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Social bees and food plant associations in the Nilgiri Biosphere Reserve, India

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Abstract: The diversity of social bees was assessed at 15 sites across five locations of the Nilgiri Biosphere Reserve, Western Ghats, India, from January to December 2007. We also conducted floristic analyses of local vegetation in each site using one-hectare sample plots. All woody species with a dbh (diameter at breast height) ≥ 30 cm were recorded within the plots. A total area of 9.72 ha was assessed for floristic composition. Similarity of floristic composition between sites was determined using the Jaccard's distance measure and a dendrogram constructed based on the hierarchical clustering of floristic dissimilarities between sites. A Bee Importance Index (BII) was developed to give a measure of the bee diversity at each site. This index was a sum of the species richness of bee species in a site and their visitation frequencies to flowers, calculated as mean flower visits hour 1 within 2 focal patches within one hectare plots. The visits of bee species to flowers were also recorded. The Jaccard distance measure indicated that the montane sites were quite dissimilar to the low elevation sites in floristic diversity. The BII was 7-9 for the wet forest sites and ranged from 4-6 for drier forest sites. Seventy three plant species were identified as social bee plants and of them 45% were visited by one species of bee, 37% by two bee species and 18% by more than two bee species, indicating a certain degree of floral specialization among bees.

Resumen: Se evaluó la diversidad de abejas sociales en 15 sitios de cinco localidades de la Reserva de la Biosfera Nilgiri, Gates Occidentales, India, de enero a diciembre de 2007. También llevamos a cabo análisis florísticos de la vegetación local en cada sitio usando parcelas de muestreo de una hectárea. Se registraron todas las especies leñosas presentes en las parcelas que tuvieran un dap (diámetro a la altura del pecho) ≥ 30 cm. Se evaluó la composición florística en un área total de 9.72 ha. Se determinó la similitud de la composición florística entre sitios con la medida de distancia de Jaccard y un dendrograma construido a partir de la clasificación jerárquica de las disimilitudes florísticas entre sitios. Se desarrolló un Índice de Importancia de las Abejas (IIA) para proporcionar una medida de la diversidad de abejas en cada sitio. Este índice se calculó a partir de la suma de la riqueza de especies de las abejas en un sitio y su frecuencia de visita a las flores, calculada como el número promedio de visitas por flor hora^{-1} en dos parches focales dentro de cada parcela de una hectárea. También se registraron las visitas de las especies de abejas a las flores. La medida de distancia de Jaccard indicó que los sitios montanos fueron bastante diferentes de los de baja altitud en su diversidad florística. El IIA fue 7-9 en los sitios de bosques húmedos y varió entre 4 y 6 para los sitios de bosque más seco. Se identificaron 73 especies vegetales como plantas de abejas sociales; de

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ellas, 45% fueron visitadas por una sola especie de abeja, 37% por dos especies de abejas y 18% por más de dos especies de abejas, lo cual indica que hay un cierto grado de especialización floral entre las abejas.

Resumo: A diversidade das abelhas sociais foi avaliada em 15 estações através de 5 localizações da Reserva de Biosfera de Nilgiri, Ghates ocidentais, Índia, de Janeiro a Dezembro de 2007. Conduzimos igualmente análises florísticas da vegetação local em cada estação usando uma parcela amostra de um hectare. Todas as espécies lenhosas no interior da parcela com DHP (diâmetro à altura do peito) ≥ 30 cm foram registadas. Uma área total de 9,72 ha foi avaliada no respeitante à composição florística. Similarmente a composição florística entre estações foi determinada usando a medida de distância de Jaccard e foi construído um dendrograma com base no cluster hierárquico das dissemelhanças entre estações. O Índice de Importância das Abelhas (BII) foi desenvolvido para dar uma medida da diversidade em abelhas em cada estação. Este índice resultou da soma da riqueza específica das espécies de abelhas numa estação e a sua frequência de visitas a flores, calculada com a média de visitas por hora dentro de 2 manchas focais no interior da parcela de um hectare. As visitas das espécies de abelhas às flores foram igualmente registadas. A medida de distância de Jaccard indicou que as estações de montanha foram quase dissimilares em relação às baixas elevações quanto à diversidade florística. O BII foi de 7-9 para as estações florestais húmidas e situou-se entre os 4-6 para as estações florestais secas. Setenta e três espécies vegetais foram identificadas como plantas de interesse para as abelhas sociais e delas 45% foram visitadas por uma espécie de abelha, 37% por duas espécies e 18% por mais do que duas espécies de abelhas, indicando um certo grau de especialização polínica entre as abelhas.

