

Foraging interaction of stingless bee *Tetragonula travancorica* with flowers in ornamental plants

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ABSTRACT: The foraging activity of the stingless bee (*Tetragonula travancorica*) was studied by observing flowers of 20 identified ornamental plants at their full bloom stage. The foraging preference of *T. travancorica* is primarily influenced by colour, size, shape, scent and the nutrient quality and availability of nectar and pollen. The Asteraceae family was the predominant group among the ornamental plants foraged by *T. travancorica*, followed by Rubiaceae, Malvaceae and Euphorbiaceae. Among the different types of hibiscus, *Malvaviscus arboreus* exhibited the highest foraging rate, potentially due to its high nectar availability (8.47 µl). The highest *T. travancorica* population was observed on red-colored ixora among different ixora varieties, likely due to its high nectar volume (1.73 µl) and sugar concentration. This study also indicated that *T. travancorica* prefers flowers with pollen containing high levels of protein and lipid. Among the foraged plants (*Antigonon leptopus*, *Malvaviscus arboreus*, *Rosa* spp., *Rosa bourboniana* and *Syagrus romanzoffiana*), *R. bourboniana* showed high protein and lipid content (7.613 and 324 mg ml⁻¹, respectively). © 2025 Association for Advancement of Entomology

KEY WORDS: Foraging resource, nectariferous, polleniferous, foraging preference

INTRODUCTION

Stingless bees, the smallest honey-producing bees, are highly social insects forming permanent colonies in concealed locations like old walls, logs, and crevices. Although their sting is significantly reduced and ineffective for defense, they can still bite to protect their hives (Aleixo *et al.*, 2013). As eusocial bees native to the tropics and subtropics (Toledo-Hernandez *et al.*, 2022), they play a crucial role in pollinating numerous tropical plant species,

potentially contributing to about one-fifth of the local angiosperm flora (Wilms *et al.*, 1996). In peninsular India, *Tetragonula travancorica* Shanas and Faseeh is a common species (Shanas and Faseeh, 2019). Despite their low honey yield per hive, its unique flavour and medicinal value drive high market demand and prices. Their abundance and diversity are vital for crop pollination in sustainable agriculture, ensuring food security.

Stingless bees are typically generalist foragers,

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efficiently collecting pollen and nectar from a wide variety of plants. Their visits to numerous species and families highlight their significant contribution to pollination (Aleixo *et al.*, 2013). Their forage includes diverse sources such as fruits, vegetables, ornamentals, medicinal and forest plants, as well as weeds (Dalio, 2013). Across different regions, stingless bees readily utilize both exotic species within their preferred plant families (including crops, ornamentals, and weeds) and native plants (Bueno *et al.*, 2023). Bee flora can be categorized into three types: nectar-only, pollen-only, and those providing both resources. Notably, stingless bees can exploit small, medium, and large tubular and non-tubular flowers for forage, demonstrating their ability to utilize flowers with varying qualities and quantities of floral rewards (Vamshikrishna *et al.*, 2021). For most bee species, nectar serves as the primary carbohydrate source, containing sucrose, fructose, and glucose in varying ratios, along with trace amounts of essential oils, minerals, and other substances.

Pollen serves as the primary source of protein and essential amino acids for most bee species. It is crucial for their intake of proteins, lipids, and various micronutrients, including vitamins and minerals (Mokkapatil *et al.*, 2024). Bees rely on pollen for their physical development, producing food for the queen, nurturing larvae into adults, and maintaining the overall health and hygiene of their colony (Thakur and Nanda, 2020). Consequently, plants that offer both nectar and pollen are vital for beekeeping, providing the majority of the necessary nutrients through these floral resources. Foraging bees utilize visual and olfactory cues, along with learned preferences, to locate and select food sources (Dyer *et al.*, 2019). Their choice of food is influenced by several factors, including scent marks, flower color, and location. Azuma *et al.* (2002) highlighted flower scent and its chemical profile as significant factors in attracting pollinators.

Hence to understand the inclination of *T. travancorica* in selecting food sources, a study was conducted considering factors like colour, shape, smell, nectar content, nectar sugar concentration, and pollen availability.

