



Spatio-temporal distribution of stingless bee (Hymenoptera: Apidae: Meliponini) colonies amidst diversified agro-ecosystems of south-eastern Karnataka, India

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Abstract

Stingless bees or dammar bees (Hymenoptera: Apidae: Meliponini) live under cryptic conditions, playing a pivotal role by performing pollination to various flowering plant species and produce useful hive products at diversified ecosystems. Total 8129 stingless bee live colonies and 198 deserted colonies were spatial and temporal distributed at residential and non-residential areas during various seasons in 2017 to 2019 at Bangalore rural, Chikkaballapur and Kolar districts of south-eastern Karnataka. Further, 17 different sites were chosen for nesting by stingless bees, of which nine sites were found suitable at non-residential areas and remaining sites becomes usual nest sites at residential areas. The human inhabited houses, schools and temples built with walls made of mud, stone and cement, abandoned fort walls, inner surface of the well walls, unused electric devices and sheds were offered for nesting by stingless bees at residential areas. However, at non-residential areas, rocky areas, abandoned brick mounds, tree trunks and even on soil surface have used by stingless bees for nesting. Analysis of variance of seasonal distribution of stingless bee colonies during different years at various districts of residential and non-residential areas of south-eastern Karnataka revealed considerable statistical variations. Thus, present studies are crucial for future investigations to recorded role of stingless bees in this part of the state. If it kindles the local people to take up meliponiculture, it would help contribute to the improvement of local biodiversity considerably. Stingless bees not only pollinate and propagate local flora, improve biodiversity and socio-economic conditions of local people. Therefore, stingless bee's conservation is necessitated to restore the local biodiversity and help produce hive products for human advantage in this part of the state.

Keywords: spatial, temporal, distribution, stingless bee colonies, south-eastern Karnataka

Introduction

Stingless bees or dammar bees (Hymenoptera: Apidae: Meliponini) [1-2] are most important, social corbiculate group of insects commonly called 'Musare Jenu' in Karnataka. These bees live in cryptic nests at crevices of old buildings or tree trunk amidst residential or natural habitat conditions. Locating nests under such cryptic places is a difficult task for a layman unless little basic knowledge if not there on honeybees presence in an ecosystem [3]. Hence, around the world, several researchers [1, 4-27] have reported the stingless bees distribution, diversity and their usefulness to the local biodiversity. Because, stingless bees are potential pollinators; pollinate 40 to 90% herbs, shrubs and small to medium sized trees amidst human inhabited places, agriculture and forest ecosystems [19]. Besides, millions of people are rearing these creatures in the name of 'Meliponiculture' [12, 20, 22] to obtain medicinally important hive products [5, 11, 13, 16-17, 21, 28] around the world. The hive products have very high demand in national and international markets [27]. Unfortunately, very few published reports available on distribution and nesting habitats of stingless bees under diversified agro-ecosystems of India in general and southern Karnataka in particular. Surprisingly, in recent past, pollinators are declining and more emphasis is given to search natural pollinators amidst diversified agro-ecosystems around the world [3, 15, 29]. Several species

of stingless bees live both in natural and man-made habitats [7, 30-33], their presence is unnoticed unfortunately due to their small size. Moreover, several cryptic nests of stingless bees are destroyed knowingly or unknowingly due to different reasons by various man-made activities at diversified agro-ecosystems [30].

At this juncture, field investigations are necessitated intensively to record the spatial [33] and temporal distribution of stingless bee population at different agro-climatic conditions. This could help detect the abundant useful resource from stingless bee nests in cryptic habitats and harness their nest products which are useful to mankind at tropical and sub-tropical climatic regions [6, 18 & 25]. Since, honeybee pollinators including stingless bees are playing pivotal role in changing landscapes [9, 34, 35], influence the local vegetation growth and development [18 & 24, 29]. In India, stingless bee culture is encouraged by different State Governments [16] to produce honey, pollen and developing brood. However, in Karnataka, such attempts should be made more intensively to encourage beekeepers. At this juncture, intensive in depth studies are necessitated as published reports are fragmentary and indicated the existence of lacunae of information on stingless bee population distribution during different seasons at various agro-ecosystems of south-eastern Karnataka. Hence the present investigation was undertaken.