Key words: Biodiversity, India, Nilgiri Biosphere Reserve, social bee diversity.

Introduction

Animals, particularly insects are considered to pollinate about 70% of crop plants worldwide and over 98% of trees in lowland tropical rain forests (Bawa 1990; Klein *et al*. 2006). The loss of these pollination services would have adverse consequences for food production and for the maintenance of biodiversity (Allen Wardell *et al*. 1998; Klein *et al*. 2006). Asia has a poorer bee fauna compared with other biogeographical regions (Michener 1979) and lower diversity compared to the Neotropics, but in terms of abundance the social apid bees (Apoidae: Apidae) are the most numerous in the pollinator spectrum (Roubik *et al.* 2005). Studies in South East Asia reveal that about 32% of flower visiting insects in Sumatra are apid bees (Momose *et al.* 1998). In medium elevation wet evergreen forest of the Western Ghats, apid bees contributed to the pollination of 18% of 86 species of trees, and 22% of the understorey shrubs (Devy & Davidar 2003, 2006). Many semelparous taxa such as species of Strobilanthes, including the spectacular mass flowering *S. kunthianus* (Acanthaceae) in peninsula India are pollinated by genus *Apis* (Anitha & Prasad 2007). Apid bees probably play an important role in pollinating crop plants in India, although quantitative data are not available. *Apis cerana* (Fabricius 1793) is important for managed pollination services and has been reported to be declining in some regions due to the introduction of *Apis mellifera*, disease and inappropriate use of pesticides (Partap 1999). Relatively little is known about *Apis florea* (Fabricius 1787), and the small 'dammer' stingless bees (Apidae: Meliponini) that are also important pollinators and producers of honey (Crane 1990).

The honey and wax produced by *Apis* spp. and the dammer bees, play an important role in the livelihood of poorer forest dwelling communities in the Nilgiri Biosphere Reserve (NBR) in India where 15 local ethnic groups harvest honey as a source of revenue. Many of the cultural practices of these ethnic groups revolve around harvesting and utilizing wild honey (Keystone Foundation 2001).

Apis dorsata (Fabricius 1793) is an economically important bee species in the NBR region due to the large quantities of honey produced. It is also the largest social bee present in the NBR and requires vertical structures such as cliffs and tall trees for hive construction. They occur across India and South East Asia and are migratory, following the availability of floral resources (Crane 1990). *Apis cerana* are medium sized bees that are not known to migrate, and are widely distributed through tropical and subtropical regions of Asia (Crane 1990). *Apis florea* is distributed in tropical and subtropical Asia and has nesting preferences for areas of dense vegetation. This species builds single comb nests and tends to migrate locally (Crane 1990). The stingless bees (Apidae: Meliponini), are small (a few mm in length) and resident species which nest among boulders, old walls, dead trees and tree cavities (Michener 2000; Roubik 2006). They are widely distributed in tropical and temperate regions of the world.

Studies have shown that there are important linkages between flowering, and bee abundance (e.g., Potts *et al*. 2003). *Apis dorsata* migrates locally in response to the availability of floral resources in South East Asia, and is able to increase rapidly in number in response to flowering events (Itioka *et al.* 2001). Such quantitative studies relating bee abundance with flowering intensity are lacking from the Indian subcontinent. Furthermore, associations between plant diversity, social bee abundance, honey production and local livelihoods have not been documented for the Asian region.

This paper specifically addresses the knowledge gap relations between plant and social bee diversity, and floral visitation in a series of contrasting sites of land use and habitat types important for forest using indigenous people within the Nilgiri Biosphere Reserve. We tested the hypothesis that the diversity of social bees (number of species and local abundance) would not differ with regard to forest type, and that flowering plants would be generalist with regard to bee species.