MATERIALS AND METHODS

Study site: The present work was conducted during September 2021 to August 2022 at College of Agriculture Vellayani, Kerala, India which lies within coordinates of 8.47°N and 76.98°E having gardens with native and exotic plants used in urban landscaping. Stingless bee foraging activity was studied weekly throughout the year by placing one hive near the field with different ornamental plants during the flowering period.

Identification of floral resources and characteristics: To identify the major flora visited by stingless bee, the flora encountered by the bees either for pollen or nectar or for both were observed regularly in and around the campus and documented. Pollen collectors were identified by the pellets of pollen adhering to their hind legs. Nectar collectors were identified by observing their abdomen, it is filled with nectar or those without pollen load in their hind leg were considered as nectar foragers. For determining flower color, ten fresh flowers were selected randomly. Flower color was identified using the color chart of Royal Horticultural Society. Flower shape was identified by selecting ten flowers randomly as described in www.theseedsite.co.uk.

Foraging preference of *Tetragonula travancorica*: The flowering plants near the hive were observed and the observations on foraging preference were recorded based on their activities. Ten flowers were observed for 10 minutes at weekly intervals from the identified plants at full bloom stage and their flowering period and floral characteristics were recorded. Nectar volume and sugar concentration was also assessed.

Pollen samples were analyzed for protein, lipid, phenol and flavonoid. Chemical composition of pollen were determined. Pollen was collected from identified plants randomly. Composite sampling was done from different flowers of same plant. Two gram of dried pollen of each sample was taken and 15 mL of 70 per cent ethanol solution was added and then it was agitated for 30 min. After agitation, the solution was shaken for two min. Then it was centrifuged for 20 min at 3500 rpm, at 28°C. The

supernatant was separated and stored at 4°C.

Total protein present in sample was estimated as per the procedure given by Lowry *et al.* (1951) and lipid by Evans and Needham (1987). Total phenol and flavonoid was estimated the procedure given by Singleton and Rossi (1965) and Ordonez *et al.* (2006).

Chemical composition of pollen samples was determined by using Gas-chromatograph coupled with mass spectrometer (GC-HRMS), model AccuTOF GCV and specification of model is electron impact EI / CI with Mass range of 10 - 2000 amu and 6000amu mass resolution. For GC, quartz capillary column of dimensions 30mm × 0.25mm × 0.25mm was used. The column temperature and flow rate were 60°C and 1.0 mL/min respectively. The inlet temperature and heating rate were 250 °C and 6°C /min respectively. Pre column pressure and split ratio were 80 KPa and 40:1 respectively. The helium gas was used as carrier gas. For determining the composition of sample, the oven was set to 280°C, but the actual temperature was only 250°C.

One-way ANOVA was used to analyze the data about foraging activity which was carried out by using statistical software, GRAPES Version 1.1.0.

RESULTS AND DISCUSSION

The present study documented *T. travancorica* foraging on 20 ornamental plant species (Table 1).

Of these, eight species exhibited year-round flowering (*Antigonon leptopus*, *Hamelia patens*, *Portulaca grandiflora*, *Nymphaea* sp., *Malvaviscus arboreus*, *Caesalpinia pulcherrima*, *Combretum constrictum*, and *Jatropha pandurifolia*), while the remaining twelve were seasonal bloomers (*Rosa bourboniana*, *Rosa* spp., *Syagrus romanzoffiana*, *Pereskia aculeata*, *Helianthus annuus*, *Zinnia elegans*, *Tecoma capensis*, *Ixora chinensis*, *Tagetes erecta* and *Euphorbia milii*).

The interactions between foraging bees, specifically *T. travancorica*, and flowers are influenced by a combination of factors, including color, shape, smell, nectar content, sugar concentration, and pollen availability. *T. travancorica* uses tactile, olfactory, and visual cues to select suitable host plants for foraging. Floral parameters such as size, shape, colour, and pattern significantly impact pollinator attraction, as well as their landing and orientation behaviour. This experiment revealed that flowers with strong orange (15%), yellowish-white (15%), strong red, and vivid reddish-orange (14%) hues were most prevalent among the bee flora. These bees showed a preference for cup, funnel, and tubular flower shapes (20%) that offered easily accessible nectar and pollen. Other attractive shapes included bowl, kidney, and globose. In this study, the majority of plant species foraged by *T. travancorica* for nectar and pollen belonged to the Asteraceae family (21%), followed by Rubiaceae (11%), Euphorbiaceae (11%), and Malvaceae

