



Research Article

## Studies on foraging behaviour of stingless bee, *Trigona iridipennis* Smith at Dharwad, Karnataka

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**Abstract :** Foraging behavior of stingless bee, *Trigona iridipennis* Smith was studied at Dharwad during 2006-07 by recording outgoing bees and incoming bees with pollen load (Pollen foragers) and without pollen load in different seasons viz., monsoon, winter and summer at Dharwad. The foraging behaviour varied significantly at different hours of the day and month of the season. Only one peak of activity of outgoing bees and incoming bees with and without pollen occurred between 1000 and 1200 hr during all the seasons. When the foraging activity irrespective of seasons was considered, the peak outgoing bees, pollen foragers and incoming bees without pollen occurred at 1200 hr (31.40, 10.52 and 17.18 bees/5 min, respectively). The activity of outgoing bees was higher in October and November, while that of pollen foragers was noticed in February. Similarly in October, November and February to May higher activity of incoming bees without pollen was recorded.

**Key Words :** Foraging behaviour, Stingless bee, *Trigona iridipennis*

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### INTRODUCTION

Stingless bees are the smallest of the honey producing bees and belong to the family Apidae and subfamily Meliponinae. They are highly social insects like honey bees living in permanent colonies, nesting in old walls, logs,

crevices and such other concealed places.

There are more than 500 species of stingless bees worldwide belonging to 18 genera (Wille and Michener, 1973). *Trigona* is the largest and most widely distributed genus, which includes 130 species under ten sub-genera. *Melipona* consists of 50 species and is confined to the neotropics. However, in India *T. iridipennis* is the only species recorded so far (Biesmeijer, *et al.*, 1994; Mohan and Devanesan, 1999; Muthuraman, 2006). As the stingless bees are important pollinators of several crops besides yielding honey (Heard, 1999) a thorough knowledge of the foraging behaviour is essential in order to maintain the colonies both for honey production and crop pollination. Hence, the present studies on foraging behaviour of *T. iridipennis* were made and the results are presented in this paper.

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### EXPERIMENTAL METHODS

These studies were made at the main campus of the

University of Agricultural Sciences, Dharwad which is located in the transitional tract of Karnataka at 15° 26' N latitude and 75° 07' East longitude and at an altitude of 678 meters above mean sea level. Three colonies of *T. iridipennis* of uniform strength maintained in earthen pots were selected from the UAS meliponary. The foraging activity in terms of the number of out going bees from the hives, number of incoming bees with pollen load (Pollen foragers) and without pollen load was recorded for a period of five minutes at two hourly intervals from 0600 to 1800 hrs. These observations were recorded at weekly interval from June 2006 to May 2007. The data obtained were pooled season wise viz., monsoon (June to September), winter (October to January) and summer (February to May) and also month wise irrespective of seasons. Then the data were analysed separately by using two factorial analysis.

## EXPERIMENTAL RESULTS AND ANALYSIS

The activity of out going bees was observed throughout the day in all the months of monsoon, winter and summer (Table 1). Lowest number of outgoing bees (2.58 bees/ 5 min) was observed at 0600 hr. The activity

gradually increased reaching the highest peak of 19.33 bees/ 5 min at 1200 hr. Thereafter, the foragers declined to the level of 4.26 bees/ 5 min at 1800 hr. When the foraging activity was considered monthwise a mean of 12.40 bees/ 5 min was observed in the month of June, which declined to 3.17 bees/ 5 min during July month. In August, the mean number of outgoing foragers increased to 7.75 bees/ 5 min, which further increased to highest level of 17.36 bees/ 5 min in September.

Considerably the lowest number of outgoing bees (2.09 bees/ 5 min) was observed early in the morning at 0600 hr but later the activity gradually increased to 29.68 bees/ 5 min by 1000 hr (Table 2). The highest peak was noticed during 1200 hr and 1400 hr with mean number of outgoing bees of 43.48 and 38.63 bees/ 5 min, respectively. The foraging activity slightly declined to 24.98 bees/ 5 min at 1600 hr and then to 8.97 bees/ 5 min at 1800 hr. The foraging activity varied from 20.94 to 24.29 bees/ 5 min in various months of winter season which however was not statistically different.

