

Honeybee Diversity, Role in Pollination and Beekeeping Scenario in South Indian Western Ghats

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Introduction

Arthropoda, the most specious phylum of invertebrates, is distinguished by jointed legs (Latin *arthron* means ‘jointed’; *poda* means ‘legs’) and their bodies covered with an outer protective, hardened shield, the exo-skeleton. A diverse group of animals like crabs, prawns, scorpions, spiders, insects etc. are included in this phylum. The insect belongs to class Insecta, which are the most overwhelming organisms in their sheer numbers and diversity of species. Their varied roles in the biosphere, as herbivores, pollinators, parasitoids, predators etc. (Lasalle and Gauld, 1993), are summed up below:

- Nutrient recycling, via degradation of organic debris, dispersal of fungi, disposal of carrion and dung, and through soil turnover.
- Pollination services and seed dispersal
- Influence on plant community composition and structure, via feeding on plant parts, including seeds.
- As food for many birds, mammals, reptiles, fish etc.
- Impacting animal community through transmission of diverse diseases on large animals, and predation and parasitism of smaller ones.

Each insect species has its own role in the ecosystem and its loss could affect the complexities and abundance of other organisms. Some insects function as keystone species as their absence could affect critical ecological functions signaling collapse of the wider ecosystem. Notable are insect pollinators necessary for fertilization, fruit and seed production and thereby maintaining the reproductive rates for many plant species, so much so some may altogether disappear if their pollinators turn rare or extinct (Powell and Powell 1987, Steffan-Dewenter and Tscharntke 1999). The honeybees, the focus of this article are insects of an order Hymenoptera, which also includes wasps and ants. Numerous studies reveal members of Hymenoptera (bees, wasps, and

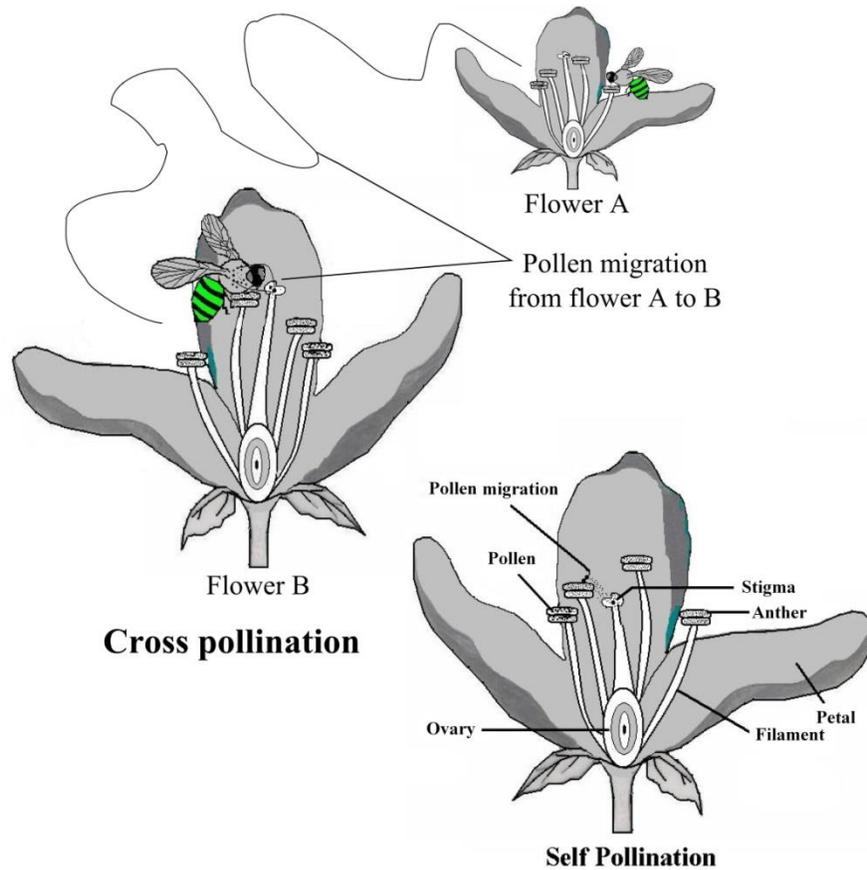
ants), Coleoptera (beetles), Lepidoptera (butterflies and moths) and Diptera (flies) as the leading pollinators. Among them, the Hymenopterans, especially the bees, are the most effective pollinators of crops and various other flowering plants, singularly accounting for pollination in about 70% of the world's cultivated crops.

