



FORAGING BEHAVIOR OF *APIS FLOREA FABRICIUS* DURING WINTER AND SPRING- SUMMER IN BANKURA AND PASCHIM MEDINIPUR DISTRICTS, WEST BENGAL

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ABSTRACT

The present study deals with qualitative and quantitative estimation of 1405 pairs of corbicular pollen pellets and 33 honey samples of *Apis florea* collected from different areas of Bankura and Paschim Medinipur districts of West Bengal. We also observed the forage pattern in the field during the time period (December to May). Altogether 71 plant species belonging to 32 families were foraged by the honeybee species at that time. Among those, *Borassus flabellifer*, *Brassica nigra*, *Eucalyptus globulus* and *Terminalia arjuna* served as the predominant pollen source. Other important pollen sources were *Coriandrum sativum*, *Lannea coromandelica* and *Phoenix sylvestris*. The pollen spectra of honey samples reveal that *A. florea* produced both unifloral and multifloral type of honeys. Among the 33 honey samples, 15 honey samples were unifloral and 18 were of multifloral in origin. Among the unifloral honey samples 3 are of *Borassus flabellifer* type, 5 are of *Brassica nigra* type, 3 are of *Eucalyptus globulus* type and 4 are of *Terminalia arjuna* type.

KEY WORDS: *Apis florea*, multifloral honey, pollen pellets, unifloral honey.

INTRODUCTION

Foraging can be defined as the search for and acquisition of food. It is one of the most consistent and demanding tasks for any living organism related to its survival. Honeybees have sophisticated foraging coordination and communication (Von Frisch, 1971; Suwannapong, 2000). This activity is only performed by workers, known as foragers or foraging bees. Honeybees forage over flowers to collect pollen grains and nectar, the former being the principal source of proteins while nectar (raw material of honey) used as a major source of carbohydrates. The plants provide these two substances collectively called bee pasturage. Thus, vegetation is of immense importance for establishment, maintenance and yield i.e. all round development of a bee colony (Pal and Karmakar, 2013). While visiting flowers for the search of nectar and pollen grains, honeybees inadvertently move from one flower to another and bee's hairy body incidentally get smeared with the pollen grains leading to pollination. Pollen analyses of honey and pollen pellets are considered to be the most suitable and widely used means to understand the forage pattern of a bee species. To decipher the details of pollen forage as well as nectar forage in an area by any particular bee species/variety, pollen analyses of both pollen pellets and honey samples are to be done simultaneously (Pal and Karmakar, 2013). The red dwarf honey bee, *Apis florea* Fabricius is a small sized 'stinging bee'. The species is wild in nature, not readily managed by man and build exposed single vertical combs hung from slender branches of trees or shrubs covered with relatively dense foliage (Wongsiri *et al.*, 1996a) or some times on buildings, caves and empty cases. Bankura and Paschim Medinipur are the two adjacent districts of south-

western part of West Bengal. Agriculture is the prime economic activity of these districts. Besides, a considerable part of the districts are covered by natural dry-deciduous rain forest and cultivated forest of *Acacia-Eucalyptus* type. *A. florea* frequently form hives among the various localities in these districts. To judge the efficacy and suitability of the flora for honey production and crop yield by the bee species, the present work was undertaken.

MATERIALS & METHODS

The present work based on the analysis of month wise collection of pollen pellets and honey samples from wild hives of *A. florea* as well as field observations in Amarkan and Chhatna Blocks of Bankura district and Garhbeta and Medinipur Blocks of Paschim Medinipur district, West Bengal (Figure 1). Altogether, 1405 pairs of corbicular pollen pellets and 33 honey samples of *A. florea* were collected from the said areas. Pollen pellets as corbicular load were collected directly from the pollen baskets of worker bees by capturing them when they return to their hive after collecting pollen grains. Pairs of pellets were preserved separately in the small (5ml) glass vials containing FAA (Formalin-Aceto-Alcohol, 5:5:90) solution. Honey samples were collected from wild hives after removing the honeybees fully or partly from the hives. Pure honey samples were collected directly from honey cells with the help of micropipettes. Slides from pollen pellets were prepared by acetolysis method (Erdtman, 1960). Palynological preparations of honey samples were done using methods recommended by Maurizio (1951) and International Commission for Bee Botany (Louveaux *et al.*, 1978). Pollen grains thus

prepared from pollen pellets as well as honey samples were examined under a Leica DML 1000 (Germany) bright field trinocular light microscope with 40x and 100x (oil) apochromatic objectives. Identification was done with the help of reference slides prepared from the local flora as well as published accounts. Preparation of reference slides were done by analyzing pollen taxa collected from the sampling sites of those two districts thorough out a calendaryear. Photomicrographs of suitable magnifications

were made with Leica MPS-60 photoautomat. Pollen pellets were categorized on the basis of their pollen constituents. Month wise incidences of different categories of pellets were evaluated. Frequencies of taxa were determined on the basis of at least one hundred load samples. For determining the frequency classes of taxa in honey samples, it was based on the count of 200-300 pollen grains for each sample.

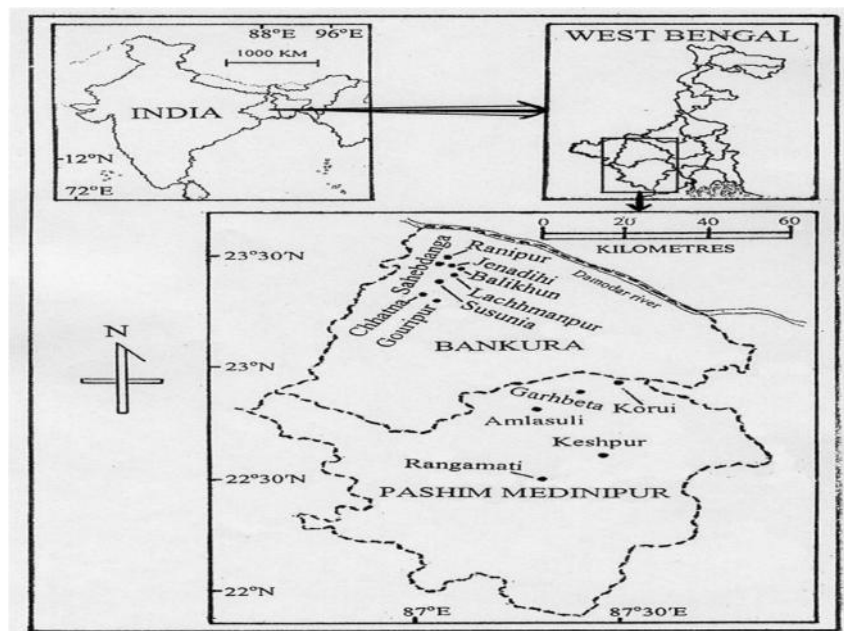


FIGURE 1. Map showing sample collection sites (•).

