EDITORA VERDE
ACTA APICOLA BRASILICA
GVAA GRUPO VERDE DE AGROECOLOGIA E ABELHAS

Exploring stingless bees and meliponiculture in Nepal

Nischal Kafle[1]*, Avishek Giri[2], Astha Dhakal[3], Abhishek Bhattarai[4], Aavash Shrestha[5]

[1]Tribhuvan University, Institute of Agriculture and Animal Science, Department of Agricultural Economics, Kirtipur, Kathmandu, [2]Agriculture and Forestry University, Faculty of Agriculture, Chitwan, Nepal, avishekgiri777@gmail.com; [3]Agriculture and Forestry University, College of Natural Resource Management, Puranchaur, Kaski, asthadhakal2000@gmail.com; [4]Agriculture and Forestry University, Faculty of Agriculture, Chitwan, Nepal, bhattaraiabhishek42@gmail.com; [5]Agriculture and Forestry University, Faculty of Agriculture, Chitwan, Nepal, aavashstha5@gmail.com. *Corresponding Author: Nischal Kafle, Kiritpur-4, Kathmandu, Nepal, PO Box: 44618, e-mail: nkafle26@gmail.com.

A R T I C L E
Received: 10-09-2024
Accepted: 07-01-2025
Published: 02-04-2025

Key words:
Colony
Brood
Wild bee
Meliponi,
Dammer
Tetragonula

A B S T R A C T

Stingless bees are crucial pollinators with significant cultural and ecological roles. They are essential for the pollination of various plants, contributing to biodiversity and the health of ecosystems. These bees also play a vital role in sustaining agricultural productivity by enhancing crop yields through their pollination services. Meliponiculture, the practice of keeping stingless bees for honey production and pollination, presents a viable livelihood option for rural communities, offering economic benefits and promoting sustainable agricultural practices. Despite their importance, stingless bees have been relatively understudied, and their unique biological traits, nesting behavior, and ecological roles remain underexplored. The lack of research has led to an absence of specific policies addressing their conservation or management in Nepal. This gap in policy and knowledge hampers efforts to protect these essential pollinators and their habitats. Effective conservation strategies and policy development are urgently needed to safeguard native stingless bee populations, ensure their continued ecological contributions, and support local livelihoods through sustainable meliponiculture practices.

INTRODUCTION

Stingless bees belong to the family of corbiculate bees (Hymenoptera, Apidae) family and are related to bumblebees, honeybees, and orchid bees. Despite their name, they do have a vestigial sting structure, but it is non-functional for defense or aggression. This remnant structure differs from the developed stinger found in other bee species (GRÜTER, 2020). Globally, over 600 species of stingless bees have been described from various groups of organisms (ENGEL, 2023).

Stingless bees have been a part of indigenous knowledge of many societies. People have been using their products as a natural source of food, as folk remedies, in crafts and as alternative source of income (ALAYA et al., 2013). Stingless bees are not only important for human culture but also play a vital role in pollinating thousands of plant species (HEARD, 1999). Hence, it contributes significantly to ecosystem biodiversity and agricultural productivity.

Meliponiculture is the practice of raising stingless bees for honey, pollen, resin, and other ecological benefits. It is gaining popularity in rural homesteads as a means of alleviating poverty and generating extra income by rearing indigenous bees. It is on the rise globally due to its ability to generate significant profits with low initial costs (VAZHACHARICKAL et al., 2020). Due to their ecological, economic, and cultural importance, stingless bees are among the most highly valued bee groups in the world (QUEZADA-EUÁN et al., 2018).

The only species of stingless bee recorded in Nepal is *Tetragonula iridipennis* Smith (Hymenoptera: Apidae). Bhatta et al. (2019) investigated the occurrence of stingless bees in Nepal through field surveys across 21 districts of Nepal and confirmed the existence of stingless bees in 9 districts. In Nepal, they are known by their local names among different communities. The Chhetri people of the far-western part of the country and the Brahmin people of the central region of the country called them *puttka,* while the Brahmin people of the west and the Chhetri people of the mid-western region called them *puttko* and *puttiko*, respectively. Tharu people in all development regions called them *mangrasha,* and Rai (Kirat) people living in the eastern part of the country recognized them as *dammer* bees (BHATTA et al., 2020).

Despite their various values, stingless bees remain largely unexplored and lack comprehensive documentation. Stingless bees, comprising around 70% of all eusocial bee species, are discussed in only about 6% of scientific publications on eusocial bees (GRÜTER, 2020). This disparity may be attributed to the challenges of studying these smaller and less conspicuous bee species, which require specialized knowledge and observation techniques.

Likewise, stingless bees that have been living in the forests of India, Sri Lanka, and Nepal for centuries have recently been confirmed. While their existence was previously denied, even after confirmation, no specific conservation initiatives have been implemented for stingless bees. Instead, they have been grouped with other Apis species for beekeeping purposes (BHATTA et al., 2019). This highlights the lack of targeted conservation strategies for these unique bee species.

Additionally, like many other organisms, stingless bees are subject to a variety of contemporary challenges, including habitat loss, climate change, the introduction of new species, and exposure to toxic agrochemicals, all of which significantly impact the population of stingless bees (TOLEDO-HERNÁNDEZ, 2022). Global efforts are underway to improve the conservation and management of stingless bees to increase colony numbers, meet the demand for stingless bee honey, and enhance their pollination services.

Studying the occurrence, behavior, significance, and conservation status of stingless bees in Nepal is crucial. It provides insights into their diverse roles within ecosystems and local communities. This comprehensive review can reveal their economic uses, ecological contributions, cultural significance, and potential conservation needs. Additionally, recording their presence and ecological contributions could lead to effective conservation strategies for safeguarding stingless bee populations and their habitats. By promoting a deeper understanding of their importance, the objective of this study is to analyze the creation of conservation initiatives that prioritize the long-term sustainability of stingless bee populations and the well-being of both ecosystems and communities in Nepal.

