; *S. robusta*; *B. flabellifer*, *S. robusta*; *B. flabellifer*; *B. flabellifer*, *S. robusta*; *B. flabellifer* |
| **May** | | |
| 21 | 2 | *Holoptelea integrifolia*; *L. coromandelica*; *L. coromandelica*; *S. robusta*; *H. integrifolia*, *S. robusta*; *H. integrifolia*, *S. robusta*; *S. robusta*; *S. robusta* |
| **June** | | |
| 06 | 1 | *L. coromandelica*; *L. coromandelica*; *L. coromandelica*, *S. robusta*; *B. flabellifer*, *S. robusta*; *S. robusta*; *S. robusta* |
| | 4 | *L. coromandelica*; *L. coromandelica*; *S. robusta*; *B. flabellifer*, *S. robusta*; *S. robusta*; *B. flabellifer*; *B. flabellifer*; *B. flabellifer*; *S. robusta* |
| **July** | | |
| 25 | 3 | *B. flabellifer*; *B. flabellifer*; *B. flabellifer*, *S. indicum*; *B. flabellifer*, *S. indicum*; *B. flabellifer* |
| **August** | | |
| 28 | 3 | *Luffa cylindrica*, *Semecarpus anacardium*; *S. anacardium* |
| **November** | | |
| 11 | 3 | *E. globulus*; *E. globulus*; *E. globulus*; *E. globulus*; *E. globulus*; *E. globulus* |

**Table 3: Calculation of correlation coefficient (r) between two variables, pollen cell frequency and pollen stack number within hive of *A. dorsata***

| Hive no. | Pollen cell frequency (x) | Pollen stacks number (y) | xy | $x^2$ | $y^2$ | r value |
|---|---|---|---|---|---|---|
| 1 | 6.79 | 38 | 252.02 | 46.10 | 1444 | **0.96** |
| 2 | 6.24 | 40 | 249.60 | 38.94 | 1600 | |
| 3 | 8.03 | 43 | 345.29 | 64.48 | 1849 | |
| 4 | 9.03 | 48 | 433.44 | 81.54 | 2304 | |
| 5 | 7.93 | 47 | 372.71 | 62.88 | 2209 | |
| 6 | 5.08 | 35 | 177.80 | 25.81 | 1225 | |
| 7 | 3.46 | 28 | 96.88 | 11.97 | 784 | |
| 8 | 3.40 | 21 | 71.40 | 11.56 | 441 | |
| 9 | 3.79 | 25 | 94.75 | 14.36 | 625 | |
| 10 | 6.10 | 37 | 225.70 | 37.21 | 1369 | |
| 11 | 6.93 | 42 | 292.06 | 48.02 | 1764 | |
| 12 | 8.59 | 45 | 386.55 | 73.79 | 2025 | |
| 13 | 6.51 | 39 | 253.89 | 42.38 | 1521 | |
| 14 | 6.98 | 41 | 286.18 | 48.72 | 1681 | |
| 15 | 6.77 | 40 | 270.80 | 45.83 | 1600 | |
| 16 | 6.92 | 42 | 290.64 | 47.89 | 1764 | |
| 17 | 7.78 | 41 | 318.98 | 60.53 | 1681 | |
| 18 | 8.40 | 44 | 369.60 | 70.56 | 1936 | |
| 19 | 8.30 | 44 | 365.20 | 68.89 | 1936 | |
| 20 | 8.88 | 49 | 435.12 | 78.85 | 2401 | |
| 21 | 8.79 | 45 | 395.55 | 77.26 | 2025 | |
| 22 | 8.10 | 44 | 356.40 | 65.61 | 1936 | |
| 23 | 5.20 | 36 | 187.20 | 27.04 | 1296 | |
| 24 | 4.80 | 33 | 158.40 | 23.04 | 1089 | |
| 25 | 4.20 | 30 | 126 | 17.64 | 900 | |
| 26 | 3.99 | 27 | 107.73 | 15.92 | 729 | |
| 27 | 3.93 | 22 | 86.46 | 15.44 | 484 | |
| 28 | 3.09 | 21 | 64.89 | 9.55 | 441 | |
| 29 | 3.20 | 23 | 73.60 | 10.24 | 529 | |
| 30 | 4.10 | 28 | 114.80 | 16.81 | 784 | |
| 31 | 5.51 | 35 | 192.85 | 30.36 | 1225 | |
| 32 | 6.60 | 41 | 270.60 | 43.56 | 1681 | |
| 33 | 6.20 | 38 | 235.60 | 38.44 | 1444 | |
| 34 | 6.92 | 41 | 283.72 | 47.89 | 1681 | |
| 35 | 7.58 | 42 | 318.36 | 57.46 | 1764 | |
| 36 | 7.31 | 41 | 299.71 | 53.44 | 1681 | |
| | **Mean= 6.26** | **Mean= 37.11** | **$\sum xy$= 8860.48** | **$\sum x^2$= 1530.01** | **$\sum y^2$= 51848** | |

