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Floral Preference and Flower Constancy of a Brazilian Stingless Bee, *Nannotrigona testaceicornis* Kept in a Greenhouse (Hymenoptera, Apidae)

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温室で飼養したブラジル産ハリナシバチの１種，*Nannotrigona testaceicornis* における花選択性と恒久訪花性

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Flower-visiting behavior of a Brazilian stingless bee, *Nannotrigona testaceicornis* studied experimentally in a greenhouse showed its typical generalist tendency at the colony level, visiting 15 out of 25 species of offered flowers. At the individual level, however, most foragers tended to visit a limited number of flower species continuously, even though other flowering plants were available. Such constancy was maintained for successive trips within a day (almost 80% in all marked bees), but was less among days. Switching was induced by the flower dearth of the so far utilized plants and casual exploitation of new plants by foragers.

INTRODUCTION

According to the previous studies (CORTOPASSI-LAURINO, 1982 ; IMPERATRIZ-FONSECA, et al., 1984 ; RAMALHO, et al., 1985 ; RAMALHO, 1987 ; ROUBIK, 1979, 1989), stingless bees collect pollen from various floral species. Therefore, this group of bees can be called a typical generalist or a polylectic group. RAMALHO (1987) mentioned a strong preference of foragers of the genus *Scaptotrigona* for *Eucaliptus* flowers despite the presence of other available resources near by. In this case, however, the preference may be caused by a constant high availability of *Eucaliptus* flowers through the year.

We studied the flower-visiting behavior of a stingless bee, *Nannotrigona testaceicornis* introduced from Brazil to Japan in 1988 and kept in a greenhouse.

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MATERIALS AND METHODS

Observation was carried out on the campus of Shimane University, Matsue, Southwestern Japan in 1988 with a single queenright colony of *Nannotrigona testaceicornis* consisting of about 2,000 workers. The studied colony of *N. testaceicornis* was successfully reared in the bee room and the greenhouse. The queen laid about 220 eggs/day on the average during the observation period. The colony was reared in a