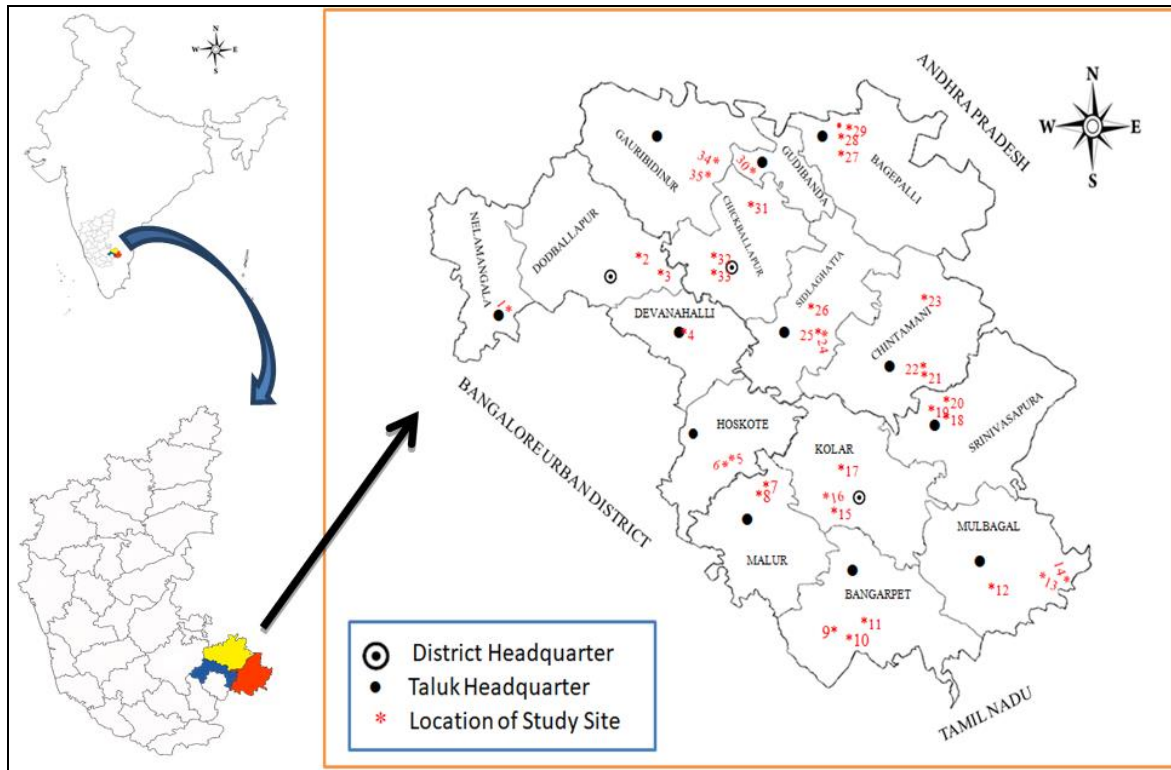


Fig 1: Map showing the study areas in south-eastern Karnataka

Materials and Methods

Study area

Present investigation was carried out in three districts namely: Bangalore rural (12°15' – 13°31'N latitude to 77°04'-77°59'E longitude with an elevation 850 to 950m msl), Chickaballapur (13°13'04''- 13°58'29''N latitude to 77°21'52''-78°12'31''E longitude with an elevation 249 to 911m msl) and Kolar (12°41'54''-13°35'47''N latitude to

77°50'29''-78°35'18''E longitude with an elevation range from 849 to 1110m msl) [35] of south-eastern Karnataka (Fig. 1). These three districts are falling under eastern dry agro-climatic zone that experiencing semi-arid climate, with typical monsoon type of weather [36-38]. Brief details on physiographic, ecological and crops grown in south-eastern districts selected for the present study are given in the Table 1.