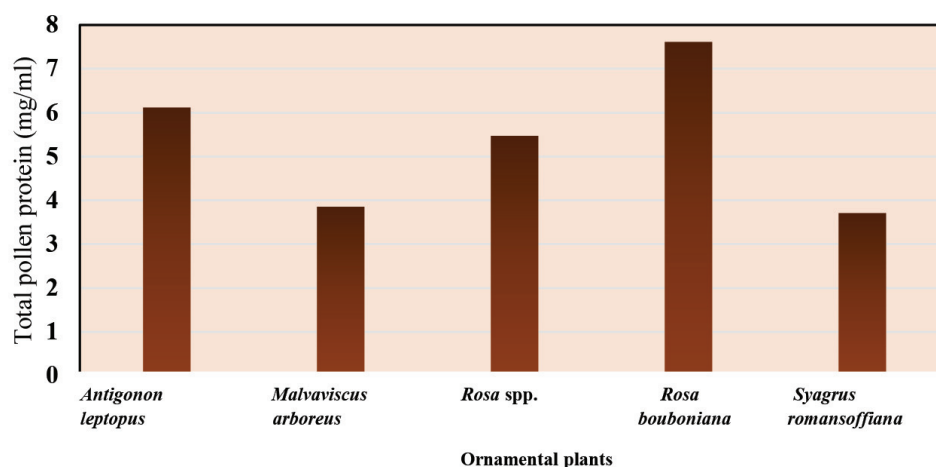


Fig. 1 Total protein content of pollen in different ornamental plants

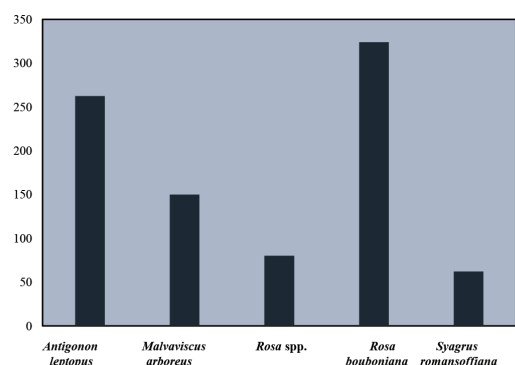


Fig. 2 Total lipid content of pollen in different ornamental plants

(11%). This aligns with Martins *et al.* (2023) findings, which identified Myrtaceae, Asteraceae, Euphorbiaceae, Melastomataceae and Malpighiaceae as dominant plant families preferred by stingless bees.

Antigonon leptopus was notable among the observed plants for its year-round nectar production, vigorous growth, and abundant flowering with a high nectar refill rate. The numerous bunched flowers offered an attractive resource, facilitating frequent nectar foraging for bees. While pollen was also available, stingless bees primarily favoured the nectar, consistent with Raju *et al.* (2001) observation of diverse insect visitors, including bees, wasps, flies, and butterflies, to these flowers. *Hamelia patens*, another year-round bloomer, attracted bees from afar with its showy, conspicuous, and bright aggregated flowers. The close arrangement of multiple flowers allowed efficient nectar collection in a single visit. Even with its long tubular corolla and concealed nectar, short-tongued bees could access the resource via capillary action. Likewise, the mass flowering of *Caesalpinia pulcherrima* and *Combretum constrictum* provided a reliable caloric reward for stingless bees, reducing foraging time, a preference also noted by Ramalho (2004) for mass-flowering plants. This aligns with Akter *et al.* (2017) finding that plants with numerous flowers and large clusters are generally more attractive to flower-visiting insects.

The experiment indicated a strong attraction of stingless bees towards fragrant flowers. Although

