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Floral hosts and pollen calendar of Asian giant honeybee, *Apis dorsata* Fabricius at southern Karnataka, India

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Observations were made during 2011 and 2012 to record the floral hosts of Asian giant honeybee, *Apis dorsata* (Hymenoptera: Apidae) by following standard methods at arid, semi-arid and malnad regions of southern Karnataka, India. These regions are enriched with 252 foraging plant species which belong to 74 families with trees (49.3%), herbs (23.5%), shrubs (21.7%) and climbers (5.5%), supplying both pollen and nectar (63%), nectar (17.7%) and pollen (18.9%) source to *A. dorsata* population during different seasons. The Shanon-Wiener diversity index (H') showed high species diversity, that is, 3.256 to 3.864, indicating the constant nectar flow with little variations to *A. dorsata* population. Since, *A. dorsata*is a voracious forager, it prefers to survive in the wild and contributes significantly to the pollination of various plants in this region leading to improvement in local vegetation. *A. dorsata* produces useful hive products to mankind. Knowledge on the floral hosts helps prepare pollen calendar that would reveal plant diversity and their interactions with insect pollinators in an ecosystem. Thus, it is important to conserve both plants and insect pollinators (for example, *A. dorsata*) to sustain our livelihoods and protect the local biodiversity.

Key words: Floral hosts, pollen calendar, *Apis dorsata,* southern Karnataka.

INTRODUCTION

Asian giant honeybee, *Apis dorsata* Fabricius (Hymenoptera: Apidae) is one of the largest bees in the genus *Apis* (Oldroyd et al., 2000). Being a voracious forager, *A. dorsata* shows high nectar and pollen gathering potential from various plants, which bear different size and shape inflorescence, secreting good amount of nectar and pollen. It migrates from place to place (for example, plains to hilly area and vice-versa) in response to varying floral resource (Dyer and Seely, 1994). During migration, *A. dorsata* interact with diversified flora for pollen and nectar. While doing so, it pollinates and propagates various flowering plants (Shubharani and Venkataramegowda, 2012) and help in local biodiversity conservation (Buchmann and Nabhan, 1996; Zayed, 2009).

In India, Karnataka State is housed with more than 4,758 plant species from 1408 genera and 178 families and accounts for about 27% of Indian floral diversity

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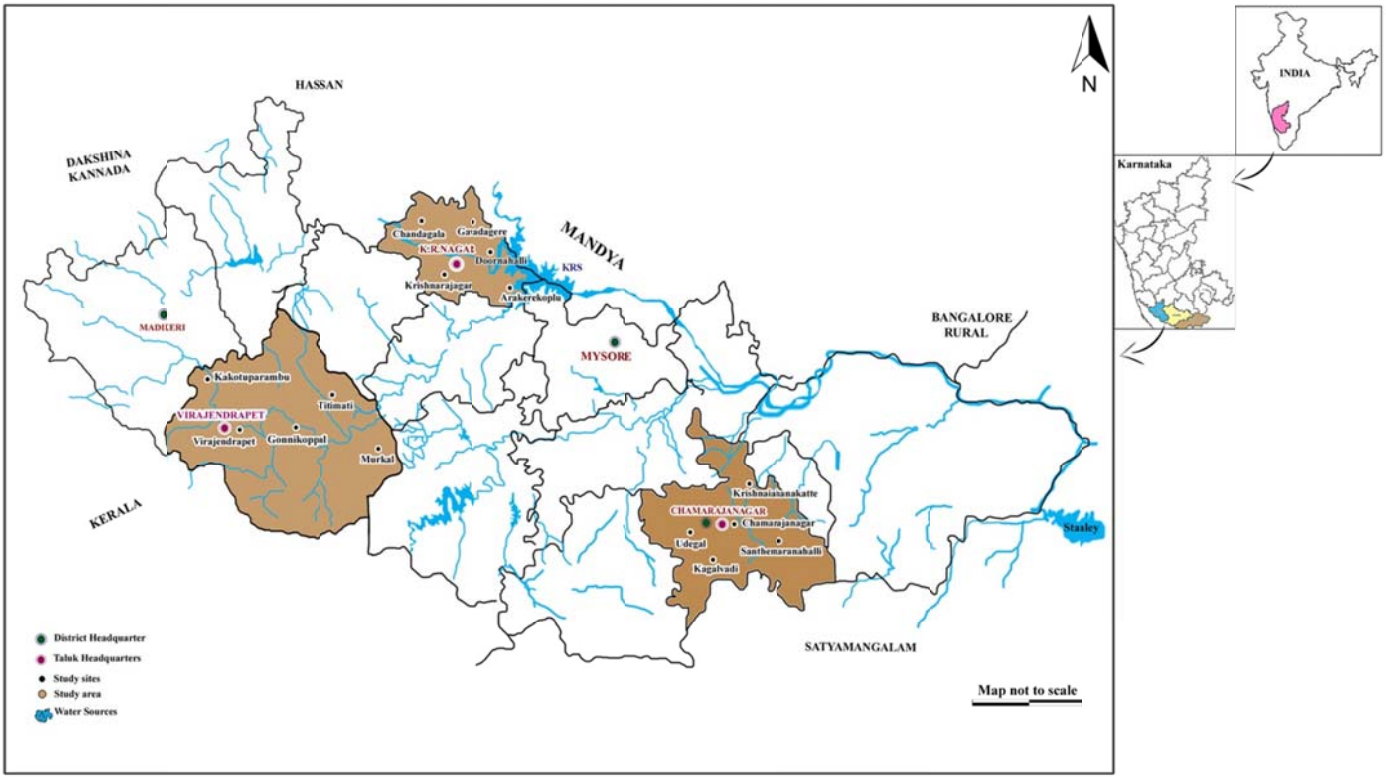

Figure 1. Map showing the study sites in southern Karnataka.