Table 1: Physiographic and ecological factors of south-eastern Karnataka

Sl.No.	District	Physiographic factors			Ecological factors					Climate	Forest coverage (%)	Vegetation (Major crops grown)
		Latitude	Longitude	Elevation (meter)	Temperature (°C)		Humidity (%)		Rain fall (mm)			
					Max	Min	Max	Min				
1.	Bangalore Rural	12° 15' to 13° 31' N	77° 04' to 77° 59' E	850 to 950	34	15	63	64	824	Dry agro-climatic zone	5.01	Paddy, Jowar, Bajra, Maize, Wheat, Oil seeds, Vegetables and Sugarcane
2.	Chickaballapur	13°13'04'' to 13° 58'29''N	77°21'52'' to 78°12'31''E	849 to 1130	32	21	79	45	750.3		11.0	Finger millets, Groundnut and Pulses, Paddy, Mulberry, Vegetables, Sugarcane, Mango & Grapes
3.	Kolar	12° 41'54'' to 13° 35'47'' N	77° 50'29'' to 78° 35'18'' E	249 to 911	37	15	79	45	744		5.0	Finger millets, Groundnut and Pulses, Paddy, Mulberry, Vegetables, Sugarcane, Mango & Grapes

Source: Anonymous, 2012a & b and 2013; Kamath, 2011 and Google.com

Methodology

Systematic field survey was conducted using random sampling (RS), all out search (AOS) and visual count (VC) methods during 2017 and 2019 at different taluks of Bangalore rural, Chikkaballapur and Kolar districts (Fig. 1). Total 35 study areas are earmarked in 15 taluks of these districts and in each and every study area, eight to nine study sites were randomly chosen after obtaining the basic

information on stingless bee colonies by meeting local people and farmers personally. Altogether, 293 study sites were selected by considering the local diversified habitats. The spatial and temporal distribution of stingless bee live colonies, deserted nests were observed using AOSM and VCM per [29, 30, 39] during different seasons. The information on nest habitats was also collected and photographed using Sony DSC-Wx7 digital still camera – 2330542.

Statistical analysis

The collected data on stingless bees live colonies, deserted colonies and nest sites distribution at residential and non-residential areas during different seasons and years at Bangalore rural, Chikkaballapur and Kolar districts were compiled systematically using analysis of variance as per [40].

Results

Distribution of stingless bee live colonies

Table 2: Stingless bee deserted colonies recorded in south-eastern Karnataka

Sl. No.	District	Year			Season		
		2017	2018	2019	Rainy	Winter	Summer
1.	Bangalore Rural	312	689	247	399	375	474
2.	Chikkaballapur	1304	1968	686	1313	1281	1364
3.	Kolar	489	1800	634	1094	628	1201
Total		2105	4457	1567	2906	2284	3039
'F' value between the years & seasons		2.878*			0.222**		
'F' value between the Districts		1.899**			19.232*		

Note: Each value is a mean of three observations.

*Values are significant at 5% level; **Values are not significant

During different seasons

Interestingly, during summer season there were more (3039) stingless bee live colonies were recorded and it was followed by rainy and winter seasons respectively 2906 and 2284 and didn't statistically varied (F=0.222; P<0.005) between the seasons (Table 2). However, during rainy, winter and summer seasons, distribution and occurrence of stingless bee live colonies varied significantly (F=19.232; P>0.05) between Bangalore rural, Chikkaballapur and Kolar districts respectively 1248, 3958 and 2923 (Table 2).

At different districts: Further, stingless bee live colonies distribution in residential areas during different years and seasons in Bangalore, Chikkaballapur and Kolar districts indicated interesting results (Table 2). Stingless bee live colonies were more during 2018 (3842) and it was followed by 2017 (1753) and 2019 (1359) and indicated considerable

During different years

Total 2105 stingless bee live colonies were recorded in 2017 and it was followed by 4457 and 1567 respectively during 2018 and 2019 and indicated considerable statistical variation (F=2.878; P>0.05) between the years in south-eastern Karnataka (Table 2). However, in Chikkaballapur district, stingless bee live colonies were more 3858 and it was followed by Kolar and Bangalore rural districts respectively 2923 and 1248 and indicated not significant variation between the districts in south-eastern Karnataka (Table 2).

statistical variation (F=2.677; P>0.05) and between Bangalore rural, Chikkaballapur and Kolar districts indicated no significant difference (F= 1.850; P>0.05) (Table 2).

At residential areas

However, similar trend was recorded with respect to the distribution of stingless bee live colonies in residential area during different seasons. Summer season scored highest (2609) and it was followed by rainy (2401) and winter (1944) stingless bee live colonies and didn't statistically varied (F=0.246; P<0.005) between the seasons (Table 3). However, during rainy, winter and summer seasons, distribution and occurrence of stingless bee live colonies varied significantly (F=18.476; P>0.05) between Bangalore rural, Chikkaballapur and Kolar districts respectively 964, 3251 and 2739 (Table 3).

