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MORPHOMETRIC VARIATION IN STINGLESS BEE (*Tetragonula* spp.) POPULATIONS FROM DIFFERENT AGRO-CLIMATIC REGIONS OF GUJARAT

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ABSTRACT

The studies on the morphometric variations in workers of stingless bees (*Tetragonula* spp.) was carried out at Department of Entomology, N. M. College of Agriculture, N. A. U., Navsari. To study the distribution and morphometric variation of worker stingless bees collected from seven agro-climatic regions of Gujarat, namely Navsari, Anand, Junagadh, Dantiwada, Tapi, Valsad and Narmada, during 2025-2026. Feral colonies were recorded from tree trunks, rock crevices, mud pots and collapsed stone walls. Morphometric observations were carried out using a Cilika BTP-10A dual-head digital trinocular microscope, and fifteen morphological characters were measured. The overall mean ($\pm$ SD) values recorded were: body length 3.52 ± 0.05 mm, head length 0.98 ± 0.11 mm, antennal length 1.82 ± 0.03 mm, tongue length 1.09 ± 0.05 mm, thorax length 1.45 ± 0.04 mm, thorax breadth 1.42 ± 0.05 mm, forewing length 3.23 ± 0.08 mm, forewing breadth 1.22 ± 0.04 mm, hindwing length 2.41 ± 0.03 mm, hindwing breadth 0.57 ± 0.02 mm, extent of hamuli 0.14 ± 0.01 mm, hindleg length 3.88 ± 0.05 mm, hindleg breadth 0.47 ± 0.04 mm and abdomen length 1.21 ± 0.02 mm, while the number of hamuli remained constant at five in all populations. Significant morphometric variation was observed among the populations, with the Junagadh population exhibiting comparatively higher values for most characters, whereas the Anand population consistently recorded lower values. Despite minor geographical variation, the morphometric characteristics were largely consistent with previous reports on *Tetragonula* spp., indicating substantial morphological uniformity among populations across Gujarat. The present findings provide baseline morphometric information that will facilitate future taxonomic, ecological, conservation studies and future DNA barcoding studies of stingless bees in western India.

Key words: *Tetragonula* spp., morphometry, worker bees, agro-climatic regions & DNA barcoding

Introduction

Stingless bees (Hymenoptera: Apidae: Meliponini) are eusocial, non-*Apis* bees distributed predominantly in tropical and subtropical regions. They are among the most important native pollinators, contributing significantly to the reproduction of wild flowering plants and the productivity of agricultural and horticultural crops (Roubik, 1993; Heard, 1999; Garibaldi *et al.*, 2013). Their small body size, non-aggressive behaviour and adaptability to

diverse environmental conditions make them valuable pollinators, particularly in protected cultivation systems (Slaa *et al.*, 2006).

Globally, stingless bees comprise nearly 605 described extant species belonging to 45 genera (Engel *et al.*, 2023). In India, stingless bees are represented by several species of the genus *Tetragonula* including *T. iridipennis*, *T. bengalensis*, *T. praeterita*, *T. laeviceps*,

T. pagdeni and *T. ruficornis*, along with

Lepidotrigona arcifera (Rahman *et al.*, 2018). Recently five additional *Tetragonula* species namely *T. vikrami*, *T. sumae*, *T. ashishi*,

T. shishirae and *T. shubhami*, have been described from Karnataka, Tamil Nadu, Maharashtra, Rajasthan and Chhattisgarh, respectively (Viraktamath and Thangjam, 2021).

Morphometric characterization provides valuable information for assessing phenotypic variation among geographically separated populations and supports taxonomic, ecological and biodiversity studies. Such investigations are particularly useful for documenting population-level variation that may arise due to differences in environmental conditions and habitat characteristics. Therefore, the present study investigated the distribution of stingless bees and evaluated the morphometric variation of worker *Tetragonula* spp. collected from seven agro-climatic regions of Gujarat.

Materials and Method

The present study was conducted during 2025-2026 at the Department of Entomology, N.M. College of Agriculture and the Department of Plant Molecular Biology and Biotechnology, Navsari Agricultural University, Navsari, Gujarat. The investigation aimed to characterize worker populations of stingless bees (*Tetragonula* spp.) collected from different agro-climatic regions of Gujarat through detailed morphometric analysis.