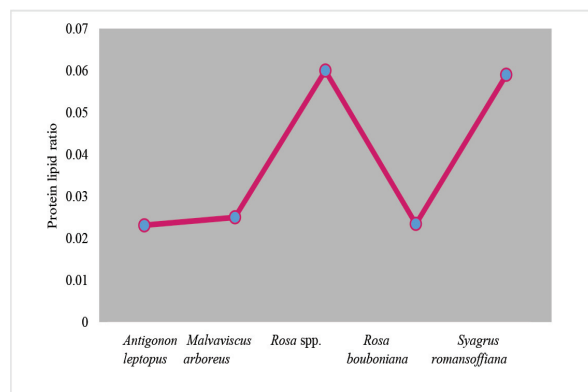


Fig. 3 Protein-lipid ratio of pollen in different ornamental plants

color is a known visual attractant, the foraging rates observed on different colored roses showed that *R. bourboniana* (1.775) attracted the highest number of bees, suggesting fragrance as a key factor (Table 2). This supports Van *et al.* (2023) finding that plants employ varied floral displays in size, shape, color or fragrance to attract pollinators. Floral scent, as reported by Dudareva and Pichersky (2006), is a complex blend of volatile compounds produced by different floral tissues. Furthermore, Azuma *et al.* (2002) identified flower scent and its chemical profiles as significant attractants for pollinators.

Nymphaea sp. and *Portulaca grandiflora* are pollen-providing plants that flower throughout the year. *Nymphaea* offers easily accessible pollen due to its exposed floral structure. However, its stigmatic watery fluid, despite lacking sugar, poses a hazard as bees were seen to inadvertently fall and become trapped. This observation echoes

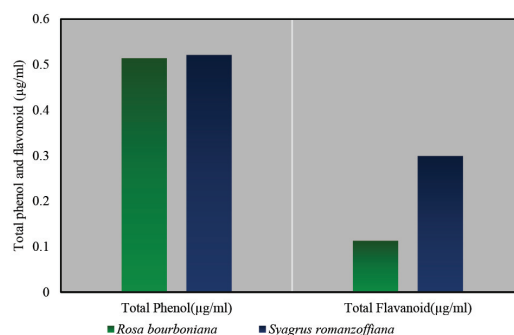


Fig. 4 Total phenol and flavonoid content of pollen in different ornamental plants

Table 1. Flowering season and flower characteristics of nectariferous and polleniferous ornamental plants

Common name	Scientific name	Family	Colour of the flower	Shape of flower
Coral vine	<i>Antigonon leptopus</i> Hook. and Arn.	Polygonaceae	Moderate purplish pink	Kidney shaped
Scarlet bush	<i>Hamelia patens</i> Jacq	Rubiaceae	Vivid reddish orange	Tubular
Moss rose/sun plant	<i>Portulaca grandiflora</i> L.	Portulacaceae	Light yellow, purplish pink	Saucer
Water lilly	<i>Nymphaea</i> sp.	Nymphaeaceae	White/Violet/Light pink	Cup like flower
Rose	<i>Rosa</i> spp.	Rosaceae	Greenish white	Cup like bloom
Scented Rose	<i>Rosa bourboniana</i> L.	Rosaceae	Light purplish pink	Cup like bloom
Ornamental palm	<i>Syagrus romanzoffiana</i> (Cham.)	Palmae	Yellowish white	Star shaped
Lemon vine	<i>Pereskia aculeata</i> L.	Cactaceae	Yellowish white	Cup like flower
Marigold	<i>Tagetes erecta</i> L.	Asteraceae	Strong orange	Head
Sunflower	<i>Helianthus annuus</i> L.	Asteraceae	Brilliant yellow	Capitulum
Hibiscus	<i>Malvaviscus arboreus</i> B.	Malvaceae	Strong red	Tubular
Hibiscus	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	Strong purplish red	Trumpet
Peacock plant	<i>Caesalpinia pulcherrima</i> L.	Fabaceae	Vivid reddish orange	Butter fly shaped
Chinese powder puff	<i>Combretum constrictum</i> B.	Combretaceae	Strong reddish orange	Globose
Chinese ixora (Red)	<i>Ixora chinensis</i> L.	Rubiaceae	reddish orange	Tubular
Ixora (Yellow)	<i>Ixora chinensis</i> L.	Rubiaceae	Pale yellow	Tubular
Cape honey suckle	<i>Tecoma capensis</i> L.	Begoniaceae	Strong orange	Funnel shaped
Peregrina	<i>Jatropha pandurifolia</i> L.	Euphorbiaceae	Strong red	Funnel shaped
Euphorbia	<i>Euphorbia mili</i> L.	Euphorbiaceae	white, Moderate red	Bowl shaped

Robertson's (1889) findings on *N. odorata*, where a tasteless and odorless fluid in the stigmatic bowl led to accidental insect falls. This contrasts with Zhang *et al.* (2021) study on the bright *Nymphaea* hybrid, which used an aromatic odour for attraction and secreted colourless, tasteless nectar on the stigma.