MATERIAL AND METHODS

Literature Search Strategy

A systematic literature search was conducted to compile a comprehensive review on stingless bees. The search was carried out across several prominent databases, including PubMed, Scopus, Web of Science, Google Scholar, and JSTOR. Keywords such as "Stingless bees," "Meliponini," "Tetragonula iridipennis," "pollination," "honey production," "stingless bee biology," and "stingless bee conservation" were used to identify relevant studies. A total of 80 research articles, books, and review papers were studied, and only relevant papers were cited in the article. Priority was given to the recently published articles and old referenced articles were referred to study the development.

Inclusion Criteria

Articles were selected based on specific inclusion criteria to ensure relevance and quality. Only peer-reviewed journal articles, books, and conference papers were included. The focus was on studies that addressed the biology, behavior, ecological role, and economic significance of stingless bees in Nepal. Research providing data on stingless bee species, their role in pollination, honey production, and conservation efforts was prioritized. Except bee promotion policy in Nepali language, articles published in English or with English abstracts were included in the study.

Data Extraction and Synthesis

Data extraction involved identifying and organizing key themes from the selected literature. Themes included stingless bee taxonomy, nesting biology, pollination ecology, honey production, and conservation status. Relevant data such as species diversity, habitat preferences, and pollination efficiency were meticulously extracted and categorized into thematic sections. This process facilitated a structured synthesis and comparison of findings across different studies, allowing for a comprehensive overview of the current state of knowledge on stingless bees.

Data Analysis

The analysis involved both descriptive and comparative approaches. A descriptive analysis provided a summary of major trends, gaps, and consensus in the literature. Comparative analysis was used to draw insights from different studies, identifying patterns and discrepancies in stingless bee research. This approach enabled a thorough understanding of the current state of research and highlighted areas requiring further investigation.

Limitations

The review acknowledged potential limitations, including publication bias and language bias. Publication bias may have influenced the review due to the availability and quality of published research. Language bias was also a consideration, as the review was limited to English-language publications, potentially excluding relevant studies in other languages.

Ethical Considerations

Since the review article did not involve primary data collection, ethical considerations were not applicable. All included studies adhered to ethical research standards and were appropriately cited, ensuring the integrity and credibility of the review.

RESULTS AND DISCUSSION

Origin, habitat and distribution

Stingless bees are currently found in tropical and sub-tropical regions worldwide. They are distributed across three major tropical regions: the Neotropic (tropical Americas), Afrotropic (Sub-Saharan Africa), and Indo-Malayan-Australasian regions (TRIANTO et al., 2024). *Tetragonula iridipennis* Smith (Hymenoptera: Apidae), commonly known as the Indian dammer bee is widely spread over the tropical and subtropical areas in the world (Sukemi, et al., 2021). The origin of *T. iridipennis* can be traced back to its initial description from Sri Lanka (MAKKAR et al., 2018). This species is now widely distributed across India and Southeast Asia. It is widespread in Asian countries, including Bangladesh, Bhutan, India, Indonesia, Myanmar, Nepal, Pakistan, and Sri Lanka (KARUPPAIAH, 2023). Many palynological and characterization investigations have been done on *T. iridipennis* from different locations in India (MAKKAR, 2018; KARUPPAIAH, 2023) but no such investigation has been done from Nepal.

According to Shrestha (2022), stingless bees are found up to 900 m above sea level and are common in Dang, Banke, and Bardiya districts of Nepal. Along with Dang, Banke and Bardiya, nests of *T. iridipennis* was confirmed in Jhapa, Chitwan, Kapilvastu, Arghakhanchi, Kailai and Kanchanpur as shown in Figure 1 (BHATTA et al., 2019). However, as other species, *Lepidotrigona arcifera* (Cockerell), have been identified in Sikkim, India, which is close to the eastern border of Nepal, the existence of other species can also be suspected (BHATTA et al., 2019).

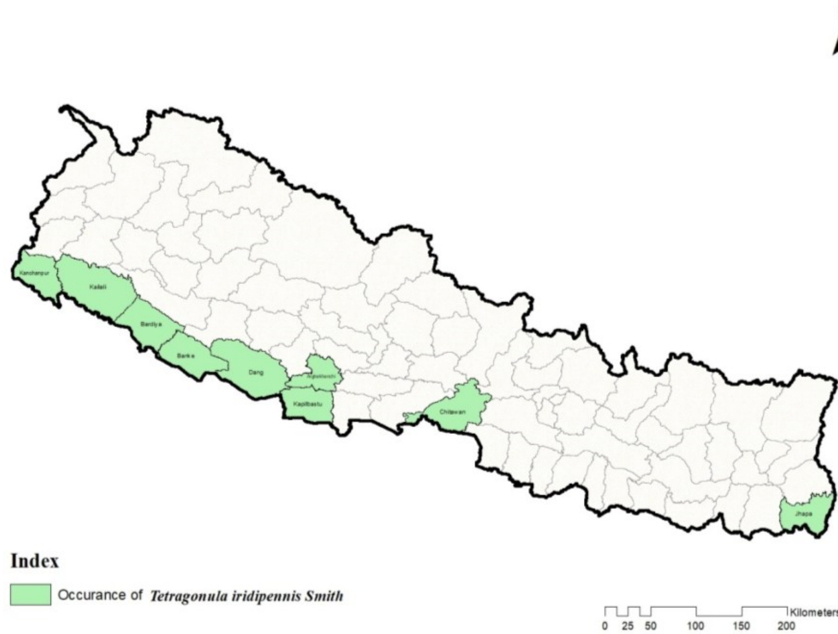

Figure 1. Map of Nepal indicating districts with confirmed nests of *Tetragonula iridipennis* Smith (Hymenoptera: Apidae).

Stingless bees can form colonies up to 2500 meters above sea level in Taiwan (*Lepidotrigona hoozana*) and up to 3400 meters in the Andes of Colombia, Ecuador, and Peru (*Parapartamona* spp.) (GRÜTER, 2020). The highest diversity of stingless bees is commonly found in lowland rainforests, especially in the Amazon basin (MELO, 2020). In Nepal, nests of stingless bees were discovered in diverse habitats, including tropical and sub-tropical regions, river basin plains, valleys, and hill slopes. However, no nests were identified above 1000 m (BHATTA et al., 2019).