Survey and Collection

Worker bee samples of *Tetragonula* spp. were collected from different geographical locations of Gujarat during 2025-2026. Surveys were conducted in the districts of Navsari, Anand, Junagadh, Dantiwada, Tapi, Valsad and Narmada to locate feral colonies nesting in tree trunks, rock crevices, mud pots and collapsed stone walls. Approximately 25 worker bees were collected from each colony at the hive entrance using clean plastic vials with minimal disturbance to the colony. The geographical coordinates (GPS) of each sampling site were recorded at the time of collection (Fig. 1).

Preservation

The collected specimens were transferred into properly labelled, sterilized plastic vials containing 90% ethanol for long-term preservation following the method described by Dar and Ahmad (2017). The preserved samples were stored at -20°C in the laboratory to maintain specimen integrity until further analysis.

Morphometric Measurements

Morphometric observations were carried out at the

Department of Entomology, N. M. College of Agriculture, Navsari Agricultural University, Navsari, Gujarat, using a Cilika BTP-10A trinocular digital microscope with an integrated image analysis system. Fifteen morphometric characters, namely body length, head length, antennal length, tongue length, thorax length, thorax breadth, forewing length, forewing breadth, hindwing length, hindwing breadth, extent of hamuli, number of hamuli, hindleg length, hindleg breadth and abdomen length, were measured in millimetres following the methods of Patel and Pastagia (2016) and Sharma *et al.*, (2023).

Result and Discussion

A survey conducted during 2025-2026 revealed that stingless bees (*Tetragonula* spp.) were widely distributed across the seven surveyed districts of Gujarat, namely

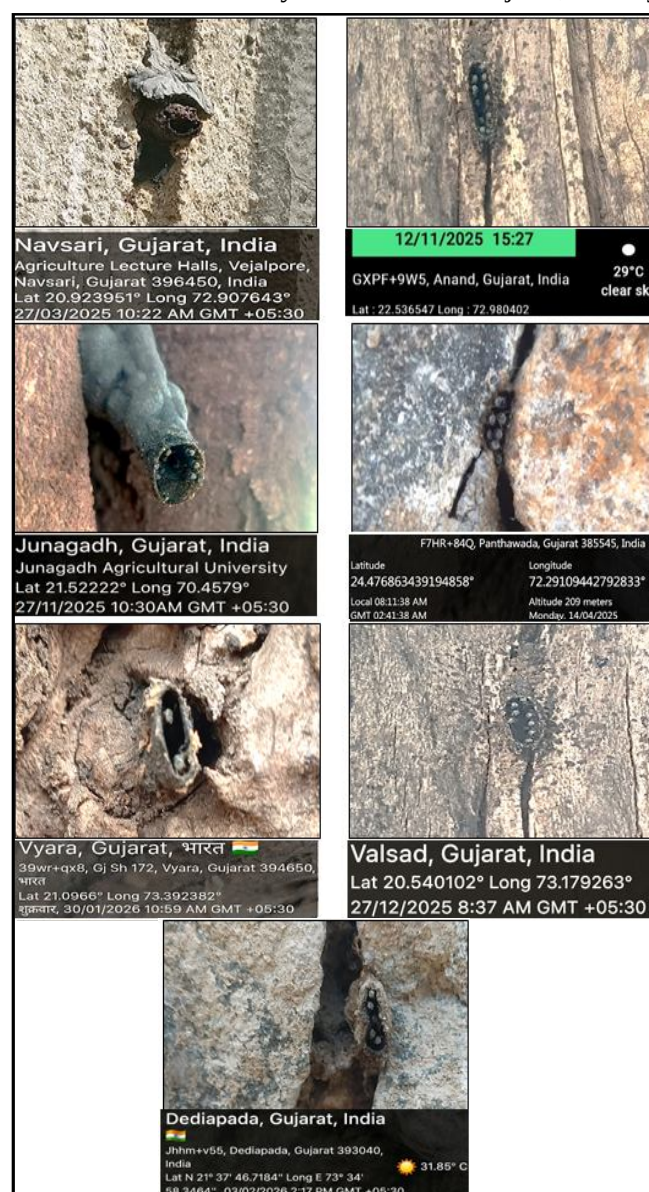


Fig. 1: Entrance holes of stingless bees feral colonies in different districts of Gujarat.