Materials and methods

Study area

The Nilgiri Biosphere Reserve (NBR) is part of the Western Ghats, a chain of ancient mountain ranges which run parallel to west coast in Indian peninsula. It was the first Biosphere Reserve established in India, declared in September 1986 under UNESCO's Man and Biosphere program. It lies between 10° 45′ N to 12° N latitudes and 76° E to 77° 15′ E longitudes with a total area of 5520 km^2 spread across the three southern states of Karnataka, Kerala and Tamil Nadu. There are six protected areas (PAs) within the reserve, *viz*., the Wynaad Wildlife Sanctuary, Nagarhole, Bandipur and Mudumalai Tiger Reserves and the Mukurti and Silent Valley National Parks. Large tracts of forests connect these PAs which fall under the category of reserve forests. Altitude varies from 250 m to 2650 m, and at least four of the major rivers of south India originate in this region - the Bhavani, Moyar, Kabini and Chaliyar. The intensity of the rainfall brought by the south west and north east monsoon winds differ across topographic and altitudinal gradients (Lengerke *et al.* 1989). The western ranges of the NBR receive higher precipitation (up to 4600 mm) while the eastern parts are part of the rain shadow, receiving less than 800 mm rainfall annually (Prabhakar 1994). Most of the precipitation is during the South West monsoon from the months of June to August. The eastern and northern parts often suffer from drought, though they receive some rainfall from October to November during the North East monsoon.

This range of topography and climate has resulted in sharp gradients of vegetation composition, ranging from thorny scrub forest dominating the north eastern region and intergrading westwards into dry and moist deciduous forests and wet evergreen forests towards the Wynaad. Most of the major vegetation types of peninsular India occur in the NBR (Champion & Seth 1968). A shola (montane evergreen forest) - grassland mosaic dominates the higher altitudes, but a high proportion has been destroyed since the 1930's (Kumar 1993).

The NBR covers two of the ten bio-geographical zones of India and with only 0.15% of India's land area, contains 20% of all angiosperms, 15% of all butterflies and 23% of all vertebrates that are found in India (Daniels 1996). This wealth of biological diversity is matched by the diversity both linguistic and cultural of local communities. Fifteen study sites were chosen in five regions of the NBR, to capture the diversity of land use and habitat types important to forest-using indigenous people [Table 1, Bees, Biodiversity and Forest Livelihoods (Darwin Initiative) Project Team, 2007]. In each location three or four one-hectare plots (Fig. 1) representative of the local vegetation of the site were selected so as to be located within a 500 m radius of a village where bee products were used for livelihoods, have tree cover to facilitate tying of pan traps and be close to a water source.

Tree diversity

A total of nine subplots of 20 x 20 m were placed randomly within the one hectare study plots. Within the subplots all trees and lianas above 30 cm dbh (diameter at breast height) were identified and their dbh measured. The total area per hectare inventoried at a site was 0.36 ha and the cumulative area inventoried in the location was 1.08 ha. The assessment was made once during January 2007 and April 2007. The geographical coordinates of each site were recorded using a GPS (Table 1). All the plants were identified to the species level using local names and scientific references (Gamble 1935; Mathew 1983). We constructed a species x site matrix and used Estimate S (version 7.5) to assess the Jaccard distance, which measures dissimilarity between sites, by dividing the difference of the sizes of the union and the intersection of two sites by the size of the union (i.e. 1 = the Jaccard coefficient). We constructed a dendrogram to provide an estimate of the species shared between sites based on a hierarchical clustering of the numerical Jaccard Index values. The statistical program Statistica (Statsoft 1984-2008) was used to construct a dendrogram showing the clustering patterns based on the proportion of dissimilarity between sites.

Bee foraging

Within each one hectare plot, two 20 m x 10 m patches were marked out which were representative of the local habitat and included patches of flowering plants. In these patches observations were made on the foraging pattern of the social bees: *Apis cerana, A. dorsata, A. florea* and *Trigona* species. Observations were made three times per day i.e., 09:00-10:00, 11:00-12:00, and 15:00-16:00 hrs to encompass the main periods of bee foraging. Half an hour was spent at every interval at each patch. The researcher walked at random through the patch and recorded the number of visits by social bees to all the flowers. Therefore, the total observation time per site on 6

Table 1. Description of sites with regard to vegetation, tribal communities and Bee Importance Index.