The most prevalent landforms in Nepal were river basin plains, which were followed by valleys and hill slopes for nesting. Nests are found in mud or cement walls, as well as in both living and dead tree trunks. Nests are located in medium- to large-canopy trees, with Sal (*Shorea robusta* (Roth.)) being the most prevalent species. Nests range in height from 0.5 to 3 meters above the ground. Additionally, fissures in house walls, wall cavities for *Apis cerena*, and the trunks of Sisam (*Dalbergia sissoo*), Khayer (*Acacia catechu*), Saj (*Terminalia alata*), Peepal (*Ficus religiosa*), and Simal (*Bombax ceiba*) are also common nesting sites (BHATTA et al., 2019). *T. iridipennis* is suspected of having subtypes, as colonies that differ in both phenotype and behavior seem to exist in India one that forms layers (colonies sampled from Assam and Meghalaya states of India), and the other that forms clusters of brood cells (colonies sampled from other parts of India) (FRANCOY et al., 2016). The one identified in Nepal belongs to the brood cells of the cluster-forming type (BHATTA et al., 2019).

Biology and characteristics of the stingless bee

Tetragonula iridipennis Smith shares numerous characteristics with other stingless bees, particularly in their social behavior and colony structure. The queens are responsible for reproduction, while the workers manage tasks such as foraging, brood care, and nest construction (Figure 2). Michener (1974) notes that these colonies rely on intricate communication systems for coordination, though the communication methods differ from those of honeybees. While honeybees are famous for their waggle dance, stingless bees exhibit zigzag and spinning behaviors, though these are less understood in terms of communicative function (GRÜTER, 2020).

Despite these social similarities, stingless bees have distinct brood-rearing methods. According to Balakrishnan et al. (2023), stingless bees use a mass provisioning system where workers fill a brood cell with food before sealing it, and the queen lays an egg on top. In contrast, honeybee larvae are fed progressively by the workers (HEIMKEN et al., 2019). This hands-off approach to brood care in stingless bees likely affects how their colonies manage resources, divide tasks, and adapt to their environment.

Tetragonula iridipennis, like many stingless bees, exhibits specific morphological features. Hazra et al. (2021) describe *T. iridipennis* workers as notably small, measuring between 2 to 16 mm. Female bees can be identified by the glabrous bands on their mesoscutum (middle thorax segment), while male genitalia serve as critical taxonomic identifiers (VIJAYAKUMAR; JEYARAAJ, 2014). Morphologically, stingless bees have fewer wing veins compared to honeybees, a trait thought to have evolved from smaller ancestral forms (MELO, 2020). The reduced venation is believed to aid in flight efficiency, especially in dense environments. This is evident from an experiment in ash-gourd that found higher foraging rate (flowers per minute) and pollination efficiency in *T. iridipennis* compared to honey bee (*A. cerena*) (CHAUHAN et al., 2019).

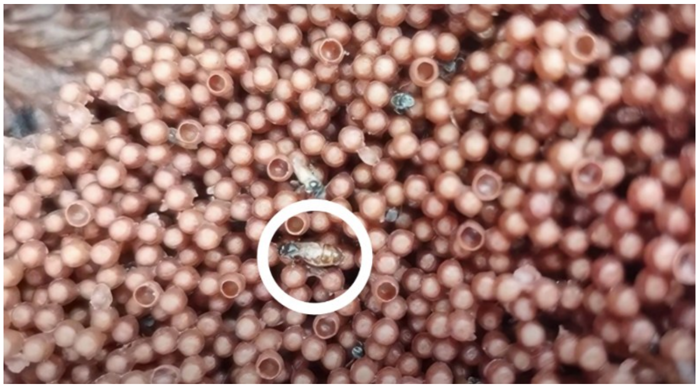

Figure 2. Highlighting the queen bee of *Tetragonula iridipennis* Smith (Hymenoptera: Apidae) within the hive.

Nesting behavior is another area where *T. iridipennis* stands out. This species prefers dark, secluded locations such as hollow tree trunks or crevices in walls. Their nests feature elliptical, black entrances measuring 9-13 mm in length and 3-9 mm in width (SAAIVIGNESH et al., 2023). Unlike honeybees, stingless bees do not reuse brood cells. Larvae spin cocoons inside the brood pots, and workers clear the cerumen (a mixture of wax and plant resin) before the adult bees emerge (SAAIVIGNESH et al., 2023). Cerumen plays a vital role in nest construction and food storage, serving as a composite building material with antimicrobial properties (CHOUDHARI et al., 2012).

Mating behavior in *T. iridipennis* is relatively simple compared to honeybees. Stingless bee queens typically mate with a single male, resulting in lower genetic diversity within the colony. This contrasts with honeybee queens, which mate with multiple males to enhance genetic variation and disease resistance (MICHENER, 1974; STARR, 2021). *T. iridipennis* workers also possess functional ovaries, enabling them to lay unfertilized eggs that develop into males. However, the presence of a physogastric queen one with an enlarged abdomen that signifies her reproductive role ensures that workers primarily focus on maintaining the colony rather than reproduction (GRÜTER, 2020).

Tetragonula iridipennis constructs nests primarily in river basin plains, valleys, and hill slopes in Nepal, often choosing mud or cement walls and tree trunks for nesting (Bhatta et al., 2019). The nest architecture includes a brood chamber surrounded by the involucrum, which helps regulate temperature and protects the brood from predators (MICHENER, 2007). Brood cells are made from soft cerumen and are arranged horizontally, with larger cells in the central region of the hive to store more larval food (WILLE, 1983). Food storage pots, which are distinct from brood cells, are also crafted from cerumen, providing space for honey and pollen reserves (Figure 3).

Tetragonula iridipennis rely on various resources for brood rearing, nest building, and colony defense. They collect pollen as the main protein source and carbohydrates from nectar, fruit sap, or honeydew (GRÜTER, 2020). Additionally, they gather resins with antimicrobial properties from preferred plants (LEONHARDT et al., 2007) and use materials like mud and wood pulp for building (ROUBIK, 1989). The foraging range depends on the time of year and the environment. The average foraging distance for Asian *T. iridipennis* is 120 meters (GRÜTER, 2020).