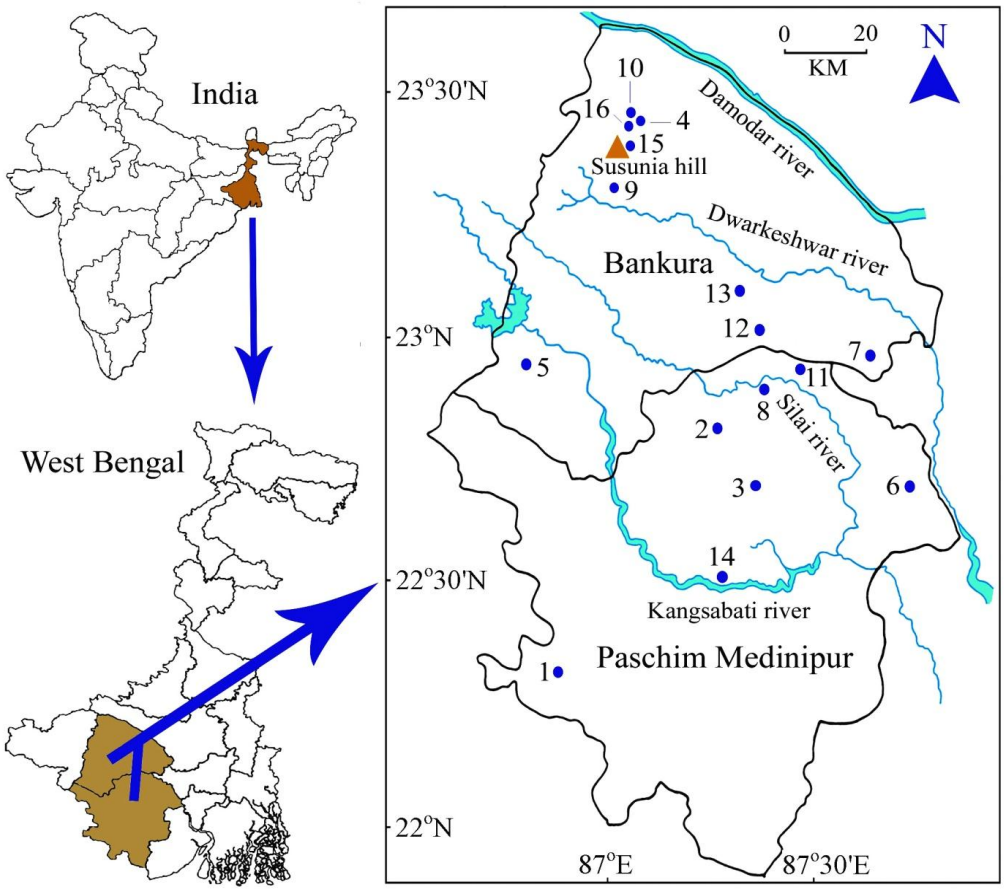
**Table 4: Characterization of pollen cell of *A. dorsata* hives in Bankura and Paschim Medinipur districts, West Bengal**

| Characters | Range | Average |
|---|---|---|
| Number of pollen stacks per pollen cell | 2-12 | --- |
| Number of pollen grains per pollen stack | 572450-1052480 | 817370 |
| Number of pollen grains per pair of corbicular pellets | 35410-96730 | 82710 |
| Number of corbicular pellets (in pair) per pollen stack | --- | 9.88 |
| Number of pollen types per pollen stack | 1-4 | --- |
| Number of pollen types per pollen cell | 1-7 | --- |
| Number of pollen grains per pollen cell | 4904220-9808490 | 6808720 |

