



Effect of Season and Timings on the Foraging Behaviour of Stingless Bee, *Tetragonula iridipennis* Smith (Hymenoptera: Apidae)

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Stingless bees are the smallest eusocial bees and crucial pollinators of tropical and subtropical ecosystems. The aim of this study is to analyse the foraging pattern and variability in resource intake of *Tetragonula iridipennis* Smith among different times and months. Foraging pattern of a *T. iridipennis* colony for pollen, nectar and resin reward collection was recorded from December 2017 to March 2018. The observations revealed that there is a difference in foraging activity within same day during different time interval as well as between months. Both pollen and nectar foraging activity was least during early morning (7.00 am to 9.00 am) hours whereas, resin foragers started their foraging activity as early as 7.00 am to 8.00 am. The pollen foraging activity attained peak from 8.00 am to 12.00 pm, resin foraging activity attained peak from 8.00 am to 11.00 but nectar foraging was observed more in noon and evening hours (12.00 pm to 5.00 pm). Foraging for all types of rewards (pollen, nectar and resin) was observed more during the month of March followed by February.

Key words: *Tetragonula iridipennis*, Foraging, Pollen, Nectar, Resin

Stingless bees are the smallest of the honey producing bees, commonly distributed in tropical and subtropical countries of the world. There are more than 500 species of stingless bees described all over the world (Michener, 2013). Large proportion of tropical plant species, summing up to one fifth of the local angiosperm flora requires the service of stingless bee pollination (Wilms *et al.*, 1996; Corlett, 2004). The most common stingless bee species of South India is *Tetragonula iridipennis* Smith (Michner, 1974). The major resources collected by stingless bees are pollen, resin and nectar. Pollen serves as a source of proteins and vitamins whereas nectar act as a source of carbohydrates for the bee's survival and colony development (Michener, 2007). Stingless bees are also known to collect resin and mud for building nest components and for defence purpose (Roubik, 2006; Leonhardt and Blüthgen 2009; Wallace and Lee, 2010). Brujin and Sommeijer (1997) observed colony foraging in four species of stingless bees *viz.*, *Melipona fasciata*, *M. beecheii*, *M. favosa* and *Tetragonisca angustata* and found that the foraging pattern of *Melipona* species was different than that of *T. angustata*. Devanesan *et al.*, (2002) observed foraging activity of *T. iridipennis* at Kerala, and reported the peak foraging activity at the month of July and least foraging activity during December and January. Danareddi (2007) reported foraging behaviour of *T. iridipennis* at different seasons and also the high activity of outgoing bees in October and November and pollen foraging in the month of February. Most of these studies were related to pollen

and nectar foraging and very few studies were done to analyse all the resources *i.e.* pollen, nectar and resin collected by stingless bees. So the aim of this study is to analyse resource intake and foraging activity of *T. iridipennis* by recording the number of pollen, nectar and resin foragers and to understand the variability within resources collected during different month and time of same day. This information will help the farmers and beekeepers for better utilisation of resources for stingless bees and thus to manage meliponiculture as well as for aided bee pollination.

Material and Methods

The present study was conducted at Apiary unit, Tamil Nadu Agricultural University, Coimbatore (11°N, 77°E) with an elevation of 409 meters above sea level. A strong colony of *T. iridipennis* maintained Apiary unit was used for observing the foraging activity. The colony reared in wooden box was connected with a transparent plastic tube at the entrance for recording the observations. The movements of foragers in and out of colony were recorded by direct visual observation at weekly interval for a period of ten minutes per hour from 7.00 am to 6.00 pm in a day during December 2017 to March 2018. The foraging activity was recorded by following the methods of Singh and Khan (2015). The number of foragers leaving their hives with waste materials (cleaner bees) and without waste materials (foragers), the number of foragers returning to their hives with resin load and pollen load was recorded. The pollen basket in metathoracic leg could be filled with pollen in case

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of pollen foragers (Plate 1) and resin drop in case of resin foragers (Plate 2). The number of nectar foragers were obtained by subtracting the number of cleaner bees (Plate 3) from the bees returning to their colony with empty corbicula (Plate 4) because after throwing away the undesirable material, these bees were observed to enter the hive without any reward. Mean foraging activity at different time and month was analysed and two-way ANOVA has been used to evaluate the differences between times of foraging behaviour in different months.

