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## **EXPLOITATION OF FLORAL RESOURCES BY *PLEBEIA REMOTA* HOLMBERG (*APIDAE*, *MELIPONINAE*)**

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### **SUMMARY**

During 1981, monthly samples of pollen and honey were taken from the food stores of three colonies of *Plebeia remota* Holmberg. The pollen samples contained pollen grains from 64 plant species, belonging to 29 botanic families, and the honey samples contained pollen from 97 species, belonging to 33 families. The most representative families in the samples were Myrtaceae, Palmaeae, Moraceae and Leguminosae.

It was assumed that those species with representation of 10 % or over were the really important food sources. It can thus be seen that the *P. remota* colonies obtained a large part of their food from few floral sources (7 for pollen, and 8 for nectar) situated within a radius of about 100 metres from the place where the colonies were kept. It is worth noting that most of the well represented species in the samples were trees.

The niche size, evenness and resource overlap were also analysed. The low values obtained for niche size ( $H'$ ) and evenness ( $J'$ ) point to the fact that *P. remota* collected significantly large amounts from few sources, but in a very heterogeneous manner from month to month. There was a high overlap (PS) between the colonies as a result of intense gathering from few sources throughout 1981.

### **INTRODUCTION**

At a certain moment, the possible area for a bee colony's action covers a given diversity and amount of potential resources. The utilization of these resources by bees may be limited by abiotic and by species interaction. Many authors on stingless bees use pollen analysis as a means to identify the food sources preferred by certain species (ABSY & KERR, 1977 ; IWAMA & MELHEM, 1979 ; ABSY *et al.*, 1980 ; ENGEL & DINGEMANS-BAKELS, 1980 ; SOMMEIJER *et al.*, 1983 ; KERR *et al.*, 1984 ; IMPERATRIZ-FONSECA *et al.*, 1984). These studies focus on the botanical aspect, without dealing with problems which concern the trophic niches of such species.

Recent research, however, has paid more attention to trophic niches. CORTOPASSI-LAURINO (1982) compiled data on *Apis mellifera* Linné and *Trigona spinipes* Fabricius. MOUGA (1984) and KLEINERT-GIOVANNINI (1984) deal more broadly with the trophic niches of *Paratrigona subnuda* Moure and *Melipona marginata marginata* Lepeletier respectively, highlighting aspects of competition between colonies and the interaction of these species with the other bees in our area of study.

Within this context, the variations in the size of the trophic niche of a colony of stingless bees reflect immediate responses to conditions governing foraging, which may be more or less favourable depending on each species' ability to adjust to local conditions.

This paper deals with a study of visits to flowers by *Plebeia remota* Holmberg during 1981, based on pollen analysis of samples taken from the food stored in the colonies' pots. These data were used to calculate monthly values for the trophic niche size for each colony and overlap among colonies. The results were compared with those hitherto obtained on the São Paulo University campus for other bee species.

## MATERIAL AND METHODS

Monthly samples of pollen and honey were taken from three colonies of *Plebeia remota* Holmberg. The colonies were kept in rational hives (NOGUEIRA-NETO, 1970) in the Bee Laboratory of the General Ecology Department, Bioscience Institute, University of São Paulo (USP). The University campus is located in the urban region of São Paulo city, at longitude 46° 43' West and latitude 23° 33' South (JOLY, 1950), and at an altitude of 753-765 metres.

The gardens of the Bioscience Institute have diversified native and foreign species of flowers. Among the Angiospermae which have been introduced from abroad, *Eucalyptus* spp, *Tipuana speciosa* Benth. and *Spathodea campanulata* P. Beauv. are abundant. The area also contains a small semi-deciduous forest of native species, covering approximately 10 hectares.

The monthly samples were acetolyzed: the pollen samples were treated by ERDTMAN'S method (1960) and the honey according to LOUVEAUX *et al.* (1970), modified by IWAMA & MELHEM (1979). Three slides per sample were prepared. The pollen grains were identified in most cases by means of their reference slide collection housed in the Bioscience Institute's Bee Laboratory at USP.

Following VERGERON'S recommendation (1964), 1 000 pollen grains were counted in each sample and percentage values were established for them. These data were used to calculate the following parameters for evaluating trophic niches:

### 1) Size of niche

The size of the monthly trophic niche ( $H'$ ) of each colony was estimated using SHANNON-WEAVER'S diversity index (1949):

$$H' = - \sum_{i=1}^n p_i \ln p_i$$

where:  $p_i$  = the pollen proportions of the  $i$  plant species visited in the month in question.