Pollination

Pollination is an important reproductive process happening in higher plants, without which they normally do not produce fruits and never any fertile seeds. Pollination refers to transfer of pollen from the anthers or male reproductive organs of the flowers to the stigmas. Pollen grains are tiny reproductive spores produced in the anthers, the male reproductive organs of the flower. These microscopic spores on getting transferred to a stigma of the gynoecium, the female reproductive organ, germinate producing long narrow pollen tubes growing through the style into the ovules produced inside ovary. The pollen tube carries the male gametes produced inside the pollen grain towards the female gamete, the egg, inside the ovule. The union of the male and the female gametes, the process of fertilization, makes the ovary developing into the fruit, and the ovule into the seed.

Many crop and wild plant species are partially or completely self-incompatible as they cannot produce fruit or seed without cross-pollination. It is not just self-incompatible plants that benefit from cross-pollination, but self-fertile varieties also produce better quality fruit and seeds on getting cross pollinated (Free, 1993). This advantage is obviously because of greater genetic variation, as the zygote or fertilized egg contains a new mixture of chromosomes from the two parents, due to cross pollination. Cross pollination is facilitated by various agencies which may be animals (zoophily), most of them insects (entomophily), wind (anemophily - especially in grasses) and water (hydrophily - mainly in submerged water plants). In flowers that are self-pollinated, as soon as the anther walls break the pollen grains get deposited on the stigma within the same flower, without the help of any external agency carrying the pollen grains. In several cases, as in cotton and lady's finger for e.g. there may be a combination of both self and cross pollination. Those which entirely favour cross pollination might have separation of sexes into male and female flowers, which may occur in the same plant (e.g. mango and pumpkin) or on separate plants (e.g. nutmeg and palmyra palm). Bees are estimated to pollinate 16% of the total

of 0.25 million flowering plant species known so far. One-third of human diet is said to be derived from products of bee pollination. About 90% of the world's plant food production is mainly based on 82 products derived mainly from only 63 plant species. The importance of bees can be realized from the fact that for 39 of these plant species bees are the major pollinators (Thakur, 2012).



Pictorial depiction of cross and self pollination

Value of pollination

Pollination is a valuable ecosystem service and also of high economic value through enhanced agricultural production especially of fruits, seeds, vegetables, fibre crops and nuts (Costanza et al., 1997; Gordon and Davis, 2003). Several studies have attempted to estimate the economic value of honey bee pollination to agricultural production. The value of insect pollination for worldwide agricultural production is estimated at 153 billion \$, representing 9.5% of the value of the world agricultural production used for human food in 2005 (Gallai et al., 2009). Such

valuation, however, excludes the benefits derived from maintaining refuges for native pollinators. Such refuges may also harbour biological control organisms therefore supporting biological diversity. The value of cross pollination by the bees is estimated to be US \$ 20.0, 3.0, 22.0, 0.7 and 224.0 billion in the United States of America, Europe, New Zealand, China and the world respectively. In India, the value is estimated to be to the tune of Rs. 3000 crore. Honey bees, apart from yielding honey and wax, and acting as pollinators, also yield valuable products like, royal jelly, bee pollen, propolis and bee venom having nutritional / medicinal values (Viraktamath et al., 2013). The economic value of vegetables in India the second largest producer of vegetables in the world pollinated by animals is \$726 million, According to Basu et al., (2011) in spite of India's area under pollination dependent vegetables going up by 40% from 1941 to 2006 vegetable production which rose somewhat steadily up to 1993 and thereafter stagnated, which has been attributed to increased use of pesticides in the country adversely affecting pollinator insects. Notably, during the same period pollinator independent crops have shown continuous and substantial increase in production in tune with the increase in area under cultivation.