RESULTS

Pollen analysis of pollen pellets

During December 226 pairs of corbicular pollen pellets were analyzed. All corbicular pollen pellets were unifloral type. Out of the 226 pairs of corbicular pollen pellets, 4 pairs were of *Acmella radicans* (1.77%), 3 pairs of *Ageratum conyzoides* (1.33%), 54 pairs of *Brassica nigra* (23.89%), 3 pairs of *Capparis zeylanica* (1.33%), 5 pairs of *Chrysanthemum indicum* (2.21%), 5 pairs of *Cocos nucifera* (2.21%), 12 pairs of *Coriandrum sativum* (5.31%), 66 pairs of *Eucalyptus globulus* (29.20%), 6 pairs of *Eupatorium odoratum* (2.65%), 3 pairs of *Hygrophila schulli* (1.33%), 2 pairs of *Inga dulcis* (0.88%), 3 pairs of *Leucaena leucocephala* (1.33%), 14 pairs of *Mikania scandens* (6.19%), 2 pairs of *Mimosa pudica* (0.88%), 35 pairs of *Phoenix sylvestris* (15.49%), 2 pairs of *Polianthes tuberosa* (0.88%), 1 pair of *Ricinus communis* (0.44%) and 6 pairs of *Tagetes erecta* (2.65%) [Figure 2 A].

During January 220 pairs of corbicular pollen pellets were analyzed. All corbicular pollen pellets were unifloral type. Out of these 220 pairs, 13 pairs were of *Acmella radicans* (5.91%), 114 pairs of *Brassica nigra* (51.82%), 3 pairs of *Chrysanthemum indicum* (1.36%), 4 pairs of *Cocos nucifera* (1.82%), 30 pairs of *Coriandrum sativum* (13.64%), 9 pairs of *Eucalyptus globulus* (4.09%), 6 pairs of *Hygrophila schulli* (2.73%), 2 pairs of *Inga dulcis* (0.91%), 33 pairs of *Phoenix sylvestris* (15.00%), 1 pair of *Polianthes tuberosa* (0.45%), 2 pairs of *Ricinus communis*

(0.91%) and 3 pairs of *Tagetes erecta* (1.36%) [Figure 2 B]. Addition to these *Syzygium jambos* also recorded from field observations.

During February 239 pairs of corbicular pollen pellets were analyzed. All corbicular pollen pellets were unifloral type. Out of these 239 pairs, 11 pairs were of *Acmella radicans* (4.60%), 11 pairs of *Alangium salvifolium* (4.60%), 3 pairs of *Allium cepa* (1.26%), 111 pairs of *Brassica nigra* (46.44%), 7 pairs of *Cocos nucifera* (2.93%), 29 pairs of *Coriandrum sativum* (12.13%), 2 pairs of *Dalbergia sissoo* (0.84%), 18 pairs of *Eucalyptus globulus* (7.53%), 5 pairs of *Foeniculum vulgare* (2.09%), 10 pairs of *Helianthus annuus* (4.18%), 8 pairs of *Holoptelea integrifolia* (3.35%), 4 pairs of *Hygrophila schulli* (1.67%), 3 pairs of *Inga dulcis* (1.26%), 4 pairs of *Mikania scandens* (1.67%), 2 pairs of *Phoenix sylvestris* (0.84%), 2 pairs of *Psidium guajava* (0.84%), 3 pairs of *Ricinus communis* (1.26%), 2 pairs of *Spinacia oleracea* (0.84%) and 4 pairs of *Spondias pinnata* (1.67%) [Figure 2 C]. Addition to these *Syzygium jambos* also recorded from field observations.

During March 252 pairs of corbicular pollen pellets were analyzed. All corbicular pollen pellets were unifloral type. Out of these 252 pairs, 10 pairs were of *Alangium salvifolium* (3.97%), 6 pairs of *Albizia lebbeck* (2.38%), 3 pairs of *Allium cepa* (1.19%), 84 pairs of *Borassus flabellifer* (33.33%), 7 pairs of *Capparis zeylanica* (2.78%), 2 pairs of *Citrullus lanatus* (0.79%), 4 pairs of

Citrus maxima (1.59%), 23 pairs of *Coriandrum sativum* (9.13%), 2 pairs of *Dalbergia sissoo* (0.79%), 1 pair of *Evolvulus nummularius* (0.40%), 5 pairs of *Flacourtia jangomas* (1.98%), 4 pairs of *Foeniculum vulgare* (1.59%), 7 pairs of *Helianthus annuus* (2.78%), 7 pairs of *Holoptelea integrifolia* (2.78%), 2 pairs of *Hygrophila schulli* (0.79%), 43 pairs of *Lannea coromandelica*

(17.06%), 8 pairs of *Madhuca indica* (3.17%), 5 pairs of *Momordica charantia* (1.98%), 12 pairs of *Spinacia oleracea* (4.76%), 4 pairs of *Spondias pinnata* (1.59%), 11 pairs of *Syzygium cumini* (4.37%) and 2 pairs of *Vernonia cinerea* (0.79%) [Figure 2 D]. Addition to these *Syzygium jambos* also recorded from field observations.