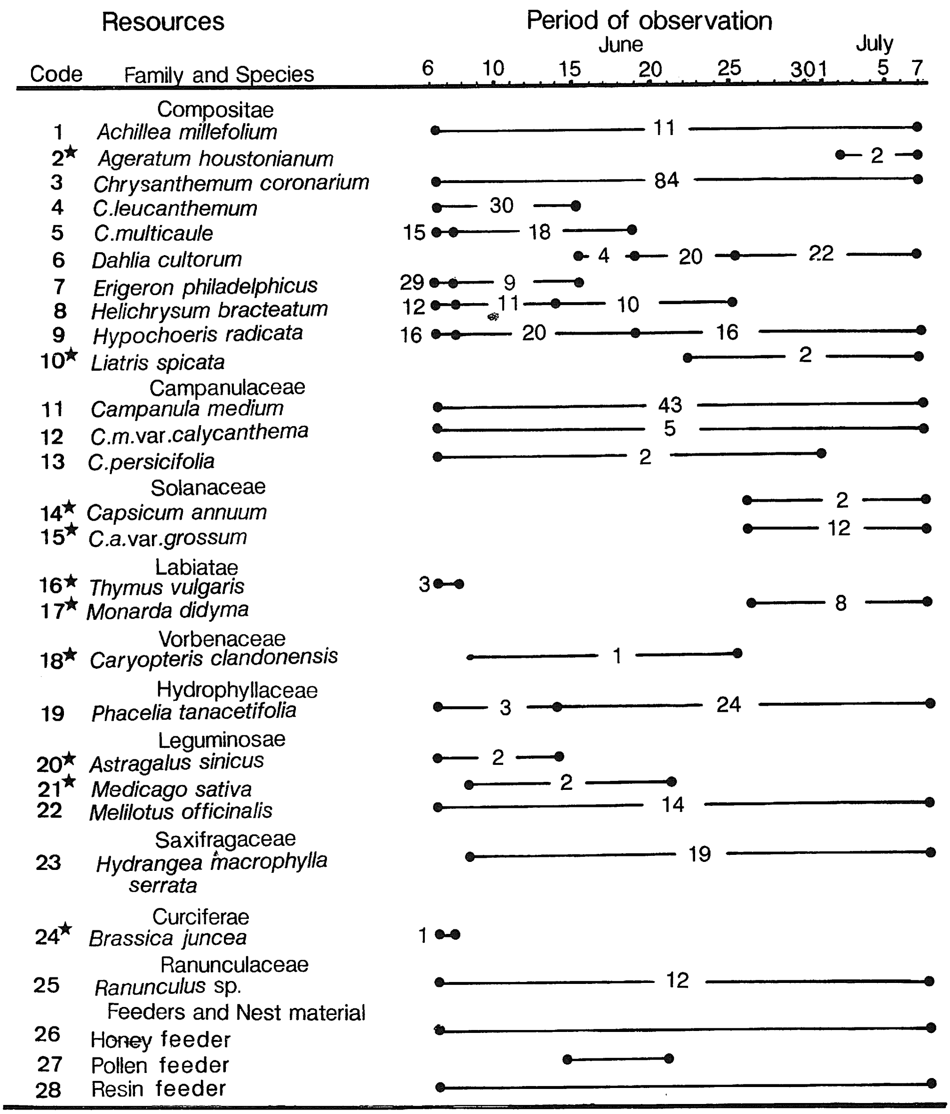

Fig. 1. Floral species and other feeders supplied in the greenhouse during the observation period between June 6 and July 7. Each horizontal bar and avexed figures show the period during which each resource supplied and the number of floral pots supplied, respectively. Asterisked floral species were not visited by marked bees.

flat wooden box with a glass lid. The box was placed in the bee room of which air temperature was kept at 25 - 28 °C. The nest box was communicated with the green-house through a plastic tube. In the vinyl roofed green house, 7.2 m (l) × 7.0 m (w) × 3.1 m (h), a total of 25 kinds of flowering plants, each planted in 1 to 84 pots (Fig. 1) and several dishes with resin (a nesting material) were supplied. Several feeders with pollen and honey also set as supplementary food resources (Fig. 2).

In additon to the colony used for observations, one more colony of *N. testaceicornis* and three colonies of *Plebeia droryana* (from Brazil) and *Trigona minangkabau* (from Indonesia), respectively were liberated together in the same greenhouse.

Ninety foragers of *N. testaceicornis* (Bee nos. 1 - 90) were individually marked on their thoraces with different color lacquer paints on May 31 and June 3 with additonal 12 marked bees (Bee nos. S1 - S12) on June 13. The numbers of marked bees observed at food resources on the first day (June 6), the peak day (June 14) and the last day (July 7) of observations were 9, 48 and 3, respectively (Fig. 4).

The flower-visiting pattern was determined by the daily observation of individual marked bees on flowers and feeders. The kinds of floral species visited by each marked bees were recorded in the morning and at the afternoon daily, for 4 - 5 hours. Unlike solitary bees, foragers of honey bees and stingless bees collect either pollen or nectar in a single trip (Inoue, 1984), but pollen and nectar foragers was not preeicsly distinguished in this study.

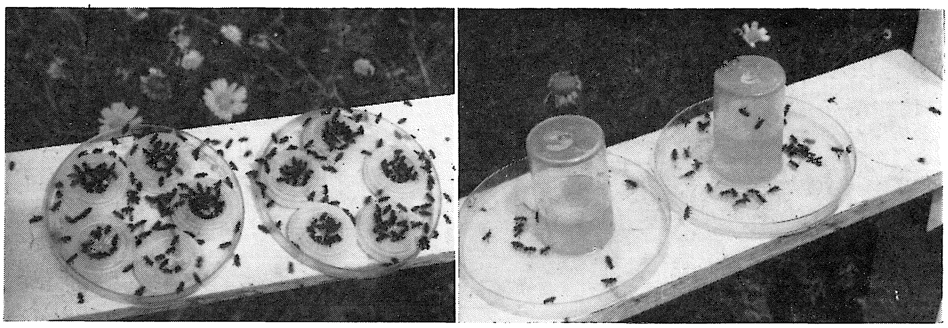

Fig. 2. Pollen feeders (Left) and honey feeders (Right).