The studies on the losses being incurred due to decline of pollination services has been, to date, mainly confined to local case studies (Needham et al. 1988). We need to increase our understanding of pollination as a critical element in the world's food supply, and pay greater attention to the maintaining of pollination services in agricultural management (Balmford et al., 2002; Klein et al., 2007). The decline in pollinator population and diversity presents a serious threat to agricultural production, conservation and maintenance of biodiversity in many parts of the world. In the Himalayan region the decline in natural pollinator abundance is reported to have adversely affected apple orchards in Himachal Pradesh, India and Maoxian Valley, China forcing the farmers resort to hand pollination (Partap and Partap, 2000). About 15% of the hundred principal crops are reportedly pollinated by domestic bees, including honey bees, and at least 80% are pollinated by wild bees (Kenmore and Krell, 1998). In the Himachal Pradesh, northern Pakistan and parts of China, where despite all agronomic inputs, production and quality of fruit crops, such as apples, almonds, cherries and pears, were reported to be on the decline (Partap and Partap, 2001). Verma and Partap (1993), Partap and Partap (1997, 2002),

Chandrasekaran et al., (2011) stated that the decline in pollinator population and diversity happening worldwide in the recent years are mainly due to the following reasons:

- Decline in the habitat, with the accompanying decrease in their food (nectar and pollen) supplies as a result of decline in pristine areas
- Land use changes due to deforestation, for extending agricultural land, urbanization, and industrialization.
- Increase in monoculture-dominated agriculture; earlier, farmers used to grow a variety of crops, which bloomed during different months of the year and provided food and shelter for a number of natural insect pollinators
- Negative impacts of modern agricultural interventions, e.g. use of chemical fertilizers and pesticides. Mono-cropping also requires increased pesticide use which led to the killing of many pollinators due to pesticides.
- Improper disposal of waste- for e.g. paper cups used for tea and soft drinks carelessly thrown can act as sticky death traps for bees.
- Infestation by diseases and predators.

Pollination syndromes of flowers:

The various traits a flower exhibits for favouring a particular method of pollination is called pollinator syndrome. These traits include flower size, shape, color, scent, pollen, presence or absence of petals and nectar glands, nature of stigma, the blooming time etc. Wind pollinated flowers are inconspicuous, being devoid of any noticeable perianth, scent, devoid of nectaries and often with brush like or feathery stigmas to capture light and smooth wind-borne pollen and produced in abundance to make up for transmission loss. Often the tiny flowers are assembled in densely clustered inflorescences as in Maize or Jowar or Ragi.

Insect pollinated flowers: These flowers, called entomophilous, in general, are conspicuous with large and brightly coloured or white petals, often scented, nectar producing and relative low in pollen production. Pollen is heavier and spinous or rough textured or sticky adhering easily on the body parts or hairs of pollinating insects. Stigmas are relatively small and sticky, than brush or feather like. Bee-visited flowers generally have lower amount of nectar with higher sugar concentration, while bat- and bird visited flowers have higher nectar volume with lower sugar

concentration. These features are well recognized and form components of pollination syndromes.

Perception of flowers by bees

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, *Apis* bees contributed to the pollination of 18% of 86 species of trees, and 22% of the understorey shrubs (Devy & Davidar 2003, 2006). Bee pollinated flowers, being basically entomophilous, are with petals, pleasant floral aroma and mainly of yellow, blue or purple colours. Individual flowers tend to be large sized or flowers are tiny as in mango, soapnut or sunflower they are aggregated into conspicuous inflorescences. Sprengel (1793) first suggested that contrasting floral patterns, such as dots or radiating lines surrounding the nectary have certain role in guiding the pollinators towards the nectary. Later time research proved that these patterns have certain significance as “nectar guides” assisting the pollinators in finding nectar within the flower with greater precision, enhancing visiting frequencies and thereby facilitating more successful pollination. Nectar guides however, are welcome signals as well for nectar robbing insects as good indicators of sucrose rich nectar. (Leonard et al., 2013; Goodale et al. 2014).

Honeybees, living in well populated colonies, are social insects, with adult individuals of at least two generations within the same colony and storing the food resources for upbringing the young. Their body covered with branched hairs, and with special ‘pollen baskets’ on their legs honeybees are ranked as most efficient pollinators. Three types of photoreceptors within the compound eye of the bee function as three channels of spectral sensitivity for especially in the green, blue, and ultraviolet (UV) wavelengths, facilitating color vision. Ironically the bees’ world is not all that colorful, as after the neural processing of the perceptions through the receptors, ultimately the bee sees its target flowers as white or in shades of gray, whether the flowers be in the sunlight or in the shade (Horridge, 2014). Bees however, like humans like sweet scented flowers over those with unpleasant smells.