2) Evenness

According to PIELOU (1977), evenness ( $J'$ ) refers to the following ratio :

$$J' = \frac{H'}{H' \text{ max.}}$$

where :  $H'$  max. = the natural logarithm of the total number of plant species found in the samples for the month in question.

Values for evenness may vary from 0 to 1, i.e. heterogeneous utilization of resources to homogeneous use.

3) Niche overlap

The overlap in food gathering by the colonies was analyzed using SCHOENER'S index (1968), which is based on percentage of similarity :

$$PS = 1 - \frac{1}{2} \sum_h^n |ph_i - ph_j|$$

where :  $ph_i$  = the pollen proportion of the  $h$  plant species present in the samples of colony  $i$  for the month in question ;

and  $ph_j$  = idem, for colony  $j$ .

Values for overlap may vary from 0 to 1, i.e. from no overlap to complete overlap of the resources utilized.

The values for niche size, evenness and percentage of similarity obtained for the different colonies wer correlated using the SPEARMAN coefficient of ordinal correlation.

RESULTS

The three colonies of *Plebeia remota* analyzed visited a total of 101 plant species belonging to 34 plant families. Pollen grains from 64 plant species were found in the pollen samples, belonging to 29 plant families, and from 97 species in the honey samples, belonging to 33 families.

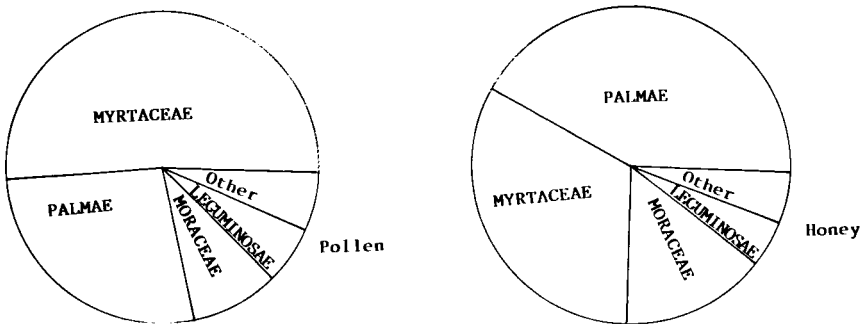


FIG. 1. — Pie diagram of the most represented families in *Plebeia remota* samples (in number of species)

TABL. 1. — Species with frequency higher than 1 %

Family	Species	Pollen	Honey	Months
AMARANTHACEAE	<i>Gomphrena</i> type		+	Sep.
ANACARDIACEAE	<i>Lythraea molleoides</i>	+		Oct.
	<i>Schinus terebinthifolius</i>	+		Jan.
BALSAMINACEAE	<i>Impatiens balsamina</i>	+		Nov. Dec.
COMPOSITAE	<i>Mikania hirsutissima</i>		+	Aug. Sep.
CRASSULACEAE	<i>Kalanchoe tubiflora</i>	+		May.
ELAEOCARPACEAE	<i>Muntingia calabura</i>	+	+	Jan. Feb. Sep. Oct. Nov. Dec.
EUPHORBIACEAE	<i>Acalypha wilkesiana</i>		+	Mar.
	<i>Alchornea sidaefolia</i> (*)		+	Nov. Dec.
	Undetermined		+	Dec.
LEGUMINOSAE	<i>Acacia podalyriaefolia</i>		+	Jul.
	<i>Caesalpinia bonducella</i>		+	Apr.
	<i>Leucaena glauca</i>	+	+	Jan. Feb. Oct. Nov. Dec.
	<i>Mimosa daleoides</i>	+	+	Jan. Feb. Mar. Aug. Sep. Oct. Dec.
	<i>Mimosa velloziana</i>	+	+	Feb.
	<i>Piptadenia</i> sp	+	+	Jan. Feb. Oct. Nov. Dec.
	<i>Tipuana speciosa</i>		+	Dec.