Although stingless bees, including *T. iridipennis*, offer several benefits such as being less aggressive due to their non-functional stings and being more resilient to certain parasites and diseases, they also present challenges in domestication. Their colonies grow slowly, and territorial behavior can lead to conflicts when colonies are placed too closely together. Additionally, some species may cause damage to plants by scraping leaves for resin used in nest construction (HEARD, 1999).

Domestication and management of stingless bees

The domestication and propagation of stingless bees (meliponiculture) is essential for maximizing economic benefits and fostering sustainable agricultural practices. It ensures better colony control, protection from threats and simplifies honey and propolis harvesting. It supports advanced research on bee behavior, breeding, genetics and productivity. By enabling the management of multiple colonies, it increases the yield of valuable bee products and facilitates pollination, benefiting both the economy and the environment (AGUS, AGUSSALIM, 2023).

Figure 3. Structural components of *Tetragonula iridipennis* Smith (Hymenoptera: Apidae) hive: (A) Pollen chamber, (B) Honey chamber, and (C) Brood chamber.

Unlike honey bees, stingless bees are less harmful towards humans and domesticated animals, their colonies rarely abscond due to the flightless nature of the old queen, and they exhibit resistance to many diseases and parasites that affect honey bees (HEARD, 1999). These traits make stingless bees easy for domestication.

In Nepal, stingless beekeepers often collect logs containing stingless bee colonies and relocate them to their backyards. According to a study by Bhatta et al. (2020), communities across Nepal exploit wild populations of *T. iridipennis* through extractive practices without implementing proper management techniques. Bee colonies are often destroyed during the extraction process of products like honey or propolis. While people sometimes move logs or tree trunks with wild colonies closer to their homes, they do not engage in the propagation or active management of these bees.

Tetragonula iridipennis make nests in the basements of old buildings, compound walls, tree trunks, and similar sites (Figure 4A-B) . Hiving feral colonies from these locations often results in damage to the buildings and walls, leading to hesitation among people to transfer these colonies. Consequently, various methods were experimented with to hive feral colonies, and eventually, a suitable method was standardized to address these challenges. To hive a feral colony of *T. iridipennis*, an effective method involves using an earthen pot. The pot's mouth is placed in front of the feral colony's entrance, with its rim sealed to the wall using mud for stability. Proper support for the pot is provided as needed. An opening is created on the opposite side of the pot to serve as a new bee entrance, which is then sealed with stingless bee wax. Worker bees begin using this new entrance and gradually move into the pot, recognizing the available space for storing brood and food. They start constructing pollen and honey pots inside the earthen hive and eventually build brood combs, initiating brood rearing within the pot. The colony and pot are left undisturbed for six months to allow the feral colony to settle. After this period, the pot containing brood, pollen, honey, worker bees, and a queen can be detached and relocated to a suitable site to establish a new colony (DEVANESAN et al., 2016).

Stingless bees are domesticated using various materials, such as earthen pots, bamboo bits, and wooden boxes. In a study by Devanesan et al. (2016), different hive types including wooden boxes, earthen pots, and bamboo bits were tested with volumes of 1500, 2250, 3000, and 3750 cc for hiving *T. iridipennis*. The results showed that bamboo bits with a 1500 cc capacity demonstrated superior brood development and honey storage compared to other hive types and capacities. Further research by Balakrishnan et al. (2023) aimed to transfer and domesticate feral colonies using seven hive models: wooden boxes, rectangular wooden boxes, bamboo logs, PVC hives, mud pots, and coconut shells. Among these, bamboo logs with a length of 30 cm and a cavity diameter of 6.5 to 7.5 cm exhibited the best brood development, fewer pests and diseases, and facilitated easier honey extraction (Figure 4C).

However, due to the scarcity of bamboo nodes, a new wooden hive was standardized for domesticating *T. iridipennis*. This hive consists of two equal halves with a total volume of 1960 cc. The inner volume measures 1960 cc, with length at 37 cm, breadth at 9 cm, and height at 10 cm. Alternatively, the inner measurements can be adjusted to length 35 cm, breadth 7 cm, and height 8 cm. The hive entrance is set at a diameter of 1 cm (DEVANESAN et al., 2016). In Nepal, there has been little to no effort towards the rearing of stingless bees, which has hindered the potential for optimal honey and propolis production.

Figure 4. *Tetragonula iridipennis* Smith (Hymenoptera: Apidae) nesting in various habitats in Nepal: (A) A dry log, (B) The rim of a wooden window, and (C) Domesticated hives.

Importance of Stingless bee ***Tetragonula iridipennis*** Smith (Hymenoptera: Apidae)

Pollinator

Stingless bees are the major biomass component of the nectar and pollen foraging insect community in many tropical areas. They are effective pollinators of both wild and cultivated crops. According Vamshikrishna et al. (2021), 30–80% of plants in various biomes are pollinated by one or more species of stingless bees. Like honey bees, stingless bees collect nectar, pollen grains, and resins from a large group of plant species. They are generalist flower visitors with a shorter foraging range than true honey bees. They are important pollinators of small-sized flowers in Nepal. The frequency of bee visitation is higher on plants near the colony (VAMSHIKRISHNA et al., 2021). The honey from native honey bee species is highly valued, yet their pollination importance is underestimated, which is highly vital from the food security point of view (NEUPANE, 2015).

Several characteristics influence stingless bees' effectiveness as pollinators. These include polylecty and adaptability, which enable them to pollinate multiple plant species and adapt to new ones. Floral constancy ensures a worker on a trip usually visits only one plant species. Domestication allows colonies to be placed in hives, inspected, propagated, fed, requested, controlled for enemies, transported, and otherwise managed. Perennial colonies allow workers to forage continuously within climatic constraints, obviating the need to develop colonies each year. Large food reserves stored in nests enable colonies to survive long periods of low food availability and result in intensive visitation of preferred flowers. In-hive pollen transfer decreases the need for bee movement between plants of self-incompatible species. Forager recruitment enables workers to recruit nest mates for rewarding floral resources, allowing the rapid deployment of large numbers of foragers (HEARD, 1999; SUJAYANAND et al., 2022).

