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# Natural vs. agricultural landscape: Potential habitat for native bees

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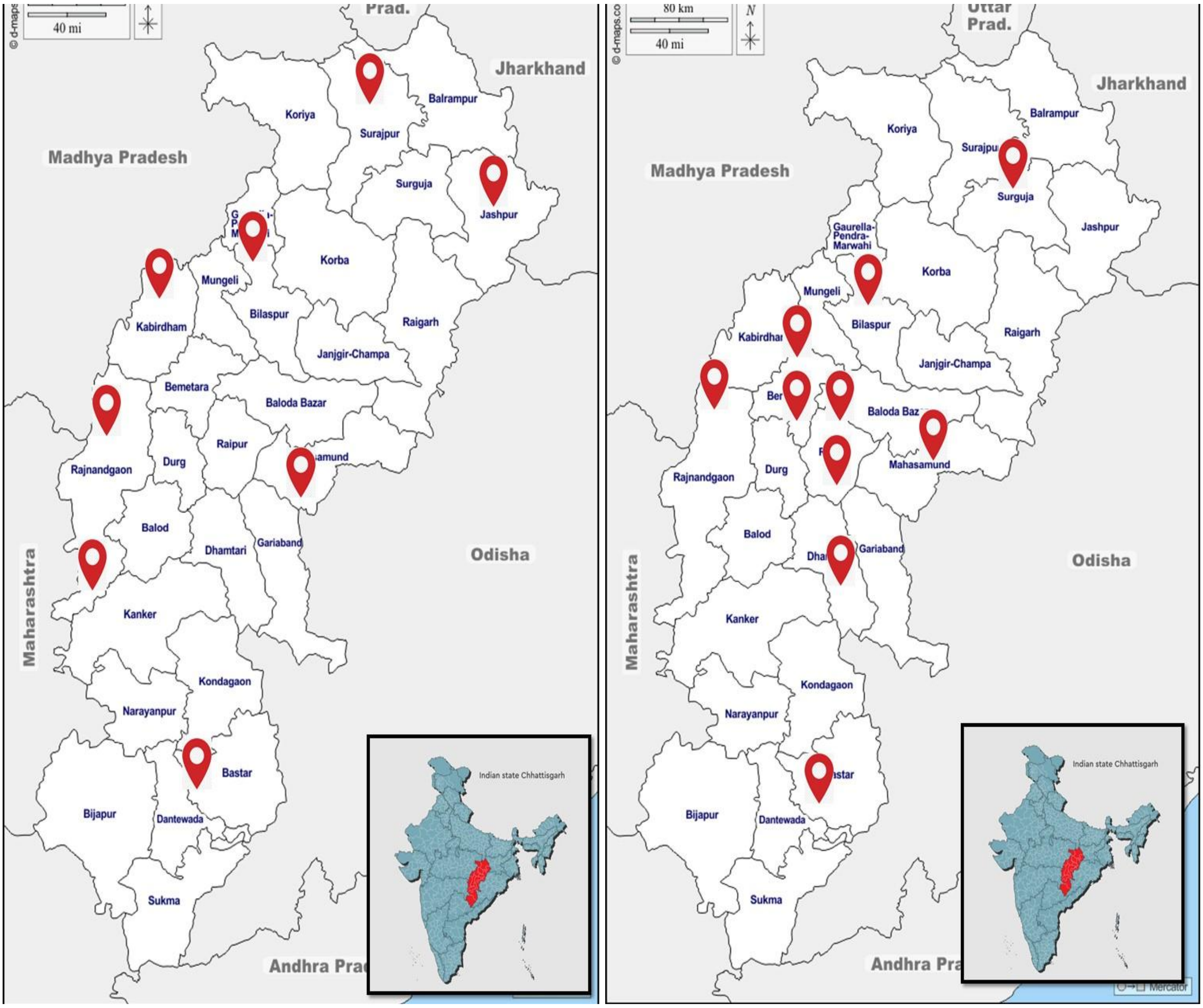
**Abstract**
Bees are the most significant group of pollinators in the world and they play a crucial role in agricultural productivity and the health of natural ecosystems. The recent decline in pollinator populations has highlighted the importance of protecting native bee populations and conducting research on the ecological needs of native bees. In this study, we investigated two types of landscape as foraging habitat for native bees. The survey was conducted in different agro-climatic zones of Chhattisgarh state. Sampling sites were divided into two categories based on habitat type *viz*., natural and agroecosystems. Species richness, evenness, similarity and diversity were calculated for both habitats by using different indices. A comparison of the species richness of the two ecosystems revealed that bee diversity differs markedly among ecosystem types. Bees from natural habitat made up a smaller proportion of the community than those from agricultural habitat. A significant difference was found between natural and agricultural ecosystems. The natural ecosystem was found to have significantly higher bee diversity in the Shannon Wiener Diversity Index, Simpson's Diversity Index, species richness in Menhinick's index and species evenness.