**Table 5: List of plant species foraged by *A. dorsata* to collect pollen grains in Bankura and Paschim Medinipur districts, West Bengal**

| Family | Plant species | No. of pollen stacks obtained | Flowering period |
|---|---|---|---|
| Acanthaceae | *Hemigraphis hirta* | 1 | March-June |
| | *Hygrophila schulli* | 2 | September-April |
| Agavaceae | *Polianthes tuberosa* | 4.33 | Throughout the year |
| Alangiaceae | *Alangium salvifolium* | **42.33** | February-April |
| Amaranthaceae | *Amaranthus spinosus* | 2.16 | June-October |
| Amaryllidaceae | *Allium cepa* | 1.33 | March-April |
| Anacardiaceae | *Lannea coromandelica* | **43.41** | February-March |
| | *Semecarpus anacardium* | 22.50 | May-June |
| | *Spondias pinnata* | 2.50 | January-April |
| Apiaceae | *Coriandrum sativum* | 31.50 | December-May |
| | *Foeniculum vulgare* | 2 | December-May |
| Arecaceae | *Borassus flabellifer* | **105.91** | March-May |
| | *Cocos nucifera* | 7.33 | Throughout the year |
| | *Phoenix sylvestris* | **40** | January-May |
| Asteraceae | *Ageratum conyzoides* | 1 | July-December |
| | *Chrysanthemum indicum* | 5 | December-April |
| | *Eupatorium odoratum* | 2.83 | November-July |
| | *Helianthus annuus* | 3.83 | February-April |
| | *Mikania scandens* | 14.83 | November-May |
| | *Tagetes erecta* | 8.50 | Throughout the year |
| | *Taraxacum officinale* | 0.66 | March-May |
| | *Tridax procumbens* | 39.50 | Throughout the year |
| | *Vernonia cinerea* | 0.33 | March-May |
| | *Xanthium stromarium* | 0.83 | April-October |
| Bombacaceae | *Bombax ceiba* | 6.50 | December-April |
| | *Ceiba pentandra* | 3 | December-April |
| Brassicaceae | *Brassica nigra* | **103.83** | November-March |
| Cactaceae | *Cereus pterogonus* | 2 | August |
| Capparaceae | *Capparis zeylanica* | 2.5 | March-June |
| Capparidaceae | *Cleome viscosa* | 5.5 | June-August |
| Chenopodiaceae | *Spinacia oleracea* | 7 | February-April |
| Combretaceae | *Terminalia arjuna* | **48** | April-June |
| Commelinaceae | *Commelina benghalensis* | 0.50 | September-November |
| | *Cyanotis axillaris* | 0.50 | September-November |
| Cucurbitaceae | *Citrullus lanatus* | 3 | February-May |
| | *Luffa cylindrica* | 5.16 | May-October |
| | *Momordica charantia* | 12.33 | February-August |
| Dipterocarpaceae | *Shorea robusta* | **40.25** | March-April |
| Euphorbiaceae | *Bridelia retusa* | 28.41 | August-September |
| | *Croton bonplandianum* | 11.83 | May-August |
| | *Phyllanthus emblica* | 1.33 | April-August |
| | *Ricinus communis* | 10 | July-February |
| Fabaceae | *Acacia auriculiformis* | **98.66** | August-November |
| | *Acacia nilotica* | 17.58 | June-September |
| | *Albizia lebbeck* | 7.08 | March-May |
| | *Bauhinia acuminata* | 1 | May-August |
| | *Bauhinia tomentosa* | 0.50 | June- September |
| | *Dalbergia sissoo* | 3 | April-August |
| | *Delonix regia* | 0.50 | April-June |
| | *Inga dulcis* | 4.16 | November-March |
| | *Leucaena leucocephala* | 6.83 | June-October |
| | *Mimosa pudica* | 5.16 | Throughout the year |
| | *Peltophorum pterocarpum* | 7.16 | March-June |
| Lamiaceae | *Ocimum sanctum* | 4.33 | July-September |
| Myrtaceae | *Callistemon citrinus* | 0.33 | April |
| | *Eucalyptus globulus* | **254.50** | November-April |
| | *Psidium guajava* | 1.33 | January-May |