Lowest number of outgoing bees was observed in the morning at 0600 hr with 7.49 bees/ 5 min and evening at 1800 hr with 9.11 bees/ 5 min, which were at par with each other (Table 3). The peak activity was noticed at 1000 hr with 36.03

**Table 1: Activity of outgoing foragers during monsoon at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
June	1.92	7.75	18.17	24.00	16.42	14.50	4.08	12.40 (3.40 <sup>c</sup> )
July	1.67	5.33	5.83	4.17	2.17	0.67	2.33	3.17 (1.84 <sup>d</sup> )
August	2.92	9.17	12.17	12.98	7.83	5.67	3.53	7.75 (2.79 <sup>c</sup> )
September	3.83	9.33	16.83	36.17	29.42	18.83	7.11	17.36 (3.98 <sup>a</sup> )
Mean	2.58(1.73 <sup>e</sup> )	7.90(2.88 <sup>d</sup> )	13.25(3.64 <sup>ab</sup> )	19.33(4.19 <sup>a</sup> )	13.96(3.50 <sup>bc</sup> )	9.92(2.94 <sup>cd</sup> )	4.26(2.12 <sup>e</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.085		0.245					
Time (T)	0.113		0.324					
M x T	0.227		0.648					

**Table 2: Activity of outgoing foragers during winter at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
October	4.53	13.73	28.13	44.67	39.87	29.60	9.47	24.29 (4.69 <sup>a</sup> )
November	1.50	11.67	34.33	42.58	42.75	26.08	9.42	24.05 (4.60 <sup>a</sup> )
December	1.23	9.93	29.67	43.27	37.73	24.40	7.40	21.95 (4.36 <sup>a</sup> )
January	1.08	11.92	26.58	43.42	34.17	19.83	9.58	20.94 (4.29 <sup>a</sup> )
Mean	2.09(1.54 <sup>d</sup> )	11.8(3.48 <sup>e</sup> )	29.68(5.47 <sup>b</sup> )	43.48(6.60 <sup>a</sup> )	38.63(6.22 <sup>a</sup> )	24.98(5.02 <sup>b</sup> )	8.97(3.06 <sup>c</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.086		NS					
Time (T)	0.114		0.328					
M x T	0.229		0.656					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

**Table 3 : Activity of outgoing foragers during summer at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
February	10.50	20.00	33.42	40.50	26.08	25.50	17.33	24.76 (4.92 <sup>a</sup> )
March	8.25	19.08	37.33	29.67	22.08	22.25	7.33	20.86 (4.48 <sup>b</sup> )
April	5.80	13.93	35.80	28.27	21.47	14.40	6.20	17.98 (4.12 <sup>c</sup> )
May	5.42	13.17	37.58	27.17	20.33	14.17	5.58	17.63 (4.06 <sup>c</sup> )
Mean	7.49(2.78 <sup>c</sup> )	16.55(4.11 <sup>d</sup> )	36.03(6.04 <sup>a</sup> )	31.40(5.63 <sup>b</sup> )	22.49(4.79 <sup>c</sup> )	18.08(4.39 <sup>d</sup> )	9.11 (3.02 <sup>c</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.048		0.137					
Time (T)	0.063		0.181					
M x T	0.127		0.363					