Table 1: Morphometric measurements (Mean $\pm$ SD) of worker *Tetragonula* spp. collected from different districts of Gujarat.

Characters	Different districts covered under south Gujarat region								
	Navsari	Anand	Junagadh	Dantiwada	Tapi	Valsad	Narmada	Range	Mean $\pm$ SD
Body length(mm)	3.52 $\pm$ 0.02	3.48 $\pm$ 0.03	3.59 $\pm$ 0.03	3.51 $\pm$ 0.03	3.55 $\pm$ 0.02	3.56 $\pm$ 0.03	3.54 $\pm$ 0.03	3.48-3.59	3.52 $\pm$ 0.05
Head length(mm)	0.90 $\pm$ 0.03	0.89 $\pm$ 0.03	1.21 $\pm$ 0.03	0.91 $\pm$ 0.02	0.98 $\pm$ 0.03	0.98 $\pm$ 0.03	0.97 $\pm$ 0.02	0.89-1.21	0.98 $\pm$ 0.11
Antennal length(mm)	1.80 $\pm$ 0.03	1.78 $\pm$ 0.02	1.87 $\pm$ 0.02	1.83 $\pm$ 0.02	1.84 $\pm$ 0.02	1.82 $\pm$ 0.02	1.80 $\pm$ 0.02	1.78-1.87	1.82 $\pm$ 0.03
Tongue length(mm)	1.11 $\pm$ 0.03	1.09 $\pm$ 0.03	1.12 $\pm$ 0.03	1.12 $\pm$ 0.02	1.07 $\pm$ 0.03	1.01 $\pm$ 0.03	1.00 $\pm$ 0.03	1.00-1.12	1.09 $\pm$ 0.05
Thorax length(mm)	1.47 $\pm$ 0.02	1.39 $\pm$ 0.03	1.51 $\pm$ 0.03	1.48 $\pm$ 0.03	1.44 $\pm$ 0.03	1.46 $\pm$ 0.02	1.42 $\pm$ 0.03	1.39-1.51	1.45 $\pm$ 0.04
Thorax breadth(mm)	1.45 $\pm$ 0.03	1.35 $\pm$ 0.02	1.48 $\pm$ 0.03	1.38 $\pm$ 0.02	1.42 $\pm$ 0.02	1.45 $\pm$ 0.02	1.44 $\pm$ 0.02	1.35-1.48	1.42 $\pm$ 0.05
Forewing length(mm)	3.22 $\pm$ 0.03	3.19 $\pm$ 0.02	3.42 $\pm$ 0.03	3.20 $\pm$ 0.02	3.24 $\pm$ 0.01	3.21 $\pm$ 0.03	3.26 $\pm$ 0.02	3.19-3.42	3.23 $\pm$ 0.08
Forewing breadth(mm)	1.21 $\pm$ 0.02	1.17 $\pm$ 0.03	1.31 $\pm$ 0.02	1.20 $\pm$ 0.02	1.22 $\pm$ 0.03	1.23 $\pm$ 0.03	1.21 $\pm$ 0.02	1.17-1.31	1.22 $\pm$ 0.04
Hindwing length(mm)	2.39 $\pm$ 0.02	2.38 $\pm$ 0.02	2.47 $\pm$ 0.03	2.41 $\pm$ 0.03	2.42 $\pm$ 0.03	2.43 $\pm$ 0.03	2.43 $\pm$ 0.03	2.38-2.47	2.41 $\pm$ 0.03
Hindwing breadth(mm)	0.57 $\pm$ 0.02	0.54 $\pm$ 0.02	0.60 $\pm$ 0.03	0.55 $\pm$ 0.02	0.57 $\pm$ 0.03	0.57 $\pm$ 0.03	0.56 $\pm$ 0.03	0.54-0.60	0.57 $\pm$ 0.02
Extent of hamuli(mm)	0.14 $\pm$ 0.02	0.13 $\pm$ 0.02	0.15 $\pm$ 0.01	0.14 $\pm$ 0.02	0.13 $\pm$ 0.02	0.12 $\pm$ 0.02	0.14 $\pm$ 0.02	0.12-0.15	0.14 $\pm$ 0.01
Number of hamuli	5.00 $\pm$ 0.00	5.00 $\pm$ 0.00	5.00 $\pm$ 0.00	5.00 $\pm$ 0.00	5.00 $\pm$ 0.00	5.00 $\pm$ 0.00	5.00 $\pm$ 0.00	5	5.00 $\pm$ 0.00
Hindleg length(mm)	3.86 $\pm$ 0.02	3.84 $\pm$ 0.02	3.98 $\pm$ 0.02	3.92 $\pm$ 0.02	3.89 $\pm$ 0.03	3.87 $\pm$ 0.03	3.89 $\pm$ 0.02	3.84-3.98	3.88 $\pm$ 0.05
Hindleg breadth(mm)	0.45 $\pm$ 0.01	0.44 $\pm$ 0.01	0.55 $\pm$ 0.02	0.48 $\pm$ 0.02	0.45 $\pm$ 0.03	0.45 $\pm$ 0.03	0.47 $\pm$ 0.03	0.44-0.55	0.47 $\pm$ 0.04
Abdomen length(mm)	1.20 $\pm$ 0.03	1.16 $\pm$ 0.02	1.23 $\pm$ 0.03	1.20 $\pm$ 0.02	1.22 $\pm$ 0.03	1.21 $\pm$ 0.03	1.22 $\pm$ 0.02	1.16-1.23	1.21 $\pm$ 0.02