Table 3: Stingless bee live colonies recorded in south-eastern Karnataka

Sl. No.	District	Residential Area						Non-residential area					
		Year			Season			Year			Season		
		2017	2018	2019	R	W	S	2017	2018	2019	R	W	S
1.	Bangalore Rural	246	523	195	314	285	365	66	166	52	85	90	109
2.	Chikkaballapur	1065	1622	564	1067	1057	1127	239	346	122	246	224	237
3.	Kolar	442	1697	600	1020	602	1117	47	103	34	74	26	84
Total		1753	3842	1359	2401	1944	2609	352	615	208	405	340	430
'F' value between the years & seasons		2.677*			0.246**			1.456**			0.082**		
'F' value between the Districts		1.850**			18.476*			4.339*			21.971		

Note: Each value is a mean of three observations.

R: Rainy; W: Winter; S: Summer seasons

*Values are significant at 5% level; **Values are not significant.

At non-residential areas

The stingless bee live colonies were high (615) during 2018 and it was followed by 2017 (352) and 2019 (208) and indicated no statistical variation (F=1.456; P<0.05) between the years (Table 3).

However, at non-residential areas, stingless bee live colonies were more (707) at Chikkaballapur district and it was followed by Bangalore rural district at (284) and in Kolar district only 184 stingless bee live colonies were recorded that indicated significant variation (F=4.339; P>0.05) between the districts (Table 3). However, during

summer season, stingless bee colonies were distributed more (430) and it was followed by rainy and winter seasons respectively 405 and 340 and it didn't indicated statistical variation (F=0.0823; P<0.05) (Table 4). Interestingly, among different districts, the distribution of stingless bee live colonies during different seasons such as rainy, winter and summer seasons indicated significant variation (F=21.971; P>0.05) (Table 3). Thus, stingless bee live colonies distribution in general within the districts didn't differed during different seasons, but differed significantly between the districts.

Table 4: Stingless bee deserted colonies recorded in south-eastern Karnataka

Sl. No.	District	Residential Area						Non-residential area					
		Year			Season			Year			Season		
		2017	2018	2019	R	W	S	2017	2018	2091	R	W	S
1.	Bangalore Rural	3	11	-	6	5	3	3	2	-	2	3	-
2.	Chikkaballapur	48	46	18	47	29	36	3	15	1	6	5	8
3.	Kolar	17	15	3	15	11	9	4	7	2	5	2	6
Total		68	72	21	68	45	48	10	24	3	13	10	14
'F' value between the years & seasons		0.327**			0.168**			1.683**			3.237*		
'F' value between the Districts		5.101*			28.322*			1.555**			3.912*		

Note: Each value is a mean of three observations.

R: Rainy; W: Winter; S: Summer seasons

*Values are significant at 5% level; **Values are not significant

Distribution of deserted colonies

At residential area

Table 4 shows the deserted colonies recorded in Bangalore rural, Chikkaballapur and Kolar districts during different years and seasons. Analysis of variance of the recorded data indicated that both between the years (2017 to 2019) and seasons (rainy to summer) did not indicated statistical significant variation (Table 4).

However, quite interestingly, between the districts both during different years (2017 to 2019) and seasons (rainy to summer) indicated significant statistical difference (Table 4).

Thus, there is a considerable variation existed between Bangalore rural, Chikkaballapur and Kolar districts with regard to the occurrence of deserted colonies of stingless bees at residential areas of south-eastern Karnataka.

At non-residential area

Table 4 shows the deserted colonies recorded in Bangalore rural, Chikkaballapur and Kolar districts during different years. Analysis of variance of the recorded data indicated that both between the years (2017 to 2019) at Bangalore rural, Chikkaballapur and Kolar districts there was no significant variation existed at non-residential areas (Table 4). However, quite interestingly, between the seasons at Bangalore rural, Chikkaballapur and Kolar districts there was a significant difference existed at non-residential areas (Table 3). Thus, irrespective of the year, there was a considerable variation existed between Bangalore rural, Chikkaballapur and Kolar districts during different seasons with regard to the occurrence of deserted colonies of stingless bees at non-residential areas of south-eastern Karnataka.