Portulaca grandiflora provides a consistent year-round pollen source, with stingless bees preferring the easily accessible single-petaled flowers over the pollen-concealing multi-petaled types. Seasonally, *Syagrus romanzoffiana* offers abundant pollen from its numerous yellowish-white flowers on branched inflorescences (45-50 rachis with 78-100 flowers each). This large pollen availability reduces bee search time and energy, leading to frequent and rapid visits. The efficiency

of stingless bees as pollinators of *Syagrus* species is highlighted by Nunez Avellaneda and Carreno (2017), who found them to transfer an average of 83 per cent of the pollen in *S. orinocensis*.

The findings indicate that stingless bee foraging is a complex process influenced by a combination of floral characteristics, including color, size, shape, scent, and importantly, the nutrient quality and quantity of nectar and pollen. Contrary to the general preference for cup-like flowers, this experiment showed that tubular flowers with high nectar volume are also attractive. For instance, among the studied hibiscus species (Table 2), the tubular *M. arboreus* exhibited the highest foraging rate (4.41), likely due to its high nectar volume (8.47 μ L) and sugar content (23.06%), providing a substantial energetic reward. *Ixora chinensis*

Table 2. Foraging preference of *Tetragonula travancorica* on different coloured roses, hibiscus and ixora (Mean numbers visited per 10 minute)

Rose	Number
Scented rose (<i>R. bourboniana</i>)	1.775 ^a
White rose (<i>Rosa</i> spp.)	1.719 ^{ab}
Red rose	1.032 ^{bc}
Orange rose	1.104 ^c
Pink rose	1.242 ^c
Yellow rose	0.958 ^c
CD(0.05)	0.505
Hibiscus	
<i>Malvaviscus arboreus</i>	4.47 ^a
<i>Hibiscus rosasinensis</i>	2.529 ^b
CD(0.05)	0.663
Ixora	
Red Ixora	2.934 ^a
Yellow ixora	2.023 ^b
CD(0.05)	0.231

served as a source of both pollen and nectar for these bees. Furthermore, among the ixora varieties (Table 2), red and yellow Chinese ixora attracted the most bees, with the red variety hosting the highest population (2.934), a trend strongly correlated with its nectar volume (1.73 μ L) and sugar concentration (16.73%) (Table 3).

Protein and lipids obtained from pollen are essential for the growth and development of bee larvae, as well as the health and reproduction of adult bees. Ghosh *et al.* (2020) found that honey bees prioritize pollen based on its protein content. Our study similarly reveals that stingless bees prefer flowers with pollen that is high in both protein and lipids, and also has a high protein-to-lipid ratio. *R. bourboniana*, the most frequently foraged plant, had high protein and lipid levels (7.613 and 324 mg/mL) (Fig. 1, 2), while *S. romanzoffiana*, a plant heavily visited for pollen, displayed a high protein-

to-lipid ratio (Fig. 3). The protein-to-lipid ratios in pollen seem to be a key factor in stingless bee foraging preferences among pollen-providing plants, and these preferred ratios are associated with the health and vitality of bee colonies (Vaudo *et al.*, 2020). Preferred *R. bourboniana* (0.514 and 0.113 μ L) and *S. romanzoffiana* (0.521 and 0.299 μ L), also had high phenol and flavonoid content compared to other pollen sources (Fig. 4). This aligns with Campos *et al.* (1997) finding that red and blue anthocyanin pigments (flavonoids) attract insect pollinators, and Liu *et al.* (2006) report that changes in pollen phenolic content influence honey bee foraging activity.

The chemical composition of pollen appears to be a significant factor influencing the foraging behavior of stingless bees, as observed in this study. This composition likely determines the amount of pollen gathered and the probability of a bee revisiting similar flowers. Our analysis of pollen from frequently foraged plants identified several chemical components with potential attractive properties: Hexadecanoic acid ethyl ester, Docosanoic acid, 1, 2, 3-propanetriylester, and Benzene dicarboxylic acid, butyl 1, 2-ethylexylester, methyl ester. This finding supports the assertion by Dobson and Bergstrom (2000) that chemicals in pollen play a crucial role in how bees recognize their host plants.