Foraging strategies

Complex strategies are involved in locating floral resources by honeybees. Bees depend heavily on pheromones for communications among themselves. Foraging is a collective process composed of both the activities of individuals, as well as of group. Groups of bees may be engaged in pollen or nectar collection or both according to pheromone signaling from a key informant bee. The required material is collected according to the need inside the hive as communicated by the queen bee. Once a bee forager comes across food resources it returns to the colony and communicates it to the hive mates by characteristic dances. The bee dance involves a complex system of movements rapidly conveying a package of information on the direction to be taken, distance, quality and quantity of food available. Based on the signals received a group darts off to the indicated target area not straying into any other potential sources which might occur on the way, true to their social loyalty. Such unified social behavior, a result of bees' innate response to external stimuli, enables the colony to exploit a forage source to the maximum. The hallmark of bee foraging behavior is its adherence to the flowers of a single species in a given locality until the returns diminish. Such floral constancy makes bees as more effective pollinators enabling them carrying more pollen of any particular species resulting in greater pollination success. That is the reason for farmers to keep bee colonies in fields of sunflower, apple orchard, coffee, cardamom etc.

The foraging time commencement of bee activity varies from day to day, well tuned to the availability of food resource and suitable factors such as floral distance between nesting site and food source, rain, humidity, temperature etc. Honeybee requires a spatio-temporally reliable supply of nectar and the distance between plant populations should not exceed natural pollinator foraging distances if they are to receive sufficient pollinator service and gene flow (Kwak et al. 1996). Honeybees from a single hive, for instance, are known to forage in 1-3 km radius from the colony (within 1 km for *A. florea* and *Trigona* sp., 1.5 km for *A. cerana* and 3 km for *A. dorsata*), but pollination efficiency is at the best 183 - 275m from the colony (Free, 1993; Corlett, 2004; Abrol, 2012). Benedek and Prener (1972) found that flower visiting rate increased with increasing air temperature, as sugar concentration increases due to water evaporation. Although normally diurnal, honeybees can forage in the night, if there is sufficient moonlight. Species of *Terminalia*, *Lagerstroemia* (Dyer 1985) and *Careya* (Diwan and Salvi, 1965) in Karnataka were reported as being actively visited by *Apis dorsata* in the moonlight.

Seasonal bee floral resource

Flowers are the mainstay of bee's life. However, not all plants necessarily are important for honeybees, those plants that supply both nectar and pollen abundantly when in bloom are often called honeybee foraging plants. Good producers of honey or pollen or both are ideal bee plants, as the bees obtain protein from pollen and carbohydrate from nectar source plants (Bista and Shivakoti, 2001). Flowering plants of several taxonomic families come into blossom at different times of the year. Depending upon the soil type, climatic factors and habitat characters, the time of the blooming may change for even the same plants species. The success of bee keeping will depend on the judicious utilization flowering and blooming times of various plants so as to ensure continuous flowering to maintain bee colonies. Gaining knowledge on such plants and designing the local landscapes in such with plants to ensure natural bee forage resources throughout the year will have much to do with the success of bee keeping. Every region has its own honey flow and dearth periods of short or long duration. Knowledge on bee flora will help in keep going the bee colonies even during lean periods (Bhalchandra et al., 2014). Generally, in the Central Western Ghats the honey flow period starts from January and lasts up to June. It is followed by a dearth period from July to September, due to paucity of flowering in the rainy season especially in the woody vegetation. In Uttara Kannada region, despite a forest cover of about 70% of its land area of 10,250 sq. km, and other forms of greenery elsewhere, the paucity of flowering in forests from June to September, a period of high-intensity monsoon rainfall, is a critical time for honey bees. Balachandran et al.'s (2014) study reveals that the mass flowering of rainy season herbs in the coastal laterite plateaus of Uttara Kannada provided food for honey bees and other insect communities during the dearth period for forage.

Diversity of honeybees in Western Ghats

The Super family Apoidea is divided into two main subgroups: Spheciformes (Wasps), and Apiformes (Bees). Bees are distinguished from wasps by: a) the presence of branched, often plumose, hairs, and b) the hind basitarsi, which are broader than the succeeding tarsal segments. The proboscis is in general longer than that of most sphecoid wasps. Michener's (2007) report shows 17, 533 species of bees worldwide, grouped under 443 genera and seven families. Of these, 633 species in 60 genera and six families were reported from India (Gupta, 2003). The

dominant honey producing bees belong to the genus *Apis*, under the family Apidae. *Apis* is represented by five species in India, of which four are native species viz. a) *Apis dorsata* (rock bee or giant bee), b) *Apis cerana* (Indian bee), c) *Apis florea* (little bee) and d) *Apis andreniformis*. *Apis mellifera* (European bee) is an introduced species. In Western Ghats, three native species (except *Apis andreniformis*) and one introduced species of honey producing *Apis* species and *Trigona iridipennis* are found.