Bees of various species play a crucial role in sustaining the ecosystem, resulting in the quality and quantity of flowers and seeds in over 70% of flowering plants (HEARD, 1999). Especially stingless bees display a greater diet breadth and range of foraging behavior than honey bees, making them vital for developing pollinators suited to specific crops and habitats. They visit most horticultural and agricultural crops, enhancing pollination and yield. For instance, stingless bees have been found to increase vegetable yields by 25% and coconut yields by 20–40% (DEVANESAN et al., 2016).

The efficiency of stingless bees as crop pollinators depends on their biological characteristics in relation to the crop and the environment (AMANO et al., 2000). Research has identified 142 stingless bee foraging plants, including vegetables, spices, oilseeds, plantation crops, ornamental plants, forest trees, medicinal plants, and wild plants (DEVANESAN et al., 2016). *Tetragonula iridipennis* colonies in West Bengal, India, had 117 different types of pollen from 49 families in their pollen loads and honey pots (LAYEK, KARMAKAR, 2018).

More than 1,000 plant species are cultivated in the tropics for food, beverages, fiber, spices, and medicines, with approximately half being pollinated by bees (VAMSHIKRISHNA et al., 2021). Of the 13 Australian epiphytic orchids confirmed to be pollinator-dependent, nine are pollinated by stingless bees. Additionally, *Trigona* spp. are noted as the most abundant and effective pollinators of androdioecious plants (HEARD, 1999). From Nepal, Thapa (2006) identified the stingless bee as a pollinator of Jamun or Breadfruit (*Syzygium cumini*).

Pollination by *Tetragonula laeviceps* increases fruit formation and decreases abnormal fruits in strawberries, while *Heterotrigona itama* enhances melon pollination (ATMOWIDI et al., 2022). In agricultural settings like glasshouses in Japan, stingless bees are promising pollinators due to their harmless nature, broad crop visitation, high temperature tolerance, year-round activity, ease of transport, and low environmental risk (AMANO et al., 2000). Moreover, Meliponini are more effective than Apis species in pollinating greenhouse crops like tomatoes (BĄK-BADOWSKA, 2019).

Bee products

Honey produced by stingless bees holds significant importance medicinally, socio-culturally, and economically. However, its relatively low output compared to other types of honey has limited the focus on this valuable resource (YAACOB et al., 2017). Despite its potential benefits, including unique medicinal properties and cultural significance, the challenges associated with lower production levels have led to less attention and investment in the production and utilization of stingless bee honey.

The nesting provisions of stingless bees, including honey, propolis, and wax, hold significance for many indigenous communities in tropical and subtropical regions. In Nepal, scattered information suggests that people keep stingless bees and utilize their products for various purposes. Honey, pollen, and larvae of stingless bees are utilized as sources of food in Nepalese communities. However, *T. iridipennis* is not utilized for propolis production in Nepal. In a study conducted by Bhatta et al. (2020) across eight districts of Nepal, 18 specific uses were identified, spanning food, medicine, crafts, and religious beliefs, highlighting the diverse cultural and practical significance of stingless bee products in the region.

Food and economic value

Globally, stingless bees are primarily reared for propolis and honey production. The commercial value of stingless bee products, such as honey and propolis, is substantial, estimated at around 610 million USD globally (GOH, 2023). Stingless bee honey stands out for its exceptional medicinal properties, commanding a high price of up to $30 per kilogram of honey (DEVANESAN, 2016). In rural areas of Nepal, stingless bee honey is sold at prices ranging from NRs. 1500 to 3000 per kilogram. It's noteworthy that a single colony of stingless bees yields approximately 1 kilogram of honey per year (BHATTA et al., 2020). This underscores the economic potential of stingless bee honey production, particularly in regions where it is valued for its medicinal qualities.

Medicinal importance

Modern scientific research has confirmed the significant medicinal potential of traditional practices involving stingless bee honey, recognizing it as having a higher medicinal value compared to honey from other bee species. Stingless bee honey has been found to possess antioxidant, anti-inflammatory, antimicrobial, and wound healing properties (YAACOB et al., 2017).

In Nepal, raw honey is highly esteemed for its medicinal benefits, with people incorporating it into various remedies. According to Bhatta et al. (2020), honey mixed with lemon juice is consumed to alleviate bronchitis, flu, and other respiratory illnesses. It is also applied topically to heal wounds in cattle and to treat eye infections, toothaches, and sore throats. Additionally, it is used to alleviate vomiting caused by excessive alcohol consumption, and it finds applications in facial treatments and hair therapy. Similarly, according to Biswa et al, (2017), Nepali community use honey of stingless bees for curing of fatigue/weakness, whooping cough, asthma, tickle in the throat, throat irritation, breathing problems, tuberculosis, baby/infant teething issues, infant immune function development, burns, pain from old injuries, stomach ulcers, diarrhoea, gastroenteritis, and localized cancer.

Pollen is utilized to cleanse the digestive system and aid in digestion (BHATTA et al., 2020). Notably, the Tharu people consume bee broods as an aphrodisiac to enhance male libido (BHATTA et al., 2020). These traditional practices underscore the rich medicinal heritage of stingless bee products in Nepal and their potential integration into modern healthcare.

Cultural importance

Stingless bees hold significant cultural importance among various communities in Nepal. For the Tharu people, the presence of mangrasha nests on their property is considered fortunate, reflecting a connection to nature and a sense of luck. The Chhetri people also use stingless bee honey to make a sacred drink called "*panchamrit*," which they serve at major events like births and funerals (BHATTA et al., 2020). This practice highlights the reverence and sacredness attributed to stingless bee products within their cultural traditions. Moreover, stingless bees have found their way into traditional songs, becoming a symbolic element that enriches the cultural heritage and folklore of the Nepalese people (BHATTA et al., 2020). This demonstrates the deep intertwining of stingless bee symbolism with cultural beliefs, rituals, and artistic expressions in Nepal.