Our study contributes to the growing understanding that bee foraging interactions with flowers are a

Table 3. Mean nectar volume and sugar concentration of major nectar yielding ornamental plants

Ornamental plants	Nectar (μ L)	Sugar (%)
<i>Antigonon leptopus</i>	Trace	8.47 ^c
<i>Hamelia patens</i>	1.50 ^c	25.45 ^b
<i>Malvaviscus arboreus</i>	8.47 ^a	23.06 ^c
<i>Ixora chinensis</i>	1.73 ^b	16.73 ^c
<i>Caesalpinia pulcherrima</i>	0.66 ^c	24.00 ^a
<i>Combretum constrictum</i>	1.00 ^d	17.73 ^d
CD(0.05%)	0.018	0.32

complex process influenced not only by visual and olfactory cues, as well as individual bee preferences, but also critically by the nutrient quality and availability of nectar and pollen. Additionally, observed that the aggregated structure of flowers plays a crucial role in attracting a large number of bees from afar, enabling them to efficiently collect sufficient nectar during each visit, thus minimizing energy expenditure.

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REFERENCES

- Akter A., Biella P. and Klecka J. (2017) Effects of small-scale clustering of flowers on pollinator, foraging behaviour and flower visitation rate. *PloS one* 12(11): 76.
- Aleixo K.P., de Faria L.B., Garofalo C. A., Fonseca V.L.I. and da Silva C. I. (2013) Pollen collected and foraging activities of *Frieseomelitta varia* (Lepeletier) (Hymenoptera: Apidae) in an urban landscape. *Sociobiology* 60(3): 266–276.
- Azuma H., Toyota M., Asakawa Y., Takaso T. and Tobe H. (2002) Floral scent chemistry of mangrove plants. *Journal of Plant Resistance* 115: 47–53.
- Bueno F.G.B., Kendall L., Alves D.A., Tamara M.L., Heard T., Latty T. and Gloag R. (2023) Stingless bee floral visitation in the global tropics and subtropics. *Global Ecology and Conservation* 43: 245.
- Campos M., Markham K.R., Mitchell K.A. and da Cunha A.P. (1997) An approach to the characterization of bee pollens via their flavonoid/phenolic profiles. *International Journal of Plant Biochemistry and Biotechnology* 8(4): 181–185.
- Dalio J. S. (2013) Foraging activity of *Apis mellifera* on *Parthenium hysterophorous*. *Journal of Pharmacy and Biological Science* 7(5): 1–4.
- Dobson H.E. and Bergstrom G. (2000) The ecology and evolution of pollen odors. *Plant Systematics and Evolution* 222: 63–87.
- Dudareva N. and Pichersky E. (2006) Floral scent metabolic pathways: their regulation and evolution. *Biological Flora* 5: 55–78.
- Dyer AG., Boyd-Gerny S., Shrestha M., Garcia J.E., van der Kooi C. J. and Wong B.B. (2019) Colour preferences of *Tetragonula carbonaria* Sm. stingless bees for colour morphs of the Australian native orchid *Caladenia carnea*. *Journal of Comparative Physiology* 205(3): 347–361.
- Evans E. and Needham D. (1987) Physical properties of surfactant bilayer membranes: thermal transitions, elasticity, rigidity, cohesion and colloidal interactions. *Journal of Physics and Chemistry* 91(16): 4219–4228.
- Ghosh S. Jeon H. and Jung C. (2020) Foraging behaviour and preference of pollen sources by honey bee (*Apis mellifera*) relative to protein contents. *Journal of Ecological Environment* 44(2): 1–7.
- Liu F.L., Zhang X.W., Chai J.P. and Yang D.R. (2006) Pollen phenolics and regulation of pollen foraging in honeybee colony. *Sociobiology* 59: 582–588.
- Lowry O.H., Rosebrough N.J., Farr A.L. and Randall R. J. (1951) Protein measurement with the Folin phenol reagent. *Journal of Biological Chemistry* 193: 265–275.
- Martins A.C., Proença C.E., Vasconcelos T.N., Aguiar A.J., Farinasso H.C., de Lima A.T., Faria J.E., Norrana K., Costa M.B., Carvalho M.M. and Dias R.L. (2023) Contrasting patterns of foraging behavior in neotropical stingless bees using pollen and honey metabarcoding. *Scientific Reports* 13(1): 14474.
- Mohammad S.M., Mahmud-Ab-Rashid N.K. and Zawawi N. (2021) Stingless bee-collected pollen (Bee Bread): Chemical and microbiology properties and health Benefits. *Molecules* 26(4): 957.
- Mokkapati J.S., Hill M., Boyle N.K., Ouvrard P., Sicard A. and Grozinger C.M. (2024) Foraging bee species differentially prioritize quantity and quality of floral rewards. *PNAS nexus* 3 (10): 443.
- Nunez Avellaneda L.A. and Carreno J.I. (2017) Pollinization on *Syagrus orinocensis* (Arecaceae). *Biologica* 22(2): 221–233.
- Ordóñez A.A.L., Gomez J.D. and Vattuone MA. (2006) Antioxidant activities of *Sechium edule* (Jacq.). *Food chemistry* 97(3): 452–458.
- Premila K. S., Devanesan S., Arthur J. J. and Shailaja K.K. (2007) Foraging plants of stingless bee, *Trigona iridipennis* Smith All India Coordinated Research Project on Honey bee and Pollinators. KAU, Vellayani. 80pp.