(Ganeshaiah et al., 2002). Of all, only few tree species appears to be used for nesting by *A. dorsata*. Moreover, several hundred flowering plant species are used for floral source by *A. dorsata*in the wild (Basavarajappa, 1998; Rao, 1998; Reddy and Reddy, 1989). Interestingly, domesticated honeybees namely *Apiscerana* and *Apismellifera* floral hosts were extensively studied at different regions of Karnataka by various authors. However, such type of studies exclusively on *A. dorsata* is meager and little is known about its flora at different parts of Karnataka and hence the foraging preference of *A. dorsata* is little known. Further, *A. dorsata* great role as pollinators of several plant species at its area of distribution is not reported in many countries (Neupane et al., 2006). Very few reports are available on the floral hosts of *A. dorsata* in India (Basavarajappa, 2012). Basavarajappa (1998 and 2004), Rao (1998) and Reddy and Reddy (1989) have reported the flowering plant species used as floral source by *A. dorsata* in the wild. However, reports on floral hosts to *A. dorsata* at arid, semi-arid and malnad regions of southern Karnataka are scanty. Moreover, there is a fairly even distribution of information on plant species (trees, shrubs, herbs and climbers), their nectar and pollen source for *A. dorsata* population and to predict pollen calendar in this part of Karnataka State.

Further, in recent past, *A. dorsata* population is declining gradually due to various man-made activities in southern Karnataka (Basavarajappa, 2012). It would affect the reproductive success of several plant species in the wild as well as at man-made ecosystems. Since, pollination is an essential ecosystem service that results in gene flow among flora both at man-made and natural ecosystems (Partap et al., 2000). Therefore, there is a dire need to identify the foraging plants (trees, shrubs, herbs and climbers) diversity and *A. Dorsata* interaction with these plant species. Being one of the most reliable natural pollinators, information on *A. dorsata* foraging plants is a pre-requisite to frame a pollen calendar to harness its hive products at different agro-ecological regions (Neupane et al., 2006). Hence, the present investigation was undertaken.

MATERIALS AND METHODS

Field observations were conducted in 2011 and 2012 to record the flowering plants namely trees, shrubs, herbs and climbers located on road sides, residential areas and in agri-horticultural ecosystems at the vicinity of *A. dorsata* colonies at arid, semi-arid and malnad regions of southern Karnataka, India (Figure 1). In arid (region with sparse rainfall, less humidity and dry conditions), semi-arid (region with moderate rainfall, humidity with congenial climate and malnad

(region with heavy rainfall, high humidity with wet climate) regions, minimum of three to maximum four study sites (100^2 meter sized areas) were earmarked randomly and altogether 12 study sites were selected. Each study site was visited nine times separately during rainy (June to September) winter (October to January) and summer (February to May) seasons. *A. dorsata* foraging plants were recorded by employing direct visual count (DVC) and an all out search (AOS) methods. Foraging plants were record by spending 10 to 15 min at every flowering plant after observing the movement of *A. dorsata* forager bees. *A. dorsata* forager bees visited flowering plants were recorded and classified into different types namely trees, shrubs, herbs and climbers as per Rao (1998) so as to determine their species richness and evenness as per Magurran (2004). Moreover, information on foraging plants was also collected from farmers, residents and people who knew about *A. dorsata* (locally called 'Hejjenu') by personal interaction. Foraging plants were photographed with the help of Canon-Power Shot S21S, 8.0 Mega Pixels Digital Camera with 12X Optical Zoom. The leaves and twigs of such flowering plants were collected and brought to the laboratory for identification with the help of herbarium, plant taxonomists and taxonomic keys as well as information given by Gamble (1967). The identified foraging plants were grouped into trees, shrubs, herbs, climbers and they were further grouped into medicinal plants (MPs) (various parts *viz*., leaf, stem, bark, root, flowers etc, of these plants are used for treating certain diseases), ornamental plants (OPs) (plants used extensively for their flowers), economically important plants (EIPs) (wood of these plants are used for timber production), fruit yielding plants (FYPs) (fruit producing plants) and vegetable plants (VPs) (leaves, tuber, flower, stem etc, of these plants are used as vegetables) to reveal their percent occurrence as per Rao (1973) and Basavarajappa (1998). Since, classifying flora into various groups is routinely practiced in beekeeping areas to understand the nectar and pollen production potential, it help to estimate the nectar flow in unifloral or multifloral honey production potential of the region (Rao, 1998; Basavarajappa, 2012).The percentage of trees, shrubs, herbs and climbers MPs, OPs, EIPs, FYPs and VPs were calculated by following the standard formula. The percent occurrence of specific type of foraging plant =*A. dorsata* foraging bees observed on specific type of plant/Total number of flowering plants on which *A. dorsata* forger bees recorded x 100. To prepare the pollen calendar, all the flowering plants were further grouped into pollen, nectar and both pollen and nectar producing plants as per Rao (1973) so as to understand their apicultural values. Analysis of variance (ANOVA) was done to know the variation in distribution of flowering plants at different regions of southern Karnataka. Moreover, Shannon-Wiener diversity index (H') was used to calculate the diversity of flowering plants at arid, semi-arid and malnad regions by following the equation as per Magurran (2004).

$$H' = -\sum p_i \ln p_i$$

H'= Shannon-Wiener Index; P_i = The proportion of individual flowering plant species found in the I^{th} species.