Crafts

The Tharu people across various developmental regions utilize both cerumen and resins from stingless bee nests for various purposes. Cerumen, a waxy substance, is employed to polish furniture, metal containers, doors, and windows in their homes, enhancing their appearance and durability. Meanwhile, resins, also known as propolis, serve as sealing glues for various applications. During the summer months, typically between April and May, the Tharu community organizes a campaign to collect cerumen and resins from stingless bee nests. These collected materials are heated and mixed together to form a large ball called "pattharkhatta," derived from "patthar," meaning "stone," and "khatta," signifying "very strong." Pattharkhatta is then utilized locally in pottery and carpentry throughout the year, where it is applied to finished pots and wooden structures to impart strength and durability (BHATTA et al., 2020). This traditional practice showcases the resourcefulness of the Tharu people in utilizing natural materials from stingless bees for practical and cultural purposes, contributing to their heritage of craftsmanship and sustainable living.

Current threats to survival of native honey bee species in Nepal

Pollination, an essential environmental service crucial for maintaining biodiversity, has only recently been recognized for its immense value to humanity (MELÉNDEZ-RAMIREZ, 2018). Studies have linked the loss of pollinator species to landscape changes, such as the conversion of native forests into other land uses, resulting in the depletion of vital resources like pollen, nectar, oils, and nesting sites for bee species. Common agricultural practices, including pesticide and herbicide use, invasion of exotic plants and animals, and the introduction of nonnative bees from other regions or continents, further threaten pollinators, displacing native bees and exacerbating their decline (MELÉNDEZ-RAMIREZ, 2018).

According to Neupane (2015), the population of native honey bee species in Nepal is declining sharply every year due to deforestation, forest fires, the use of pesticides, unscientific honey harvests, the emergence of new pests and predators, urbanization, and changes in cropping systems.

The native populations of stingless bees, like many insect groups globally, face significant threats from habitat destruction, climate change, and competition from introduced bee species such as A. mellifera (TOLEDO-HERNÁNDEZ et al., 2022). These factors, coupled with the loss of traditional ecological knowledge related to meliponiculture, are the primary drivers behind the decline in native stingless bee populations (TOLEDO-HERNÁNDEZ et al., 2022), which is alarming due to its potential impact on plant species and ecosystem stability.

Anthropogenic actions, particularly the inadequate use of pesticides, pose a significant threat to insect biodiversity overall. Even pesticides labeled as safe can impair bee activities, challenging claims of non-target safety and highlighting the need for more stringent pesticide regulations and sustainable agricultural practices (BARBOSA et al., 2015). Stingless bees, belonging to the Meliponini tribe, are particularly vulnerable to pesticide exposure, with studies showing toxic effects on their health and sensitivity compared to other bee species (MELÉNDEZ-RAMIREZ, 2018).

The spread of illnesses and pests from A. mellifera to stingless bees is another significant concern related to the decline of pollinators (TOLEDO-HERNÁNDEZ et al., 2022). Understanding and managing pest and disease pressures in stingless bee populations is crucial to ensuring their health and productivity. A study conducted in Kerala, India, identified pests and diseases that resulted in a significant reduction in honey yield from stingless bees, highlighting the importance of addressing these challenges (JAYALEKSHMI, KAU, 2015).

Lastly, the count of stingless bee colonies is declining due to the diminishing availability of nesting habitats. Traditional human living habits, such as mud houses and huts, which provided suitable nesting sites for stingless bees, are becoming less common (BALAKRISHNAN, 2023). As these traditional habitats are depleted or replaced with modern structures, stingless bees are losing essential nesting opportunities, contributing to a reduction in their populations.

Policy and way forward

The Bee Promotion Policy, introduced in 2017, focuses on economic benefits through other Apis species but does not specifically address stingless bees (APICULTURE DEVELOPMENT CENTER, 2023). The policy undermines significant ecological and economic roles of stingless bees in Nepal. While the policy includes promises for wild bee conservation programs, bee tourism through wild honey hunting, and a comparative study on pollination importance between non-honeybees, wild bees and other pollinators, there has been limited to no visible action in these areas.

To ensure the long-term sustainability of stingless bee populations in Nepal, it is essential to prioritize focused research on their distribution, behavior, and ecological roles, addressing gaps in knowledge and the impacts of climate change. The revision of the Bee Promotion Policy to include specific provisions for stingless bees is crucial, alongside the development of targeted conservation strategies that protect their habitats and promote sustainable beekeeping practices. Engaging local communities through educational campaigns, workshops, and training will raise awareness and involve them in conservation efforts.

Additionally, promoting sustainable meliponiculture practices and establishing certified markets for stingless bee products can provide economic incentives while ensuring the health of colonies. Collaborative efforts among government bodies, NGOs, research institutions, and local communities will enhance the effectiveness of conservation strategies. Integrating stingless bee conservation into broader environmental and climate change initiatives, coupled with eco-tourism and habitat protection programs, will safeguard these vital pollinators, benefiting both ecosystems and local livelihoods.

CONCLUSION

Stingless bees (*Tetragonula iridipennis*) have long existed in the forests of Nepal, but their presence has only recently been confirmed. Beyond their critical role as pollinators, they hold significant economic, medicinal, and cultural value. However, various human activities, including deforestation, forest fires, pesticide use, unscientific honey harvesting, the emergence of new pests and predators, urbanization, and shifts in cropping systems, pose severe threats to their survival. Domesticating stingless bees offers dual benefits: it provides economic opportunities through bee products and crop pollination while aiding in the conservation of native species, thereby supporting ecological balance. Despite their importance, there have been no substantial efforts in research, protection, or promotion of the commercial rearing and production of stingless bee products in Nepal. Therefore, efforts from government, non-governmental organizations, and local communities are essential to ensure the sustainable conservation and utilization of stingless bee populations in the country.

REFERENCES

AGUS, A.; AGUSSALIM, A. Approach for the Domestication and Propagation of Stingless Bees. In: Recent Advances in Global Meliponiculture, IGI Global, p.69–80, 2023. 10.4018/978-1-6684-6265-2.ch004

AMANO, K.; NEMOTO, T.; HEARD, T. What are stingless bees, and why and how to use them as crop pollinators? A review. Jarq-Japan Agricultural Research Quarterly, 34(3):183-190, 2000.