| | | | |
|---|---|---|---|
| | *Syzygium jambos* | 2.50 | January-March |
| | *Syzygium cumini* | 1.33 | March-April |
| | *Syzygium reticulatum* | 16.75 | May-June |
| Nelumbonaceae | *Nelumbo nucifera* | 4.66 | April-November |
| Papaveraceae | *Papaver somniferum* | 1 | February-March |
| Pedaliaceae | *Sesamum indicum* | **82.75** | April-June |
| Poaceae | *Poa* sp. | 0.83 | September-November |
| Ranunculaceae | *Nigella sativa* | 2.83 | February-March |
| Rhamnaceae | *Ziziphus mauritiana* | 30.66 | August-October |
| Rubiaceae | *Anthocephalus cadamba* | 16.58 | July-August |
| | *Haldina cordifolia* | 4.83 | July-August |
| Rutaceae | *Citrus* × *aurantiifolia* | 4.16 | June-August |
| | *Citrus maxima* | 1 | February-April |
| | *Murraya paniculata* | 7.33 | Throughout the year |
| Salicaceae | *Flacourtia jangomas* | 2.33 | February-March |
| Sapindaceae | *Litchi chinensis* | 1.33 | January-March |
| | *Sapindus mukorosii* | 1.33 | December-January |
| Sapotaceae | *Madhuca longifolia* | 5.66 | March-April |
| | *Mimusops elengi* | 1.66 | June-August |
| Simaroubaceae | *Ailanthus excelsa* | 3.50 | January-February |
| Solanaceae | *Solanum melongena* | 8.16 | Throughout the year |
| | *Solanum sisymbriifolium* | 1 | April-August |
| Tiliaceae | *Corchorus capsularis* | 3.66 | May-June |
| | *Corchorus olitorius* | 3.16 | May-June |
| | *Grewia asiatica* | 1 | December-February |
| Ulmaceae | *Holoptelea integrifolia* | 12 | February-March |
| Verbenaceae | *Lippia alba* | 24.41 | May-October |




1. Anarda, 2. Amlasuli, 3. Anandapur, 4. Balikhun, 5. Bansol, 6. Daspur, 7. Deshra, 8. Garhbeta, 9. Gauripur, 10. Jenadihi, 11. korui, 12. Piardoba, 13. Ramsagar, 14. Rangamati, 15. Seulibona, 16. Suabasha.