Site	Location	Latitude	Altitude (m.a.s.l.)	Forest type	Dominant tribal group	BII
Pulinjur	Chamraj	11º 82’	1013	DDF	Sholiga	5
Bedaguli	Chamraj	11º 85’	1304	EV	Sholiga	9
Kalidimbam	Chamraj	11º 59’	1256	SE	Irula	7
Geddesal	Chamraj	11º 59’	1250	SE	Sholiga	5
Situkunni	Coonoor	11º 28’	582	DDF	Irula	4
Pudukadu	Coonoor	11º 33’	890	SE	Alu Kurumba	9
Marikode	Coonoor	11º 36’	1094	SE	Alu Kurumba	6
Bekkapathy Mund	Kotagiri	11º 49’	1831	ME	Toda	4
Koduthen Mund	Kotagiri	11º 51’	1665	ME	Toda	4
Mundakadavu	Nilambur	11º 34’	96	DDF	Kattunaickens	6
Appankapu	Nilambur	11º 46’	198	MDF	Kattunaickens	4
Mancheri	Nilambur	11º 30’	258	MDF	Cholanaickens	4
Chemmanatham	Sigur	11º 57’	877	DDF	Irula	6
Siriyoor	Sigur	11º 53’	875	DDF	Irula	-
Benne	Sigur	11º 60’	936	MDF	Kattunaickens	5

DDF=Dry deciduous forest, MDF=Moist deciduous forest, EV=Wet evergreen forest, SE=Semi-evergreen forest, ME=Montane evergreen, BII=Bee Importance Index.

patches (1200 m^2) was 9 hours for a month.

Bee diversity

A Bee Importance Index (BII) was developed by the authors to provide an approximate measurement of potential pollination services provided by bees in a site. The value of the index ranges between 4 to 9, where the lowest value indicates low diversity and low abundance of social bees and vice versa. The BII was calculated for each location using two independent measures. The first measure was the total number of social bee species recorded in each plot over a year. Plots were ranked from one to four based on the number of species recorded. If only one species was recorded in the site, the rank was 1, and if all four species were recorded, the site was ranked 4. The second measure was the visitation of social bees to flowers summed over all observation hours over the entire year, and calculated as bees recorded per hour of observation. This measure included all species of social bees and gave a rough measure of the abundances of social bees in a site. The plots were ranked in ascending order based on visits per hour. Sites where flowers were visited 1-5 times were ranked 1, 6-10 as 2, 11-15 as 3, 16-20 as 4