**Table 4: Activity of incoming foragers with pollen load during monsoon at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
June	0.67	2.42	8.42	10.83	6.75	6.63	1.18	5.27 (2.25 <sup>a</sup> )
July	0.00	1.33	2.50	1.17	1.00	0.00	0.33	0.90 (1.13 <sup>d</sup> )
August	1.00	2.52	3.50	2.53	1.93	1.17	1.87	2.07 (1.58 <sup>c</sup> )
September	1.00	1.82	3.67	5.92	5.33	3.87	1.93	3.36 (1.90 <sup>b</sup> )
Mean	0.67(1.05 <sup>e</sup> )	2.02(1.57 <sup>cd</sup> )	4.52(2.18 <sup>a</sup> )	5.11(2.23 <sup>a</sup> )	3.75 (1.96 <sup>ab</sup> )	2.92 (1.69 <sup>bc</sup> )	1.33 (1.31 <sup>de</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.051		0.146					
Time (T)	0.067		0.193					
M x T	0.135		0.387					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

bees/ 5 min. When the foraging activity was considered monthwise, the activity was found highest with 24.76 bees/ 5 min in February, then it declined to 20.86 bees/ 5 min during March. In the month of April and May the activity further declined to 17.98 bees/ 5 min and 17.63 bees/ 5 min, respectively, which were at par with each other.

Activity of pollen foragers during monsoon is presented in Table 4. Lowest number of pollen foragers of 0.67 bees/ 5 min and 1.33 bees/ 5 min were observed during early morning 0600 hr and late evening 1800 hr, respectively. The activity gradually increased reaching the higher levels at 1000 hr (4.52 bees/ 5 min), 1200 hr with (5.11 bees/ 5 min)

and 1400 hr with (3.75 bees/ 5 min). When the pollen foraging activity was considered monthwise, highest foragers (5.27 bees/ 5 min) was observed in June, which declined to the lowest level of 0.90 bees/ 5 min during July. Thereafter, the activity increased in the month of September with mean of 3.36 bees/ 5min.

The pollen foraging activity was observed throughout the day in all the months of winter season (Table 5). Lowest number of bees with pollen load (0.33 bees/ 5 min) was observed at 0600 hr. The activity gradually increased reaching the highest peak (10.45 bees/ 5 min) at 1200 hr. Thereafter, the activity declined to the level of 1.48 bees/

**Table 5: Activity of incoming foragers with pollen load during winter at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
October	1.00	2.13	6.00	10.22	8.28	6.78	1.60	5.15(2.24 <sup>ab</sup> )
November	0.33	1.36	8.75	14.33	11.83	9.58	1.42	6.80 (2.45 <sup>b</sup> )
December	0.00	1.37	3.87	10.33	9.67	6.67	1.33	4.75 (2.08 <sup>b</sup> )
January	0.00	1.08	2.25	6.92	3.17	2.62	1.58	2.52 (1.63 <sup>c</sup> )
Mean	0.33 (0.88 <sup>e</sup> )	1.49 (1.40 <sup>d</sup> )	5.22 (2.31 <sup>c</sup> )	10.45(3.27 <sup>a</sup> )	8.24 (2.86 <sup>ab</sup> )	6.41(2.57 <sup>bc</sup> )	1.48 (1.40 <sup>d</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.064		0.183					
Time (T)	0.084		0.242					
M x T	0.169		0.485					

5min at 1800 hr. considerably higher pollen foraging activity (5.15 to 6.80 bees/ 5 min) was observed in October and November. The activity declined to 4.75 and 2.52 bees/ 5 min during the month of December and January, respectively.

Pollen foraging activity was observed throughout the day in all the months of summer season (Table 6). Lowest number of bees with pollen load (1.88 bees/ 5 min) was observed at 0600 hr. The activity gradually increased reaching the highest peak of 18.52 bees/ 5 min at 1000 hr. Thereafter, the foragers declined slowly to the level of 3.13 bees/ 5min at the end of the day. When the foraging activity was considered monthwise, a highest of 11.64 bees/ 5 min was observed in February month. Lower foraging activity was observed (8.36 to 9.42 bees/ 5 min) from March to May, which did not vary statistically.

The foraging activity of incoming bees without pollen was observed throughout the day in all the months of monsoon, winter and summer seasons. Lowest number of incoming bees without pollen load (1.25 bees/ 5 min) was observed early in the morning (0600 hr), (Table 7). The activity gradually increased reaching the highest peak of 13.16 bees/ 5 min at 1200 hr. But at the end of the day (1800 hr) it declined to the lowest level of 6.10 bees/ 5 min. The foraging activity was higher in June (11.06 bees/ 5 min) and September (11.67

bees/ 5 min) followed by August (5.26 bees/ 5 min) and July with (1.40 bees/ 5 min).