LILIACEAE	<i>Asparagus</i> s.l.	+	+	Sep. Oct. Nov. Dec.
LORANTHACEAE	<i>Struthanthus</i> sp	+	+	Nov.
	Undetermined	+	+	Aug. Sep. Oct. Nov.
MALPIGHIACEAE	<i>Byrsonima intermedia</i>	+	+	Nov.
MELASTOMATAACEAE	<i>Miconia</i> sp	+	+	Janv.
MELIACEAE	<i>Cabralea</i> s.l. (*)	+	+	Oct. Nov.
MORACEAE	<i>Cecropia</i> sp	+	+	Jan. Feb. Mar. Aug. Oct. Nov. Dec.
	<i>Morus nigra</i>	+	+	Aug. Sep. Oct.
	<i>Sorocea ilicifolia</i> (*)	+	+	Sep.
MYRTACEAE	<i>Eucalyptus</i> spp	+	+	Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep Nov. Dec.
	<i>Psidium</i> s.l.	+	+	Nov. Dec.
PALMAE	<i>Archontophoenix</i> sp	+	+	Jan. Feb. Mar. Apr. May Jun. Jul. Aug. Sep. Oct. Nov. Dec.
	Undetermined	+	+	Jan.
RHAMNACEAE	<i>Hovenia dulcis</i>	+	+	Nov. Dec.
ROSACEAE	<i>Eriobotrya japonica</i>	+	+	Mar.
SAPINDACEAE	<i>Serjania</i> type (*)	+	+	Oct.
SOLANACEAE	<i>Solanum</i> sp	+	+	Mar.
ULMACEAE	<i>Trema micrantha</i>	+	+	Sept. Oct.
Undetermined	5 spp	+	+	May Jun. Aug. Oct. Nov. Dec.

(\*) Taxa that occur only as woody plants.

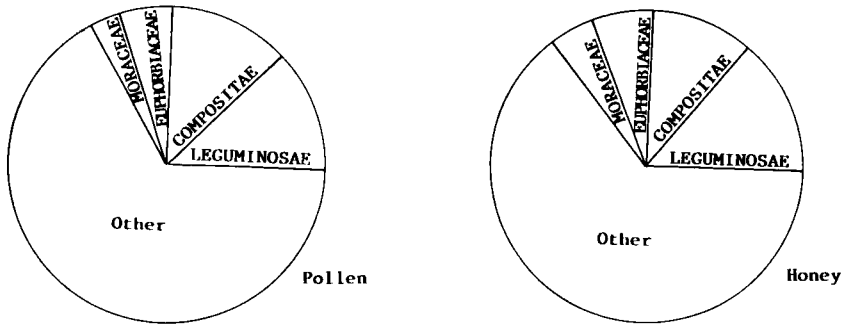


FIG. 2. — Pie diagram of the most represented families in *Plebeia remota* samples (in frequency)

Figure 1 shows the plant species which appeared most in terms of numbers of species in the pollen and honey samples. Figure 2 shows the families with the largest percentage representation in both types of sample. It can be seen that the Leguminosae family, found in pollen and honey alike with a higher number of specific representatives, had a secondary percentage share in the samples.

The two most important families for pollen collection were Myrtaceae and Palmae, with the position inverted for nectar. Moraceae and Leguminosae took third and fourth place in both types of sample.

Table 1 shows the list of plant species which appeared at a percentage of over 1% in the samples. Altogether, 40 species were present with this representation, belonging to 21 plant families, but five of these species were not identified even in terms of the family. In the pollen samples 22 species were found, belonging to 13 families, while in the honey samples the figure rose to 33 species belonging to 16 families.

Figures 3 to 8 show the plant species present at a percentage of over 10% in the pollen and honey samples from the three colonies of *Plebeia remota*. Only in two colonies, B and C (Figs. 7 and 8), was it possible to obtain honey samples all year round.