RESULTS

1. *Preference of floral species*

Among 25 floral species offered in the greenhouse, foragers of *Nannotrigona testaceicronis* visited only 15 species (Table 1). The other 10 species were not visited probably due to a fewer number of supplied pots (Fig. 1). Foragers collected both pollen and nectar from the above 14 sepcies, except for *Campanula medium*. Foragers could not absorb nectar from this flower due to larger bell-shaped flowers compared with bee tongues.

Mostly preferred species were *Campanula medium* (22.0% in terms of percentage

Table 1. Total frequencies of 41 marked bees observed on various resources.*

Bee code	No. of days observed	Resource code**																		
		1	3	4	5	6	7	8	9	11	12	13	19	22	23	25	26	27	28	Total
61	26	1				2				15	1		8				4	7		38
62	25		1							25	1						1			28
99	23			7									16				1		1	25
S 10	20									13			7			2		4	1	27
95	20									6								2	12	20
11	19	17				1			2								1	1	4	26
S 3	17					2		2	2					10				2		18
93	17	1	1	1		2				4	1	2	8		1			3	6	30
2	16	12								1			1					1	3	18
S 1	15		1			1	1			10	2		2	2				1	1	21
88	13		1			2	1	3									8	2		17
7	12	2				4				8	2					2	1			19
22	12		12																	12
32	11					1			1								8	1	2	13
38	10		1											9						10
83	10		6					1					3				6	1	1	18
3	9		8							1				1						10
60	9		9															4		13
1	8		8					1		1				1				1		12
76	8						1			2		1	1	1				1	1	8
94	8		5		2				1								1	1	2	12
S 12	7	1	1						3											5
85	7																7			7
75	6									1							6			7
17	5									3	1			1			3			8
84	5					1				3		1	1							6
S 8	4								1	2	1	1	2	5						12
12	4									1							3			4
63	4							2						2				1		5
74	4									4										4
96	4																4			4
35	3												2				1			3
68	3																3			3
90	3																		3	3
98	3									1									2	3
S 11	2	1	2					1										1		5
S 2	2							1		2							1			4
25	2																		2	2
S 4	1		1						1	1										3
S 5	1									1										1
S 6	1		1																	1
S 7	1										1							1		2
S 9	1																	1		1
8	1		1							1										2
24	1									1										1
26	1									1							1			2
30	1									1										1
47	1	1																		1
49	1																1			1
61	1																1			1
65	1																1			1
67	1									1										1
78	1																1			1
Total	391	36	59	8	2	16	3	11	11	110	10	5	51	32	1	4	64	36	41	500

* Each marked bee was counted on floral species (1 – 25), feeders (26, 27) and resin dish (28) between June 6 and July 7. If the same individual visited two different floral species through a day, the number of frequencies for this bee was counted as twice.

** Resource codes are shown in Fig. 1.

visits), *Chrysanthemum coronarium* (11.8%), *Phacelia tanacetifolia* (10.2%), *Achillea millefoli* (7.2%) and *Melilotus officinalis* (6.4%). Some bees also frequently collected resin (8.2%), visited the honey feeders (12.8%) and the pollen feeders (7.2%) (Table 1). As we did not measure the amount of nectar and pollen produced by flowers, it is impossible to compare the food availability in these floral species quantitatively. Significant difference was slightly present between the rank of the preference order in floral species and the rank of the number of pots supplied ($0.01<P<0.05$, by SPERMAN's coefficient of rank correlation). This suggested that the quality of flowers was more important factor than the abundance of flowers at the flower choice.

The nubmer of resources utilized by bees increased as a function of the period during which the bees observed on flowers or feeders (Fig. 3). Apparently, bees selected more floral resources according to their longevities, reaching up to 9 in maximum.

Figure 4 shows temporal changes in the number of markd bees observed on 15 floral species and feeders between June 6 and July 7. The total number of foragers observed on each floral species well coincided with the number of marked bees. This trend was clearly shown in those flowers which were mostly preferred by bees, i. e. *Campanula medium*, *Chrysanthemum coronarium* and *Phacelia tanacetifolia*.