In the beginning of the day (0600 hr), lowest number of bees without pollen load (0.78 bees/ 5 min) was observed which gradually increased reaching the highest peak of 21.03 bees/ 5 min by noon (1200 hr) during winter (Table 8). Thereafter the activity declined to the level of 10.10 bees/ 5 min at the end of the day (1800 hr). Foraging activity when considered monthwise, varied from 9.89 to 16.21 bees/ 5 min from October to January which however was at par with each other statistically.

In summer lowest number of bees without pollen load (4.50 bees/ 5 min) was observed at 0600 hr (Table 9). Considerably higher activity of 17.64 and 17.34 bees/ 5 min was recorded at 1000 and 1200 hr. However, the activity declined to the level of 11.25 bees/ 5 min at the end of the day 1800 hr. When the foraging activity was considered monthwise higher activity was noticed in February and March with 13.94 and 12.88 bees/ 5 min, which declined gradually with lowest number of bees without pollen load (11.25 bees/ 5 min) during the month of May.

The activity of outgoing foragers irrespective of season is presented in (Table 10). Outgoing foraging activity when compared irrespective of seasons showed that

**Table 6 : Activity of incoming foragers with pollen load during summer at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
February	2.50	11.67	19.92	20.58	13.00	10.83	3.00	11.64 (3.32 <sup>a</sup> )
March	1.53	3.58	16.42	16.00	12.58	11.25	4.58	9.42 (2.99 <sup>b</sup> )
April	1.80	4.67	18.40	13.93	10.13	7.00	2.60	8.36 (2.81 <sup>b</sup> )
May	1.68	5.92	19.33	13.42	10.92	5.42	2.35	8.43 (2.81 <sup>b</sup> )
Mean	1.88(1.53 <sup>a</sup> )	6.46(2.58 <sup>c</sup> )	18.52(4.36 <sup>a</sup> )	15.98(4.04 <sup>b</sup> )	11.66(3.48 <sup>c</sup> )	8.63 (2.99 <sup>d</sup> )	3.13 (1.89 <sup>f</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.039		0.112					
Time (T)	0.052		0.149					
M x T	0.104		0.298					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

**Table 7: Activity of incoming foragers without pollen load during monsoon at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
June	1.92	4.58	13.92	16.25	17.17	13.33	10.25	11.06 (3.26 <sup>a</sup> )
July	0.00	2.00	2.33	1.50	1.67	0.00	2.33	1.40 (1.31 <sup>c</sup> )
August	1.00	3.30	5.92	10.73	6.75	4.70	4.40	5.26 (2.31 <sup>b</sup> )
September	2.10	4.25	9.58	24.17	21.92	12.25	7.40	11.67 (3.27 <sup>a</sup> )
Mean	1.25(1.27 <sup>c</sup> )	3.53(1.97 <sup>d</sup> )	7.94(2.79 <sup>bc</sup> )	13.16(3.45 <sup>a</sup> )	11.88(3.26 <sup>ab</sup> )	7.57(2.56 <sup>c</sup> )	6.10(2.46 <sup>cd</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.079		0.226					
Time (T)	0.105		0.299					
M x T	0.210		0.599					

**Table 8 : Activity of incoming foragers without pollen load during winter at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
October	1.80	6.47	14.80	24.33	20.53	18.93	7.80	13.52 (3.53 <sup>a</sup> )
November	1.00	20.50	17.17	22.67	24.08	16.25	11.83	16.21(3.80 <sup>a</sup> )
December	0.33	3.25	11.00	16.80	15.73	11.87	10.27	9.89 (3.02 <sup>a</sup> )
January	0.00	4.58	10.42	20.33	14.67	11.92	10.50	10.35 (3.07 <sup>a</sup> )
Mean	0.78(1.08 <sup>d</sup> )	8.70(2.65 <sup>c</sup> )	13.35(3.70 <sup>ab</sup> )	21.03(4.61 <sup>a</sup> )	18.75(4.35 <sup>a</sup> )	14.74(3.87 <sup>ab</sup> )	10.10(3.23 <sup>bc</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.152		NS					
Time (T)	0.201		0.575					
M x T	0.403		1.151					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