**Fig. 1: Map showing localities from where pollen samples were collected (●)**

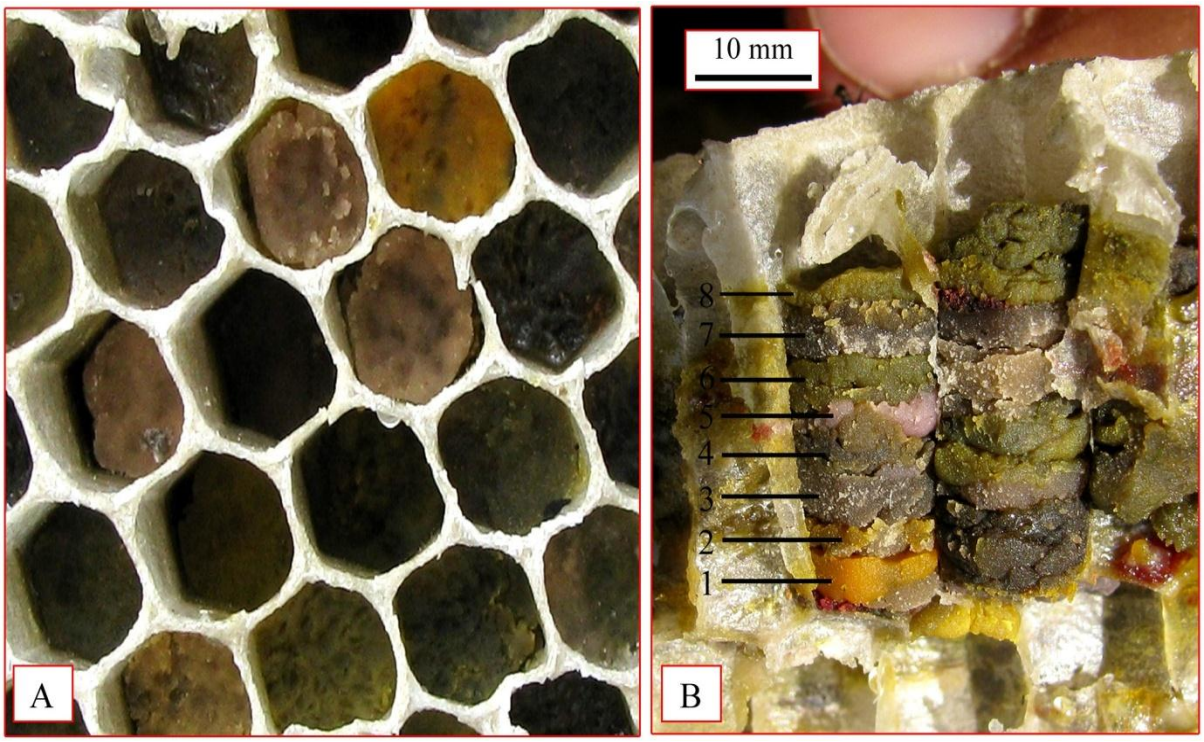



**Fig. 2: Showing pollen cells (A) and longitudinally ruptured pollen cells with several successive pollen stacks (B) of *A. dorsata***