2. *Flower constancy*

Figure 5 shows the frequency distribution of the number of floral species visited by individual marked bees in a day between June 6 and July 7, Seventy seven percent of bees visited only one resource in a day. This shows the strong flower constancy for a short period.

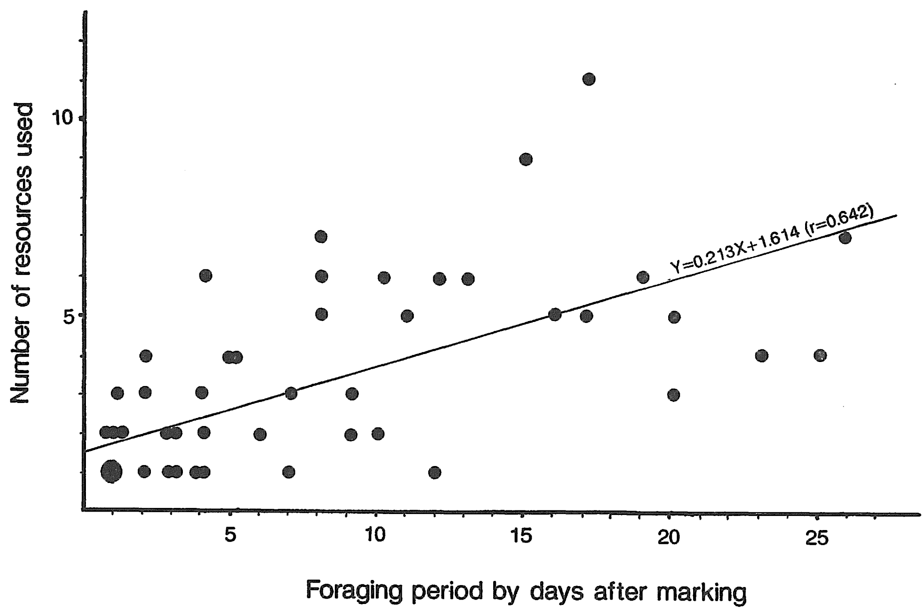

Fig. 3. Relationship between the duration of foraging period by each of marked bees and the number of resources used by them.

In spite of this clear flower constancy in a day, the majority of foragers selected more than one floral species, up to 11, during the observation period (Table 1). Figure 6 shows the daily sequences of resources utilized by 10 marked bees of which the foraging activities were continued over 15 days. Figure 7 shows percentages of visits by 10 markd bees.