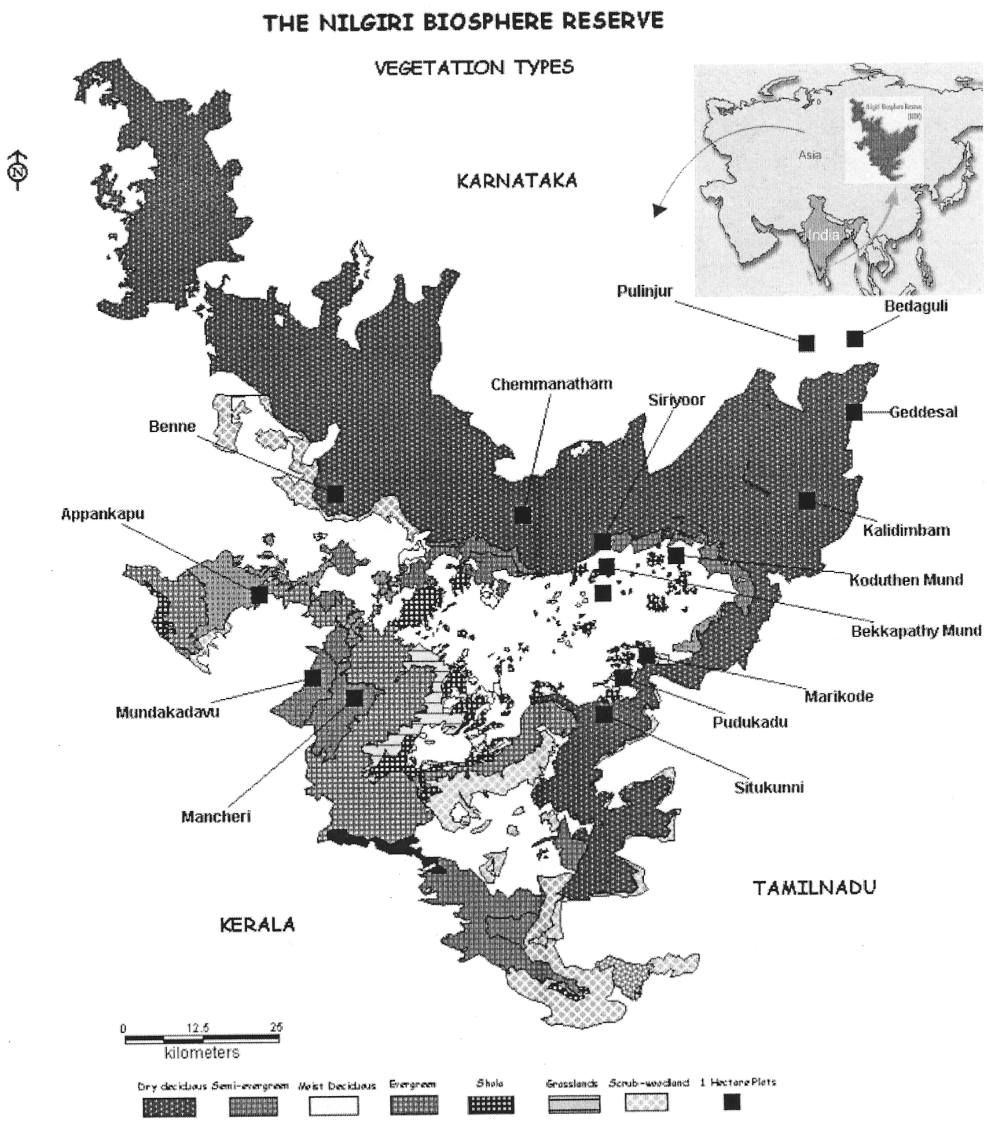

Fig. 1. Map of the study region showing location of the sites within the NBR.

and 21-25 as 5. Spearman's rank correlation was then used to test for association between the number of social bee species and bee visitation. If associated, then just one rank would be used. If not, these two ranks would be summed for a consolidated rank of BII for each plot since they are equally important in assessing bee diversity in a site.

Flower visitation patterns

The visits of social bee species to the flowers of various species within the plots were recorded. Casual observations of bee visits to other flowers were also recorded. The different species of social bees visiting each flowering plant was listed and analyzed with regard to flower specialization and generalization. Species receiving visits from only one species of bee were termed specialists and those receiving visits from more than 3 species as generalists.

Results

Similarity of forest types across sites

The Jaccard distance measure indicated that sites in different locations such as Benne in Sigur, Mudumalai and Appankappu in Nilambur were closely clustered with only 15% dissimilarity. Kurimandae in Chamrajnagar, though on the eastern side of the NBR (Fig. 1), is closely clustered with Benne and Appankappu which is on the western side with a dissimilarity of less than 20% (Fig. 2). The upper montane locations in Kotagiri (> 1500 m asl) were quite dissimilar to the low elevation sites *viz.*, Bekkapathy and Koduthen, suggesting that their species composition was a subset of those of other sites, and were left out of the dendrogram (Fig. 2). Maricode in Coonoor showed the maximum dissimilarity of almost 35%.

Bee Importance Index

The database had visitation records only for a few months during peak flowering time and was mostly restricted to the dry season in all the sites (Jan to May and marginally for Sept-Oct). For some sites, there were only 2 months in which bees were recorded visiting flowers, whereas for other sites bee visitation to flowers was over 4-5 months. The other months have no records either because none of the patches had flowering plants, or because there were no bee visitation. Therefore, the data are comparable since they have been collected at about the same season (dry) in different sites. The number of bee visits per hour per site (for each bee species and summed over all the bee species) was also strikingly different between sites. Therefore, we decided to combine all the data to give an average of bee visitation frequencies per site, which when compared with the raw data gives a fairly good indication of bee abundance.

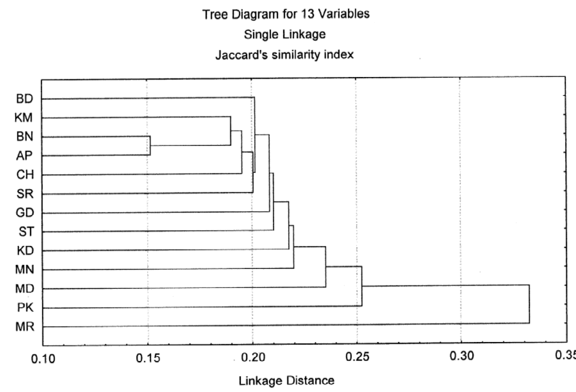

Fig. 2. A dendrogram indicating the proportion of dissimilarity between sites as measured by the Jaccard distance. Bekkapathy and Kodithen did not show any similarity with other sites and were excluded from the dendrogram. (AP = Appankapu, BD = Bedaguli, BN = Benne, CH = Chemmanatham, GD = Geddesal, KD = Kalidimbam, KM = Pulinjur, MD = Mundakadavu, MN = Mancheri, MR = Marikode, PK = Pudukadu, SR = Siriyoor, ST = Situkunni).