Values are expressed as Mean $\pm$ SD. Measurements are in millimetres (mm).

Navsari, Anand, Junagadh, Dantiwada, Tapi, Valsad and Narmada. Feral colonies were observed nesting in tree trunks, rock crevices, mud pots and collapsed stone walls, indicating their adaptability to a variety of natural and man-made habitats. The entrance tubes of all colonies

were short irrespective of the location. Similar nesting habits and colony characteristics have been reported by Rahman *et al.*, (2018), Singh and Khan (2019) and Jarpla (2025).

The morphometric observations of worker

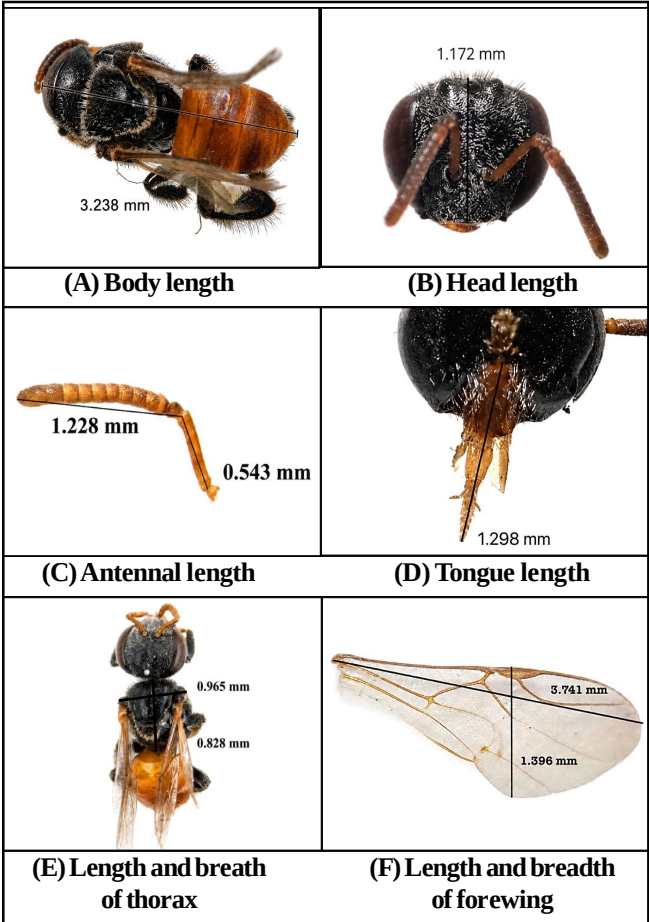


Fig. 2: Morphological parts of *Tetragonula* spp. workers.

