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Diversity and distribution of stingless bees in India

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Abstract
This review presents a comprehensive analysis of the distribution and diversity of stingless bees in India. Stingless bees are vital pollinators and sources of medicinal products, yet their distribution in India remains inadequately documented. This review paper synthesizes data on approximately 25 species from three genera—*Lepidotrigona*, *Lisotrigona*, and *Tetragonula*. *Tetragonula* is the most diverse and widespread genus, with 16 species recorded. The distribution of these bees varies regionally, with higher abundance in south-eastern India, while other regions show limited documentation. Recent discoveries have expanded the known diversity, but significant gaps persist, particularly in the northern and central regions of India. Enhanced research efforts are necessary to map the full range of species and understand their ecological roles and conservation needs.

Keywords: Distribution, Diversity, *Lepidotrigona*, *Lisotrigona*, Pollination, Stingless bees, *Tetragonula.*

Introduction

Biodiversity includes the full spectrum of life in all its varieties and forms. It encompasses the ecosystems where life thrives, the relationships between different habitats and their species, the natural surroundings, and the mechanism that sustain these connections [1, 2]. In 1985, Walter G. Rosen coined the term biodiversity from 'biological diversity' [1].

However, according to scientific estimates, there are between 1.5 and 20 billion different plant and animal species on earth. At present, most plant and animal species have not yet been discovered. India has a wide range of climatic conditions (like temperate, subtropical, tropical, alpine, etc.). Due to climatic changes, India has a diverse array of plants and animals, making it one of the world's "mega biodiversity countries" [3]. Geographically, India comprises roughly 2.4% of the planet's total land area, while it hosts around 8% of all known species worldwide. The Western Ghats, Himalayas, Indo-Burma, and Sunderland are the four hotspots in India out of the 35 hotspots that have been identified so far around the world [4].

In India, there are around 89000 animal species and 47000 species of plants and fungi [5, 6, 7]. Although there is little information on the biodiversity of Indian forests, one estimate suggests that India has 16500 spp. of flowering plants, 6500 spp. of algae, 2850 spp. of bryophytes, 1100 spp. of pteridophytes, 17000 spp. of fungi and bacteria, 8000 spp. of invertebrates, 68000 spp. of insects, 5000 spp. of mollusks, 2546 spp. of fishes, 200 spp. of amphibians, 1200 spp. of birds, and 390 spp. of mammals [8].

Insects are the most numerous, successful, and dominant organisms on Earth. They are six-legged invertebrates classified under the Class Insecta within the Phylum Arthropoda and the Kingdom Animalia. The biodiversity of insects includes the diverse range of living organisms found in various environments, such as marine, terrestrial, and freshwater habitats [3]. Among insects, bees serve a significant role in sustaining biodiversity and ensuring the well-being of ecosystems. Bees are an excellent example of symbiosis known as mutualism. Bees depend on flowers to survive, and flowers rely on bees to survive. For the bees, pollen and nectar of flowers are major sources of essential nutrients [9]. About 70-80% of flowering plants are known to be pollinated by them. Until now, honeybees have primarily been used in managed pollination services [10].

Honey bee colonies have rapidly declined, resulting in low crop yields [10, 11]. Some of the main reasons for declining honey bee colonies are- The misuse of pesticides by humans, which destroys colonies and contaminates beehives, as well as logging, diseases, pests such as trachea mites, bushfires, and habitat destruction [12]. These issues also affect bee pollinators in naturalistic environments like forests, which leads to a decline in plant and animal species that depend on fruit and seeds for survival. Hence, it became necessary to discover appropriate substitutes that could be utilized to manage pollination in both natural and agricultural conditions. This search concludes that stingless bees**,** which have existed in tropical and subtropical ecosystems since creation, are a great alternative to honey bees. They contribute significantly to primary health care by producing healing nest products like honey, propolis, and beebread [13].