The Bee Importance Index (BII) ranged from 4 to 9 and was marginally higher for the wet forest sites (evergreen, semi-evergreen and montane evergreen) compared with the drier deciduous sites (dry and moist deciduous) (Wilcoxon signed rank test = 1.483, $p = 0.06$, Table 1). However, the montane sites had lower BII's (mean 4.6) compared with the evergreen and semi-evergreen vegetation (mean 7.5, Table 1). Chamrajnagar and Coonoor had higher bee indices (6.4) than Sigur and Nilambur (5), but these differences were not statistically significant (Wilcoxon signed rank test = 1.095, ns).

Bee visitation frequencies

The analysis of bee visits to the 73 species of plants indicated that 45% of plant species were visited by just one species of bee, 37% by two species, and 18% by more than two species (Table 2). This indicates that plants are specialized to particular species of bees. The most frequent bee visitor was *Apis cerana* that visited 74% of plant species; *Trigona* sp. visited 41% of plant species; *A. florea* visited 38% of plant species and *A. dorsata* only 27% of plant species (Table 2). The single species visits were mostly by *A. cerana* (17 species) and the *Trigona* sp. (13 species). *A. florea* had no single species visits and *A. dorsata* had three indicating that while the bees are generalists, some are more broadly generalist than others. Among multiple bee visits, all bee species were similarly represented with *Apis cerana* on 13 species and the other bee species on 10-11 species (Table 2).

Table 2. Records of bee visit to 73 wild and cultivated plant species in the study areas.

Species	Family	*Apis cerana*	*Apis dorsata*	*Apis florea*	*Trigona* spp.	Total bee species
Andrographis sp.Wall.	Acanthaceae				1	1
Strobilanthes ciliatus Nees					1	1
Strobilanthes sp. Bl		1		1		2
Achyranthes aspera L.	Amaranthaceae	1				1
Rauvolfia serpentina (L.) Benth. ex Kurz	Apocynaceae				1	1
Coriandrum sativum L.	Apiaceae	1		1		2
Bidens pilosa L.	Asteraceae	1		1		2
Sonchus oleraceus L.		1				1
Unidentified 1		1		1		2
Brassica juncea (L.)Cosson	Brassicaceae	1		1		2
Capparis zeylanica L.	Capparaceae				1	1
Viburnum punctatum Buch-Ham.	Caprifoliaceae	1	1	1	1	4
Chenopodium album L.	Chenopodiaceae	1		1		2
Terminalia paniculata Roth	Combretaceae	1	1	1		3
Erigeron karvinskianus DC.	Compositae	1		1		2
Galinsoga parviflora Cav.		1		1		2
Convolvulus sp. L.	Convolvulaceae	1		1		2
Melothira perpusilla Cogn.	Cucurbitaceae	1		1		2
Erythroxylon monogynum Roxb.	Erythroxylaceae	1	1	1	1	4
Phyllanthus emblica L.	Euphorbiaceae	1				1
Nothapodytes nimmoniana (J. Grah.) D.J. Mabberley	Icacinaceae	1				1
Murdannia sp. L.	Juncaceae				1	1
Leucas aspera Spr.	Lamiaceae	1				1
Oenothera rosea Ait.		1		1		2
Persea macrantha (Nees)Kosterm.	Lauraceae	1	1	1		3
Indigofera sp. L.	Leguminosae				1	1
Pisum sativum L.		1		1		2
Pterolobium hexapetalum (Roth) Santapau & Wagh		1				1
Vicia faba L.		1				1
Lagerstroemia reginae Roxb.	Lythraceae				1	1

Contd…

Table 2. Continued.