**Keywords:** Natural, agricultural, habitat, bee, ecosystem

## 1. Introduction
To ensure pollinator conservation, it's crucial to preserve healthy habitat areas. Ecosystem functioning may be affected by biodiversity losses, such as those caused by intensifying land use. However, rather than only being influenced by species richness per se, ecological functioning is also influenced by the variety and combination of functional traits present in the community. (Balvanera, *et al*., 2005; Cadotte *et al*., 2011; Hooper *et al*., 2012) [1, 4, 14]. It is commonly accepted that as land use intensifies, species and functional-trait diversity will also decline. (Flynn *et al*., 2009; Luck *et al*., 2013) [8, 20]. Among the most prevalent effects of human activity on the earth is the alteration of natural habitats for agricultural use. The species diversity of pollinators is decreasing due to agricultural intensification (Dobson *et al*., 1997) [7].

Some characteristics of cultivated habitats (especially those dominated by annual crops) contribute, such as tillage, loss of native plant diversity, and lack of dead wood, but there are also management-related differences that may have an impact on both species diversity and the representation of various functional groups. Typically, diversity decreases as management intensity rises. (e.g., Hole *et al*. 2005; Clough *et al*. 2007; Rundlof *et al*. 2008; Batary *et al*. 2011; though see Brittain *et al*. 2010) [13, 5, 22, 2, 3]. However, most of the studies comparing the biodiversity benefits of organic farms only with those of conventionally managed farms, rather than natural habitats (e.g., Hole *et al*., 2005; Clough *et al*., 2007; Rundlof *et al*., 2008; Tuck *et al*., 2014; but see Hodgson *et al*., 2010; Kehinde and Samways, 2012) [13, 5, 22, 23, 12, 17]. We can't tell how farming communities maintain the structure and functional richness of their natural surroundings until we compare them to natural habitats.

## 2. Materials and methods
### 2.1 Site description
Extensive surveys were undertaken from July 2019 to August 2020 in three agro-climatic zones of Chhattisgarh state to document native bees The survey locations were divided into two categories *viz*. natural ecosystems and agroeco systems. Bees were collected from various ecosystems and locations. Natural ecosystems include forest areas and grasslands with no human interference, whereas agroeco systems include agricultural lands, orchards, and kitchen gardens.




A. Natural habitats B. Agricultural habitats

**Fig 1:** Locations selected for the collection of native bees from Chhattisgarh, India

### 2.2 Sampling

Sweep net and yellow pan traps (YPT) were used for sampling bees. Each pan was filled with 250 ml of water. Three drops of liquid detergent were mixed with water in each pan to break the water's surface tension. Samples were collected at every alternate day and traps were refilled and placed again. To ensure thorough sampling of bee fauna, sweep net collection was also undertaken. Specimens were dehydrated following (Heraty and Hawks, 1998) [10] and later were mounted, labeled and identified to species level. All the specimens of this study are deposited in the National Insect Museum of ICAR-National Bureau of Agricultural Insect Resources, Bengaluru.

### 2.3 Statistical analysis

Samples across the sampling duration were combined for analysis. For each colour pan trap following observations were undertaken:

#### 2.3.1 The species richness was calculated using following models (Magurran, 2004)

Margalef's index ($D_{Mg} = (S - 1)/\ln N$)

Menhinick's index ($D_{Mn} = S/\sqrt{N}$)

#### 2.3.2 Diversity index was computed following (Hill, 1973)

Shannon Weaver diversity index ($H' = -\Sigma [p_i \ln (p_i)]$)

#### 2.3.3 Species Evenness was calculated following (Hill, 1973)

$E = H' / \ln S$

Where H' is the diversity index calculated from Shannon Weaver's diversity index.

#### 2.3.4 Relative abundance

Samples from all the coloured pan traps were compiled and used to calculate the relative abundance by the following formula (Curtis and McIntosh, 1951) [6]

$$\text{Relative abundance} = \frac{\text{Total number of individuals of one species}}{\text{Total number of individuals of all species}} \times 100$$

#### 2.2.5 Effective number of species (ENS)

ENS = Exponential of H'

**2.2.6 Beta diversity**

The most widely used index for assessment of Beta diversity is Jaccard Index (JI) (Jaccard, 1912) [15]. Jaccard's index was calculated for both the ecosystem by using the following formula:

JI = j/a+b-c

Statistical test ANOVA was used to test the difference between the indices of natural and agricultural ecosystems.