a) *Apis dorsata dorsata* (Kan: Kadu jenu, Hej-jenu)

Apis dorsata is commonly referred to as the “Rock bee,” or “Giant honey bee” owing to its large body size. It has three subspecies in India viz *Apis dorsata dorsata*, *Apis dorsata laboriosa* and *Apis dorsata bighami*. *A. d. laboriosa*, the giant Himalayan honey bee, is confined to the high altitudes (range 2,500 and 4,000 m) in the northern region. *A. d. bighami* is distributed in restricted areas of the North-East namely in Khasia hills, Sikkim and Meghalaya. (Roubik et al., 1985; Allen, 1995; Otis 1996; Thapa et al. 2001). *A. d. dorsata*, which constitutes the Western Ghats subspecies, occurs at altitudes from 0 to 1,500 m. It is considered as key stone species in the forest ecosystem as it plays a crucial role in the sustenance of forest flora and fauna. The combs of this species measure 1.5 to 2.1 m from side to side and 0.6 to 1.2 m from top to bottom. The nests are not easily accessible as they are located on cliff faces located far above the ground and on the underside of branches of tall trees (Crane, 1999; Dyer and Seeley, 1994). They produce good lot of wax and honey, and are migratory in nature. Being very ferocious and inflicting painful stings these are not normally good for domestication. The hives are made more on the crown branches of the *Tetrameles nudiflora* and trees.

Habit and distribution: *Apis dorsata* is a seasonally nomadic bee migrating to locations about 100-200 km distance every year. It has a well-organized mass defense reaction. An intruder once marked by the odour or specific pheromone is chased for kilometers and stung. The timing of migration is correlated with the change in the season (rainy to dry period). It is distributed from India to the east to the coast of Vietnam and into the Southeast Asian islands.



Apis dorsata on *Cucumis sativa*



Apis dorsata on *Syzygium hemisphericum*



A. dorsata colonies in *Tetrameles nudiflora*



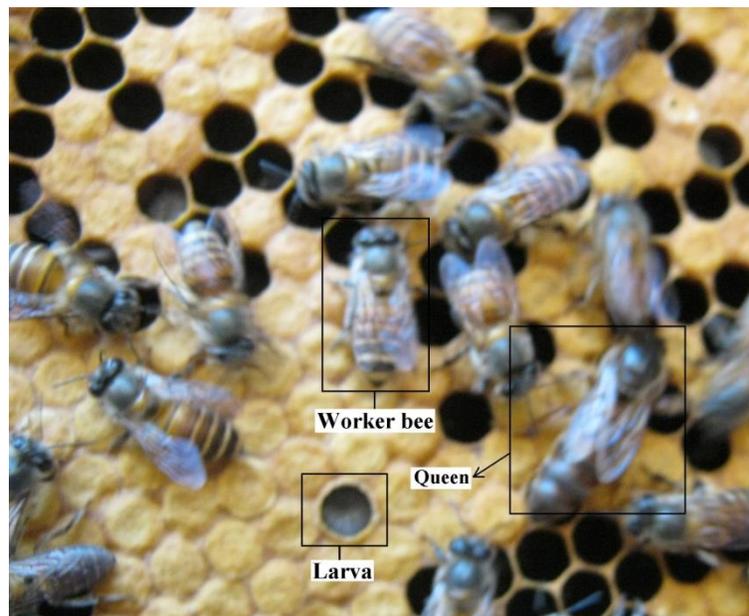
A. dorsata colonies in *Alstonia scholaris*

b) *Apis cerana indica* (Kan: Thuduve-Jenu):

Ruttner (1988) classified *Apis cerana* into subspecies based on the living habitats and genetical diversity; of these *Apis cerana indica* and *A. cerana cerana* occur in India. In Western Ghats, the subspecies *A. cerana indica* is recognized into two morpho-types like ‘hills bee’ (black coloured) and plains bee (yellow coloured). Both types are distributed in an around Western Ghats regions. Black morph occurs in moderate to high rainfall areas with moderate temperature, while the yellow morph prefers low rainfall high temperature situations. Currently, the beekeepers in Uttara Kannada prefer yellow morphs because of their ability to withstand higher temperature and forage scarcity, a situation increasingly being felt in the district. *Apis cerana*, the Indian bee is medium sized, yellowish brown and comparatively quiet in nature. The radial cell of the forewing on the basal portion and apical portions have lengths 1.2 mm and 1.8 mm respectively. The length of labial palp is 1.8 mm. The bee colonies are associated with dry, shadowy and dark