APICULTURE DEVELOPMENT CENTER. Bee Promotion Policy 2073. 2023. Available in: <https://www.apidc.gov.np/en-publications>.

ATMOWIDI, T.; PRAWASTI, T. S.; RIANTI, P.; PRASOJO, F. A.; PRADIPTA, N. B. Stingless Bees Pollination Increases Fruit Formation of Strawberry (*Fragaria x annanassa* Duch) and Melon (*Cucumis melo* L.). Tropical Life Sciences Research, 33(1):43–54, 2022. 10.21315/tlsr2022.33.1.3

AYALA, R.; GONZALEZ, V. H.; ENGEL, M. S. Mexican Stingless Bees (Hymenoptera: Apidae): Diversity, Distribution, and Indigenous Knowledge. In: VIT, P.; PEDRO, S. R. M.; ROUBIK, D., editors. Pot-Honey. Springer New York, p.135–152, 2013. 10.1007/978-1-4614-4960-7_9.

BĄK-BADOWSKA, J.; ŻEBER-DZIKOWSKA, I.; GWOREK, B.; KACPRZYK, W.; CHMIELEWSKI, J. The role and significance of stingless bees (Hymenoptera: Apiformes: Meliponini) in the natural environment. Environmental Protection and Natural Resources, 30(2):1-5, 2019. 10.2478/oszn-2019-0005

BALAKRISHNAN, S. V.; BOOPATHIRAJA, A.; SURESH, K.; ELAMPARITHI, R.; SELVAKUMAR, S.; KUMAR, R. Domestication, Proliferation, and Hive Modeling of Feral Stingless Bee (*Tetragonula iridipennis* Smith) Colonies. Biological Forum: An International Journal, 15(8), 2023.

BARBOSA, W. F.; TOMÉ, H. V. V.; BERNARDES, R. C.; SIQUEIRA, M. A. L.; SMAGGHE, G.; GUEDES, R. N. C. Biopesticide-induced behavioral and morphological alterations in the stingless bee Melipona quadrifasciata. Environmental Toxicology and Chemistry, 34(9): 2149-2158, 2015. 10.1002/etc.3053.

BHATTA, C. P.; GONZALEZ, V. H.; MAYES, D.; SIMES, M.; SMITH, D. R. Nesting biology and niche modeling of *Tetragonula iridipennis* (Smith) (Hymenoptera: Apidae, Meliponini) in Nepal. Journal of Apicultural Research, 58(4):501-511, 2019. 10.1080/00218839.2019.1614729.

BHATTA, C.; GONZALEZ, V. H.; SMITH, D. Traditional uses and relative cultural importance of *Tetragonula iridipennis* (Smith) (Hymenoptera: Apidae: Meliponini) in Nepal. Journal of Melittology, 97: 1-13, 2020. 10.17161/jom.vi97.13620.

BISWA, R.; SARKAR, A.; KHEWA, S. Ethnomedicinal uses of honey of stingless bees by Nepali community of Darjeeling foothills of West Bengal, India. Indian Journal of Traditional Knowledge, 16(4): 648–653, 2017.

CHAUHAN, A.; SINGH, H. K.; KUMARANAG, K. M. Pollination potential of stingless bee *Tetragonula iridipennis* Smith in ash gourd. Indian Journal of Entomology, 81(4): 854–859, 2019.

CHOUDHARI, M. K.; PUNEKAR, S. A.; RANADE, R. V.; PAKNIKAR, K. M. Antimicrobial activity of stingless bee (*Trigona* sp.) Propolis used in the folk medicine of Western Maharashtra, India. Journal of Ethnopharmacology, 141: 363–367, 2012. 10.1016/j.jep.2012.02.047.

DEVANESAN, S.; PREMILA, K. S.; SHAILAJA, K. K. Meliponiculture for Pollination Support, Yield Enhancement, and Poverty Eradication. In: Biodiversity for Sustainable Development, p.267–272, 2016. 10.1007/978-3-319-42162-9_18.

ENGEL, M.; RASMUSSEN, C.; AYALA, R.; OLIVEIRA, F. Stingless bee classification and biology (Hymenoptera, Apidae): A review, with an updated key to genera and subgenera. ZooKeys, 1172: 239–312, 2023. 10.3897/zookeys.1172.104944.

FRANCOY, T. M.; BONATTI, V.; VIRAKTAMATH, S.; RAJANKAR, B. R. Wing morphometrics indicate the existence of two distinct phenotypic clusters within a population of *Tetragonula iridipennis* (Apidae: Meliponini) from India. Insectes Sociaux, 63(1): 109–115, 2015. 10.1007/s00040-015-0442-2.

GOH, L.P.W.; JAWAN, R.; FAIK, A.A.M.; GANSAU, A.J. A review of stingless bees' bioactivity in different parts of the world. Journal of Medicine and Life, 16(1):16–21, 2023. 10.25122/jml-2022-0160.

GRÜTER, C. Stingless Bees: Their Behaviour, Ecology, and Evolution. Springer Nature, 2020.

HAZRA, T.; MORE, S.; MURMU, M.; MAHATO, S.; GHORAI, N.; BERA, S.; KHAN, M.A. Palynological characterization of stingless bee *Tetragonula iridipennis* Smith (Hymenoptera: Apidae: Meliponini) honey from Chotanagpur Plateau, Eastern India. Bee World, 98(3):89–93, 2021. 10.1080/0005772X.2021.1874698.

HEARD, T. The role of stingless bees in crop pollination. Annual Review of Entomology, 44:183–206, 1999. 10.1146/annurev.ento.44.1.183.

HEIMKEN, C.; AUMEIER, P.; KIRCHNER, W. H. Mechanisms of food provisioning of honeybee larvae by worker bees. Journal of Experimental Biology, 212(7):1032–1035, 2009. 10.1242/jeb.022582.

JAYALEKSHMI, C. R.; KAU, P. Pests and diseases of stingless bees *Trigona iridipennis* Smith (Meliponinae: Apidae). Insectes Sociaux, 2015.

KARUPPAIAH, V. The complete mitochondrial genome of the Indian dammer bee, *Tetragonula iridipennis*, and the phylogenomics of Meliponini. Frontiers in Ecology and Evolution, 11: 1171242, 2023. 10.3389/fevo.2023.1171242.