Stingless bees

Stingless bees are eusocial insects that inhabit colonies, sharing their environment with one another [14]. Stingless bees are classified within the subfamily Meliponinae of the family Apidae, which is part of the superfamily Apoidea in the order Hymenoptera of the class Insecta. Stingless bees, like honeybees, are colonial eusocial insects, but taxonomically, stingless bees are distinct from honeybees. The honeybees are included in the Apinae subfamily, whereas the stingless bees are included in the Meliponinae subfamily of the family Apidae. Meliponini and Trigonini, are the two tribes included in the subfamily Meliponinae, which are divided into *Melipona* and *Trigona* genera, respectively [15, 16]. The Trigonini tribe includes all stingless bee species found in Asia and Africa. The different genera in this tribe include *Trigona*, *Nanotrigona*, *Tetragona*, *and Plebeia. Trigona* is the largest and most widely occurring genus, encompassing 130 species categorized into 10 subgenera [17]. Most *Trigona* species are relatively long-

winged and small. *Melipona* species tend to be short-winged and large, some being as large as honey bees [18].

Based on paleontological and biogeographical evidence, stingless bees are hypothesized to have originated in Africa and subsequently dispersed to various tropical and subtropical regions worldwide. This hypothesis is upheld by the information that the ancestral species of stingless bees, which possessed a highly developed sting system, is exclusively found in Africa. This distribution pattern and the presence of the ancestral lineage in Africa provide substantial evidence for the African origin and subsequent global spread of stingless bees [19]. Stingless bees are described as "stingless" because they lack a functional sting apparatus. Instead, they rely on their well-developed mandibles, which serve as a formidable defensive mechanism for protecting the colony and the nest [9].

Stingless bees, similar to honey bees, are eusocial insects that establish colonies and preferentially nest in obscured and protected environments. They commonly occupy natural cavities such as those in tree trunks and hollow logs, as well as anthropogenic structures like brick walls and building voids [20]. The behavior of stingless bees is profoundly influenced by their nesting biology, with nests being central to their social dynamics and serving as significant examples of complex animal architecture and ecological adaptation [21]. The stingless bee nest consists of a queen bee, a small number of drones, and thousands of worker bees, which also maintain a caste structure and develop complex communication [22]. Queen and Males (drones) are fertile bees, whereas worker bees are sterile female bees. Queen bee plays a crucial role in regulating the different systems in the hive. Worker bees gather pollen and nectar for feeding as well as sap for constructing hives [9]. Stingless bees can be domesticated in hives through a process called meliponiculture. In India, this technique has been used since ancient times to harness the medicinal properties of their honey, propolis, and beeswax [23, 24, 25].

Diversity of stingless bees in India

India is considered one of the world's biodiversity hotspots due to its various bioecological conditions. The present understanding of stingless bees in India and their varieties remains unclear. About a century ago, Bingham (1897) identified the majority of Indian species under Melipona [26]. According to past reports, the Indian subcontinent is the habitat of five identified species of stingless bees and evidently, several unnamed species still need to be classified [27, 28].

Rasmussen (2013) outlined the diversity of stingless bees in the Indian subcontinent [29]. Rasmussen reports that the stingless bee species found in the Indian subcontinent are *Lisotrigona cacciae*, *L. mohandasi*, *Lepidotrigona arcifera*, *Tetragonula bengalensis*, *T. gressitti*, *T. iridipennis*, *T. praeterita*, *and T. ruficornis*. This classification encompasses eight species across three genera: *Lisotrigona*, *Lepidotrigona*, and *Tetragonula*. According to Rahman (2015), Indian stingless bees comprise two genera and six distinct species: *Tetragonula iridipennis*, *T. bengalensis*, *T. laeviceps*, *T. ruficornis*, *T. praeterita* and *Lepidotrigona arciferal* [30].

At present with including the new discovery of stingless bees species there are about 25 species of stingless bees present in India that belong to 3 genera namely *Lepidotrigona* (Schwarz, 1939), *Tetragonula* (Moure, 1961) and *Lisotrigona* (Moure, 1961). Of these, *Tetragonula* is the predominant genus, with 16 species, followed by *Lepidotrigona* and *Lisotrigona*, which have five and four species each, respectively [29, 30, 31, 32, 33, 34, 35].