NS=Non-significant

**Table 9: Activity of incoming foragers without pollen load during summer at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
February	8.00	10.83	15.58	19.75	13.75	15.17	14.50	13.94 (3.76 <sup>a</sup> )
March	4.67	11.08	18.00	16.42	12.75	15.08	12.17	12.88 (3.60 <sup>ab</sup> )
April	3.40	10.13	23.07	16.93	16.53	10.40	8.07	12.65 (3.51 <sup>b</sup> )
May	1.92	5.92	13.92	16.25	17.17	13.33	10.25	11.25 (3.31 <sup>c</sup> )
Mean	4.50 (2.17 <sup>c</sup> )	9.49 (3.14 <sup>d</sup> )	17.64(4.24 <sup>a</sup> )	17.34(4.22 <sup>a</sup> )	15.05(3.93 <sup>b</sup> )	13.50(3.73 <sup>b</sup> )	11.25 (3.41 <sup>c</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.040		0.115					
Time (T)	0.053		0.152					
M x T	0.107		0.305					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

**Table 10: Activity of outgoing foragers during 2006-07 irrespective of season at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
June	1.92	7.75	18.17	24.00	16.42	14.50	4.08	12.40 (3.40 <sup>f</sup> )
July	1.67	5.33	5.83	4.17	2.17	0.67	2.33	3.17 (1.84 <sup>h</sup> )
August	2.92	9.17	12.17	12.98	7.83	5.67	3.53	7.75 (2.79 <sup>g</sup> )
September	3.83	9.33	16.83	36.17	29.42	18.83	7.11	17.36 (3.98 <sup>e</sup> )
October	4.53	13.73	28.13	44.67	39.87	29.60	9.47	24.29 (4.69 <sup>ab</sup> )
November	1.50	11.67	34.33	42.58	42.75	26.08	9.42	24.05 (4.60 <sup>abc</sup> )
December	1.23	9.93	29.67	43.27	37.73	24.40	7.40	21.95 (4.36 <sup>bcd</sup> )
January	1.08	11.92	26.58	43.42	34.17	19.83	9.58	20.94 (4.29 <sup>cde</sup> )
February	10.50	20.00	33.42	40.50	26.08	25.50	17.33	24.76 (4.92 <sup>a</sup> )
March	8.25	19.08	37.33	29.67	22.08	22.25	7.33	20.86 (4.48 <sup>bcd</sup> )
April	5.80	13.93	35.80	28.27	21.47	14.40	6.20	17.98 (4.12 <sup>de</sup> )
May	5.42	13.17	37.58	27.17	20.33	14.17	5.58	17.63 (4.06 <sup>e</sup> )
Mean	4.05 (2.02 <sup>f</sup> )	12.08(3.49 <sup>d</sup> )	26.32(5.05 <sup>b</sup> )	31.40(5.47 <sup>a</sup> )	25.03(4.84 <sup>b</sup> )	17.99(4.12 <sup>c</sup> )	7.45(2.74 <sup>e</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.072		0.203					
Time (T)	0.055		0.155					
M x T	0.192		0.538					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

significantly highest (31.40 bees/ 5 min) outgoing foragers were observed at 1200 hr followed by 1000 (26.32 bees/ 5 min) and (25.03 bees/ 5 min) 1400 hr. The activity was significantly lowest at 0600 hr with mean of 4.05 bees/ 5 min. Maximum activity (24.76 bees/ 5 min) was observed in the

month of February which was at par with activity in October (24.29 bees/ 5min) and November (24.05 bees/ 5min). Significantly lowest activity of 3.17 bees/ 5 min was recorded in the month of July.