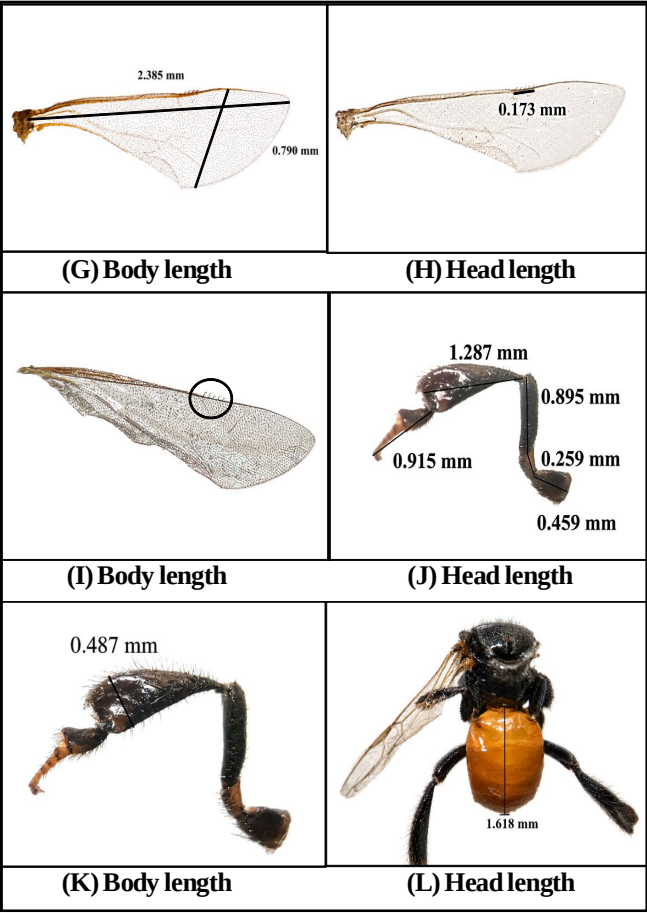


Fig. 3: Morphological parts of *Tetragonula* spp. workers.

Tetragonula spp. collected from different districts of Gujarat revealed noticeable variation in the measured characters. Body length ranged from 3.48 ± 0.03 to 3.59 ± 0.03 mm, with an average of 3.52 ± 0.05 mm. Head length varied between 0.89 ± 0.03 and 1.21 ± 0.03 mm, averaging 0.98 ± 0.11 mm, while antennal length ranged from 1.78 ± 0.02 to 1.87 ± 0.02 mm with a mean of 1.82 ± 0.03 mm. Tongue length varied from 1.00 ± 0.03 to 1.12 ± 0.03 mm, with an average of 1.09 ± 0.05 mm. Thorax length ranged from 1.39 ± 0.03 to 1.51 ± 0.03 mm, averaging 1.45 ± 0.04 mm, whereas thorax breadth varied from 1.35 ± 0.02 to 1.48 ± 0.03 mm with an average of 1.42 ± 0.05 mm. Forewing length ranged from 3.19 ± 0.02 to 3.42 ± 0.03 mm, with an average of 3.23 ± 0.08 mm, while forewing breadth varied between 1.17 ± 0.03 and 1.31 ± 0.02 mm, averaging 1.22 ± 0.04 mm (Table 1 and Fig. 2). Similarly, hindwing length ranged from 2.38 ± 0.02 to 2.47 ± 0.03 mm with an average of 2.41 ± 0.03 mm, whereas hindwing breadth varied from 0.54 ± 0.02 to 0.60 ± 0.03 mm, averaging 0.57 ± 0.02 mm. The extent of hamuli ranged from 0.12 ± 0.02 to 0.15 ± 0.01 mm with an average of 0.14 ± 0.01 mm, while the number of hamuli remained constant at five in all populations. Hindleg length varied from 3.84 ± 0.02 to 3.98 ± 0.02 mm, with an average of 3.88 ± 0.05 mm, and hindleg breadth ranged from 0.44 ± 0.01 to 0.55 ± 0.02 mm, averaging 0.47 ± 0.04 mm. Abdomen length ranged from 1.16 ± 0.02 to 1.23 ± 0.03 mm, with an average of 1.21 ± 0.02 mm (Table 1 and Fig. 3).

The observed geographical variation was relatively small, suggesting considerable morphological uniformity among *Tetragonula* populations across Gujarat. The constant number of hamuli (five) in all populations further supports the morphological stability of the species and agrees with the observations of Rasmussen (2013). The morphometric measurements obtained in the present study were comparable with those reported by Patel and Pastagia (2016), Tej *et al.*, (2017), Purwanto and Trianto (2021), Sharma *et al.*, (2023) and Jarpla (2025), indicating that the Gujarat populations conform closely to previously described morphometric characteristics of *Tetragonula*. The comparatively larger body size observed in the Junagadh population and the relatively smaller dimensions recorded in the Anand population may reflect local environmental influences or population-level variability.