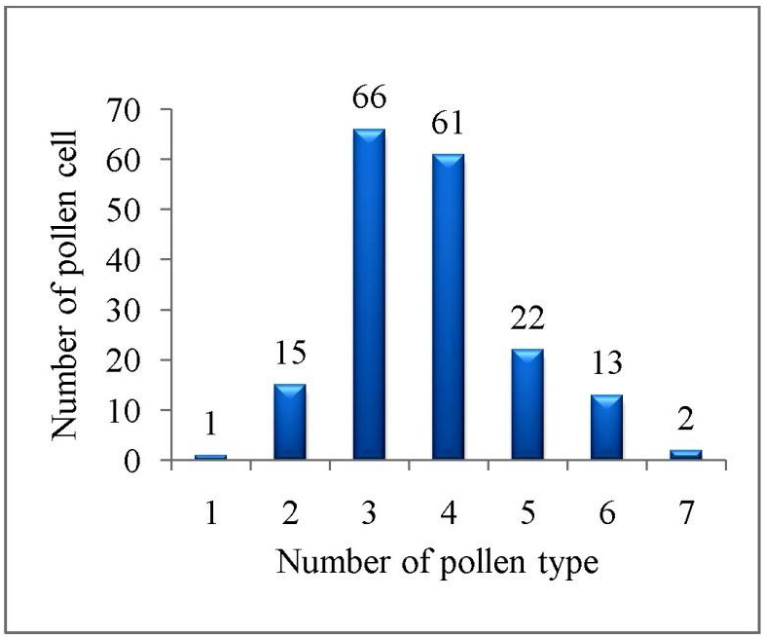



**Fig.3: Pollen cells contained various number of pollen types**

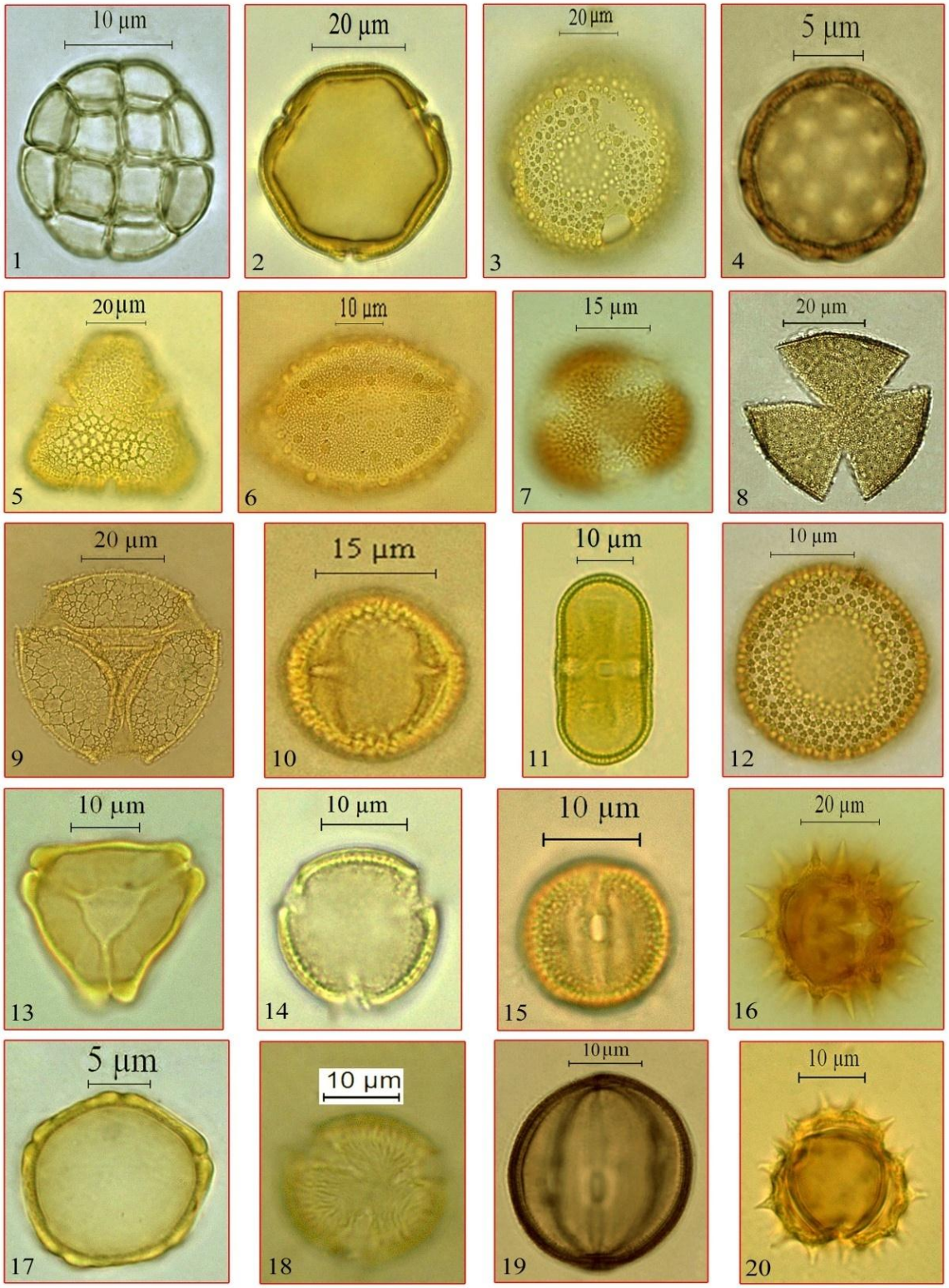



**Figure 4. Pollen types obtained from pollen stacks of *A. dorsata*. 1. *Acacia auriculiformis*, 2. *Ailanthus excelsa*, 3. *Alangium salvifolium*, 4. *Amaranthus spinosus*, 5. *Bombax ceiba*, 6. *Borassus flabellifer*, 7. *Brassica nigra*, 8. *Cereus pterogonus*, 9. *Citrullus lanatus*, 10. *Citrus × aurantiifolia*, 11. *Coriandrum sativum*, 12. *Croton bonplandianum*, 13. *Eucalyptus globulus*, 14. *Flacourtia jangomas*, 15. *Haldina cordifolia*, 16. *Helianthus annuus*, 17. *Holoptelea integrifolia*, 18. *Lannea coromandelica*, 19. *Leucaena leucocephala*, 20. *Mikania scandens*.**