The following three types were found in 10 marked bees: (1) Almost only one

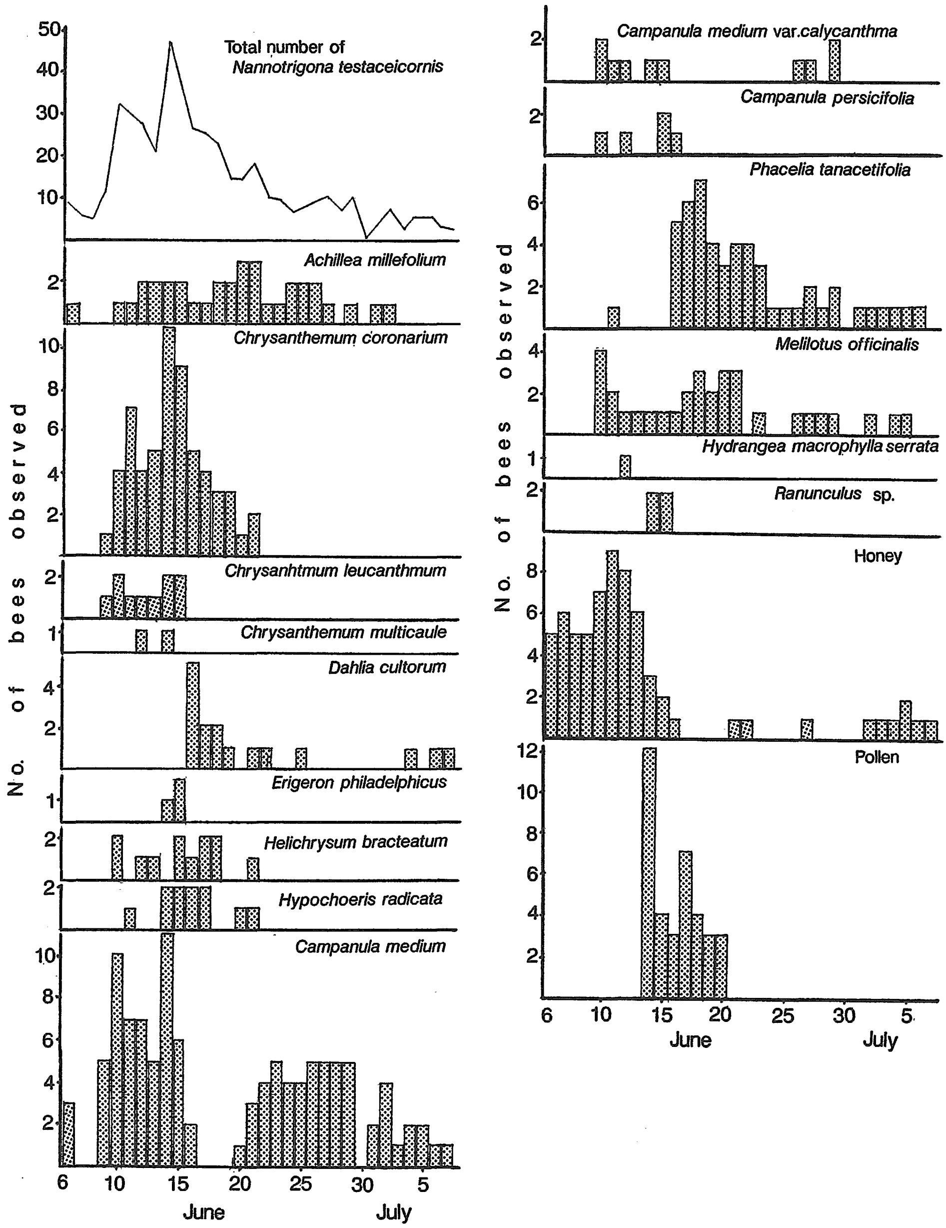

Fig. 4. Temporal changes in the number of marked bees that visited on floral and other artificial resources.

resource was used (No. 62); (2) A major resource occupied nearly or more than half among the total number of resources (Nos. 2, 11, 64, 95, 99, S1, S3, S10); (3) No dominant resource. Any resource occupied less than half (No. 93). Among 10 marked bees, 9 belongs to the types (1) and (2). Among 9 bees with clear flower constancy, the selected floral species were differed depending on individuals.

DISCUSSION

Foragers of the stingless bees, *Nannotrigona testaceicornis* seemed to use a limited number of floral species based mainly on its quality than the abundance. The most preferred species, i. e. *Campanula medium*, *Chrysanthemum coronarium*, *Phacelia tanacetifolia*, *Achillea millefolium* and *Melilotus officinalis* might have been quantitatively attractive for bees. The floral attractiveness may closely relate to the foraging efficiency. As one of floral qualities, the flower structure must be important. The tendency that individul bee visit a limited number of floral species in their life span has been known even in typical polylectic bees, such as *Apis* and *Bombus* (GRANT, 1950; FREE, 1970; MICHENER, 1974), probably induced by learning and communication system in the colony (KERR et al., 1963).

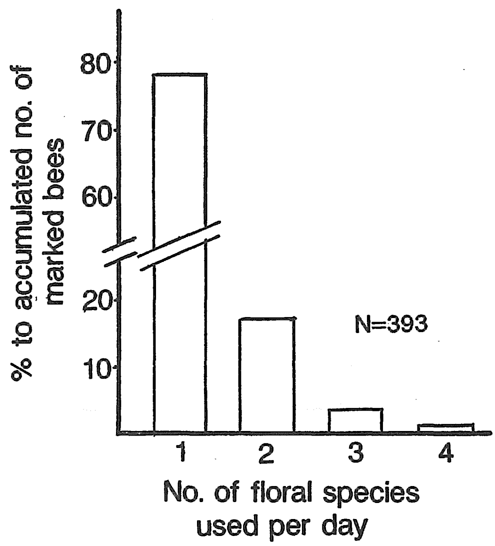

Fig. 5. Frequency distribution of the number of floral species exploited by individual marked bees in a day.