Significantly highest pollen foragers (10.52 bees/ 5 min)

**Table 11 : Activity of incoming foragers with pollen load during 2006-07 irrespective of season at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
June	0.67	2.42	8.42	10.83	6.75	6.63	1.18	5.27 (2.25 <sup>cd</sup> )
July	0.00	1.33	2.50	1.17	1.00	0.00	0.33	0.90 (1.13 <sup>e</sup> )
August	1.00	2.52	3.50	2.53	1.93	1.17	1.87	2.07 (1.58 <sup>f</sup> )
September	1.00	1.82	3.67	5.92	5.33	3.87	1.93	3.36 (1.90 <sup>e</sup> )
October	1.00	2.13	6.00	10.22	8.28	6.78	1.60	5.15 (2.24 <sup>cd</sup> )
November	0.33	1.36	8.75	14.33	11.83	9.58	1.42	6.80 (2.45 <sup>e</sup> )
December	0.00	1.37	3.87	10.33	9.67	6.67	1.33	4.75 (2.08 <sup>de</sup> )
January	0.00	1.08	2.25	6.92	3.17	2.62	1.58	2.52 (1.63 <sup>f</sup> )
February	2.50	11.67	19.92	20.58	13.00	10.83	3.00	11.64 (3.32 <sup>d</sup> )
March	1.53	3.58	16.42	16.00	12.58	11.25	4.58	9.42 (2.99 <sup>b</sup> )
April	1.80	4.67	18.40	13.93	10.13	7.00	2.60	8.36 (2.81 <sup>b</sup> )
May	1.68	5.92	19.33	13.42	10.92	5.42	2.35	8.43 (2.81 <sup>b</sup> )
Mean	0.96 (1.15 <sup>e</sup> )	3.32 (1.85 <sup>e</sup> )	9.42 (2.95 <sup>b</sup> )	10.52 (3.18 <sup>d</sup> )	7.88 (2.77 <sup>c</sup> )	5.98 (2.41 <sup>d</sup> )	1.98 (1.53 <sup>f</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.047		0.134					
Time (T)	0.036		0.102					
M x T	0.126		0.354					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

**Table 12: Activity of foragers without pollen load during 2006-07 irrespective of season at Dharwad**

Hours→ Months↓	Mean number of bees/ 5 minutes/ colony							Mean
	0600	0800	1000	1200	1400	1600	1800	
June	1.55	2.21	3.80	4.09	4.20	3.72	3.28	11.06 (3.26 <sup>bc</sup> )
July	0.71	1.56	1.68	1.41	1.44	0.71	1.64	1.40 (1.31 <sup>e</sup> )
August	1.22	1.94	2.52	3.35	2.69	2.26	2.20	5.26 (2.31 <sup>d</sup> )
September	1.60	2.17	3.16	4.95	4.71	3.54	2.74	11.67 (3.27 <sup>bc</sup> )
October	1.51	2.60	3.91	4.95	4.56	4.37	2.84	13.52 (3.53 <sup>abc</sup> )
November	1.22	3.83	4.19	4.80	4.95	4.07	3.51	16.21 (3.80 <sup>a</sup> )
December	0.88	1.93	3.39	4.15	4.00	3.51	3.28	9.89 (3.02 <sup>c</sup> )
January	0.71	2.24	3.29	4.55	3.87	3.51	3.31	10.35 (3.07 <sup>c</sup> )
February	2.90	3.36	4.00	4.50	3.77	3.95	3.87	13.94 (3.76 <sup>ab</sup> )
March	2.27	3.40	4.30	4.11	3.64	3.95	3.56	12.88 (3.60 <sup>ab</sup> )
April	1.97	3.26	4.85	4.17	4.12	3.30	2.92	12.65 (3.51 <sup>abc</sup> )
May	1.55	2.53	3.80	4.09	4.20	3.72	3.28	11.25 (3.31 <sup>abc</sup> )
Mean	2.18 (1.51 <sup>f</sup> )	7.24 (2.59 <sup>e</sup> )	12.98 (3.57 <sup>bc</sup> )	17.18 (4.09 <sup>a</sup> )	15.23 (3.85 <sup>ab</sup> )	11.94 (3.38 <sup>c</sup> )	9.15 (3.03 <sup>d</sup> )	
Factors	S.E. ±		C.D. (P=0.05)					
Months (M)	0.092		0.259					
Time (T)	0.071		0.198					
M x T	0.246		0.686					