Results and Discussion

Resin foraging

The observations on resin foraging revealed that the peak resin collection activity was observed from morning 8.00 am to 10.00 am with maximum population of 11.16 foragers. 10 min⁻¹ and the resin collection gradually declined and became very minimum from evening 5.00 pm to 6.00 pm (0.78 foragers 10 min⁻¹). The activity of resin collection was more during the month of March (5.93 foragers

Table 1. Nectar foraging activity of *T. iridipennis* from Dec-2017 to Mar- 2018

| Time/Month | Mean number of foragers 10 min ⁻¹ | | | | | | | | | | | Average |
|------------|--|------------------|-------------------|------------------|-------------------|------------------|------------------|-------------------|-------------------|-------------------|------------------|------------------|
| | 7-8 am | 8-9 am | 9-10 am | 10-11 am | 11am-12 pm | 12-1 pm | 1-2 pm | 2-3 pm | 3-4 pm | 4-5 pm | 5-6 pm | |
| Dec 2017 | 13.88* | 11.88 | 44.13 | 33.63 | 29.50 | 42.88 | 50.88 | 48.38 | 55.38 | 45.88 | 51.75 | 38.92c (5.97) |
| Jan 2018 | 1.25 | 26.63 | 43.38 | 48.75 | 47.00 | 62.88 | 56.25 | 44.13 | 45.38 | 36.50 | 42.50 | 41.33c (6.10) |
| Feb 2018 | 20.00 | 54.75 | 73.50 | 69.50 | 75.50 | 84.13 | 79.00 | 66.50 | 58.88 | 52.25 | 41.63 | 61.42b (7.57) |
| Mar 2018 | 51.25 | 40.38 | 49.50 | 49.75 | 70.75 | 87.88 | 82.25 | 91.75 | 99.63 | 89.13 | 51.63 | 69.44a (8.20) |
| Average | 21.59d (3.92) | 33.41c (5.30) | 52.63ab (7.17) | 50.41b (6.99) | 55.69ab (7.28) | 69.44a (8.15) | 67.09a (8.07) | 62.69ab (7.82) | 64.81ab (7.90) | 55.94ab (7.27) | 46.88b (6.67) | |
| CD @0.05 % | Month | | 0.6042 | | | | | | | | | |
| | Time | | 1.0002 | | | | | | | | | |
| | Month X Time | | NS | | | | | | | | | |

*Mean of four replications. Means in the column/row followed by same alphabets do not differ significantly

Figures in the parentheses are $\sqrt{x + 0.5}$ transformed value

10 min⁻¹ min) and February (5.25 foragers 10 min⁻¹) compared to January (4.13 foragers 10 min⁻¹) and December (4.83 foragers 10 min⁻¹) (Fig.1). Significant

difference was observed with mean number of resin foragers and foraging times in every month.