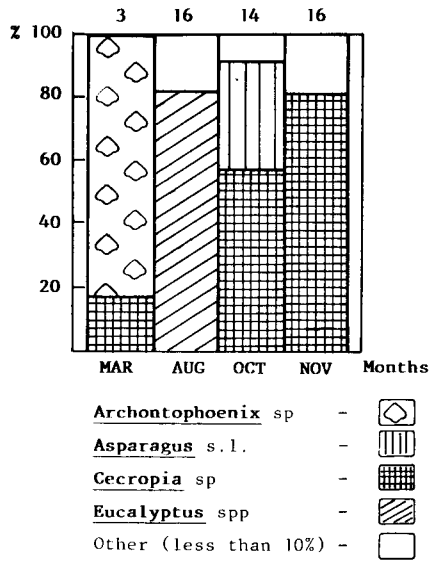


FIG. 3. — Relative frequency of pollen types with percentage higher than 10% - pollen samples - colony A

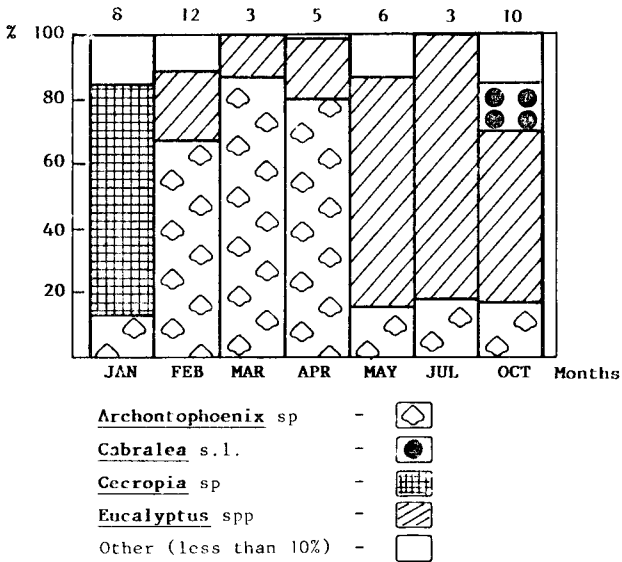


FIG. 4. — Relative frequency of pollen types with percentage higher than 10% - pollen samples - colony B



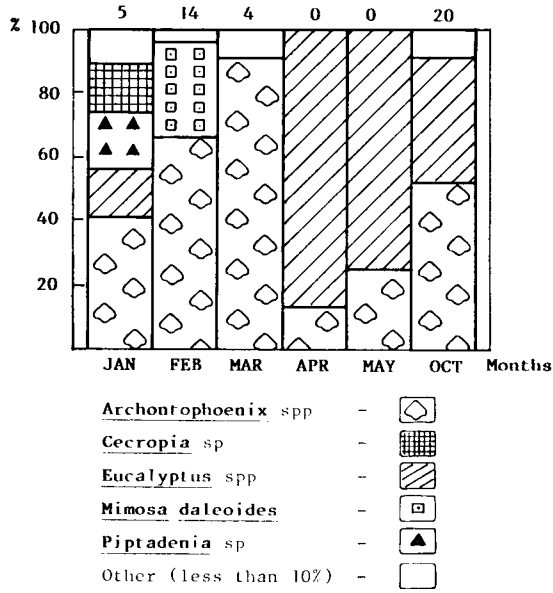


FIG. 5. — Relative frequency of pollen types with percentage higher than 10% - pollen samples - colony C

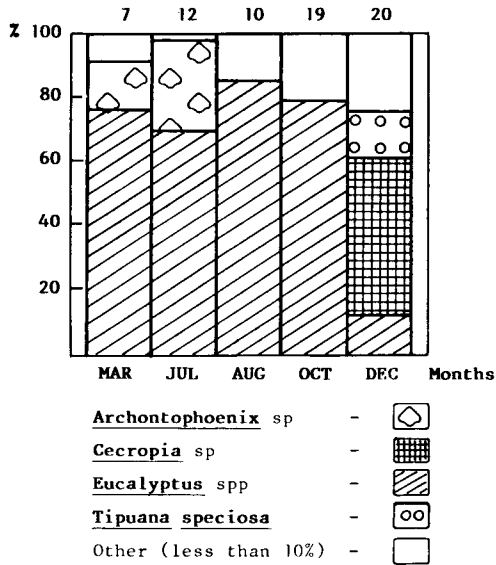


FIG. 6. — Relative frequency of pollen types with percentage higher than 10% - honey samples - colony A