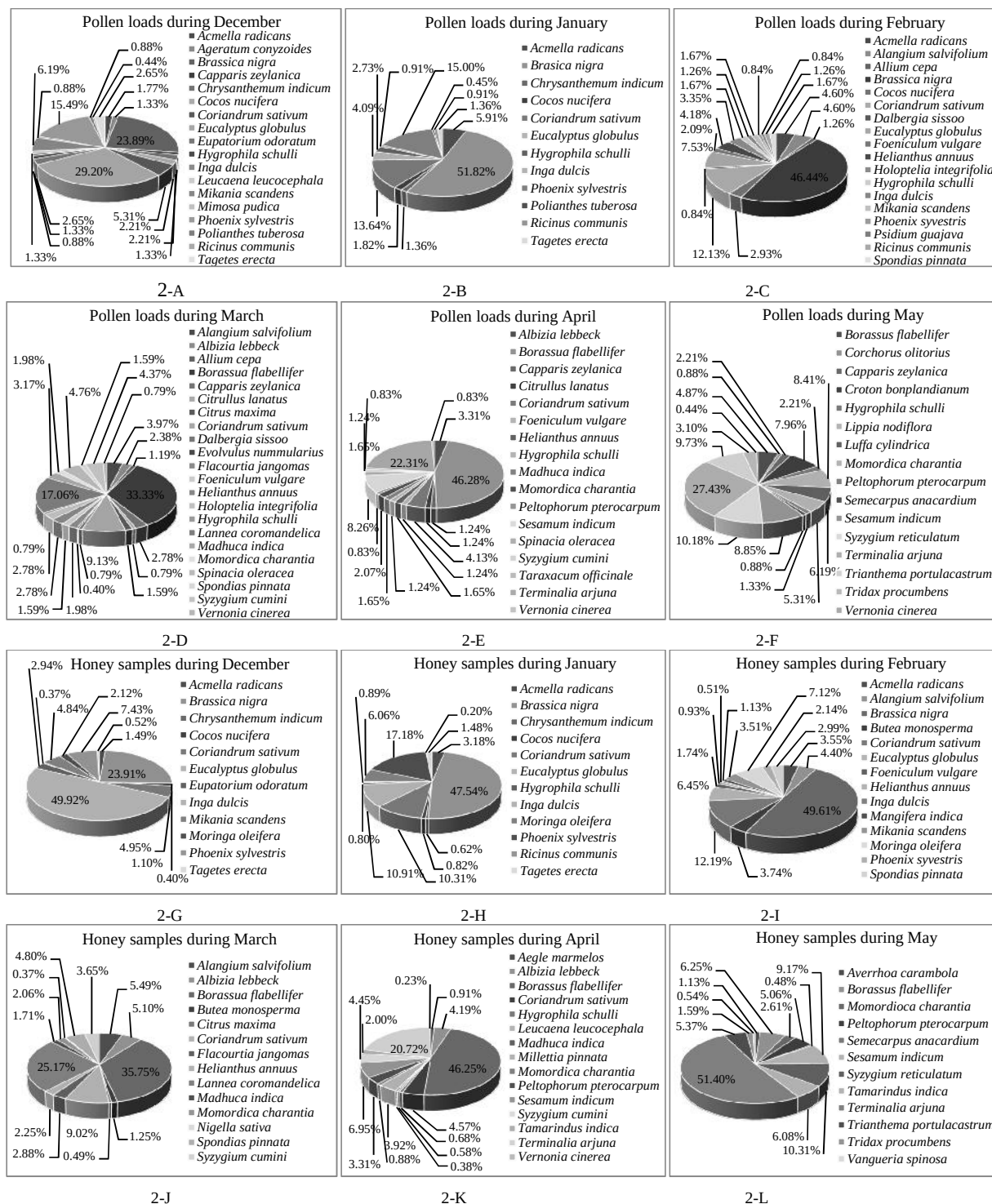


FIGURE 2. A-L Pie diagrams showing the month wise average percentage of pollen types in pollen pellets and honey samples of *Apis florea* in Bankura and Paschim Medinipur districts, West Bengal.

During April 242 pairs of corbicular pollen pellets were analyzed. All corbicular pollen pellets were unifloral type. Out of these 242 pairs, 8 pairs were of *Albizia lebbeck* (3.31%), 112 pairs of *Borassus flabellifer* (46.28%), 3 pairs of *Capparis zeylanica* (1.24%), 3 pairs of *Citrullus lanatus* (1.24%), 10 pairs of *Coriandrum sativum* (4.13%), 3 pairs of *Foeniculum vulgare* (1.24%), 4 pairs of *Helianthus annuus* (1.65%), 3 pairs of *Hygrophila schulli* (1.24%), 4 pairs of *Madhuca indica* (1.65%), 5 pairs of *Momordica charantia* (2.07%), 2 pairs of *Peltophorum pterocarpum* (0.83%), 20 pairs of *Sesamum indicum* (8.26%), 4 pairs of *Spinacia oleracea* (1.65%), 3 pairs of *Syzygium cumini* (1.24%), 2 pairs of *Taraxacum officinale* (0.83%), 54 pairs of *Terminalia arjuna* (22.31%) and 2 pairs of *Vernonia cinerea* (0.83%) [Figure 2 E].

During May 226 pairs of corbicular pollen pellets were analyzed. All corbicular pollen pellets were unifloral type. Out of the 226 pairs corbicular pollen pellets, 11 pairs were of *Borassus flabellifer* (4.87%), 5 pairs of *Capparis zeylanica* (2.21%), 2 pairs of *Corchorus olitorius* (0.88%), 18 pairs of *Croton bonplandianum* (7.96%), 5 pairs of *Hygrophila schulli* (2.21%), 19 pairs of *Lippia nodiflora* (8.41%), 14 pairs of *Luffa cylindrica* (6.19%), 12 pairs of

Momordica charantia (5.31%), 3 pairs of *Peltophorum pterocarpum* (1.33%), 2 pairs of *Semecarpus anacardium* (0.88%), 21 pairs of *Sesamum indicum* (8.85%), 23 pairs of *Syzygium reticulatum* (10.18%), 62 pairs of *Terminalia arjuna* (27.43%), 21 pairs of *Trinthena portulacastrum* (9.73%), 7 pairs of *Tridax procumbens* (3.10%) and 1 pair of *Vernonia cinerea* (0.44%) [Figure 2 F]. Addition to these *Murraya paniculata* also recorded from field observations.

Pollen analysis of honey samples

During December 5 honey samples were analyzed. Among them 3 honey samples were unifloral to *Eucalyptus globulus* (Table 1, Sample No. 11, 12 and 52) and 2 honey samples were multifloral. From these samples obtained pollen types were *Acmella radicans*, *Brassica nigra*, *Chrysanthemum indicum*, *Cocos nucifera*, *Coriandrum sativum*, *Eucalyptus globulus*, *Eupatorium odoratum*, *Inga dulcis*, *Mikania scandens*, *Moringa oleifera*, *Phoenix sylvestris* and *Tagetes erecta* (Figure 2 G). Other plants *Ageratum conyzoides*, *Cassia fistula*, *Grewia asiatica*, *Mimosa pudica*, *Psidium guajava*, *Ricinus communis* and *Sapindus mukorosi* also identified by field observations.

TABLE 1. Quantitative analysis of honey samples of *A. florea* as per Louveaux et al., 1978.