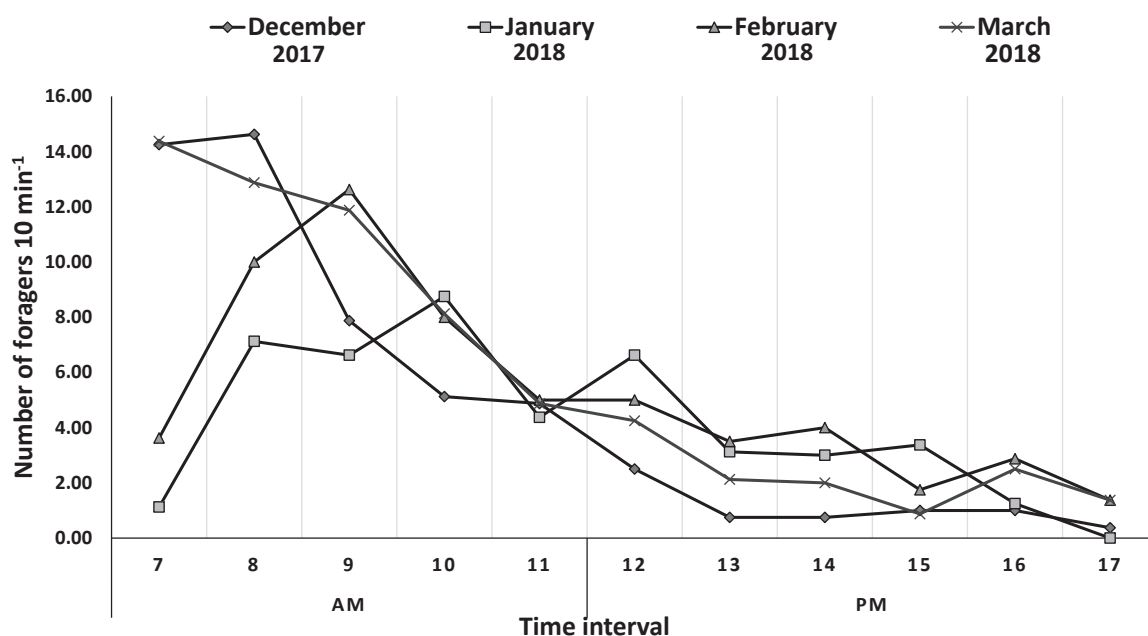


Fig.1. Resin foraging activity of *T. iridipennis* at different hours

Pollen foraging

During the study period activity of pollen foragers was observed throughout the day with most active phase in late morning hours (Fig.2). Pollen foraging

activity reached peak from 9.00 am to 1.00 pm (28.53- 33.69 foragers 10 min⁻¹). The pollen foraging activity started declining by 3.00 pm and reached the lowest point by 6.00 pm (4.97 foragers 10 min⁻¹)

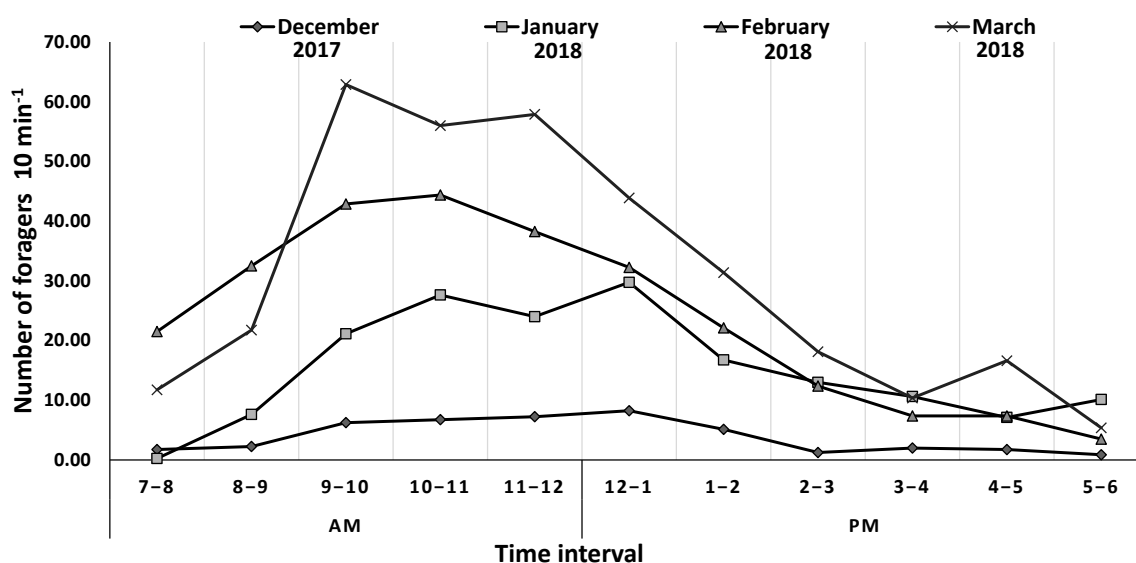


Fig.2: Pollen foraging activity of *T. iridipennis* at different hours

¹). The activity of pollen collection was more during March (30.55 foragers 10 min⁻¹) followed by February (24.05 foragers 10 min⁻¹) and less in December (3.95 foragers 10 min⁻¹).