Rasmussen (2013) states that stingless bees are particularly prevalent in the southern areas of India and along the coast of the Bay of Bengal [29]. Despite this, their distribution is scattered across the country. For example, in the desert region of Rajasthan, the genus *Tetragonula* includes *Tetragonula iridipennis* (Smith, 1854) and *Tetragonula shishirae* [33]. In Madhya Pradesh, *Lisotrigona cacciae* (Nurse, 1907) is present, while in Uttar Pradesh, *Tetragonula bengalensis* (Cameron, 1897) and *Tetragonula ruficornis* (Smith, 1870) are found. Additionally, stingless bees are also distributed in various other states, indicating a broad and uneven distribution throughout India. At various places in India, the diversity of stingless bees is still undiscovered. The nests are widely dispersed throughout India, but their identification has not been completed because of a lack of studies. With ongoing research at various places, the number of stingless bee species can be increased in the future.

Table 1: Diversity of Stingless Bees in Indian States

S. No.	Name of Species	Distribution	References
1.	*Lepidotrigona amruthae* (Viraktamath & Thangjam, 2022)	Mizoram	[35]
2.	*Lepidotrigona arcifera* (Cockerell, 1929)	Sikkim, Andhra Pradesh, Tamil Nadu, Kerala, Karnataka, Nagaland, Meghalaya, West Bengal, Assam	[29, 30, 36, 37]
3.	*Lepidotrigona rajithae* (Viraktamath & Thangjam, 2022)	Mizoram	[35]
4.	*Lepidotrigona sikkimensis* (Viraktamath & Thangjam, 2022)	Sikkim	[35]
5.	*Lepidotrigona thenzawlensis* (Viraktamath & Thangjam, 2022)	Mizoram	[35]
6.	*Lisotrigona cacciae* (Nurse, 1907)	Madhya Pradesh, Matale (Sri Lanka)	[29, 38]
7.	*Lisotrigona chandrai* (Viraktamath & Jose, 2017)	Kerala	[32]
8.	*Lisotrigona mohandasi* (Jobiraj & Narendran, 2004)	Kerala	[29, 39]
9.	*Lisotrigona revanai* (Viraktamath & Sajan Jose, 2017)	Maharashtra	[32]
10.	*Tetragonula ashishi* (Viraktamath & Jagruti, 2022)	Maharashtra	[34]
11.	*Tetragonula bengalensis* (Cameron, 1897)	Assam, Arunachal Pradesh, Meghalaya, Nagaland, West Bengal	[29, 30, 40, 41]
12.	*Tetragonula calophyllae* (Shanas & Faseeh, 2019)	Kerala, Goa	[31, 42]
13.	*Tetragonula gressitti* (Sakagami, 1978)	Arunachal Pradesh, Nagaland	[43, 44]

14.	*Tetragonula iridipennis* (Smith, 1854)	Karnataka, Kerla, Andhra Pradesh, Tamil Nadu, Punjab, West Bengal, Rajasthan, Chhattisgarh, Uttarakhand, Himachal Pradesh	[20, 29, 30, 45, 46, 47, 48, 49, 50, 51]
15.	*Tetragonula kyrdemkulaiensis* (Viraktamath & Rojeet, 2021)	Meghalaya	[33]
16.	*Tetragonula laeviceps* (Smith, 1857)	Gujarat	[52, 53]
17.	*Tetragonula perlucipinnae* (Shanas & Faseeh, 2019)	Kerala	[31]
18.	*Tetragonula praeterita* (Walker, 1860)	Sri Lanka	[29, 30]
19.	*Tetragonula ruficornis* (Smith, 1870)	Punjab, Uttar Pradesh, Uttarakhand, Haryana, Punjab, Delhi	[29, 30, 31, 54]
20.	*Tetragonula shishirae* (Viraktamath, 2022)	Rajasthan	[34]
21.	*Tetragonula shubhami* (Viraktamath, 2022)	Chhattisgarh	[34]
22.	*Tetragonula srikantanathi* (Viraktamath, 2021)	Tripura	[33]
23.	*Tetragonula sumae* (Viraktamath, 2022)	Tamil Nadu	[34]
24.	*Tetragonula travancorica* (Shanas & Faseeh, 2019)	Karnataka, Kerala, Tamil Nadu	[31, 55, 56]
25.	*Tetragonula vikrami* (Viraktamath, 2022)	Karnataka	[34]

1. Genus *Lepidotrigona*

This genus was described by Schwarz (1939) with *Lepidotrigona arcifera* Cockerell as the type species. In the genus *Lepidotrigona* The mesonotum is bordered with tiny, thick, slightly scale-like, or tomentose, light to yellowish hairs [36].