Sl. no.	Sample No.	Date of Collection	Pollen types	Predominant Pollen (>45%)	Secondary Pollen (16-45%)	Important Minor Pollen (3-15%)	Minor pollen (<3%)
1	11	05.12.09	<i>Eucalyptus globulus</i> (59.42%)	<i>Brassica nigra</i> (16.30%)	<i>Coriandrum sativum</i> (6.52%), <i>Mikania scandens</i> (3.99%), <i>Moringa oleifera</i> (4.35%) and <i>Phoenix sylvestris</i> (5.07%)	<i>Coriandrum sativum</i> (5.22%) and <i>Phoenix sylvestris</i> (7.84%)	<i>Acmella radicans</i> (1.81%) and <i>Eupatorium odoratum</i> (2.54%).
2	12	18.12.09	<i>Eucalyptus globulus</i> (55.60%)	<i>Brassica nigra</i> (20.15%)	<i>Coriandrum sativum</i> (5.22%) and <i>Phoenix sylvestris</i> (7.84%)	<i>Coriandrum sativum</i> (5.22%) and <i>Phoenix sylvestris</i> (7.84%)	<i>Acmella radicans</i> (1.12%), <i>Eupatorium odoratum</i> (2.24%), <i>Inga dulcis</i> (1.87%), <i>Mikania scandens</i> (2.99%) and <i>Moringa oleifera</i> (2.99%).
3	52	20.12.12	<i>Eucalyptus globulus</i> (48.09%)	<i>Brassica nigra</i> (23.28%)	<i>Cocos nucifera</i> (3.05%), <i>Coriandrum sativum</i> (6.11%), <i>Eupatorium odoratum</i> (4.96%), <i>Mikania scandens</i> (4.96%) and <i>Phoenix sylvestris</i> (6.87%)	<i>Cocos nucifera</i> (3.05%), <i>Coriandrum sativum</i> (6.11%), <i>Eupatorium odoratum</i> (4.96%), <i>Mikania scandens</i> (4.96%) and <i>Phoenix sylvestris</i> (6.87%)	<i>Acmella radicans</i> (2.67%).
4	33	21.12.11	Nil	<i>Brassica nigra</i> (29.44%) and <i>Eucalyptus globulus</i> (44.39%)	<i>Coriandrum sativum</i> (3.27%), <i>Eupatorium odoratum</i> (3.74%), <i>Mikania scandens</i> (7.01%) and <i>Phoenix sylvestris</i> (8.88%)	<i>Coriandrum sativum</i> (3.27%), <i>Eupatorium odoratum</i> (3.74%), <i>Mikania scandens</i> (7.01%) and <i>Phoenix sylvestris</i> (8.88%)	<i>Acmella radicans</i> (1.87%) and <i>Tagetes erecta</i> (1.40%).
5	53	30.12.12	Nil	<i>Brassica nigra</i> (30.36%) and <i>Eucalyptus globulus</i> (42.11%)	<i>Coriandrum sativum</i> (3.64%), <i>Mikania scandens</i> (5.26%), <i>Moringa oleifera</i> (3.24%) and <i>Phoenix sylvestris</i> (8.50%)	<i>Coriandrum sativum</i> (3.64%), <i>Mikania scandens</i> (5.26%), <i>Moringa oleifera</i> (3.24%) and <i>Phoenix sylvestris</i> (8.50%)	<i>Chrysanthemum indicum</i> (2.02%), <i>Cocos nucifera</i> (2.43%), <i>Eupatorium odoratum</i> (1.21%) and <i>Tagetes erecta</i> (1.21%).
6	54	12.01.13	Nil	<i>Brassica nigra</i> (43.45%)	<i>Acmella radicans</i> (4.14%), <i>Coriandrum sativum</i> (12.76%), <i>Eucalyptus globulus</i> (8.97%), <i>Hygrophila schulli</i> (3.10%), <i>Moringa oleifera</i> (8.62%) and <i>Phoenix sylvestris</i> (15.86%)	<i>Acmella radicans</i> (4.14%), <i>Coriandrum sativum</i> (12.76%), <i>Eucalyptus globulus</i> (8.97%), <i>Hygrophila schulli</i> (3.10%), <i>Moringa oleifera</i> (8.62%) and <i>Phoenix sylvestris</i> (15.86%)	<i>Chrysanthemum indicum</i> (2.07%) and <i>Tagetes erecta</i> (1.03%).
7	13	17.01.10	<i>Brassica nigra</i> (50.87%)	<i>Phoenix sylvestris</i> (16.72%)	<i>Coriandrum sativum</i> (9.06%), <i>Eucalyptus globulus</i> (9.41%) and <i>Moringa oleifera</i> (6.27%)	<i>Coriandrum sativum</i> (9.06%), <i>Eucalyptus globulus</i> (9.41%) and <i>Moringa oleifera</i> (6.27%)	<i>Acmella radicans</i> (2.44%), <i>Cocos nucifera</i> (1.39%), <i>Inga dulcis</i> (2.09%) and <i>Tagetes erecta</i> (1.74%).
8	34	30.01.12	<i>Brassica nigra</i> (53.85%)	Nil	<i>Coriandrum sativum</i> (6.33%), <i>Eucalyptus globulus</i> (14.48%) and <i>Phoenix sylvestris</i> (14.48%)	<i>Coriandrum sativum</i> (6.33%), <i>Eucalyptus globulus</i> (14.48%) and <i>Phoenix sylvestris</i> (14.48%)	<i>Cocos nucifera</i> (2.71%), <i>Hygrophila schulli</i> (0.90%) and <i>Tagetes erecta</i> (1.81%).
9	01	31.01.09	<i>Brassica nigra</i> (48.14%)	Nil	<i>Acmella radicans</i> (4.75%), <i>Coriandrum sativum</i> (12.88%), <i>Eucalyptus globulus</i> (12.20%), <i>Moringa oleifera</i> (5.08%) and	<i>Acmella radicans</i> (4.75%), <i>Coriandrum sativum</i> (12.88%), <i>Eucalyptus globulus</i> (12.20%), <i>Moringa oleifera</i> (5.08%) and	<i>Chrysanthemum indicum</i> (1.02%), <i>Inga dulcis</i> (2.37%) and <i>Ricinus</i>