Means in the column/row followed by same alphabets do not differ significantly by DMRT at 5%

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

was observed at 1200 hr followed by 1000 hr with mean of 9.42 bees/ 5 min. The activity was significantly lowest at 0600 hr with mean of (0.96 bees/ 5 min). Maximum activity (11.64 bees/ 5 min) was observed in the month of February, which was followed by March, April and May with a mean 9.42, 8.36bees/5 min and 8.43bees/5 min, respectively. Significantly lowest activity of 0.90 bees/5min was recorded in the month of July (Table 11).

Activity of bees without pollen load was compared irrespective of seasons and the result showed that significantly highest bees without pollen load (17.18 bees/ 5 min) was observed at 1200 hr which was at par with 1400 hr with 15.23 bees/ 5 min (Table 12). The activity was significantly lowest during early in the morning 0600 hr with mean of 2.18 bees/ 5min. Maximum activity (16.21 bees/ 5 min) was observed in the month of November which was at par with the activity recorded in October, February, March, April and May (11.25 to 13.94 bees/ 5 min). Significantly lowest activity of 1.40 bees/ 5 min was recorded in the month of July. Devanesan *et al.* (2002) recorded two-peak activity of *T. iridipennis* at 1200 and 1500 hr from Kerala. Similarly Roopa (2002) recorded two peaks of outgoing bees during 1200 to 1300 and 1600 to 1700 hr, pollen foragers during 1000 to 1100 and 1300 to 1400 and nectar foragers during 1300 to 1400 and 1500 to 1600 hr at Bangalore. The variations in these findings are obviously due to differences in colony conditions, climatic factors and foraging sources in these places.

## REFERENCES

- Biesmeijer, J.C., Nieuwotadt, M.G.L., Sommeijer, M.J. and Bruijn, L.L.M. (1994). Pollen foraging strategies of two domesticated stingless bee species in Costa Rica. Proc. Vth Intrnl. Con. On Apic. In Trop. Cli., Trinidad, West Indies, pp. 214-220.
- Cervanica, C.R., Barile, G. E., Veeresh, G.K., Shankar, R.O. and Ganeshaiyah, K.N. (1982). Foraging behaviour of *T. biroi* Friese. Proc. Int. Symp. On Pollin. In tropic, Bangalore, pp. 78-80.
- Devanesan, S., Nisha, M.M, Bennet, R. and Shailaja, K.K. (2002). Foraging behaviour of stingless bees, *Trigona iridipennis* Smith, *Insect Environ.*, **8**(3): 131-133.
- Heard, T.A. (1999). The role of stingless bees in crop pollination. *Ann. Rev. Entomol.*, **44**: 183-206.
- Mohan, Rakhee and Devanesan, S. (1999). Dammer bees, *Trigona iridipennis* Smith. (Apidae: Meliponinae) in Kerala. *Insect Environ.*, **5** (2): 79.
- Muthuraman, M. (2006). Prospects and Retrospects of Meliponiculture. [http://www.tnau.ac.in/apps/productive/Apiculture/olo\\_a\\_pp\(1-10\)](http://www.tnau.ac.in/apps/productive/Apiculture/olo_a_pp(1-10)).
- Roopa, C.A. (2002). Bioecology of stingless bees, *Trigona iridipennis* Smith, M. Sc. (Ag.) Thesis, University of Agricultural Sciences, G.K.V.K. BANGALORE, KARNATAKA (India).
- Wille, A. and Michener, C.D. (1973). The nest architecture of stingless bees with special reference to those of Costa Rica (Hymenoptera: Apidae). *Rev. Biol. Trop.*, **21**: 1-278.

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