- Raju A.J.S., Raju V.K., Victor P. and Naidu S.A. (2001) Floral ecology, breeding system and pollination in *Antigonon leptopus* L. (Polygonaceae). *Plant Species Biology* 16(2): 159–164.
- Ramvalho M. (2004) Stingless bees and mass flowering trees in the canopy of Atlantic Forest: a tight relationship. *Acta Botanica Brasilica* 18: 37–47.
- Riendriasari S. and Rahayu A.A.D. (2022) Foraging Preference of Stingless Beekeeping in Three Types of Land Use at Lombok Island. *Journal of Ilmu Kehutanan* 16(2): 159–170.
- Robertson C. (1889) Flowers and insects. I. *Botanical Gazette* 14(5): 120–126
- Shanas S. and Faseeh, P. (2019) A new subgenus and three new species of stingless bees (Hymenoptera: Apidae: Apinae: Meliponini) from India. *ENTOMON* 44(1): 33–48.
- Singleton V.L. and Rossi J.A. (1965) Colorimetry of total phenolics with phosphomolybdic-phosphotungstic acid reagents. *American Journal of entomology and viticulture* 16(3): 144–158.
- Suryanarayana M.C., Rao G.M. and Singh T.S.M.S. (1992) Studies on pollen sources for *Apis cerana* F and *Apis mellifera* L bees at Muzaffarpur, Bihar, India. *Apidologie* 23(1): 33–46.
- Thakur M. and Nanda V. (2020) Composition and functionality of bee pollen: A review. *Trends Food Science and Technology* 98: 82–106.
- Toledo-Hernandez E., Pena-Chora G., Hernandez-Velazquez V.M., Lormendez C.C., Toribio-Jimenez J., Romero-Ramirez Y. and Leon-Rodriguez R. (2022) The stingless bees (Hymenoptera: Apidae: Meliponini): a review of the current threats to their survival. *Apidologie* 53(1): 8.
- Vamshikrishna M. M., Vinaykumar Venkateshalu J.B., Gopali P. S., Ajjappalavara B. B. and Prashant P. (2021) Foraging flora of stingless bees, *Tetragonula* spp. in Bagalkot, Karnataka, India. *Journal of Experimental Zoology in India* 24: 1449–1453.
- Van derKooij C.J., Reuvers L. and Spaethe J. (2023) Honesty, reliability, and information content of floral signals. *iScience*, 26: 7.
- Vaudo A.D., Tooker J.F., Patch H.M., Biddinger D.J., Coccia M., Crone M.K., Fiely M., Francis J.S., Hines H.M., Hodges M. and Jackson S.W. (2020) Pollen protein:lipid macronutrient ratios may guide broad patterns of bee species floral preferences. *Insects* 11 (2): 132.
- Wilms W., Imperatriz-Fonseca V.L. and Engels W. (1996) Resource partitioning between highly eusocial bees and possible impact of the introduced Africanized honey bee on native stingless bees in the Brazilian Atlantic rainforest. *Studies on Neotropical. Fauna and Environment* 31(3-4): 137–151.
- Zhang H., Wu H., Zhou Q., Zhao R., Sheng Q. and Zhu Z. (2021) Flowering characteristics and reproductive biology of *Nymphaea* hybrid, a precious water lily. *Scientia Horticulturae* 2: 87.

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