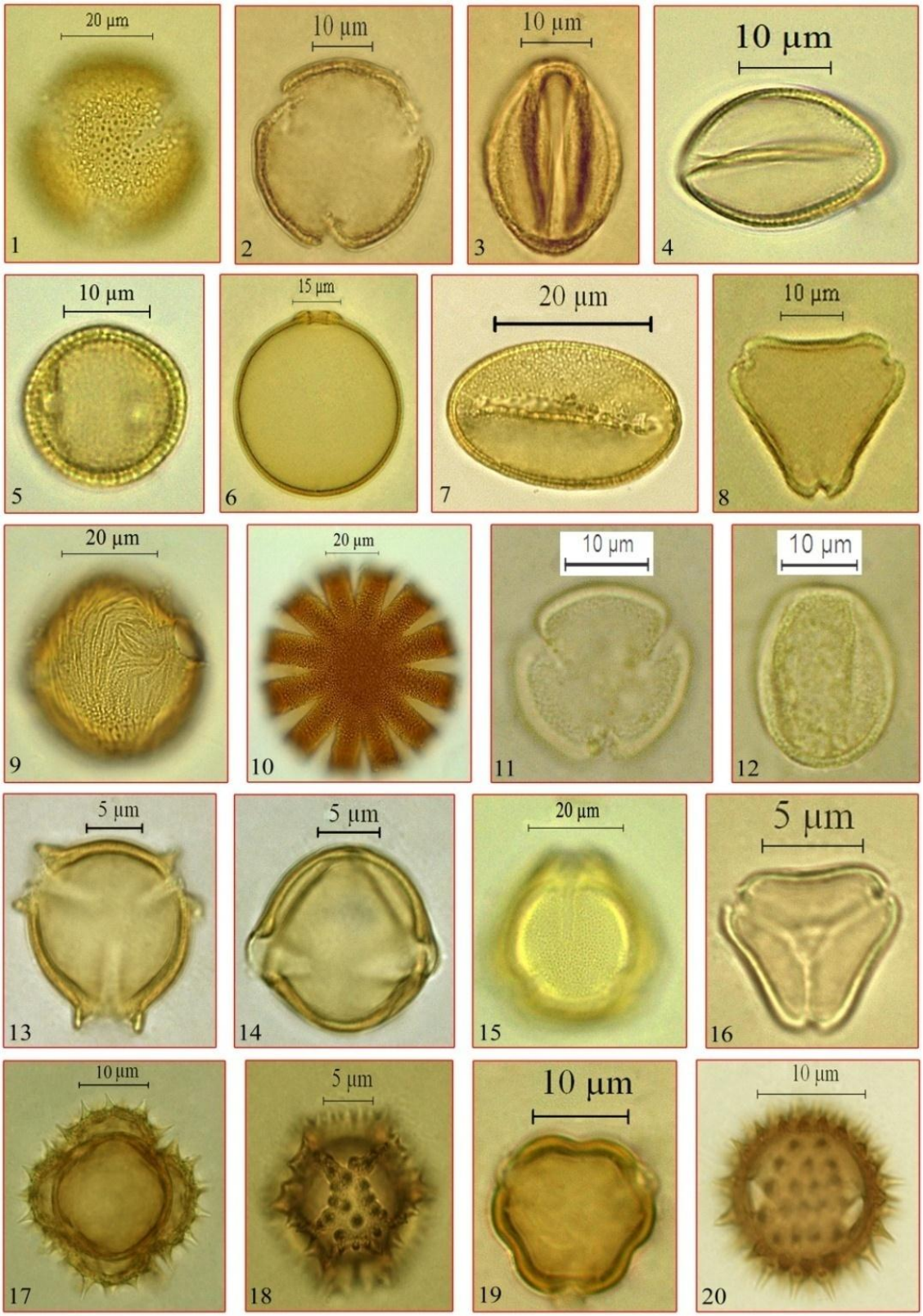



**Figure 5. Pollen types obtained from pollen stacks of *A. dorsata*. 1. *Nigella sativa*, 2-3. *Papaver somniferum*, 4. *Phoenix sylvestris*, 5. *Phyllanthus emblica*, 6. *Poa* sp., 7. *Polianthes tuberosa*, 8. *Psidium guajava*, 9. *Semecarpus anacardium*, 10. *Sesamum indicum*, 11-12. *Shorea robusta*, 13-14. *Solanum melongena*, 15. *Solanum sisymbriifolium*, 16. *Syzygium reticulatum*, 17. *Tagetes erecta*, 18. *Taraxacum officinale*, 19. *Terminalia arjuna*, 20. *Tridax procumbens*.**