10	24	31.01.11	Nil	<i>Brassica nigra</i> (41.40%) and <i>Phoenix sylvestris</i> (26.32%)	<i>Phoenix sylvestris</i> (12.54%), <i>Acmella radicans</i> (4.56%), <i>Coriandrum sativum</i> (10.53%), <i>Eucalyptus globulus</i> (9.47%), <i>Moringa oleifera</i> (4.91%)	<i>communis</i> (1.02%). <i>Tagetes erecta</i> (2.81%).
11	02	07.02.09	<i>Brassica nigra</i> (66.58%)	Nil	<i>Alangium salvifolium</i> (3.49%), <i>Coriandrum sativum</i> (7.98%), <i>Eucalyptus globulus</i> (5.24%), <i>Mikania scandens</i> (3.24%), <i>Moringa oleifera</i> (6.73%) and <i>Spondias pinnata</i> (3.74%)	<i>Helianthus annuus</i> (0.75%), <i>Mangifera indica</i> (0.50%) and <i>Phoenix sylvestris</i> (1.75%).
12	03	14.02.09	<i>Brassica nigra</i> (53.99%)	Nil	<i>Acmella radicans</i> (4.35%), <i>Coriandrum sativum</i> (11.23%), <i>Eucalyptus globulus</i> (8.70%), <i>Foeniculum vulgare</i> (5.43%) and <i>Moringa oleifera</i> (5.80%)	<i>Alangium salvifolium</i> (2.90%), <i>Inga dulcis</i> (2.54%), <i>Mikania scandens</i> (2.17%) and <i>Phoenix sylvestris</i> (2.90%).
13	35	26.02.12	Nil	<i>Brassica nigra</i> (38.41%)	<i>Acmella radicans</i> (3.99%), <i>Alangium salvifolium</i> (4.35%), <i>Butea monosperma</i> (5.80%), <i>Coriandrum sativum</i> (13.04%), <i>Eucalyptus globulus</i> (6.52%), <i>Foeniculum vulgare</i> (3.26%), <i>Mikania scandens</i> (7.97%) and <i>Moringa oleifera</i> (12.32%)	<i>Helianthus annuus</i> (2.17%) and <i>Phoenix sylvestris</i> (2.17%).
14	04	28.02.09	Nil	<i>Brassica nigra</i> (44.21%)	<i>Acmella radicans</i> (6.01%), <i>Alangium salvifolium</i> (6.87%), <i>Butea monosperma</i> (12.88%), <i>Coriandrum sativum</i> (15.02%), <i>Eucalyptus globulus</i> (6.44%) and <i>Mangifera indica</i> (5.15%)	<i>Helianthus annuus</i> (1.72%) and <i>Mikania scandens</i> (1.72%).
15	55	28.02.13	Nil	<i>Brassica nigra</i> (44.88%)	<i>Acmella radicans</i> (3.41%), <i>Alangium salvifolium</i> (4.39%), <i>Coriandrum sativum</i> (13.66%), <i>Eucalyptus globulus</i> (5.37%), <i>Moringa oleifera</i> (10.73%), <i>Spondias pinnata</i> (11.22%) and <i>Phoenix sylvestris</i> (3.90%).	<i>Mikania scandens</i> (2.44%).
16	05	05.03.09	Nil	<i>Borassus flabellifer</i> (29.31%) and <i>Lannea coromandelica</i> (31.72%)	<i>Alangium salvifolium</i> (11.03%), <i>Albizia lebbeck</i> (6.90%), <i>Butea monosperma</i> (4.14%), <i>Helianthus annuus</i> (7.24%), <i>Spondias pinnata</i> (4.14%) and <i>Syzygium cumini</i> (3.10%)	<i>Flacourtia jangomas</i> (2.41%).
17	36	09.03.12	Nil	<i>Borassus flabellifer</i> (32.44%), <i>Coriandrum sativum</i> (16.44%) and <i>Lannea coromandelica</i> (29.33%)	<i>Alangium salvifolium</i> (5.33%) <i>Flacourtia jangomas</i> (11.11%) and <i>Madhuca indica</i> (3.11%)	<i>Nigella sativa</i> (2.22%).
18	06	13.03.09	Nil	<i>Borassus flabellifer</i> (34.18%) and <i>Lannea coromandelica</i> (24.47%)	<i>Alangium salvifolium</i> (4.22%), <i>Butea monosperma</i> (3.38%), <i>Coriandrum sativum</i> (9.28%), <i>Madhuca indica</i> (3.38%), <i>Spondias pinnata</i> (9.28%) and <i>Syzygium cumini</i> (7.17%)	<i>Citrus maxima</i> (2.95%) and <i>Momordica charantia</i> (1.69%).
19	07	21.03.09	Nil	<i>Borassus flabellifer</i> (38.68%) and <i>Lannea coromandelica</i> (22.17%)	<i>Alangium salvifolium</i> (8.49%), <i>Albizia lebbeck</i> (4.25%), <i>Coriandrum sativum</i> (9.43%), <i>Flacourtia jangomas</i> (3.77%), <i>Madhuca indica</i> (3.77%), <i>Spondias pinnata</i> (5.19%) and <i>Syzygium cumini</i> (4.25%)	Nil
20	25	29.03.11	Nil	<i>Borassus flabellifer</i> (36.23%) and <i>Lannea coromandelica</i> (20.77%)	<i>Alangium salvifolium</i> (3.86%), <i>Albizia lebbeck</i> (9.18%), <i>Coriandrum sativum</i> (8.70%), <i>Helianthus annuus</i> (6.28%), <i>Momordica charantia</i> (8.21%) and <i>Spondias pinnata</i> (6.76%).	Nil
21	37	30.03.12	Nil	<i>Borassus flabellifer</i> (43.63%) and <i>Lannea coromandelica</i> (22.55%)	<i>Albizia lebbeck</i> (10.29%), <i>Coriandrum sativum</i> (10.29%), <i>Spondias pinnata</i> (3.43%) and <i>Syzygium cumini</i> (7.35%)	<i>Momordica charantia</i> (2.45%).
22	38	07.04.12	<i>Borassus flabellifer</i> (59.46%)	Nil	<i>Albizia lebbeck</i> (11.71%), <i>Coriandrum sativum</i> (11.71%) and <i>Syzygium cumini</i> (12.16%)	<i>Hygrophila schulli</i> (2.70%) and <i>Madhuca indica</i> (2.25%).
23	39	13.04.12	<i>Borassus flabellifer</i> (52.74%)	Nil	<i>Aegle marmelos</i> (5.47%), <i>Albizia lebbeck</i> (9.95%), <i>Coriandrum sativum</i> (6.97%), <i>Leucaena leucocephala</i> (3.48%), <i>Momordica charantia</i> (3.98%), <i>Syzygium cumini</i> (12.44%) and <i>Tamarindus indica</i> (4.98%).	Nil
24	14	22.04.10	Nil	<i>Borassus flabellifer</i> (44.83%)	<i>Albizia lebbeck</i> (3.45%), <i>Coriandrum sativum</i> (3.94%), <i>Milletia pinnata</i> (6.90%), <i>Peltophorum pterocarpum</i>	Nil

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25	56	28.04.13	<i>Borassus flabellifer</i> (54.70%)	Nil	(8.37%), <i>Sesamum indicum</i> (13.30%), <i>Tamarindus indica</i> (5.91%) and <i>Terminalia arjuna</i> (13.30%). <i>Helianthus annuus</i> (3.24%), <i>Milletia pinnata</i> (7.69%), <i>Peltophorum pterocarpum</i> (5.98%), <i>Sesamum indicum</i> (13.68%) and <i>Terminalia arjuna</i> (14.10%)	<i>Coriandrum sativum</i> (2.56%) and <i>Momordica charantia</i> (1.28%).
26	15	30.04.10	<i>Borassus flabellifer</i> (46.11%) and <i>Terminalia arjuna</i> (45.56%)	Nil	Nil	<i>Coriandrum sativum</i> (2.22%), <i>Milletia pinnata</i> (1.67%), <i>Sesamum indicum</i> (1.94%), <i>Tamarindus indica</i> (1.11%) and <i>Vernonia cinerea</i> (1.39%).
27	40	30.04.12	<i>Terminalia arjuna</i> (51.38%)	<i>Borassus flabellifer</i> (19.66%)	<i>Milletia pinnata</i> (7.24%), <i>Peltophorum pterocarpum</i> (5.52%) and <i>Sesamum indicum</i> (12.76%)	<i>Hygrophila schulli</i> (1.38%) and <i>Syzygium cumini</i> (2.07%).
28	41	06.05.12	<i>Terminalia arjuna</i> (59.72%)	Nil	<i>Borassus flabellifer</i> (10.19%), <i>Sesamum indicum</i> (13.89%), <i>Tamarindus indica</i> (12.96%) and <i>Vangueria spinosa</i> (3.24%).	Nil
29	57	10.05.13	Nil	<i>Sesamum indicum</i> (19.35%), <i>Syzygium reticulatum</i> (21.20%) and <i>Terminalia arjuna</i> (32.72%)	<i>Momordica charantia</i> (8.76%), <i>Peltophorum pterocarpum</i> (3.23%) and <i>Tamarindus indica</i> (14.75%)	Nil
30	26	13.05.11	Nil	<i>Sesamum indicum</i> (20.00%), <i>Terminalia arjuna</i> (31.71%)	<i>Borassus flabellifer</i> (9.76%), <i>Peltophorum pterocarpum</i> (7.32%), <i>Syzygium reticulatum</i> (13.17%), <i>Tamarindus indica</i> (8.78%) and <i>Trianthema portulacastrum</i> (9.27%).	Nil
31	16	18.05.10	<i>Terminalia arjuna</i> (88.79%)	Nil	<i>Borassus flabellifer</i> (4.04%) and <i>Syzygium reticulatum</i> (5.38%)	<i>Sesamum indicum</i> (1.79%).
32	17	29.05.10	Nil	<i>Peltophorum pterocarpum</i> (19.82%), <i>Syzygium reticulatum</i> (22.12%), <i>Terminalia arjuna</i> (34.10%)	<i>Momordica charantia</i> (6.91%) and <i>Trianthema portulacastrum</i> (14.75%)	<i>Tridax procumbens</i> (2.30%).
33	42	30.05.12	<i>Terminalia arjuna</i> (61.35%)	Nil	<i>Averrhoa carambola</i> (6.76%), <i>Borassus flabellifer</i> (13.53%), <i>Trianthema portulacastrum</i> (8.21%) and <i>Tridax procumbens</i> (7.25%)	<i>Semecarpus anacardium</i> (2.90%).