RESULTS

The distribution of foraging plant families of *A. dorsata* at arid, semi-arid and malnad regions of southern Karnataka is given in Table 1. Altogether 252 flowering plants belong to 74 families were interacted by *A. dorsata* for its floral source at southern Karnataka (Table 1). Amongst regions, malnad has highest (117) for aging plant species, which supported the *A. dorsata* population by extending nectar and pollen source. However, the foraging plants at semi-arid and arid regions were 73 and 62 species, respectively (Table 1). Analysis of variance of the data indicated that there was a significant variation ($F=5.6848$; $P>0.001$) existed between the regions with respect to the distribution of foraging plants (Table 1).

Further, distribution of flora type (trees, shrubs, herbs and climbers) and their importance to mankind as MPs, EIPs, OPs, FYPs and VPs, their percent contribution and the apicultural value of these plant species in terms of nectar and pollen supply to *A. dorsata* population at arid, semi-arid and malnad regions of southern Karnataka is depicted in Table 2. Among them, trees contributed highest (49.3%) floral source, it was followed by herbs and shrubs respectively 23.5 and 21.7%. The climbers extended 5.5% floral source to *A. dorsata* population (Table 2). Amongst foraging plants, medicinal plants (for example, *Centellaasiatica*, *Tinosporacordifolia*, *Hibiscus rosasinensis* etc.), fruit yielding plants (for example, *Mangiferaindica, Anonareticulata, Anonasquamosa, Tamarindusindica* etc.), economically important plants (for example, *Santalum album, Terminalia* sp. etc.), ornamental plants (for example, *Abutilon rosea, Impatiens balsaminia* etc.) and vegetable plants (for example, *Lagenarialecuantha, Momordicacharantia, Cucurbita maxima* etc.) were contributed floral source respectively 38.6, 15.6, 21.4, 15.7 and 8.7% to *A. dorsata* population at southern Karnataka (Table 2). Total, both pollen and nectar yielding plants provided more (63.4%) floral source to *A. dorsata* compared to nectar yielding plants (17.7%) and pollen yielding plants (18.9%) (Table 2). Altogether, 63.4% foraging plants have provided both pollen and nectar to *A. dorsata* population. However, 18.9 and 17.7% foraging plants have provided respectively pollen and nectar separately to *A. dorsata* (Table 2). In arid region, both pollen and nectar yielding plants yielded highest (54%) floral source for *A. dorsata*. It was followed by pollen yielding and nectar yielding plants respectively, 25.4 and 20.6% for *A. dorsata* (Table 2). In semi-arid region, both pollen and nectar yielding plants yielded highest (72.7%) floral source for *A. dorsata*. But, the nectar yielding and pollen yielding plants have provided only 15.6 and 11.7% floral source, respectively, for *A. dorsata* (Table 2). In malnad region, both pollen and nectar yielding plants provided more (63.6%) floral source for *A. Dorsata* as compared to nectar yielding and pollen yielding plants (Table 2).

Further, interaction of *A. dorsata* population with the blooming period of foraging plants at arid, semi-arid and malnad regions of southern Karnataka are depicted in Table 3. The Shannon-Wiener diversity index (H^1) of foraging plants indicated no much variation between the regions. However, the H^1 was in between 3.256 and 3.864 and it has larger value of H' (< 2) index. However, foraging plants were more (117 species) at malnad

Table 1. Distribution of foraging plant families of *Apis dorsata* at different regions of southern Karnataka.

S/N	Families	No. of species extended floral sources at			Total
		Arid	Semi-arid	Malnad	
1	Acanthaceae	1	2	2	5
2	Alangiaceae	-	-	1	1
3	Amaranthaceae	1	-	2	3
4	Anacardiaceae	1	3	3	7
5	Annonaceae	-	2	-	2
6	Apiaceae	-	-	1	1
7	Apocynaceae	-	1	1	2
8	Araceae	2	-	1	3
9	Asclepidaceae	1	1	-	2
10	Asteraceae	4	2	4	10
11	Balsaminaceae	1	1	1	3
12	Basellaceae	-	1	-	1
13	Bignoniaceae	-	1	3	4
14	Bombaceae	-	-	2	2
15	Brassicaceae	-	1	1	2
16	Burseraceae	-	-	1	1
17	Cactaceae	-	-	1	1
18	Caprifoliaceae	-	-	1	1
19	Caricaceae	1	-	-	1
20	Casuarinaceae	-	1	-	1
21	Celastraceae	-	-	2	2
22	Clusiaceae	2	-	6	8
23	Combretaceae	2	-	3	5
24	Convolvulaceae	-	-	3	3
25	Cucurbitaceae	5	5	-	10
26	Datiscaceae	-	-	1	1
27	Dilleniaceae	-	-	1	1
28	Dipterocapaceae	-	-	2	2
29	Droseraceae	-	1	-	1
30	Ebenaceae	1	-	1	2
31	Elaeocarpaceae	-	-	3	3
32	Elatinaceae	-	-	1	1
33	Euphorbiaceae	2	2	3	7
34	Fabaceae	15	12	14	41
35	Flacourtiaceae	1	-	2	3
36	Hydrocotylaceae	-	1	-	1
37	Icacinaceae	-	-	1	1
38	Lamiaceae	2	2	3	7
39	Lauraceae	-	-	1	1
40	Lecythidaceae	-	1	-	1
41	Lophopetalum	-	-	1	1
42	Lythraceae	-	-	2	2
43	Magnoliaceae	1	-	-	1
44	Malvaceae	3	4	3	10
45	Melastomataceae	-	-	1	1
46	Meliaceae	-	2	4	6
47	Menispermaceae	-	1	1	2