According to Rassumen (2013) and Rahman (2015) and others, *Lepidotrigona arcifera* is the only species that is present in India [29, 30]. But Viraktamath & Thangjam, (2022) discovered four new species in northeast India. These are – *Lepidotrigona amruthae*, *L. rajithae*, *L. sikkimensis*, *L. thenzawlensis. L. sikkimensis* is present in the Sikkim state, while other three species are present in the Mizoram state [35]. Therefore, at present, mainly five species of genus *Lepidotrigona* are present in India.

Species of the genus *Lepidotrigona* are mainly distributed in northeast Indian states like Sikkim, Nagaland, West Bengal, Assam, etc. The highly distributed species is *Lepidotrigona arcifera*. It was first reported from the Testa Bridge of the Himalayas in India [57].

2. Genus *Listotrigona*

Moure (1961) characterized this genus with Melipona cacciae Nurse designated as the type species. These tiny *Listotrigona* bees have body lengths between 2.50 to 3.00 mm, a little linear malar space, converging inner eye margins and significantly decreased wing venation [58].

In India two species of *Listotrigona* - *Lisotrigona cacciae* **(**Nurse, 1907) and *Lisotrigona mohandasi* **(**Jobiraj & Narendran, 2004) are present [29]. However, Viraktamath & Jose (2017) discovered two new species of *Listotrigona* - *Lisotrigona chandrai* and *Lisotrigona revanai* in India [32].

The genus *Listotrigona* is not equally distributed in all parts of India. Till now, these bees have been discovered only at some places in southern India and in Madhya Pradesh. These bees are less frequent than *Tetragonula* bees in India.

3. Genus *Tetragonula*

Moure (1961) described this genus with *Trigona iridipennis* Smith as the type species. The genus *Tetragonula* is distinguished by the existence of longitudinal hair bands on mesoscutum, an extension of the scutellum beyond the propodeum and a sericeous region on the ventral surface of the hind basitarsus. Male bees could be distinguished from female bees by the male genitalia that protruded from the tip of the abdomen [59].

The highest species diversity of stingless bees in India had been reported on the genus *Tetragonula* with more than 30 described species [27]. *Tetragonula* is the most widespread genus present all over India. At present 16 species of *Tetragonula* are present in India these are - *Tetragonula ashishi, T. bengalensis, T. calophyllae, T. gressitti, T. iridipennis, T. kyrdemkulaiensis, T. laeviceps, T. perlucipinnae, T. praeterita, T. ruficornis, T. shishirae, T. shubhami, T. srikantanathi, T. sumae, T. travancorica, T. vikrami*.

The largest and most common species group in the Indo-Pacific regions is "*iridipennis*." *T. iridipennis* has been widespread from India to Solomon Island. The most of work on stingless bees was done on Nesting biology, pollination and Morphometry analysis of *T. iridipennis* [20, 46, 48, 50].

Conclusion

The study of stingless bees in India has unveiled a rich diversity of approximately 25 species across three genera—*Lepidotrigona*, *Lisotrigona*, and *Tetragonula*—primarily concentrated in the south-eastern regions. Despite this, their distribution remains inadequately documented in many areas, highlighting significant gaps in our understanding of their geographic and ecological ranges. These bees play crucial roles as pollinators in both natural ecosystems and agricultural systems, yet their ecological interactions and habitat preferences are not fully explored. To address these gaps, there is an urgent need for systematic surveys and detailed research to map their distribution comprehensively and assess their responses to environmental changes. Enhanced documentation will be critical for developing effective conservation strategies, as well as for optimizing their use in sustainable agriculture and ecosystem management. Future research should prioritize investigating the full extent of their range, understanding their ecological roles, and identifying their conservation needs. Such efforts will not only aid in the preservation of these valuable pollinators but also contribute to broader biodiversity conservation goals and improve agricultural productivity through better pollination management. Integrating these findings into conservation and agricultural practices will ensure the long-term sustainability of stingless bee populations and their essential ecosystem services.

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Conflict of Interest
The authors do not have any conflict of interest.

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