LAYEK, U.; KARMAKAR, P. Nesting characteristics, floral resources, and foraging activity of *Trigona iridipennis* Smith in Bankura district of West Bengal, India. Insectes Sociaux, 65:117-132, 2018. 10.1007/s00040-017-0593-4.

LEONHARDT, S. D.; DWORSCHAK, K.; ELTZ, T.; BLÜTHGEN, N. Foraging loads of stingless bees and utilization of stored nectar for pollen harvesting. Apidologie, 38(2):125–135, 2007. 10.1051/apido:2006059.

MAKKAR, G. S.; CHHUNEJA, P. K.; SINGH, J. Stingless bee, *Tetragonula iridipennis* Smith, 1854 (Hymenoptera: Apidae: Meliponini): Molecular and morphological characterization. Proceedings of the National Academy of Sciences, India Section B: Biological Sciences, 88(1):285–291, 2018. 10.1007/s40011-016-0757-4.

MELÉNDEZ-RAMIREZ, V.; AYALA, R.; DELFÍN, H. Crop pollination by stingless bees. In: Pot-Pollen in Stingless Bee Melittology, p.139–153, 2018. 10.1007/978-3-319-61839-5_11.

MELO, G. A. Stingless bees (Meliponini). In: STARR, C.K. (ed.), Encyclopedia of Social Insects, Cham: Springer, 2020.

MICHENER, C. D. The Bees of the World. Johns Hopkins University Press, 2007. 10.56021/9780801885730.

MICHENER, C.D. The Social Behavior of the Bees: A Comparative Study. Belknap Press of Harvard University Press, 1974.

NEUPANE, K. Scenario of indigenous honeybee species in Nepal. 2015.

QUEZADA-EUÁN, J. J.; NATES-PARRA, G.; MAUÉS, M.; ROUBIK, D.; IMPERATRIZ-FONSECA, V. L. The economic and cultural values of stingless bees (Hymenoptera: Meliponini) among ethnic groups of tropical America. Sociobiology, 65(4), 534-557, 2018. 10.13102/sociobiology.v65i4.3447.

ROUBIK, D. W. Extant families, subfamilies, tribes, genera, and subgenera of the Apoidea: A partial checklist. In: Ecology and Natural History of Tropical Bees, Cambridge University Press, p.390–397, 1989. 10.1017/CBO9780511574641.005.

ROUBIK, D. W. Stingless bee nesting biology. Apidologie, 37(2):124–143, 2006. 10.1051/apido:2006026.

SAAIVIGNESH, B.; MANICKAVASAGAM, S.; BANUJAA. Nesting etiquacy of stingless bee *Tetragonula "Iridipennis"* species group. Indian Journal of Entomology, 71(3):e10576, 2023. 10.55446/IJE.2023.1250.

SHRESTHA, T. Basic Learning for Beekeeping. 1st ed., Lalitpur, Nepal: Bhawani Shrestha, 2022.

STARR, C. K. (Ed.). Encyclopedia of Social Insects. Springer Nature, 2021. 10.1007/978-3-030-28102-1.

SUJAYANAND, G. K.; JAGADEESWARAN, R.; CHANDRA, A. Stingless bee: Importance in pollination. Vigyan Varta, 3(7): 50–53, 2022.

SUKEMI, Y.; PARAMITA, S.; ARUNG, E. T. DPPH-scavenging activity of propolis of *Tetragonula iridipennis* from East Kalimantan. Journal of Chemical Engineering and Applications, p.320–322, 2021. 10.2991/absr.k.210408.054.

THAPA, R. Honeybees and other insect pollinators of cultivated plants: A review. Journal of the Institute of Agriculture and Animal Science, 27:1-23, 2006. 10.3126/jiaas.v27i0.691.

TOLEDO-HERNÁNDEZ, E.; PEÑA-CHORA, G.; HERNÁNDEZ-VELÁZQUEZ, V.M.; LORMENDEZ, C.C.; TORIBIO-JIMÉNEZ, J.; ROMERO-RAMÍREZ, Y.; LEÓN-RODRÍGUEZ, R. The stingless bees (Hymenoptera: Apidae: Meliponini): A review of the current threats to their survival. Apidologie, 53(1):8, 2022. 10.1007/s13592-022-00913-w.

TOLEDO-HERNÁNDEZ, E.; PEÑA-CHORA, G.; VELÁZQUEZ, V. M.; LORMENDEZ, C.; TORIBIO-JIMÉNEZ, J.; ROMERO-RAMÍREZ, Y.; LEÓN-RODRIGUEZ, R. The stingless bees (*Hymenoptera*: Apidae: Meliponini): A review of the current threats to their survival. Apidologie, 53:3, 2022. 10.1007/s13592-022-00913-w.

TRIANTO, M.; ARISURYANTI, T.; PURWANTO, H.; UBAIDILLAH, R. Taxonomic study on selected species of stingless bees (Hymenoptera: Apidae: Meliponini) in Sulawesi Island, Indonesia. Biodiversitas Journal of Biological Diversity, 25(5):5, 2024. 10.13057/biodiv/d250547.

VAMSHIKRISHNA, N.; VINAYKUMAR, M.; VENKATESHALU GOPALI, J.; AJJAPPALAVARA, P.; PATIL, B.; MANGALGIKAR, P. Foraging flora of stingless bees, *Tetragonula* spp. in Bagalkot, Karnataka, India. Journal of Experimental Zoology, 24:1449–1453, 2021.

VAZHACHARICKAL, P. J.; JAGDISH, K. S.; ANIL, G. B. An overview of global meliponiculture with a special focus on Kerala, India. International Journal of Current Research and Academic Review, 8(12), 2020.

WILLE, A. Biology of the stingless bees. Annual Review of Entomology, 28(1):41–64, 1983. 10.1146/annurev.en.28.010183.000353.

YAACOB, M.; RAJAB, N.; SHAHAR, S.; SHARIF, R. Stingless bee honey and its potential value: A systematic review. Food Research, 2:124–133, 2017. 10.26656/fr.2017.2(2).212