places viz. holes of old trees or dead trees, earthen pots, sunshade of buildings etc.; occasionally it also occurs in holes in the earth or in termite mounds. These bees are very suitable for apiculture as they can be reared on movable frames. A colony produces 5 -15 kg honey/year. The honey is considered superior compared to other honey sources. These bees are good gatherers of honey and pollen. While collecting honey and pollen they also pollinate the plant.

Habits and distribution: *Apis cerana* is easier to domesticate as it is non-nomadic unlike *A. dorsata* and *A. florea*. Stinging nature is medium but could be higher in swarming period. They build seven to eight parallel combs in a colony. Top of the comb, known as honey comb is meant for storing honey and pollen while the bottom where the queen lays egg to brood the new bees, is known as brood comb. It does not normally attack unless provoked. This is the most widely domesticated bee in India as its domestication is easier being non-migratory. Its distribution is across the plains of Central and Southern India, Sri Lanka, Bangladesh, Burma, Malaysia, Indonesia and the Philippines as a uniform population in this subcontinent. But in the higher altitudes of North India it is replaced by *A. cerana cerana*.



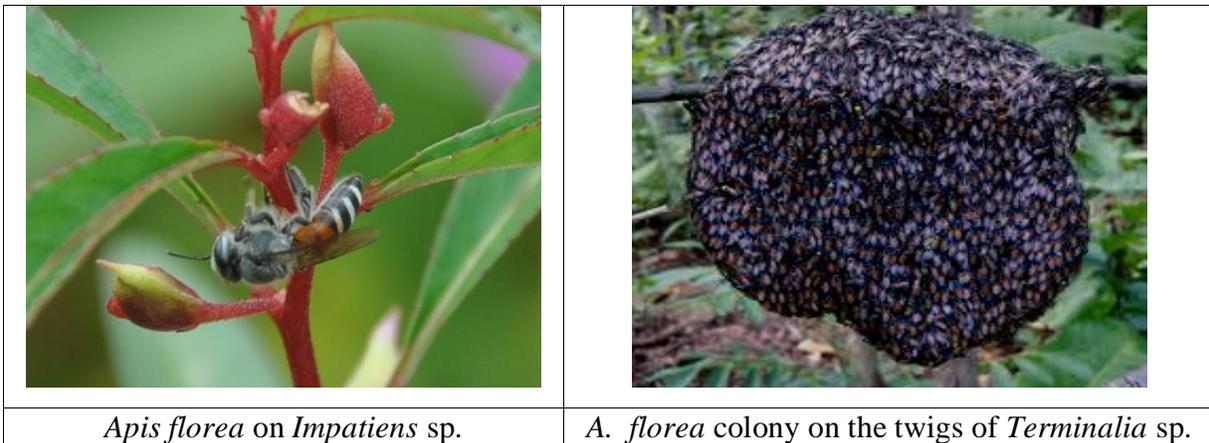
***Apis cerana indica*: A queen and the workers**

c) *Apis florea* (Kan: Kolu-Jenu)

Commonly called as Dwarf Bee or Little Bee, the quantity of honey collected is less and mostly consumed by the bees themselves. The combs are single and similar to that of *Apis dorsata* in

structure. The average body length and height are 6 mm and 3 mm respectively. It has white stripes on the brown abdomen. In the drones (males), the “thumb” of the bifurcated basal-tarsus of the hind leg is much longer. *A. florea* usually constructs its hive on small branches from the tree trunk or in bamboo groves, forming colonies encircling the branches. Kutch area of Gujarat is a major producer of honey from it (Soman and Chawda, 1996).

Habits and distribution: More known as crop pollinator than a honey producer, *A. florea* often migrates between plains and adjacent low hills, depending on seasonal variations in forage availability. The species generally occurs in warmer climate of Oman, Iran, Saudi Arabia, Pakistan, India, Sri Lanka, Indonesia, Thailand and Africa (Ruttner, 1988, Hepburn et al., 2005).



d) *Apis mellifera*

Apis mellifera, native to Africa, Europe and the Middle East, was introduced into India in late 70's or early 80's, first into Punjab, Haryana and Himachal Pradesh and later into South Indian states. Larger in size compared to *A. cerana*, it builds larger multiple combs having greater honey storage capacity than its Indian counterpart. Fecundity, brood rearing and colony build up are also much higher/ faster in this species (Atwal and Sharma 1968, Hamaed and Adhlakha, 1973; Rana and Goyal, 1994).