Table 1. Contd

48	Molluginaceae	-	1	-	1
49	Moraceae	1	2	1	4
50	Moringaceae	1	-	-	1
51	Musaceae	1	-	-	1
52	Myrtaceae	3	4	3	10
53	Nyctanthaceae	-	1	-	1
54	Nycteginaceae	-	2	-	2
55	Oxallidaceae	-	-	1	1
56	Palmae	1	-	1	2
57	Periplocaceae	-	1	1	2
58	Piperaceae	-	-	1	1
59	Poaceae	-	1	-	1
60	Portulaceae	1	-	1	2
61	Rubiaceae	-	-	4	4
62	Rutaceae	3	4	5	12
63	Santalaceae	-	-	1	1
64	Sapinadaceae	1	-	2	3
65	Sapotaceae	-	2	-	2
66	Scrophulariaceae	-	-	1	1
67	Smilaceae	-	-	1	1
68	Solanaceae	-	5	1	6
69	Sterculaceae	-	1	2	3
70	Ulmaceae	-	-	1	1
71	Verbenaceae	3	1	3	7
72	Violaceae	-	-	2	2
73	Vitaceae	-	1	1	2
74	Zingiberaceae	1	-	-	1
Total		62	73	117	252
'F' Value			5.6848* ; P > 0.001		

Note:* significant.

Table 2. Type of foraging plant and their apicultural value to *Apis dorsata* at different regions of southern Karnataka

S/N	Region	Type of Flora				Type of Flowering plant					Apicultural value		
		C	H	S	T	MP	EP	OP	FP	VP	Pollen	Nectar	Both
1.	Arid	7.9	23.8	23.8	44.5	30.2	17.5	17.5	19.0	15.8	25.4	20.6	54.0
2.	Semi-arid	5.2	24.7	23.4	46.7	41.6	19.5	14.3	16.9	7.7	11.7	15.6	72.7
3.	Malnad	3.4	22.0	17.8	56.8	44.1	27.1	15.3	11.0	2.5	19.5	16.9	63.6
Mean for southern Karnataka		5.5	23.5	21.7	49.3	38.6	21.4	15.7	15.6	8.7	18.9	17.7	63.4

C = Climber; H = Herb; S = Shrub; T = Tree; MPs = Medicinal plants; EIPs = Economically Important Plants; OPs = Ornamental Plants; FYPs = Fruit Yielding Plants; VPs = Vegetable Plants.

region and showed high (3.864) Shannon-Wiener diversity index as compared to arid and semi-arid regions, where the foraging plant species were respectively 62 and 73 and the H^1 was 3.256 and 3.405 (Table 3).

Foraging plant families and their floral hosts for *A. dorsata* at southern Karnataka is given in Table 4. Amongst 74 families, Fabaceae family contributed more (15.9%) foraging source (40 flowering plant species), followed by Rutaceae (12 flowering plant species) family supplying 5.3% floral source to *A. dorsata* (Table 4).

Table 3. Interaction of *Apis dorsata* population with blooming period of foraging plants at different regions of southern Karnataka.