Nectar foraging

The observation on nectar foraging activity of *T. iridipennis* during the study period indicated that the

Table 2. Outgoing foraging activity of *T. iridipennis* from Dec-2017 to Mar- 2018

| Time/Month | Mean number of foragers 10 min ⁻¹ | | | | | | | | | | | |
|-------------|--|---------------|----------------|----------------|----------------|---------------|-----------------|----------------|---------------|----------------|---------------|---------------|
| | 7-8 am | 8-9 am | 9-10 am | 10-11 am | 11am-12 pm | 12-1 pm | 1-2 pm | 2-3 pm | 3-4 pm | 4-5 pm | 5-6 pm | Average |
| Dec 2017 | 20.50* | 45.38 | 42.63 | 50.88 | 50.63 | 63.75 | 61.00 | 73.88 | 61.00 | 47.63 | 23.63 | 49.17b (6.84) |
| Jan 2018 | 10.13 | 48.25 | 66.13 | 64.38 | 62.50 | 72.88 | 65.25 | 75.00 | 84.38 | 52.75 | 39.38 | 58.27b (7.40) |
| Feb 2018 | 57.13 | 89.75 | 111.25 | 109.50 | 112.00 | 101.88 | 90.25 | 82.63 | 75.88 | 53.13 | 30.38 | 83.07a (8.84) |
| Mar 2018 | 77.38 | 67.63 | 97.88 | 105.50 | 106.38 | 92.25 | 82.25 | 82.00 | 107.63 | 109.00 | 48.25 | 88.74a (9.30) |
| Average | 41.28d (5.80) | 62.75c (7.57) | 79.47ab (8.77) | 82.56ab (8.92) | 82.88ab (8.92) | 82.69a (9.02) | 74.69abc (8.58) | 78.38ab (8.76) | 82.22a (8.99) | 65.63bc (7.94) | 35.41d (5.80) | |
| CD @ 0.05 % | Month | | 0.6127 | | | | | | | | | |
| | Time | | 1.0160 | | | | | | | | | |
| | Month X Time | | NS | | | | | | | | | |

*Mean of four replications. Means in the column/row followed by same alphabets do not differ significantly

Figures in the parentheses are $\sqrt{x + 0.5}$ transformed values

highest activity occurred from 11.00 am to 5.00 pm (55.69- 69.44 foragers 10 min⁻¹) and least foraging activity was observed from 7.00 am to 8.00 am (21.59 foragers 10 min⁻¹) (Table.1). Maximum number of nectar foragers was noticed during the month of March (69.44 foragers 10 min⁻¹) and the minimum number of foragers was observed during December (38.92 foragers 10 min⁻¹).

Outgoing foraging activity

The observations on foraging activity of *T. iridipennis* showed that the movement of outgoing foragers started early in the morning before 7.00 am during March, which was otherwise during cooler months. The mean number of outgoing foragers was maximum between 9.00 am to 4.00 pm during

December, January, February and March and attained highest between 9.00 am to 1.00 pm (79.47- 82.88 foragers 10 min⁻¹) and from 3.00 to 4.00 pm (82.22 foragers 10 min⁻¹). During the entire study period, outgoing foragers were least active in early morning (35.41-41.28 foragers 10 min⁻¹) and late evening hours (41.12 foragers 10 min⁻¹) and 5.00 am to 6.00 pm, respectively (Table.2). Monthly observations on outgoing foraging activity of *T. iridipennis* revealed that the maximum number of outgoing foragers was observed during March (88.74 foragers 10min⁻¹) and February (83.07 foragers 10 min⁻¹), whereas the months of December and January (49.17-58.27 foragers 10 min⁻¹) is influenced for minimum number of outgoing foragers.