## DISCUSSION

Mean pollen cell frequencies and pollen stacks number were higher in the months of March, April, May and December. Whereas the values became lower during the months of July, August and September. The higher value of correlation coefficient (r) between pollen cell frequency and pollen stack number indicated that these two parameters are very positively correlated (Table 3). During March, April and May important polleniferous plants viz. *Borassus flabellifer*, *Lannea coromandelica*, *Sesamum indicum*, *Shorea robusta* and *Terminalia arjuna* supplied huge amount of pollen to the bee species. The month of December is the flowering period of some vital polleniferous plants like *Brassica nigra*, *Eucalyptus globulus* and *Phoenix sylvestris*. The November month is also dominated by *Eucalyptus globulus* and to some extent by *Acacia auriculiformis*. Importance of *Borassus flabellifer*, *Brassica nigra*, *Eucalyptus globulus*, *Lannea coromandelica*, *Phoenix sylvestris* and *Terminalia arjuna* as bee plants was already established by Layek *et al*[18] in those areas for the honeybee species *A. florea*. The plant species *Borassus flabellifer* and *Terminalia arjuna* also recognized as good pollen sources by Seethalakshmi and Percy[19], Laxmikant and Devendra[12] from outside West Bengal. In the present work we have recorded *Shorea robusta*, an important pollen supplier of *A. dorsata* for the first time. During this pollen flow seasons the bee species collect huge amount of pollen and stored within pollen cells for future use. This phenomenon was established by the palynological analysis of the pollen cell no. 1 of hive no. 4, pollen cell no. 1 and 4 of hive no. 6, pollen cell no. 1 of hive no. 19, pollen cell no. 5 of hive no. 20, pollen cell no. 2 of hive no. 21 and pollen cell no. 3 of hive no. 25 (Table 2). The pick flowering period of *Lannea coromandelica* and *Shorea robusta* in West Bengal were belonging to the month of March. The bee species collected these pollen grains and stored in pollen cells of hive for some periods like up to April (pollen cell no. 1 of hive no. 4), May (pollen cell no. 2 of hive no. 21) and June (pollen cell no. 1 and 4 of hive no. 6). Other pollen types viz. *Brassica nigra* and *Eucalyptus globulus* were also stored up to April, though the bee species collected these pollen grains during the month of December to February (pollen cell no. 1 of hive no. 19). Pollen grains of *Borassus flabellifer* and *Sesamum indicum* were also stored up to July, though pollens were collected from April to May (pollen cell no. 3 of hive no. 25). Major pollen supplying plant for the bee species is totally absent during the month of July, August and September, the so called dearth period for honeybees in those regions[20]. Though, some plant species like *Acacia nilotica*, *Anthocephalus cadamba*, *Croton bonplandianum*, *Semecarpus anacardium*, *Tridax procumbens* and *Ziziphus mauritiana* supplied pollen grains to the bee species during that time.

## CONCLUSION

Pollen cell frequency of a hive can be used as an indicator of pollen flow season for a honeybee species in a geographical area. There are two major pollen flow seasons for *A. dorsata* in Bankura and Paschim Medinipur districts of West Bengal. One of them was lying during the months of March to May with mean pollen cell frequencies of 8.07 to 9.40. The other one was lying during November-December with mean pollen cell frequencies of 6.68 to 7.83. The former pollen flow season is dominated by *Borassus flabellifer*, *Lannea coromandelica*, *Sesamum indicum*, *Shorea robusta* and *Terminalia arjuna*. The latter one is dominated by *Acacia auriculiformis*, *Brassica nigra*, *Eucalyptus globulus* and *Phoenix sylvestris*. After collection, the pollen grains stored as pollen stacks (made up of an average of 9.88 pairs of corbicular pollen pellets) within pollen cells of the hive up to 3 months to tolerate the pollen dearth period of the bee species i.e. July to September in those areas.

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