Table 5: Stingless bees live colonies recorded on various habitats in south-eastern Karnataka

Sl. No.	Nesting site	District			Season		
		Bangalore Rural	Chikkaballapura	Kolar	R	W	S
1.	Mud wall (RH)	548	1903	1850	1331	1240	1730
2.	Stone wall (RH)	416	804	505	760	458	507
3.	Cement wall (RH)	107	353	257	263	197	257
4.	Temple wall (Cement wall)	86	257	21	114	111	139
5.	Door wood Frame	15	43	9	28	16	23
6.	School building (Cement wall)	-	9	6	6	4	5
7.	House basement	1	43	9	24	12	17
8.	Electric pipe	10	8	14	8	8	16
9.	Windows wood Frame	24	27	40	21	18	52
10.	Electric shed (Stone wall)	0	386	157	170	160	213
11.	Fort wall	24	-	-	10	4	10
12.	Well wall	-	117	15	49	39	44
13.	Rocky area	-	18	-	4	7	7
14.	Tree trunk	-	22	2	10	7	7
15.	Ground surface	1	2	1	-	3	1
16.	Wooden lot	-	3	2	2	-	3
17.	Brick mound	-	-	14	6	-	8
Total		1232	3995	2902	2806	2284	3039
'F' value		0.325**			0.023**		

Note: RH: Residential House; R: Rainy; W: Winter; S: Summer season.

Each value is a mean of three observations.

** Value is not significant.

Nest sites of stingless bees

There are 17 different sites were chosen by stingless bees to nest at different habitats in south-eastern Karnataka (Table 5). Distributions of stingless bee live colonies on different sites at Bangalore rural, Chkkaballapur and Kolar districts are shown in Table 5. Analysis of variance of the data indicated that there was no significant variation (F=0.325; P<0.05) existed between the districts (Table 5). Different

types of nest sites, number of stingless bee live colonies distribution on different nest sites during various seasons at different districts are depicted in Table 5. Similarly, the deserted colonies recorded on various sites at different districts in south-eastern Karnataka are shown in Table 6. During the present study, stingless bee deserted colonies were found on nine sites and it was dissimilar between Bangalore rural, Chikkaballapur and Kolar districts (Table

6). Analysis of variance of the data indicated that there is a considerable statistical difference ($F=2.959$; $P>0.05$) existed between the districts with respect to the occurrence of

deserted colonies of stingless bees during various seasons in south-eastern Karnataka (Table 6).

Table 6: Stingless bee deserted colonies distributed at different sites in south-eastern Karnataka

Sl. No.	Nest site	District			Season		
		Bangalore Rural	Chikkaballapur	Kolar	Rainy	Winter	Summer
1.	Mud wall (RH)	22	37	39	38	37	37
2.	Stone wall (RH)	8	19	10	11	16	10
3.	Cement wall (RH)	-	5	9	7	4	3
4.	Temple wall (Cement wall)	5	12	-	6	6	5
5.	House basement	-	3	1	4	-	-
6.	Windows wooden frame	-	-	2	2	-	-
7.	Electric shed (stone wall)	-	4	8	10	5	7
8.	Well wall inside	-	3	-	2	1	-
9.	Wooden lot	-	1	-	1	-	-
Total		35	94	69	81	55	62
'F' value		2.959*			0.162**		

Note: Each value is a mean of three observations. RH: Residential House.

*Values are significant at 5% level; **Values are not significant.