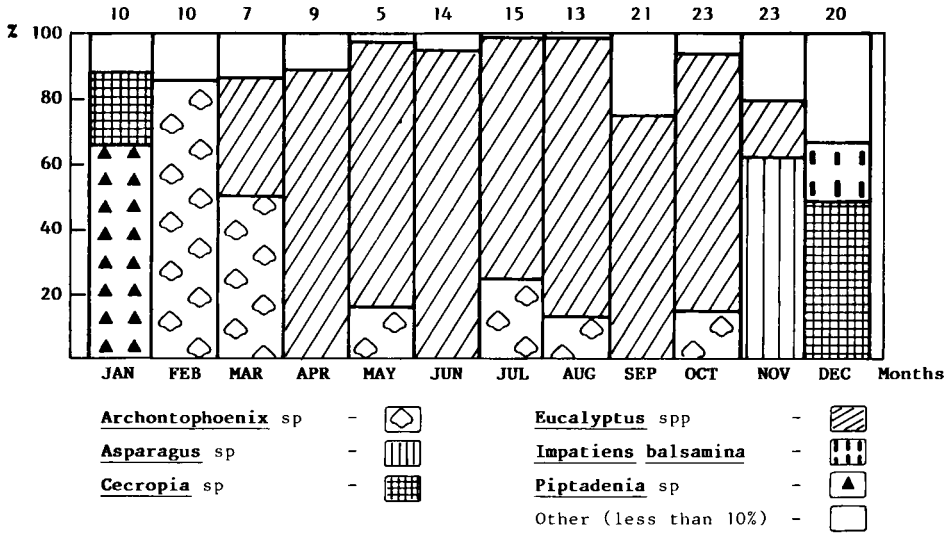


FIG. 7. — Relative frequency of pollen types with percentage higher than 10% - honey samples - colony B