S/N	Blooming period	Regions		
		Arid	Semi-arid	Malnad
1.	April – Aug.	1	1	-
2.	April – Feb.	-	-	1
3.	April – July	1	-	1
4.	April - June	1	3	5
5.	April - May	2	3	1
6.	April – Nov.	-	-	2
7.	April – Oct.	-	-	2
8.	April – Sept.	2	-	-
9.	All seasons	9	-	1
10.	Aug. – Dec.	1	1	3
11.	Aug. – Feb.	-	2	-
12.	Aug. – March	-	-	1
13.	Aug. – May	-	-	1
14.	Aug. – Nov.	1	1	2
15.	Aug. – Oct.	-	2	-
16.	Aug. – Sept.	2	1	1
17.	Dec. – April	-	-	1
18.	Dec. – Aug.	-	-	1
19.	Dec. – Feb.	1	-	1
20.	Dec. – March	-	-	2
21.	Dec. – May	-	-	1
22.	Feb. – June	-	1	2
23.	Feb. – April	3	2	3
24.	Feb. – Aug.	-	-	2
25.	Feb. – Dec.	-	-	2
26.	Feb. - July	-	-	3
27.	Feb. – March	2	-	2
28.	Feb. - May	2	1	2
29.	Feb. – Oct.	-	-	1
30.	Feb. – Sep.	-	1	2
31.	Jan – Feb.	2	-	-
32.	Jan. – June	-	-	1
33.	Jan. – April	-	2	1
34.	Jan. – Dec.	-	-	13
35.	Jan. – Feb.	2	1	1
36.	Jan. – March	1	1	4
37.	Jan. - May	-	-	3
38.	Jan. – Nov.	-	-	1
39.	Jan. – Oct.	-	-	2
40.	July – Aug.	1	2	1
41.	July – Dec.	-	1	-
42.	July – Feb.	-	-	1
43.	July – March	-	-	1
44.	July – Nov.	-	1	-
45.	July – Oct.	2	1	-
46.	July – Sept.	1	7	-
47.	June – Aug.	2	1	2
48.	June – Dec.	1	2	-
49.	June – Feb.	-	-	1
50.	June – July	1	-	1
51.	June – Nov.	1	-	1
52.	June – Oct.	1	1	-
53.	June – Sept.	1	4	2
54.	March – June	-	-	2
55.	March - May	-	-	1
56.	March – April	3	6	-
57.	March – Aug.	1	1	-
58.	March – July	-	1	2
59.	March – June	-	-	2
60.	March - May	4	5	1
61.	March – Nov.	-	-	1
62.	March – Oct.	-	-	1
63.	March – Sept.	-	1	1
64.	March. – Aug.	-	-	-
65.	May – June	-	-	1
66.	May – Aug.	2	2	1
67.	May – Dec.	-	2	1
68.	May – July	-	-	1
69.	May – Nov.	-	-	3
70.	May – Sept.	1	-	-
71.	Nov. – April	-	-	1
72.	Nov. – Dec.	1	-	4
73.	Nov. – Feb.	-	-	1
74.	Nov. – Jan.	1	-	2
75.	Nov. – March	1	2	1
76.	Nov. - May	-	-	1
77.	Oct. – Dec.	-	1	1
78.	Oct. – Feb.	1	1	-
79.	Oct. – Jan.	-	1	1
80.	Oct. – March	-	-	2
81.	Oct. – May	-	1	-
82.	Oct. – Nov.	-	-	1
83.	Sept. – March.	2	-	-
84.	Sept. – April	-	1	-
85.	Sept. – Dec.	-	2	2
86.	Sept. – Feb.	-	1	-
87.	Sept. – Jan.	-	1	-
88.	Sept. – March	-	-	-
89.	Sept. – Oct.	1	1	-
Total		62	73	117
H^1 Index		3.256	3.405	3.864

Table 3. Contd

The Asteracea, Cucurbitaceae, Malvaceae and Myrtaceae families contributed 4.4% each floral source (from 10 flowering plant species each). Similarly, the Clusiaceae family has contributed 3.5% floral source to

Table 4. Foraging plant families and their floral hosts to *Apis dorsata* at southern Karnataka.

S/N	Family	Species	Per cent	Total families	Per cent
1.	Alangiaceae, Apiaceae, Basellaceae, Burseraceae, Cactaceae, Caprifoliaceae, Caricaceae, Casuarinaceae, Datiscaceae, Dilleniaceae, Droseraceae, Elatinaceae, Hydrocotylaceae, Icacinaceae, Lauraceae, Lecythidaceae, Lophopetalum, Magnoliaceae, Melastomataceae, Molluginaceae, Moringaceae, Musaceae, Nyctanthaceae, Oxallidaceae, Piperaceae, Poaceae, Santalaceae, Scrophulariaceae, Smilaceae, Ulmaceae and Zingiberaceae	1 each	0.4	31	41.9
2.	Annonaceae, Apocynaceae, Asclepidaceae, Bombaceae, Brassicaceae, Celasteraceae, Dipterocapaceae, Ebenaceae, Lythraceae, Menispermaceae, Nycteginaceae, Periplocaceae, Portulaceae, Sapotaceae, Violaceae and Vitaceae	2 each	0.9	17	23.0
3.	Amaranthaceae, Araceae, Balsaminaceae, Convolvulaceae, Elaeocarpaceae, Flacourtiaceae, Sapindaceae and Sterculiaceae	3 each	1.3	8	10.8
4.	Bignoniaceae, Moraceae and Rubiaceae	4 each	1.8	3	4.0
5.	Acanthaceae and Combretaceae	5 each	2.2	2	2.7
6.	Meliaceae and Solanaceae	6 each	2.6	2	4.0
7.	Anacardiaceae, Euphorbiaceae, Lamiaceae and Verbenaceae	7 each	3.1	4	5.4
8.	Clusiaceae	8 each	3.5	1	1.4
9.	Asteraceae, Cucurbitaceae, Malvaceae and Myrtaceae	10 each	4.4	4	4.0
10.	Rutaceae	12	5.3	1	1.4
11.	Fabaceae	40	15.9	1	1.4
Total		252	41.4	74	100.0

Data is based on Table 1.

A. dorsata from its eight flowering plant species (Table 4). Moreover, from Anacardiaceae, Euphorbiaceae, Lamiaceae and Verbenaceae families, seven flowering plant species supplied 3.1% each floral source to *A. dorsata* population. Further, from Meliaceae and Solanaceae families, six flowering plant species have contributed 2.6% floral source each to *A. dorsata* population. Furthermore, Acanthaceae and Combretaceae families supplied floral source from their five flowering plant species each and contributed 2.2% floral source to *A. dorsata*. However, from Bignoniaceae, Moraceae and Rubiaceae families, four flowering plant species each have supplied 1.8% floral source each to *A. dorsata* population. Similarly, other foraging plant families percent contribution is depicted in Table 4.