**3. Result**

**3.1 Natural ecosystem**

A total of 390 bees belonging to three families, 27 genera and 40 species were collected from the natural ecosystem of different sites. The value of the diversity index of the total captured population whereas follows:

Shannon Wiener Diversity Index (3.16) shows a high level of diversity. Shannon Wiener Diversity Index (0.94) which means there is only a six percent (6) chance that two randomly selected individuals would be of the same species. Menhinick's diversity index (2.12) and Margalf richness index (6.87) show the diversity of the natural ecosystem is high. The value of species evenness (0.84) shows the population is very much uneven and has many species (Table 1).

**3.2 Agro ecosystem**

333 bees were captured from agro-ecosystem belonging to three families and 34 species. The diversity of bees was calculated with the help of various diversity indices. The value of the Shannon Wiener Diversity Index (2.89) shows high diverse population. The value of Simpson's Diversity Index (0.92) represents only 8 per cent chance of randomly selected two individuals would be of the same species. The value of Species evenness (0.82), Menhinick's diversity index (1.86), and Margalf richness index (5.68) show the high species richness in the population (Table 1).

**Table 1:** Value of diversity indices of two ecosystem

| Diversity index | Man-made ecosystem | Natural ecosystem |
|---|---|---|
| Shannon-Wiener Diversity Index | 2.89 | 3.16 |
| Simpson's Diversity Index | 0.92 | 0.94 |
| Species evenness | 0.82 | 0.84 |
| Menhinick's diversity index | 1.86 | 2.12 |
| Margalf's richness index | 5.68 | 6.87 |
| Effective no. of species | 18.11407 | 23.66 |

Overall Jaccard's index between natural and man-made ecosystems for bee species was found to be 0.43 (43% of species were similar between the ecosystems).

The similarity between the ecosystems was calculated separately for each ecosystem and found to be 0.67 for the man-made ecosystem (67 percent of the species are similar to those found in the natural ecosystem) and 0.54 for the natural ecosystem (54 percent of the species in a natural ecosystem are similar to species present in a man-made ecosystem).

Similarities between the population were also calculated for each group *viz*; man-made ecosystem 0.82 and natural ecosystem 0.68 showing that 82 per cent of the individual of the man-made ecosystem were similar to the bee population found in the natural ecosystem and 68 per cent of the bee population in the natural ecosystem were similar to the individual of the man-made ecosystem.

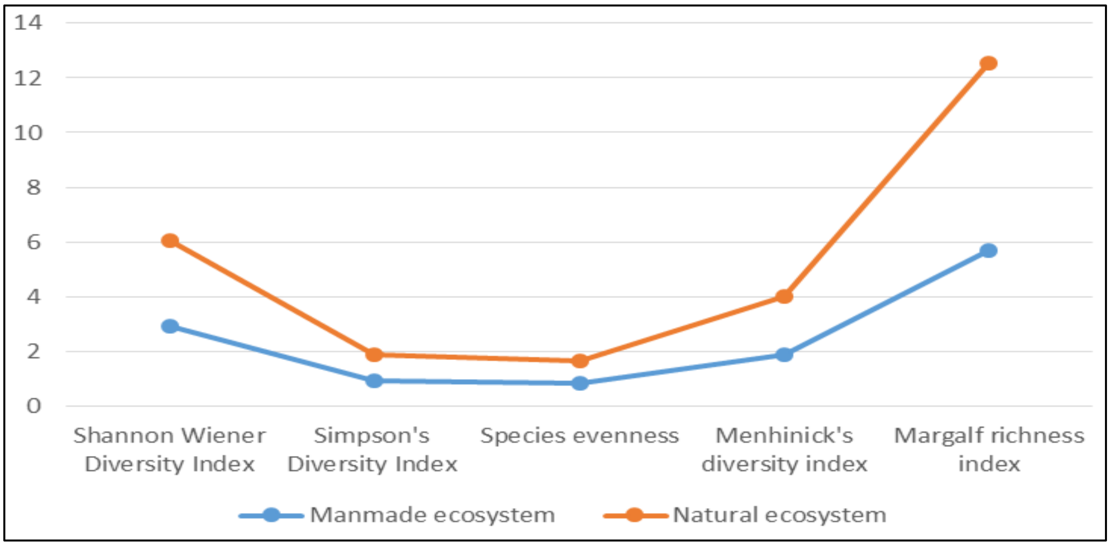



**Fig 2:** Differences in the diversity of bees in the natural and agroecosystem.

Bee diversity differs markedly among ecosystem types. bees from natural habitats made up a smaller proportion of the community than in man-made habitats (ANOVA, $F_{2,6}$= 44.31, $P$ = 0.0001). There was found a significant difference between natural and man-made ecosystems. The natural ecosystem was found significantly higher in bee diversity in Shannon Wiener Diversity Index and Simpson's Diversity Index; species richness in Menhinick's index and species evenness.