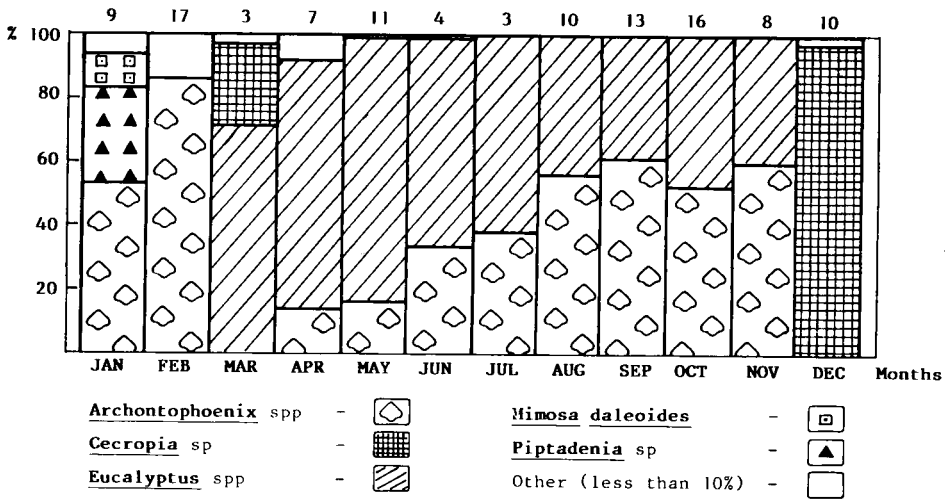







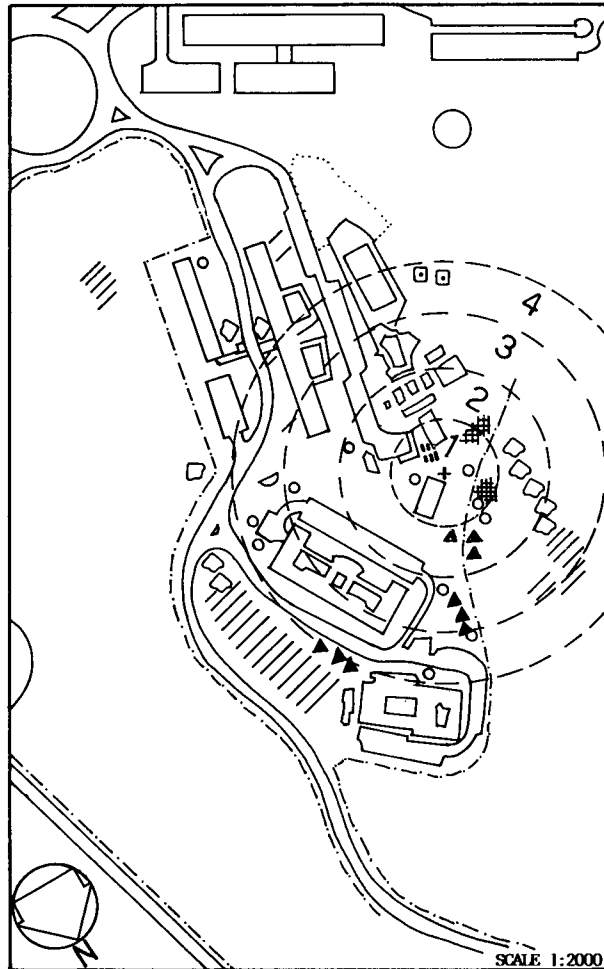


FIG. 8. — Relative frequency of pollen types with percentage higher than 10% - honey samples - colony C

		APPROX. NO. OF INDIV.			
		until	area 3	area 4	
<u>Archontophoenix</u> sp	-		> 50	> 10	tree
<u>Cecropia</u> sp	-		08	00	tree
<u>Eucalyptus</u> spp *	-		> 10	> 10	tree
<u>Impatiens balsamina</u>	-		>100	undet.	herb.
<u>Mimosa daleoides</u> **	-		-	> 50	herb.
<u>Piptadenia</u> sp	-		13	05	tree
<u>Tipuana speciosa</u>	-		21	10	tree



\* There are over than 50 individuals in the wood, beyond area 4.

\*\* There were few rare individuals in the other areas.

It was assumed that those species with representation of 10 % or over were the really important food sources (RAMALHO & KLEINERT-GIOVANNINI, unpubl.). *Plebeia remota* colonies obtained a large part of their food from few floral sources (7 for pollen, and 8 for nectar), mainly trees, situated within a radius of about 100 metres from the place where the colonies were kept (Fig. 9).

The quantitative similarity in the pollen spectrum of the colonies over 9 months was due mainly to foraging from *Eucalyptus* spp, *Archontophoenix* sp, and *Cecropia* sp.

As regards the remaining resources with a high pollen representativity in samples from *Plebeia remota*, though they were less frequent they can be grouped as follows :

(1) near the colonies :

— flowering for a medium period (4 to 6 months) : *Piptadenia* sp and *Tipuana speciosa* Benth ;

— flowering for a long period (more than 6 months) : *Impatiens balsamina* L. (12 months) ;

(2) at a large distance :

— flowering for short periods (maximum 3 months) : *Cabralea* s.l. ;

— flowering for medium periods : *Mimosa daleoides* Benth. ;

(3) indefinite location, with short sporadic flowering : *Asparagus* s.l.

Figures 10-13 show the values for niche size and evenness. The low values obtained point to the fact that *P. remota* collected mainly from few sources, but in a very heterogeneous manner from month to month.

If the data for the pollen spectrum are compared with those for niche size, it can be seen that, in some cases, they increased as collecting from *Eucalyptus* spp and *Archontophoenix* sp diminished. The highest values for  $H'$  were found in January and October for pollen, and in January and December for honey, with the appearance of other food items with percentage higher than 10 %.

Correlations of  $H'$  and  $J'$  were only significant for pollen samples from colony A and honey samples from colonies B and C (Table 2). Few resources are well exploited, and the proportionality with which they appear in the samples determines similar fluctuations in these rates.