Figure 2 shows the floral calendar for *A. dorsata* at arid, semi-arid and malnad regions of southern Karnataka. Since the foraging activity of *A. dorsata* coincide with the blooming of flowering plants, data from the Figure 2 clearly demonstrated that there was a considerable fluctuation with respect to the blooming period of foraging plants which occurred at different regions of southern Karnataka. Moreover, only few flowering plants (4%) showed blooming during most parts of the year and the remaining flowering plants bloomed during different months (Table 3). In general, the flowering plants blooming was good during January, February, March and April as compared to other months, where it was less than 10%, accordingly, the *A. dorsata* population interacted with these plants for nectar and pollen. In general, the floral source was almost normal and it was consistently available to *A. dorsata* during the years 2011 to 2012 at southern Karnataka (Figure 2).

DISCUSSION

Apis dorsata foraged on ornamental plants, medicinal plants, fruits yielding plants, vegetable plants, economically important plants which belong

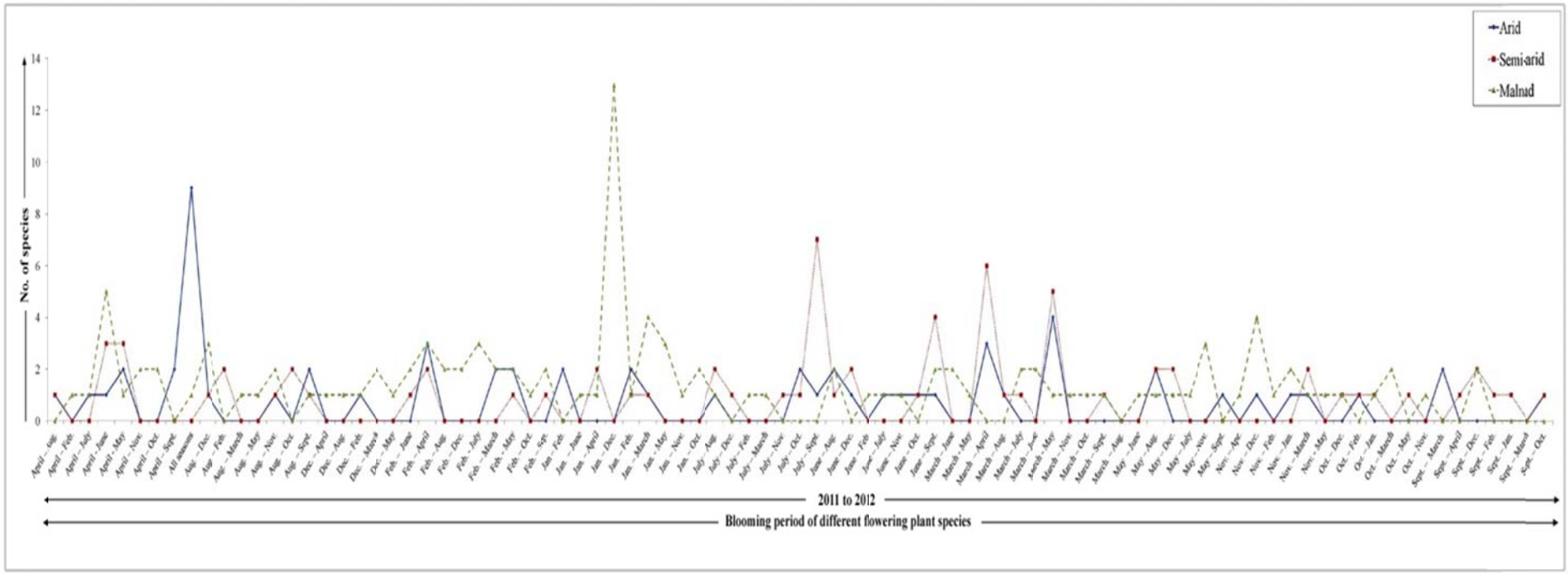

Figure 2. Floral calendar for *Apis dorsata* at arid, semi-arid and malnad regions of southern Karnataka.

to trees, shrubs, herbs and climbers at different regions of southern Karnataka. About 252 foraging plant species, which belongs to 74 different families were interacted by *A. dorsata* foragers during their nectar and pollen collection and proved themselves as voracious forager (Oldroyd et al., 2000). Classifying available flowering plants into various types is a common practice in apiculture, to understand the nectar and pollen potential of a region that could help predict pollen calendar and honey flow (Basavarajappa, 2012). Moreover, by visiting different species of trees, shrubs, herbs and climbers, which bear different size and shaped flowers and inflorescence secreting good amount of nectar and pollen, *A. dorsata* proved itself as one of the most reliable natural pollinator (Neupane et al., 2006).Thus, all the foraging plants are vital to *A. dorsata* for normal survival and its interaction could help assist certain plant species pollination and propagation in this part of the state. Hence, our observations agree with the earlier reports of Neupane et al. (2006), Shubharani and Venkataramegowda (2012).

Since interaction with each plant species is vital to *A. Dorsata* with respect to their specific apicultural values, that is, pollen, nectar and both pollen and nectar source. Therefore, classifying plant species, which produce both nectar and pollen for honeybees, are called ‘honeybee plants’, plants which produce nectar, but little or no pollen are typically termed as ‘honey plants’ and plants yield pollen, but little or no nectar are termed as ‘pollen plants’ from the conservation point of view. Pollen plants are important especially at the time of colony build-up, when the honeybees need large amount of protein for their brood rearing. However, nectar plants are also important for developing colonies. In the present investigation

interaction with pollen, nectar and both pollen and nectar producing plants by *A. dorsata* was recorded during their blooming period at different regions of southern Karnataka. Diversified flowering plant species bloom during different months of the year and few species bloom throughout the year and showed good Shannon-Wiener diversity index (H^1) of more than two. This show good species richness and eveness (Magurran, 2004) and regarded as medium to high diverse in terms of species occurrence (Barbour et al., 1999) at southern Karnataka. However, high number of species richness in malnad region is attributed to the occurrence of heavy rainfall that contributes to the growth of many plant species. Further, the climatic, edaphic variability and anthropogenic activities are other factors associated with the difference in species richness at arid, semi-arid and malnad regions of southern Karnataka (Raghunandan and Basavarajappa, 2014).