Species	Family	*Apis cerana*	*Apis dorsata*	*Apis florea*	*Trigona* spp.	Total bee species
Hiptage benghalensis (L.) Kurz.	Malpighiaceae	1	1	1	1	4
Trichilia connaroides (Wight&Arn.) Bentv.	Meliaceae	1	1	1	1	4
Diploclisia glaucescens Diels	Menispermaceae				1	1
Acacia mearnsii De Wild	Mimosaceae	1				1
Albizia amara Boiv.					1	1
Maesa indica W.	Myrsinaceae		1			1
Rhodomyrtus tomentosa W.	Myrtaceae	1				1
Syzygium arnottiana Walp.		1	1			2
Syzygium cumini (L.) Skeels		1	1			2
Ligustrum perrottetii A.DC.	Oleaceae	1	1	1	1	4
Olea dioica Roxb.		1	1		1	3
Oxalis corniculata L.	Oxalidaceae	1		1		2
Persicaria chinensis (L.) Gross	Polygonaceae	1				1
Passiflora subpeltata Ortega	Passifloraceae	1				1
Ziziphus rugosa Lam.	Rhamnaceae	1		1	1	3
Rubus ellipticus Sm.	Rosaceae	1		1		2
Acronychia pedunculata (L.) Miq.	Rubiaceae	1				1
Tarenna asiatica (L.) Kuntze ex Schumann		1				1
Canthium dicoccum (Gaertner) Teijsm. & Binnend.		1	1		1	3
Atalantia monophylla Corr.	Rutaceae				1	1
Clausena dentata (Willd.) Roemer		1			1	2
Murraya paniculata (L.) Jack			1			1
Naringi crenulata (Roxb.) Nicolson		1	1		1	3
Toddalia asiatica Lam.		1		1	1	3
Sapindus emarginatus Vahl	Sapindaceae				1	1
Solanum nigrum L.	Solanaceae	1	1			2
Solanum tuberosum L.		1		1		2
Symplocos cochinchinensis (Lour.) S. Moore	Symplocaceae	1		1		2
Vaccinium leschenaultii W.	Vacciniaceae	1	1			2
Gmelina asiatica L.	Verbenaceae		1		1	2
Premna tomentosa Willd.		1				1
Tectona grandis L.f.		1				1
Curcuma pseudo-montana Grah.	Zingiberaceae	1			1	2
Globba bulbifera Roxb.					1	1
Tribulus terrestris L.	Zygopyllaceae			1	1	2
Unidentified 2	Unidentified	1		1		2
Unidentified 3		1				1
Unidentified 4			1			1
Unidentified 5					1	1
Unidentified 6		1				1
Unidentified.7		1			1	2
Unidentified 8			1		1	2
Unidentified 9		1	1	1	1	4
	Total	54	20	28	30	

Discussion

The Nilgiri Biosphere Reserve located within the Western Ghats - Sri Lankan biodiversity hotspot is rich in human ethnic diversity and is a region of ecological and sociological importance (Prabhakar 1994). The forest dwelling communities in this region use important natural resources: honey and wax that are produced by four species of social bees. Therefore, understanding the ecology of the bee species and their dependence on forest vegetation is critical to understand the dynamics of honey production in this region.

Our preliminary investigation suggests that bee diversity, as indicated by species richness and abundance, is higher (ranging from 7-9 in the BII value) in the wet forests but does not differ across regions. Bees also differ in their selection of flowers, and *Apis cerana* was found to visit more plant species than other bee species. Of the 73 species of flowers observed 23% were visited only by *A. cerana*. *A. dorsata* and *A. florea* were more generalists and tended to visit species that were visited by the other bees too. Flower size and shape probably plays a major role in attracting or limiting bee visits (Fenster *et al*. 2004).

There was considerable heterogeneity between sites in terms of vegetation composition. The higher elevation sites appear to be quite distinct from the low elevation sites. The vegetation and land use of the NBR shows considerable fragmentation due to varying land use intensity (Fig. 1, Prabhakar 1994). The sites also vary considerably in the BII, with semi - evergreen and evergreen forests ranging between 4 - 9 and moist deciduous and dry deciduous forests, from 4 - 6.

Social bees, like many other pollinating taxa are facing an uncertain future. Studies have shown that in some European countries bees and their food plants have declined (Biesmeijer *et al.* 2006). Tropical bees perform an important ecosystem service by pollinating wild and crop plants, and provide an important source of livelihood for forest dwelling communities. However, despite their economic importance, little is known about their ecology and conservation status. Tropical bees are probably affected by habitat fragmentation (Aizen & Feinsinger 1994) and have suffered losses in highly degraded habitats (Liow *et al.* 2001). Studies have shown that less fragmented primary forests are very important in maintaining viable population of bees (Liow *et al*. 2001). Loss of bees would result in significant impacts on forest biodiversity, since many species are dependent on bees for pollination, and many local communities also depend on honey and wax as a source of livelihood.

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