Conclusion

The present study provides a comprehensive morphometric characterization of worker *Tetragonula* spp. collected from seven agro-climatic regions of Gujarat. Although minor variations were observed among populations for the fifteen morphometric characters

examined the overall measurements showed a high degree of similarity indicating considerable morphological uniformity across the surveyed regions. The observed variations are likely attributable to geographical and environmental influences rather than distinct species-level differentiation. These findings provide baseline morphometric information on stingless bee populations of Gujarat and will serve as a valuable reference for future taxonomic, biosystematic and conservation studies. The comparatively lower morphometric values recorded in the Anand population also suggest the need for further integrative studies combining morphometric and molecular approaches to clarify its taxonomic status.

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References

- Dar, S.A. and Ahmad S.B. (2017). Morphometric variations and expression of body colour pattern of honeybee, *Apis cerana* F. in Kashmir. *Journal of Entomology and Zoology Studies*, 5, 364-371.
- Engel, M.S., Rasmussen C., Ayala R. and de Oliveira F.F. (2023). Stingless bee classification and biology (*Hymenoptera*, *Apidae*): a review, with an updated key to genera and subgenera. *ZooKeys*, 1172, 239.
- Garibaldi, L.A., Steffan-Dewenter I., Winfree R., Aizen M.A., Bommarco R. and Cunningham S.A. (2013). Wild pollinators enhance fruit set of crops regardless of honeybee abundance. *Science*, 339, 1608-1611.
- Heard, T.A. (1999). The role of stingless bees in crop pollination. *Annual Review of Entomology*, 44(1), 183-206.
- Jarpla, M. (2025). Studies on stingless bees and their role in mango pollination. *Thesis Ph.d*; Navsari Agricultural University, Navsari, Gujarat, India. 155.
- Patel, H.K. and Pastagia J.J. (2016). Morphometric variation in workers of stingless bees *Tetragonula laeviceps* Smith in South Gujarat. *International Journal of Plant Protection*, 9, 445-449.
- Purwanto, H. and Trianto M. (2021). Species description, morphometric measurement and molecular identification of stingless bees (*Hymenoptera: Apidae: meliponini*) in meliponiculture industry in West Java Province, Indonesia. *Serangga*, 26(1), 13-33.

- Rahman, A., Das P.K., Rajkumari P., Saikia J. and Sharmah D. (2018). Stingless bees (*Hymenoptera: Apidae: Meliponini*): diversity and distribution in India. *Apidologie*, **39**, 102-118.
- Rasmussen, C. (2013). Stingless bees (*Hymenoptera: Apidae: Meliponini*) of the Indian subcontinent: Diversity, taxonomy and current status of knowledge. *Zootaxa*, **3647(3)**, 401-428.
- Roubik, D.W. (1993). Tropical pollinators in the canopy and understory: field data and theory for stratum "preferences". *Journal of Insect Behaviour*, **6**, 659-673.
- Sharma, V.G.; Jethva D.M., Wadaskar P.S., Kachot A.V. and Davaria P.J. (2023). Morphometric studies of stingless bees (*Tetragonula iridipennis* Smith) in Saurashtra region of Gujarat state. *The Pharma Innovation Journal*, **12(5)**, 1582-1585.
- Singh, P. and Khan M.S. (2019). Morphometric characterization of the stingless bees, *Tetragonula iridipennis* Smith (*Hymenoptera: Apidae*). *Journal of Entomology and Zoology Studies*, **7(5)**, 852-859.
- Slaa, E.J., Sanches-Chaves L.A., Malagodi-Braga K.S. and Hofstede F.E. (2006). Stingless bees in applied pollination: practice and perspectives. *Apidologie*, **37(2)**, 293-315.
- Tej, M.K., Srinivasan M.R., Vijayakumar K., Natarajan N. and Kumar S.M. (2017). Morphometry analysis of stingless bee *Tetragonula iridipennis* Smith (1854). *International Journal of Current Microbiology Applied Sciences*, **6(10)**, 2963-2970.
- Viraktamath, S. and Thangjam R. (2021). Two new species of *Tetragonula* (Hymenoptera: apidae: meliponini) from north-East India with notes on their nest structure. *Biologia*, **76(6)**, 1691-1704.