Good floral source is one of the key factors that determine the *A. dorsata* colony distribution, accordingly, good colony density was recorded in this part of the state (Basavarajappa, 2012). Constructing pollen calendar for *A. dorsata* requires in depth study. However, attempts were made to provide baseline information on foraging plants of *A. dorsata* in this part of the state. As the pollen calendar differs from place to place and region to region preparing a pollen calendar for *A. dorsata* which would help predict the seasonal honey flow inturn idea of locally available bee flora prepared to know local biodiversity. In view of these reasons, pollen calendar of arid, semi-arid and malnad regions are prepared. Since different regions of southern Karnataka are located in the tropics, weather is always pleasant with moderate climate throughout the year (Kamath, 2001). Perhaps, prevailed climate might have help grow diversified flowering plants, which bloom during different seasons and provided good amount of nectar and pollen for *A. dorsata*. Thus, nectar flow was continuous with little variations at different regions of southern Karnataka. Basavarajappa (1998, 2004 and 2012) reported that, certain plant species acted as both floral source and nest hosting trees for *A. dorsata* at maidan areas of Karnataka. Manjunath (2008) reported the plant species, which provide both floral source and nesting sites for *A. dorsata* in Mysore. Reddy and Reddy (1989) and Rao (1998) reported hundreds of flowering plant species utilized by *A. dorsata* for its floral source. However, during the present study, 62, 73 and 113 flowering plants supported *A. dorsata* population respectively at arid, semi-arid and malnad regions of southern Karnataka. Similar type of observations were made by Basavarajappa (1998), Joshi et al. (1998 a, b), Lakshmi and Suryanarayana (1998), Rao (1998), Singh et al. (1998), Singh (2002), Solomonraju (2002), Basavarajappa (2004), Bhattacharya et al. (2005), Kumaret al. (2005), Singh et al. (2006), Tiwari et al. (2010), Basavarajappa (2010 and 2012), Shubharani and Venkataramegowda (2012) at different parts of India.

Since, honeybees (for example, *A. dorsata*) are indispensable components of terrestrial ecosystems, their presence are essential for the reproductive success of several plant species in the wildas well as at man-made ecosystems. Therefore, identification of foraging plants into trees, shrubs, herbs, climbers and then into economically important plants, fruit yielding plants, medicinal plants, ornamental plants and vegetable plants would help reveal their percent occurrence, apicultural value (Rao, 1973; Basavarajappa, 1998 and 2010)) and inturn understand local plant diversity. Thus, results presented in this paper agreed with the reports of earlier workers.

Furthermore, *A. dorsata* is a seasonal migrant, migrates from place to place in response to varying floral resource (Dyer and Seely, 1994). It travels more than three kilometers in search of forage and it would cover about 10 sq km in a day. During its migration and emigration, they visit various places in search of suitable floral hosts for pollen and nectar. The variability among flowering plants (trees, shrubs, herbs and climbers) showed species richness (number of species) and evenness (species distribution) from different regions of southern Karnataka that revealed good diversity for insect pollinators like *A. dorsata*.

Thus, presence of *A. dorsata* would indicate the status of flora of that region. Since, collecting data on foraging plants their usefulness to honeybee pollinators are prerequisite to frame a plan for effective crop pollination and production of bee hive products at different agro-ecological regions (Neupane et al., 2006), such types of studies exclusively on *A. dorsata* are presented for the first time in this part of the State. As *A. dorsata* is one of the major pollinators of angiosperms, its presence is important at all types of ecosystem for local biodiversity conservation (Buchmann and Nabhan, 1996; Zayed, 2009) and human survival. Its great role as pollinators of several plants at its area of distribution is well understood at various countries (Neupane et al., 2006). Moreover, reproductive success of several plant species in the wild as well as at man-made ecosystems is depended on *A. dorsata*.

The knowledge of flowering plants diversity is useful for establishing the apicultural activities and the state of honey production and shows the importance of insect-plant interaction in the environment. Thus, bee plants of the region would provide a greater insight into the pollination biology; in turn reveal the importance of conservation of both plants and insect pollinators. The services provided by plants and honeybees play a crucial role in sustaining our livelihoods and protect our health (Sobuj and Rahman, 2011).

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Barbour M, Burk JH, Pitts WD, Gillians FS, Schwartz MW (1999).Terrestrial Ecology. Chicago, Illinois: Addson Wesley Longman, Inc. pp. 69- 85.

Basavarajappa S (1998). Status of natural colonies of *Apis dorsata* in maidan region of Karnataka. Indian Bee J. 60(3): 143 - 146.

Basavarajappa S (2004). Status of the Asian giant honeybee *Apis dorsata* F. and its conservation in southern part of the Deccan peninsula, Karnataka, India. In: Perspectives in Animal Ecology and Reproduction, (Edn. Gupta VK and Verma A) Daya Publishing House,New Delhi, India. pp. 45-71.