Habit and distribution: Ability to acclimatize to even semi-desert tropics as well as to cold temperate zones; has made of more global in distribution. Native to western Asia, Africa, and Europe, being a good honey maker and pollinator humans introduced it into rest of Asia, Australia and America.

e) *Trigona iridipennis* (Kan: Misri Jenu; Eng: Dammer bee)

Member of family Apidae *Trigona* genus the dammer bees belong to sub- family Meliponinae, which has 7 other genera and 15 sub genera and altogether 500 species (Wille, 1983). Dammer is a kind of resin for construction of their nest along with wax produced from their body. These smallest of bees are stingless although they bite the intruders in defense. The bees' number in a colony might range from a hundred to thousands or more (Michener, 2000). *Trigona* comb differs from those of other honeybees of *Apis* genus in having elliptical cells instead of hexagonal ones. Resin than wax is major substance used for comb making unlike in other honeybees. It is easier to domesticate *Trigona* but honey production is much lesser. The honey, dark and bitter, is attributed with medicinal importance and highly valued. The nests are built in trunks of trees, logs, wall crevices or under the roofs of dwellings. In the nest, there is a group of separate cells for brood rearing and another group of larger "sacs" for storage of pollen and honey.

Habits and distribution: Dammer bee possess many characteristics that enhance their importance as crop pollinators like perenniality, polylecty, floral constancy, recruitment, harmlessness and resistant to diseases and parasites of honey bees suit them for pollination. It builds nest in dark enclosures with a material made of wax, resins, propolis and mud. They are loosely clustered small elliptical cells for rearing their brood and similar but larger food pots in which pollen and honey are stored. The distribution is mainly in Southern Asia to Australia.

	
<i>Trigona iridipennis</i> on Cucurbits	<i>Trigona iridipennis</i> in bee box

Beekeeping (Apiculture) scenario in Western Ghats

Apiculture (Latin “apis” = bee) is the science of keeping and managing practice of *Apis* bees. It is a forest and agro-based industry, which is beyond the ordinary realms of industry, in the sense that the humans derive benefits from interaction between two living things like plants and bees without affecting adversely both. Plants, including many crops, prosper and the bees flourish sheltered by humans, giving honey and different other products like beeswax, propolis, bee pollen, bee venom and royal jelly, other by-products of beekeeping. Beeswax is used in carpentry, production of candles and cosmetics. Propolis is a substance made by bees from plant resin. It is used for cosmetics, medicine and food. Royal jelly is a special nutrient combination, prepared by worker bees. Feeding a female larva with more royal jelly transforms it into a queen, who attains maturity earlier; whereas the other female larvae fed with minimum of royal jelly develop into workers taking more number of days to reach adulthood. The queen has a longer lifespan of 2-3 years whereas the workers hardly last beyond a month. Bee keeping has a long history spanning back into pre-history. In view of the high nourishing qualities of honey and increasing global demand bee keeping has great potential, especially in a biodiversity rich country like India, to create more rural livelihoods. At the same time bee keeping in larger scale can enormously benefit agricultural productivity through pollination services, a valuation seldom ever thought of by economists in this country. Scores of flowering plants in the wild also depend on bees for their pollination services.



Mud pot bee hive



A beekeeper in Uttara kannada

Ranking seventh among the honey producing countries India has been exporting honey since 1991-1992. The quantity exported was around 8,000 tons until 1998, increasing substantially to 15,587 tons in 2009. India exports honey to approximately 62 countries, with Belgium, Germany, Saudi Arabia, the United Kingdom, and the United States being the major purchasers (Sharma, et al., 2012). The major honey-producing Indian states are Punjab, Haryana, Uttar Pradesh, Bihar and West Bengal. The average number of beehives in the world was estimated to be 72.52 million, of which India, China, Turkey, Ethiopia and Iran occupy the top five positions accounting for 40.69% of the hives. Despite having the credit of having largest number of bee hives in the world India ranks only seventh in honey production (Michener, 2007; VanEngelsdorp et al., 2009). A variety of factors may be responsible for this backwardness in Indian honey production in spite of having rich diversity of bees.