Switching of flowers did not occur so frequent in *N. testaceicornis*, although it is thought to be a generalist type forager. If the flowers which they have been used became senile, preferred floral species must be changed in the greenhouse. Figure 6 predicts that the use of plural resources is arisen by the two following procedures. The first is casual exploitation of new resources, even if the preferred resources are stable (Bee nos. 2, 11, 62, 93, S1, S3, S10). Bees can secure a new favorable resource through this minority process (HEINRICH, 1978, 1979). The second is apparently complete replacement of the resources caused by flower dearth or change of field tasks. In Nos. 64 and 99, they changed to new resources by taking out of formerly used resources, while in no. 95, her tasks were proceeded in the order of resin - pollen - resin.

Some bees carried resin for building and defensive resources (Nos. 2, 11, 93, 95, 99, S1, S10). Among seven bees, Nos. 2, 99 and S10 engaged this task as they aged. Age of these bees after marking was 32 days in No. 2, 32 days in no. 99 and 23 days in no.

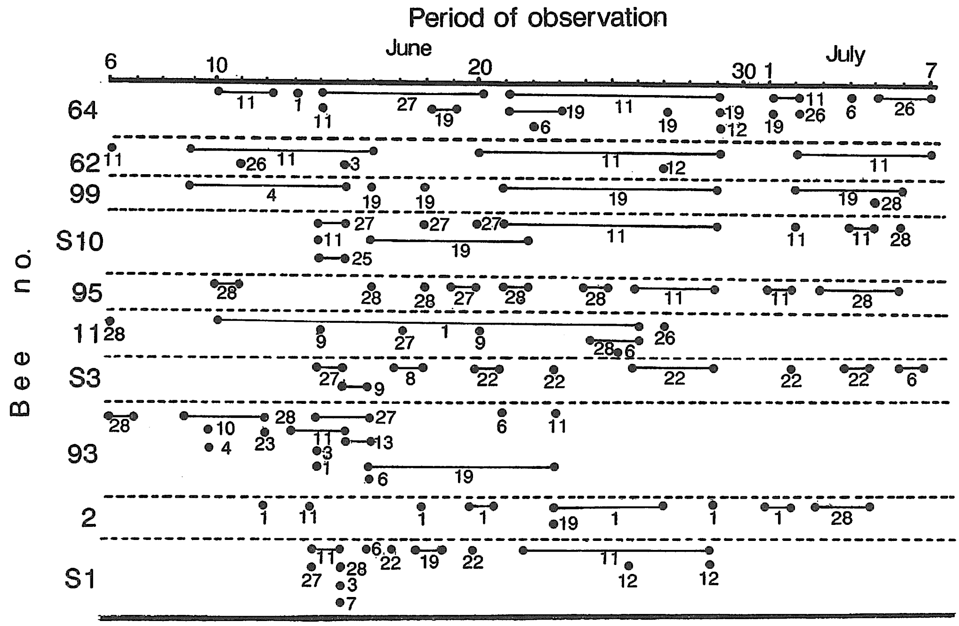

Fig. 6. Kinds of resources used by ten marked bees of which foraging activities continued over 15 days.

S10, while Nos. 93 and S1 foraged resin in the early part of observation and followed by change to food foraging. Nos. 11 and 95 repeated alternatively food foraging and resin collection during her life span. In *N. testaceicornis*, polyethism relating to ages was not yet studied, however, in *Trigona minangkabau*, new foragers generally first collected nectar and later collect pollen and resin, through these tasks were performed intermixingly (Inoue, et al., 1985).