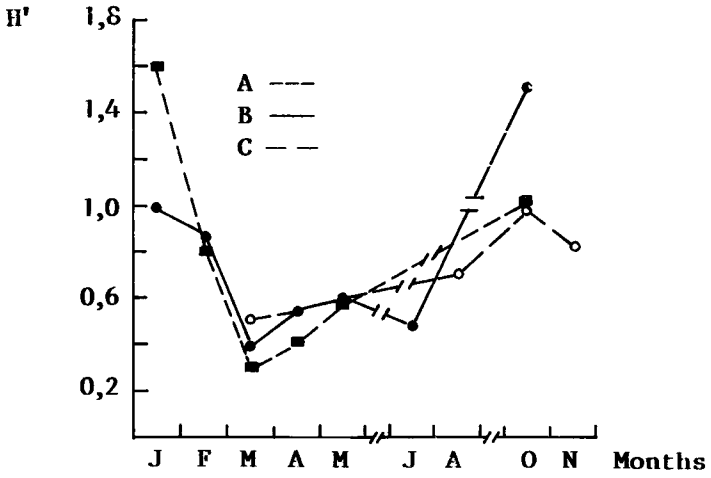


FIG. 10. — Niche size ( $H'$ ) - pollen samples

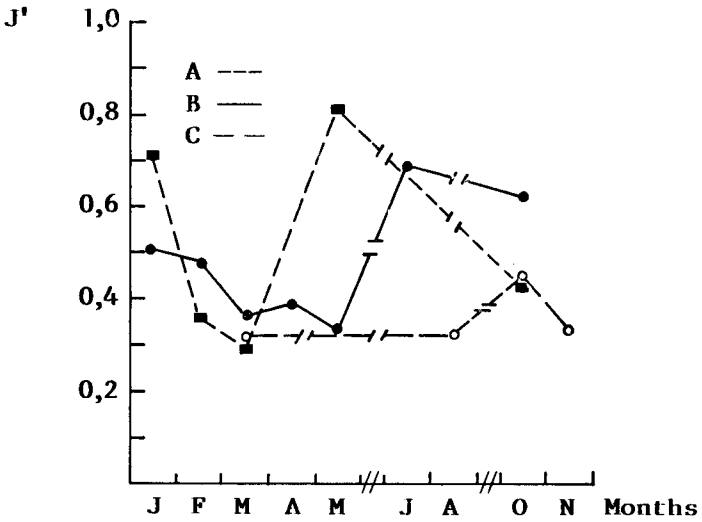


FIG. 11. — Evenness ( $J'$ ) - pollen samples

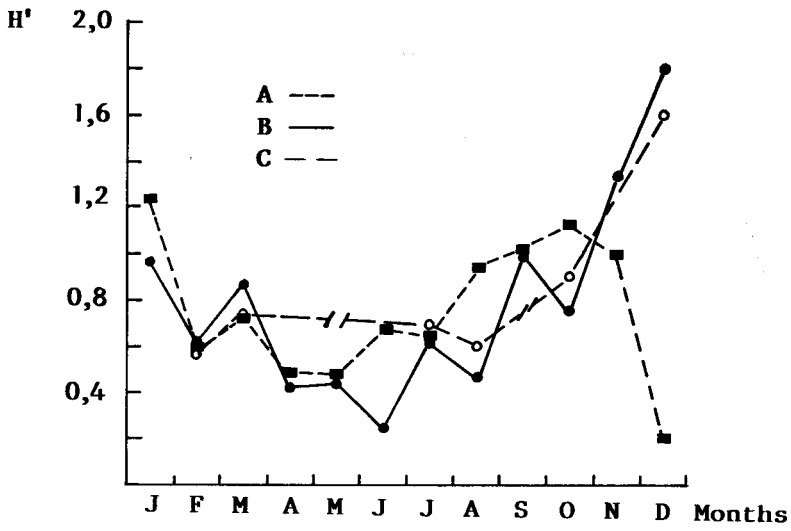


FIG. 12. — Niche size ( $H'$ ) - honey samples

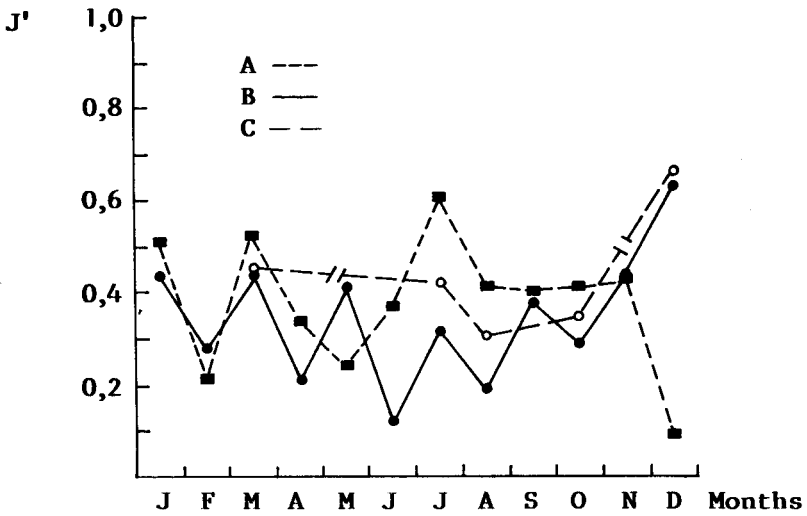


FIG. 13. — Evenness ( $J'$ ) - honey samples

TABLE 2. — Spearman ordinal correlation coefficient (rs)