Foraging to gather food resources is a unique



Plate 1. Forager bee with pollen load in corbicula phenomenon in bees. Unlike honeybees, stingless bees also collect resin from plant and non-plant resources (Roubik, 2006). The collected resin is used

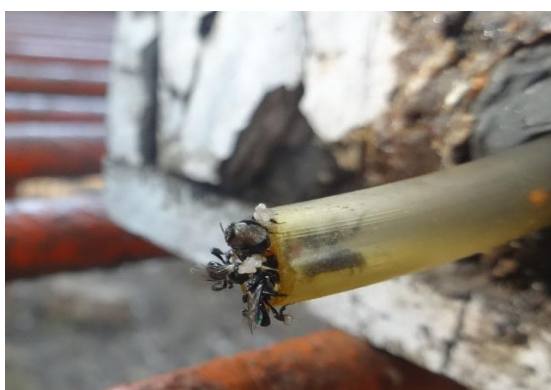


Plate 2. Forager bee with resin load in corbicula

to protect their colony from invaders as well as from microorganisms. In this study, the foraging activity for the collection of resin, pollen and nectar was more

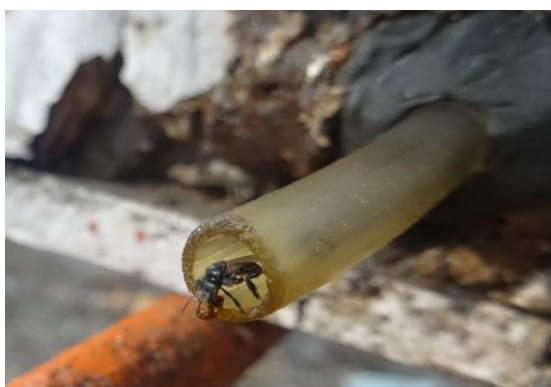


Plate 3. Cleaner bee with waste material in its mandible

during the month of March followed by February compared to the cooler months of December and January. This may be due to the changes in weather especially the temperature and sunshine which might impact the internal and external activity of stingless bee foragers. Hilario *et al* (2012) and Figueiredo *et al* (2013) also opined that the foraging activity of stingless bees was lower in winter months and during cold days, the flight activity was less intense and the

beginning of foraging time getting delayed compared to warmer days.

The peak time of foraging activity varies for different resources. Generally, the foraging activity was less intense in early morning and late evening hours. Resin and pollen foraging activity attained peak at morning 8.00 am to 11.00 am and 9.00 am to 1.00 pm respectively (Fig.1 and Fig.2). Resin collection activity started declining after 11 am and



Plate 4. Forager bee with empty corbicula

became negligible during evening hours. This may be due to the increase in stickiness of the resin source once the temperature and sunlight increases, which makes the task more difficult for the bees to collect and load the resin in their corbicula. Pollen foraging was more distinct earlier in the day than nectar, which is similar to the findings of Sommeijer *et al.* (1983) and could be supported by the fact that the pollen is abundantly available in early morning hours (Roubik, 1982). Distinct peak of pollen collection during late morning hours was similar to the findings of Bruijn and Sommeijer (2007) and Devanesan *et al.* (2002) but disagree with the result of Danaraddi (2007) who reported a peak of pollen foraging at 12 noon.

Conclusion

The present study revealed the foraging pattern of *T. iridipennis*. Pollen foraging activity was more from 9.00 am to 12.00 noon and peak resin foraging activity was from 7.00 am to 10.00 am, but nectar foraging was more from 11.00 am to 6.00 pm. The month of march 2018 recorded the maximum activity of rewards collection. Farmers and beekeepers interested in meliponiculture are not aware of the foraging behaviour and floral sources of stingless bees in India. Understanding about the foraging behaviour and preference of floral resources between different season will be helpful to the farmers and beekeepers for improving meliponiculture and also to fetch better yield in bee dependent crops.

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