Despite prospects of a blooming market for honey, both due to domestic and international demand, the scanty attention which the farmers of Western Ghats pay towards apiculture is a matter of concern despite the region's endowment of a rich floral capital. The increased use of pesticides, herbicides and other chemicals in coffee and tea estates and other cash crops like ginger, cardamom etc., clearing of tall forest trees that gave habitats for bees, especially for *A. dorsata*, from human settlements and estate areas, conversion of lands for mining and other alternative uses, monoculture tree plantations etc. would have, in all probability affected bee keeping and contributed towards the general laxity among the local population for it, despite good governmental schemes for promoting apiculture such as "Swarna Bhoomi Yojana." Many farmers are still unaware of the multiplicity of benefits from beekeeping, including pollination services and lack of awareness and motivation was conspicuous in places where we carried out field work in Uttara Kannada district of Central Western Ghats.

Need for promoting bee keeping in Western Ghats, India

Two species of honey bees, *Apis cerana* and *Apis mellifera* are mainly domesticated in the Western Ghats states. *A. mellifera* is found more suitable for the conditions of southern Western Ghats from south Karnataka to Kerala and parts of Tamil Nadu. Central and Northern parts of Western Ghats from Uttara Kannada and Maharashtra is considered more suitable for rearing of *A. cerana*. Bee-keeping can be developed into one of the best developmental options for Western

Ghats regions, because this region treasuring vast variety of bee flora. It could be developed into a significant employment, perhaps next only to farming and fishing. At the same time it has only favourable impact on environment and productivity, through pollination services rendered by the bees, unlike intensive farming or fishing. Apiculture development needs to be taken up seriously for the following reasons:

- Honey production does not require ownership of land and is ideal for generation of employment to rural people (especially women and self-help groups).
- The products like honey, beeswax and propolis are not perishable and can be stored for long periods and even exported.
- The technology required beekeeping is minimal and can be practiced with ease even by educationally backward segments of the society. No foreign technology is involved here and the equipments used are of low cost.
- The necessary materials are locally available and input required is very low. Production cost of honey is very low compared to other farming activities or cattle keeping.
- A great variety of plants in Western Ghats are ready sources of nectar and pollen.
- It supports agricultural activities through facilitating critical processes like cross pollination thereby enhancing food production.
- Bee colonies can be shifted easily to make best use of flowering of wild plants and crops at different times. Crop production and propagation of wild plants are promoted.
- Beekeepers do not burden on natural resources; there is no slashing and burning of forests for creation of grasslands or crop fields; digging up of soil or lopping of trees for manure are not needed for bee-keeping. Instead bee keeping helps to improve the ecology and food production through cross pollination.
- Honey itself makes good nourishment, being rich in various nutrients and is used both in traditional and modern health care medicine. Regular intake of pure honey is believed to increase immunity in humans.
- It facilitates healthy linkages between biodiversity (insects and plants) towards sustainable livelihoods.
- Bees are prey for a variety of insects, mammalian and bird predators thereby making themselves important links in the trophic networks operating in ecosystems.

- Bee keeping ideally practiced will dissuade locals from destructive collection of wild honey, so that bulk of the wild bees can be spared for performing the vital ecosystem services.
- Rural economic activities will increase as if such places turn into centres of honey production, purification and marketing.
- Honey revolution just like white revolution would be a deterrent for current trends in large-scale emigration to the cities.

Recommendations

1. Creation of awareness to farmers on pollination benefits, organic farming, and beekeeping (Apiculture and Meliponiculture) involving government departments, NGO's etc. is important.
2. Awareness creation on the kind of locations to be chosen for bee keeping
3. Awareness on bee forage plants to furnish forage resources year-round is essential. Such plants need to be raised in hedge rows of agriculture areas, buffer zones of forests, road sides etc.
4. The importance and profitability of widespread planting of soapnut tree need to be highlighted.
5. Soppinbeta forest trees, shade trees in tea and coffee plantations etc. should be designed to promote bee keeping.
6. Honey hunters need to be trained in eco-friendly harvesting methods
7. Grazing, fire, and mowing can have damaging impacts on pollinators but can be used carefully in a manner that benefits pollinators.
8. Bio-pesticide and uses of predators of pest for biocontrol need to be popularized.
9. Potential of bee keeping for supplementary income, locality wise, needs to be explored. Also should be popularized commencement of bee keeping associated ancillary small-scale and cottage industries.

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