Discussion

Stingless bees commonly called 'dammar bees' [1] or Musare Jenu' in Karnataka are live in cryptic nests at various types of crevices at residential and non-residential areas. They establish colonies in live and dead trees trunk and man-made structures amidst residential and non-residential areas. Altogether, 8129 stingless bee live colonies were recorded at Bangalore rural, Chikkaballapur and Kolar districts of south-eastern Karnataka. Distribution of stingless bee's colonies was unevenly distributed during different years at these districts. Although these districts are experiencing dry climate in general, few physiographic and environmental factors along with the local vegetation perhaps impacted the uneven distribution of stingless bee population. Similar type of trend prevailed even at residential and non-residential areas at different districts of south-eastern Karnataka. Among the studied districts, Chikkaballapur scored more (3858) live colonies compared to Kolar and Bangalore rural districts in south-eastern Karnataka. Perhaps, good forest coverage (11%) and locally available crops with moderate ecological conditions of Chikkaballapur district might have supported the good population of stingless bees both at residential and non-residential areas. Further, summer season favored more (3039) stingless bee live colonies compared to rainy and winter seasons at residential and non-residential areas. However, 198 deserted colonies were recorded at residential areas in Bangalore rural, Chikkaballapur and Kolar districts during different years and seasons, and indicated that season didn't influenced the desertification of stingless bee colonies in this part of the state. However, other factors which directly or indirectly influence the desertification of stingless bee colonies shouldn't be ignored. Furthermore, deserted colonies recorded in Bangalore rural, Chikkaballapur and Kolar districts indicated no significant variation existed at non-residential areas. Thus, irrespective of the year, there was a considerable variation existed between these districts during different seasons with regard to the occurrence of deserted colonies of stingless bees at non-residential areas of south-eastern Karnataka. Hence, stingless bee's population distributed at various man-made habitats including residential and non-residential areas of Bangalore rural, Chikkaballapur and Kolar districts in south-eastern Karnataka. Many studies [1, 4-27] have reported

the distribution of stingless bee population along with other parameters. Therefore, this type of observations are very essential in recent times, as stingless bees are one of the potential pollinators; pollinate 40 to 90% herbs, shrubs and small to medium sized trees midst human inhabited places, agriculture and forest ecosystems [19] in the wild and are reported improperly. Their valuable pollination is not recorded because of their small size and cryptic nesting behavior, many times unnoticed. Hence, stingless bee's population distribution, potential pollination and propagation services to innumerable plant species which can be made aware by recording the spatial and temporal distribution of their population at different habitats. Of course, locating stingless bee colonies is a difficult task for a layman unless little basic knowledge on these species is essential [1, 3] under different man-made and natural habitat conditions.

Stingless bees are cryptic species prefer to live under crevices or hidden habitats [33]. To nest under cryptic conditions, stingless bees chosen total 17 different sites amidst residential and non-residential areas in south-eastern Karnataka. At residential area, houses built with mud, stone wall and plastered with cement have attracted more for the stingless bees to nest at these districts. Moreover, the temples and school buildings built with cement walls also attracted more for the nesting by stingless bees. Further, the wooden doors, windows frame were chosen for nesting of colonies by stingless bees. The electric pipes, electric devices stored shed built with stone wall, abandoned fort wall, well wall and brick mounds were found suitable to nest by stingless bees. Accordingly these sites were chosen by stingless bees at residential areas in south-eastern Karnataka. However, the rocky areas live and dead tree trunks, wooden lots and undisturbed ground surfaces were selected for nesting by stingless bee population at non-residential areas in south-eastern Karnataka. Perhaps, various human inhabited places might have provided suitable habitat conditions to stingless bees to reside under cryptic places [33, 41] to lead safe survival thereby help improve the local biodiversity [33- 35]. Furthermore, several people are rearing stingless bees [13, 20, 22] to produce medicinally important honey [4-5, 11, 16-17, 21, 28]. By selling the honey, local people could get seasonal income and thereby it could help improve the economic conditions of local

population in rural area. Surprisingly, the hive products have very high demand in national and international markets [27], necessitated to undertake meliponiculture in rural areas where there is a good distribution of stingless bee population both under residential and non-residential areas. Unfortunately, very few people are interested to take up meliponiculture as stingless bees show cryptic nesting behavior, and honey is produced little compared to *Apis* species despite the good source of flora at different habitat conditions. On this line in depth investigations are necessitated further to examine the possibilities to undertake meliponiculture at different districts of south-eastern Karnataka [29, 30, 42]. The honeybees distribution and identification of the species which are useful for beekeeping is need of the day [43]. Critical studies on those aspects are on the way and results of such investigations will be published elsewhere for the benefits to the farmers and to the scientific community. Our observations are on par with the observations of [1, 3-27, 29, 30, 32-33].

Conclusions

Recording the distribution of stingless bees live colonies help undertake meliponiculture to produce medicinally important honey. It would improve the socio-economic conditions of the local farmers/beekeepers and possible to improve local biodiversity midst dry agro-climatic conditions of south-eastern Karnataka. In this regard, our studies are crucial for future investigations to get into the details on prospects of meliponiculture, pollination potential and contribution of stingless bees on local biodiversity in this part of the state.

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Author Agreement

There are no competing interests listed by the authors.

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