During January 5 honey samples were analyzed. Among them 3 honey samples were unifloral to *Brassica nigra* (Table 1, Sample No. 01, 13 and 34) and other 2 were multifloral. Samples comprises the pollen types of *Acmella radicans*, *Brassica nigra*, *Chrysanthemum indicum*, *Cocos nucifera*, *Coriandrum sativum*, *Eucalyptus globulus*, *Hygrophila schulli*, *Inga dulcis*, *Moringa oleifera*, *Phoenix sylvestris*, *Ricinus communis* and *Tagetes erecta* (Figure 2 H). Addition to these *Syzygium jambos* also recorded from field observations.

During February 5 honey samples were analyzed. Among them 2 honey samples were unifloral to *Brassica nigra* (Table 1, Sample No. 02 and 03) and other 3 were multifloral types. From these samples obtained pollen types were *Acmella radicans*, *Alangium salvifolium*, *Brassica nigra*, *Butea monosperma*, *Coriandrum sativum*, *Eucalyptus globulus*, *Foeniculum vulgare*, *Helianthus annuus*, *Inga dulcis*, *Mangifera indica*, *Mikania scandens*, *Moringa oleifera*, *Phoenix sylvestris* and *Spondias pinnata* (Figure 2 I). Other plants *Allium cepa*, *Cucurbita maxima*, *Dalbergia sissoo*, *Dolichos lablab*, *Justicia gendarussa*, *Melia azedarach*, *Nigella sativa*, *Psidium guajava*, *Ricinus communis* and *Syzygium jambos* also identified by field observations.

During March 6 honey samples were analyzed. All honey samples were multifloral and yields pollen types of

Alangium salvifolium, *Albizia lebbeck*, *Borassus flabellifer*, *Butea monosperma*, *Citrus maxima*, *Coriandrum sativum*, *Flacourtia jangomas*, *Helianthus annuus*, *Lannea coromandelica*, *Madhuca indica*, *Momordica charantia*, *Nigella sativa*, *Spondias pinnata* and *Syzygium cumini* (Figure 2 J). Other plants *Allium cepa*, *Citrullus lanatus*, *Cucurbita maxima*, *Dalbergia sissoo*, *Foeniculum vulgare*, *Inga dulcis*, *Justicia gendarussa*, *Litchi chinensis*, *Murraya koenigii* and *Syzygium jambos* also identified by field observations.

During April 6 honey samples were analyzed. Among them 3 honey samples were unifloral to *Borassus flabellifer* (Table 1, Sample No. 38, 39 and 56), 1 honey sample was unifloral to *Terminalia arjuna* (Table 1, Sample No. 40) and other 2 were multifloral. From these samples obtained pollen types were *Aegle marmelos*, *Albizia lebbeck*, *Borassus flabellifer*, *Coriandrum sativum*, *Hygrophila schulli*, *Leucaena leucocephala*, *Madhuca indica*, *Milletia pinnata*, *Momordica charantia*, *Peltophorum pterocarpum*, *Sesamum indicum*, *Syzygium cumini*, *Tamarindus indica*, *Terminalia arjuna* and *Vernonia cinerea* (Figure 2 K). Other plants *Averrhoa carambola*, *Azadirachta indica*, *Cassia fistula*, *Citrullus lanatus*, *Cucurbita maxima*, *Foeniculum vulgare*, *Helianthus annuus*, *Psidium guajava* and *Taraxacum officinale* also identified by field observations.

During May 6 honey samples were analyzed. Among them 3 honey samples were unifloral to *Terminalia arjuna* (Table 1, Sample No. 16, 41 and 42) and other 3 were multifloral. From these samples obtained pollen types were *Averrhoa carambola*, *Borassus flabellifer*, *Momordica charantia*, *Peltophorum pterocarpum*, *Semecarpus anacardium*, *Sesamum indicum*, *Syzygium*

reticulatum, *Tamarindus indica*, *Terminalia arjuna*, *Trianthema portulacastrum*, *Tridax procumbens* and *Vangueria spinosa* (Figure 2L). Addition to these *Citrullus lanatus*, *Corchorus olitorius*, *Lippia nodiflora*, *Luffa cylindrica*, *Murraya paniculata* also recorded from field observations.

TABLE 2. List of plant species foraged by *Apis florea* during December to May in Bankura and Paschim Medinipur districts, West Bengal (N= nectar, P= pollen grains, N+P= Nectar and pollen grain both).