**Appendix A**

**Table 2:** Similarity of the species between natural and man-made ecosystem

| Species | Abundance in natural ecosystem | Abundance in man-made ecosystem | Similarity |
|---|---|---|---|
| *Hoplonomia westwoodi* | | X | 0 |
| *Nomia crassipes* | | | 1 |
| *Curvinomia strigata* | | | 1 |
| *Gnathonomia thoracica* | | X | 0 |
| *Maynenomia sinensis* | | | 1 |
| *Maynenomia ghatensis* | | X | 0 |
| *Maynenomia* sp. 1 | | X | 0 |
| *Maynenomia immsi* | | X | 0 |
| *Leukemia interstitial* | | | 1 |
| *Lipotriches fulvinerva* | | X | 0 |
| *Lipotriches exagens* | | X | 0 |
| *Lipotriches* sp. 1 | X | | 0 |
| *Lipotriches* sp. 2 | | X | 0 |
| *Lipotriches* sp. 3 | X | | 0 |
| *Steganomus lieftchinki* | | X | 0 |
| *pachynomia aliena* | | X | 0 |
| *Macronoma antennata* | | X | 0 |
| *Austronomia* sp. 1 | | | 1 |
| *Austronomia* sp. 2 | | X | 0 |
| *Austronomia* sp. 3 | | X | 0 |
| *Lassioglossum* sp. 1 | | | 1 |
| *Halictus* sp. 1 | | | 1 |
| *Seladonia lucidipennis* | | | 1 |
| *Megachile lanata* | | | 1 |
| *Megachile bicolor* | | | 1 |
| *Megachile anthracina* | X | | 0 |
| *Megachile carbonaria* | X | | 0 |
| *Megachile vigilans* | | | 1 |
| *Megachile* sp. 1 | | X | 0 |
| *Lithhurgus* sp. 1 | X | | 0 |
| *Lithhurgus* sp. 2 | X | | 0 |
| *Coelixys fuscipennis* | X | | 0 |
| *Euaspis carbonaria* | X | | 0 |
| *Amegilla zonata* | | | 1 |
| *Amegilla cingulifera* | | | 1 |
| *Amegilla violacea* | | | 1 |
| *Amegilla bicincta* | X | | 0 |
| *Thyreus histrio* | | X | 0 |
| *Thyreus ceylonicus* | | X | 0 |
| *Xylocopa pubescence* | X | | 0 |
| *Xylocopa latipes* | | | 1 |
| *Xylocopa fenestrata* | | | 1 |
| *Xylocopa nasalis* | | | 1 |
| *Xylocopa* sp. 1 | X | | 0 |
| *Ceratina binghami* | | | 1 |
| *Ceratina smaragdula* | | | 1 |
| *Ceratina hieroglyphica* | | X | 0 |
| *Apis dorsata* | | | 1 |
| *Apis florea* | | | 1 |
| *Apis cerana indica* | | | 1 |
| *Tetragonula* sp. 1 | | X | 0 |
| *Tetralonia* sp. 1 | X | | 0 |
| Total species richness | 40 | 34 | 23 |
| Symbol “ ” used for species present, “X” used for absence of the species. “1” indicates the similarity and “0” indicates the difference of the species in both the ecosystems. | | | |

## 4. Discussion

Forrest *et al.* (2015) [9] found a similar result and recorded organic farms had higher species richness than conventional farms, but functional diversity was lower in both farm types than in natural habitats. Agriculture intensification reduces species diversity in many groups, including pollinators. (Dobson *et al*. 1997; Kerr and Cihlar, 2004; Kennedy *et al*. 2013) [7, 19, 18]. (Bartual *et al*. 2019) In order to predict pollinators in agroeco systems, it is necessary to go beyond the simple pooling of semi-natural habitat types and emphasis the importance of considering their vegetation traits. The loss of a landscape can reduce the availability of resources needed for pollinators to survive, resulting in the new habitat no longer being able to support the original organisms and causing the loss of diversity (Johnson and Klemens, 2005) [16].

## 5. Conclusion
Natural habitats play a more significant role in managing the bee fauna than agricultural landscapes. Natural habitat retains a higher population and greater diversity of native bees. Hence, it is important to conserve natural habitats for the conservation of faunal diversity. The addition of semi-natural habitats to farms would be beneficial in raising populations of native bees, therefore increasing the functional diversity of farm bee assemblages. More fundamentally, our findings highlight the limitations of agricultural habitat and the vital role of natural habitat in sustaining functionally diverse native pollinator populations.

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