Floral preference of *N. testaceicornis* can be understood by the two traits; generalist at the species level and flower constancy or majoring (definition by Heinrich, 1978) at the individual level as in honey bees. Michener (1974) points out that flower constancy probably promotes the foraging efficiency, because a bee can work more efficiently, if her sense organs and behavior are temporarily "set" for a particular kind of flower from which food is obtainable in a particular way. Another bee may also adopt the same efficient way on different kind of flower. Communication about the abundance and location of flowers was not observed in our observation, which was done by the dance language in the honey bee, *Apis mellifera* and by the trail pheromone in some stingless bees (Michener, 1974).

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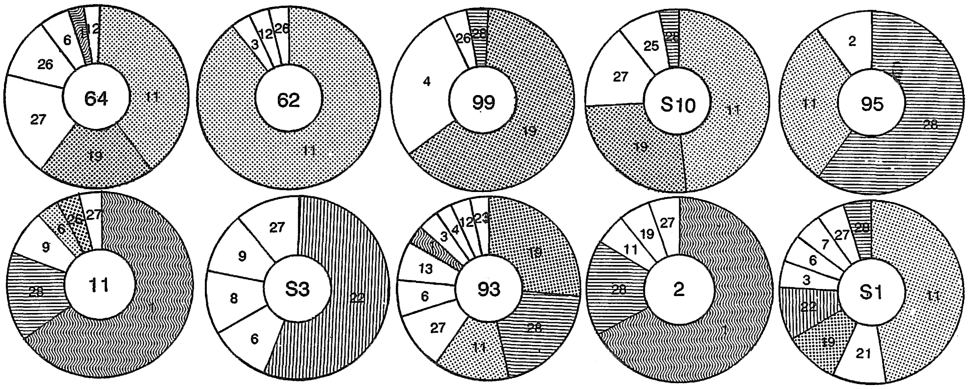

Fig. 7. Percent ratios of resources used by each of ten marked bees of which the individual bee numbers is shown at the center of each circle.

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REFERENCES

CORTOPASSI-LAURINO, M.: Divisào de recursos troficos entre abelhas sociais, principalmente em *Apis mellifera* Linné e *Trigona* (*T.*) *spinipes* FABRICIUS (Hym., Apidae). Ph D Thesis, Institute de Biociências, Univ. São Paulo, 180 pp., 1982.

FREE, J. B.: J. Anim. Ecol., **39**: 395 - 402, 1970.

GRANT, V.: Bot. Rev., **16**: 379 - 398, 1950.

HEINRICH, B.: Ecology, **60**: 245 - 255, 1978.

HEINRICH, B.: Bumblebee economics. Harvard University Press, Cambridge, Massachusetts, 245 pp., 1979.

IMPERATRIZ-FONSECA, V. L., KLEINERT-GIVANNINI, A. and RAMALHO, M.: Bolm. Zool., 8: 115 - 131, 1984.

INOUE, T., SALMAH, S., ABBAS, I. and YUSUF, E.: Res. Popul. Ecol., **27**: 373 - 392, 1985.

KERR, W. E., FERREIRA, A. and de MATTOS, N. S.: J. New York Entomol. Soc. **71**: 80 - 90, 1963.

MICHENER, C. D.: The social behavior of the bees. A comparative study. Belknap Press of Harvard University Press, Cambridge, Massachusetts, 404 pp., 1974.

RAMALHO, M.: Freqüência de uso de recursos florais por *Scaptotrigona* spp. (Apidae, Meliponinae). M. S. c. Thesis, Instituto de Biociências. Universidade de São Paulo, 88 pp., 1987.

RAMALHO, M., IMPERATRIZ-FONSECA, V. L., KLEINERT-GIVANNINI, A. and Cartopassi-Laurino, M.: Apidologie, **16**: 307 - 330, 1985.

ROUBIK, D. W.: Proc. IVth Int. Symp. Pollination, Md. Agric. Exp. Sta., Spec. Misc. Pabl. **1**: 403 - 417., 1978.

ROUBICK, D. W.: Ecology and natural history of tropical bees. Cambridge, University Press, New York, 514 pp. 1989.