Family	Plant species	Habit	Flowering-season	Status
Acanthaceae	<i>Hygrophila schulli</i> (Buch.-Ham.) M. R. & S. M. Almeida	Herb	September-April	N+P
	<i>Justicia gendarussa</i> Burm. f.	Shrub	February-March	N
	<i>Polianthes tuberosa</i> L.	Herb	Throughout the year	P
Agavaceae	<i>Trianthema portulacastrum</i> L.	Herb	April-October	N+P
Aizoaceae	<i>Alangium salvifolium</i> (L. f.) Wang.	Tree	February-April	N+P
Amaryllidaceae	<i>Allium cepa</i> L.	Herb	March-April	N+P
Anacardiaceae	<i>Lannea coromandelica</i> (Houtt.) Merr.	Tree	February-March	N+P
	<i>Mangifera indica</i> L.	Tree	January-March	N
	<i>Semecarpus anacardium</i> L. f.	Tree	May-June	N+P
Apiaceae	<i>Spondias pinnata</i> (L. f.) Kurz	Tree	January-April	N+P
	<i>Coriandrum sativum</i> L.	Herb	December-May	N+P
	<i>Foeniculum vulgare</i> Mill.	Herb	December-May	N+P
Arecaceae	<i>Borassus flabellifer</i> L.	Tree	March-May	N+P
	<i>Cocos nucifera</i> L.	Tree	Throughout the year	N+P
	<i>Phoenix sylvestris</i> L. Roxb.	Tree	January-May	N+P
Asteraceae	<i>Acmella radicans</i> (Jacquin) R. K. Jansen	Herb	December-March	N+P
	<i>Ageratum conyzoides</i> L.	Herb	July-December	N+P
	<i>Chrysanthemum indicum</i> L.	Herb	December-April	N+P
	<i>Eupatorium odoratum</i> L.	Shrub	November-July	N+P
	<i>Helianthus annuus</i> L.	Shrub	February-April	N+P
	<i>Mikania scandens</i> B. L. Rob.	Creeping	November-May	N+P
	<i>Tagetes erecta</i> L.	Herb	Throughout the year	N+P
	<i>Taraxacum officinale</i> F. H. Wigg	Herb	March-May	N+P
	<i>Tridax procumbens</i> L.	Herb	Throughout the year	N+P
	<i>Vernonia cinerea</i> Less.	Herb	March-May	N+P
Brassicaceae	<i>Brassica nigra</i> L.	Herb	November-March	N+P
Capparaceae	<i>Capparis zeylanica</i> L.	Creeping	February-April	P
Chenopodiaceae	<i>Spinacia oleracea</i> L.	Herb	January-April	P
Combretaceae	<i>Terminalia arjuna</i> DC. Wight & Arn.	Tree	April-June	N+P
Convolvulaceae	<i>Evolvulus nummularius</i> (L.) L.	Herb	February-May	P
Cucurbitaceae	<i>Citrullus lanatus</i> (Thunb.) Matsum. & Nakai	Prostrate or climber	February-May	N+P
	<i>Cucurbita maxima</i> Duchesne	Prostrate or climber	Throughout the year	N
	<i>Luffa cylindrica</i> L.	Prostrate or climber	May-October	N+P
	<i>Momordica charantia</i> L.	Prostrate or climber	February-August	N+P
Euphorbiaceae	<i>Croton bonplandianum</i> Baill.	Herb	April-August	P
	<i>Ricinus communis</i> L.	Shrub	July-February	N+P
Fabaceae	<i>Albizia lebbek</i> (L.) Benth.	Tree	March-May	N+P
	<i>Butea monosperma</i> (Lam.) Taub.		February-April	N
	<i>Cassia fistula</i> L.	Tree	March-April	N
	<i>Dalbergia sissoo</i> Roxb.	Tree	April-August	N+P
	<i>Dolichos lablab</i> L.	Creeping	November-April	N
	<i>Inga dulcis</i> (Roxb.) Willd	Tree	November-March	N+P
	<i>Leucaena leucocephala</i> (Lam.) de Wit	Tree	June-October	N+P
	<i>Milletia pinnata</i> (L.) Panigrahi	Tree	March-June	N
	<i>Mimosa pudica</i> L.	Herb	Throughout the year	N+P
	<i>Peltophorum pterocarpum</i> DC. K. Heyne	Tree	March-June	N+P
Malvaceae	<i>Tamarindus indica</i> L.	Tree	April-August	N
	<i>Grewia asiatica</i> L.	Tree	December-January	N
	<i>Azadirachta indica</i> A. Juss.	Tree	March-May	N
Meliaceae	<i>Melia azedarach</i> L.	Tree	February-April	N
Moringaceae	<i>Moringa oleifera</i> Lam.	Tree	November-March	N+P
Myrtaceae	<i>Eucalyptus globulus</i> Labill.	Tree	November-April	N+P
	<i>Psidium guajava</i> L.	Tree	January-May	N+P
	<i>Syzygium cumini</i> L. Skeels	Tree	March-April	N+P
	<i>Syzygium jambos</i> L. (Alston)	Tree	January-March	N+P
	<i>Syzygium reticulatum</i> (Wight) Walp.	Tree	May-June	N+P
Oxalidaceae	<i>Averrhoa carambola</i> L.	Tree	March-September	N
Pedaliaceae	<i>Sesamum indicum</i> L.	Herb	April-June	N+P
Ranunculaceae	<i>Nigella sativa</i> L.	Herb	January-March	N
Rubiaceae	<i>Vangueria spinosa</i> Roxb.	Shrub	May-July	N

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Rutaceae	<i>Aegle marmelos</i> L. Corr. Serr.	Tree	April-July	N
	<i>Citrus maxima</i> Burm. Men.	Tree	February-April	N+P
	<i>Murraya koenigii</i> (L.) Sprengel	Shrub	February-April	N
	<i>Murraya paniculata</i> (L.) Jack	Tree	Throughout the year	N+P
Salicaceae	<i>Flacourtia jangomas</i> (Lour.) Raeusch.	Tree	February-March	N+P
Sapindaceae	<i>Litchi chinensis</i> Sonn.	Tree	February-March	N
	<i>Sapindus mukorossi</i> Gaertn.	Tree	November-January	N
Sapotaceae	<i>Madhuca indica</i> J. F. Gmel.	Tree	March-April	N+P
Tiliaceae	<i>Corchorus olitorius</i> L.	Herb	May-June	N+P
Ulmaceae	<i>Holoptelea integrifolia</i> (Roxb.) Planchon	Tree	February-March	P
Verbenaceae	<i>Lippia nodiflora</i> (Linn.) Rich.	Herb	May-July	N+P

DISCUSSION

Present work reveals that 71 species of angiosperms belonging to 32 families were visited by *A. florea* in Bankura and Paschim Medinipur district of West Bengal during December to May (Table 2). Some of those

angiospermic pollen taxa have been depicted in plate 1. Among those, 19 plant species contributed only nectar, 6 taxa contributed only pollen grains and remaining 46 species supplied both nectar and pollen grains.