Basavarajappa S (2010). Studies on the impact of anthropogenic interference on wild honeybees in Mysore district, Karnataka, India. AJAR. 5(4): 298- 305.

Basavarajappa S (2012). Study on the biological constraints of rock bee, *Apis dorsata* F. in southern Karnataka. UGC Major Research Project Final Report, New Delhi, India. pp. 10-150.

Bhattacharya A, Datta K, Datta SK (2005). Floral biology, floral resource constraints and Pollination limitation in *Jatrophacurcas.* Pak. J. Biol. Sci. 8(3): 456-460.

Buchmann SL, Nabhan, GP (1996). The Forgotten Pollinators.Island Press, Washington DC.p. 292.

Dyer FC, Seeley, TD (1994). Colony migration in tropical honeybee, *Apis dorsata* F. (Hymenoptera: Apidae). Insectes Soc.41:129-140.

Gamble JS (1967). Flora of Presidency of Madras. II edn.Vol.I & II.Botanical Survey of India, Calcutta. pp. 1- 500.

Ganeshaiah KN, Kathuria S, Shaanker RU (2002). Floral source of Karnataka: A geographic perspective. Curr. Sci. 83(7): 810-813.

Joshi MA, Rao M, Suryanaryana, MC. (1998a). Nyctanthes arbor-tristis – a bee forage source for Apis dorsata. Indian Bee J. 60(1): 20.

Joshi M A, Singh TS, Rao GM, Suryanarayana, MC (1998b). Common arboreal bee forage plants of India – Samanea saman (Jacq.) Merr. Indian Bee J. 60(1):26.

Kamath US (2011). Karnataka State Gazetter.Government Press, Banagalore, India. pp. 1-49.

Kumar MA, Singh PK, Singh, J (2005). Floral calendar for beekeeping at Bichpuri, Agra. Indian Bee J. 67(3-4): 156-160.

Lakshmi K, Suryanarayana, MC (1998). Common arboreal bee forage plants of India – the wood apple, *Feronialimonia* (L.) Swingle.Indian Bee J.60(4):215.

Magurran A (2004). Measuring Biological Diversity. Blackwell Science Ltd., USA. p.6.

Manjunath MG (2008). Studies on the nesting behavior of giant honeybee, *Apis dorsata* F. in Mysore, Karnataka.M.Phil. Dissertation, University of Mysore. pp. 1-91.

Neupane KR, Dhakal DD, Thapa RB, Gautam DM (2006). Foraging preference of giant honeybee, *Apis dorsata* F. to selected horticultural crops. J. Inst. Agric. Anim. Sci. 27: 87-92.

Oldroyd BP, Osborne KE, Mardan M (2000). Colony relatedness in aggregations of *Apis dorsata* Fabricius (Hymenoptera: Apidae). Insectes Soc. 47:94-95.

Partap U, Shukla AN, Verma LR (2000).Comparative attractiveness of broad leaf mustard, cauliflower and radish to *Apiscerana* in Kathmandu valley of Nepal. In: M. Matsuka, Verma, L. R., Wongsiri, S., Shrestha, K. K. and U. Parthap. (Eds.) Asian Bee and Beekeeping: Progress of Res. Dev. Oxford and IBH Publ. Co., Pvt. Ltd., New Delhi, India. pp. 203-205.

Raghunandan KS, Basavarajappa S (2014). Bio-ecology of Asian giant honeybee, *Apis dorsata* F. (Hymenoptera :Apidae) at arid, semi-arid and malnad regions of south-western Karnataka, India. JBES4(2): 205- 224.

Rao RR (1973). Studies on the flowering plants of Mysore district. Ph. D., Thesis,Dep. of Bot.Uni. of Mysore, Mysore. pp.112-519.

Rao SRK (1998). Bee flora of Chintapalli, Andhra Pradesh. Indian Bee J.60(3):152.

Reddy MS, Reddy CS (1989).Height dependent nest site selection in *Apis dorsata*. Indian Bee J. 51(3): 105-106.

Shubharani R, Venkataramegowda S (2012). Physicochemical and pollen analysis of Western Ghats honey of Karnataka, South-India.Int. J. Sci. Nat. 3(4): 831-835.

Singh J, Agarwal OP, Mishra RC (2006). Foraging rates of different *Apis*species visiting parental lines of *Brassica napus* L. Zoos Print J.21(4):2226-2227.

Singh S (2002). Food source and temperature influence the nesting of *Apis dorsata.* Proc. 6th AAA Int. Conf. & World Apiexpo. Bangalore, India. p. 41.

Singh S, Jain KL, Saini K (1998). Comparison of nutritional value as determinant of honeybee preference for pollen sources. Indian Bee J.60(3):137.

Sobuj NA, Rahman M (2011). Assessment of plant diversity in Khadimnagar National Park of Bangladesh. Int. J. Environ. Sci. 2(1): 79-91.

Solomonraju B (2002). The rock honeybee, *Apis dorsata* and its pollination potential.Proc. 6th AAA Int. Conf. & World Apiexpo. Bangalore, India. p. 81.

Tiwari P, Tiwari JK, Ballabha, R (2010). Studies on Sources of Bee-forage for Rockbee (*Apis dorsata* F.) from Garhwal Himalaya, India: A Melissopalyonological approach. Nat. Sci.8(6):5-15.

Zayed A (2009). Bee genetics and Conservation.Apidologie 40:237-262.