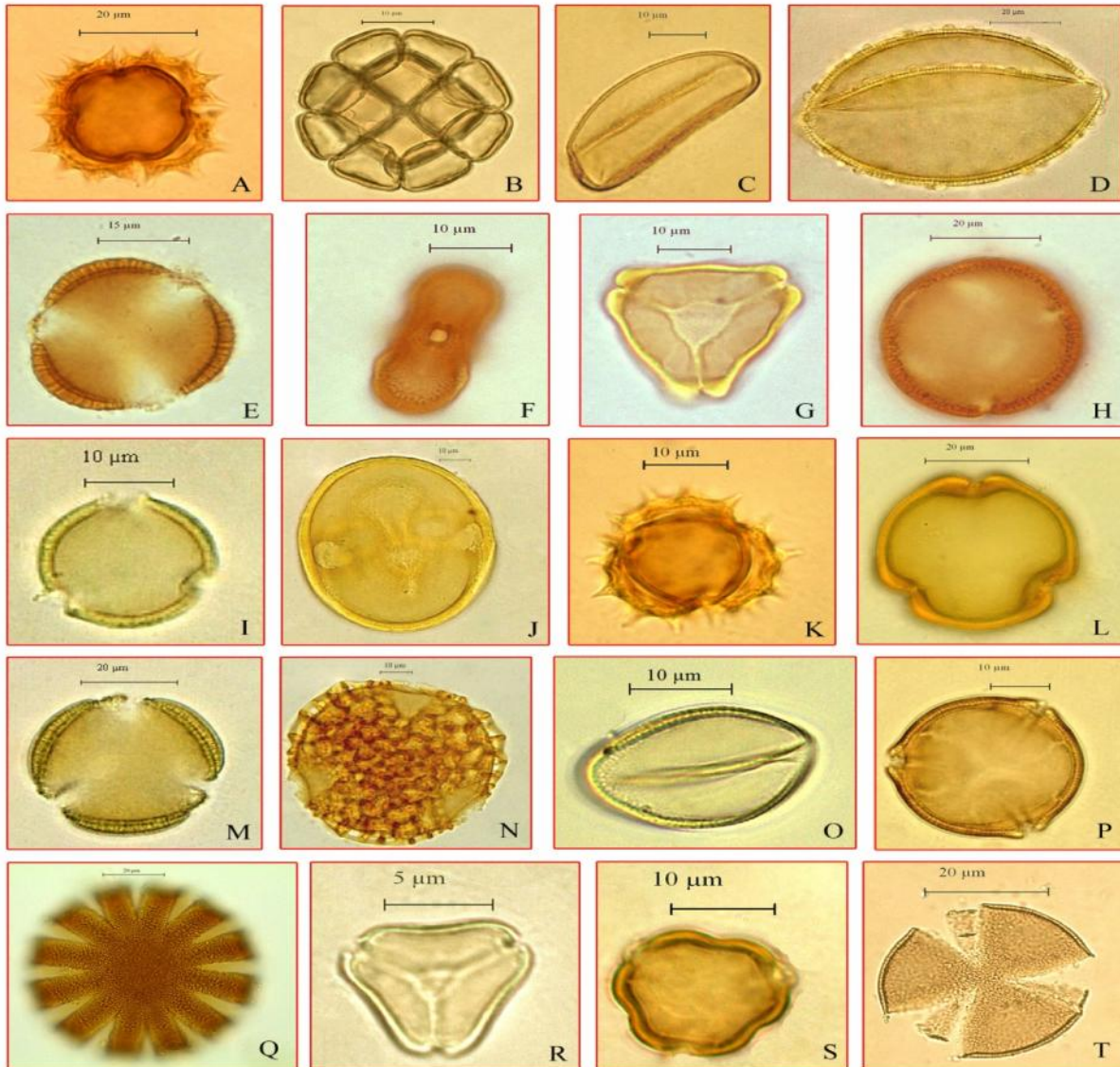


PLATE 1. Pollen grains of (A) *Acmella radicans*, (B) *Albizia lebbeck*, (C) *Allium cepa*, (D) *Borassus flabellifer*, (E) *Brassica nigra*, (F) *Coriandrum sativum*, (G) *Eucalyptus globulus*, (H) *Evolvulus nummularius*, (I) *Lansea coromandelica*, (J) *Madhuca indica*, (K) *Mikania scandens*, (L) *Moringa oleifera*, (M) *Nigella sativa*, (N) *Peltophorum pterocarpum*, (O) *Phoenix sylvestris*, (P) *Ricinus communis*, (Q) *Sesamum indicum*, (R) *Syzygium reticulatum*, (S) *Terminalia arjuna* and (T) *Trianthema portulacastrum*.

Plants offer only nectar are *Aegle marmelos*, *Averrhoa carambola*, *Azadirachta indica*, *Butea monosperma*,

Cassia fistula, *Cucurbita maxima*, *Dolichos lablab*, *Grewia asiatica*, *Justicia gendarussa*, *Litchi chinensis*,

Mangifera indica, *Melia azedarach*, *Millettia pinnata*, *Moringa oleifera*, *Murraya koenigii*, *Nigella sativa*, *Sapindus mukorosi*, *Tamarindus indica* and *Vangueria spinosa*. The plants provide only pollen grains are *Capparis zeylanica*, *Croton bonplandianum*, *Evolvulus nummularius*, *Holoptelea integrifolia*, *Polianthes tuberosa* and *Spinacia oleracea*. The plants tender both nectar and pollen grains are *Acmella radicans*, *Ageratum conyzoides*, *Alangium salvifolium*, *Albizia lebbeck*, *Allium cepa*, *Borassus flabellifer*, *Brassica nigra*, *Chrysanthemum indicum*, *Citrullus lanatus*, *Citrus maxima*, *Cocos nucifera*, *Corchorus olitorius*, *Coriandrum sativum*, *Dalbergia sissoo*, *Eucalyptus globulus*, *Eupatorium odoratum*, *Flacourtia jangomas*, *Foeniculum vulgare*, *Helianthus annuus*, *Hygrophila schulli*, *Inga dulcis*, *Lannea coromandelica*, *Leucaena leucocephala*, *Lippia nodiflora*, *Luffa cylindrica*, *Madhuca indica*, *Mikania scandens*, *Mimosa pudica*, *Momordica charantia*, *Murraya paniculata*, *Peltophorum pterocarpum*, *Phoenix sylvestris*, *Psidium guajava*, *Ricinus communis*, *Semecarpus anacardium*, *Sesamum indicum*, *Spondias pinnata*, *Syzygium cumini*, *Syzygium jambos*, *Syzygium reticulatum*, *Tagetes erecta*, *Taraxacum officinale*, *Terminalia arjuna*, *Trianthema portulacastrum*, *Tridax procumbens* and *Vernonia cinerea*.

CONCLUSION

During the period from December to May, *A. florea* accumulates surplus honey in their hives. The pollen spectra of honey samples reveal that *A. florea* produced both unifloral and multifloral honeys. Among the total of 33 honey samples collected during winter and spring-summer, 15 honey samples were unifloral and 18 were of multifloral in origin. Among the unifloral honey samples 3 were *Borassus flabellifer* type, 5 were *Brassica nigra* type, 3 were *Eucalyptus globulus* type and 4 were *Terminalia arjuna* type. Other important nectar yielding plants were *Butea monosperma*, *Coriandrum sativum*, *Lannea coromandelica*, *Moringa oleifera*, *Peltophorum pterocarpum*, *Phoenix sylvestris*, *Sesamum indicum*, *Syzygium reticulatum* and *Tamarindus indica*. The most important pollen pellets providing taxa during that period were *Borassus flabellifer*, *Brassica nigra*, *Coriandrum sativum*, *Eucalyptus globulus*, *Lannea coromandelica*, *Phoenix sylvestris* and *Terminalia arjuna*.

Among the plant taxa that were foraged by *A. florea*, a large numbers are of agri- horticultural plants cultivated in those areas viz. *Allium cepa*, *Brassica nigra*, *Citrullus lanatus*, *Citrus maxima*, *Cocos nucifera*, *Coriandrum sativum*, *Cucurbita maxima*, *Dolichos lablab*, *Foeniculum*

vulgare, *Helianthus annuus*, *Litchi chinensis*, *Mangifera indica*, *Momordica charantia*, *Moringa oleifera*, *Nigella sativa*, *Psidium guajava*, *Sesamum indicum* and *Spinacia oleracea*. While collecting nectar and pollen from the flowers of above mentioned crops, *A. florea* help in their pollination that result in higher yields and better quality produce. Thus, colonies of *A. florea* through pollination services benefits society by increasing food security and improving livelihoods and also plays in conserving biological diversity in agricultural and natural ecosystems.

RECOMMENDATION

From the above study, it should be recommended that winter and spring-summer period may utilize to collect honey from wild hives as well as managed bee hive during apicultural practice in West Bengal.

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