Colonies	$H' \times J'$						$H' \times PS$						
	A		B		C		AB		AC		BC		
	rs	sl	rs	sl	rs	sl	rs	sl	rs	sl	rs	sl	
A	P	1.00	= 0.05	—	—	—	—	—	—	—	—	—	
	h	0.70	> 0.05	—	—	—	—0.70	> 0.05	0.5	> 0.5	—	—	
B	P	—	—	0.32	> 0.05	—	—	—	—	—	—	—0.37	> 0.05
	h	—	—	0.81	< 0.05	—	—	—0.90	= 0.05	—	—	—0.75	< 0.05
C	P	—	—	—	—	0.37	> 0.05	—	—	—	—	—0.43	> 0.05
	h	—	—	—	—	0.62	< 0.05	—	—	—0.56	> 0.05	—0.66	< 0.05

P = pollen

h = honey

sl = significance level

Figures 14 and 15 show the values obtained when calculating resource overlap. It can be seen that there was a high overlap between the colonies as a result of intense gathering from few sources throughout 1981.

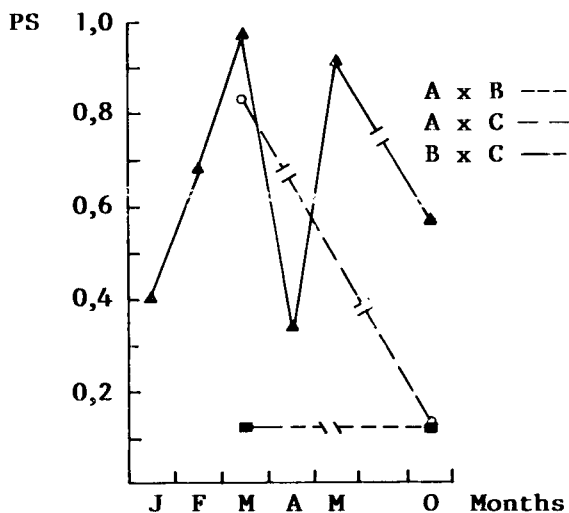


FIG. 14. — Resource overlap (PS) between colonies - pollen samples

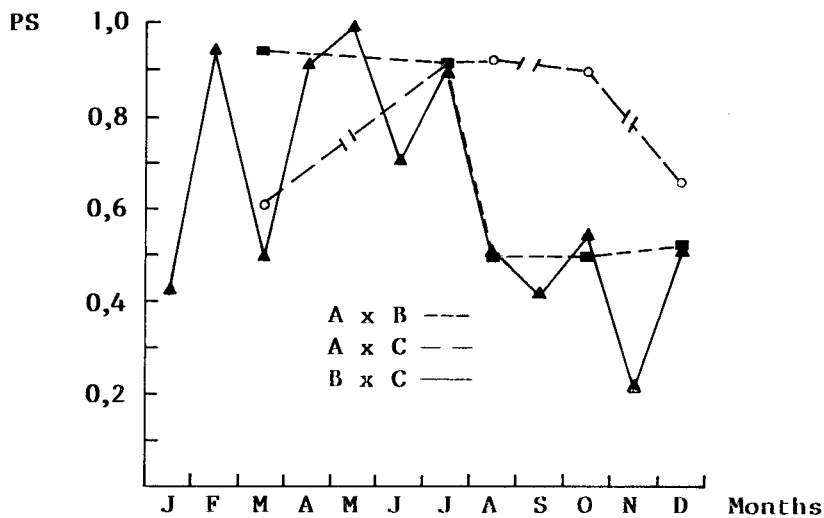


FIG. 15. — Resource overlap (PS) between colonies - honey samples



The negative correlation between values of  $H'$  and of PS honey samples from colonies AxB and BxC (Table 2) shows that as the size of the trophic niche diminished the colonies became more similar in foraging terms, i.e. the foraging gradually converged onto a few common sources, which may have been more productive for fairly long periods.

## DISCUSSION

Preliminary studies performed on the same site in September and October 1980 showed that *P. remota* occupied an intermediate position on the scale of polylecty covering 10 species of the Apidae family (IMPERATRIZ-FONSECA, pers. inf.). The total number of species (101) and families (34) found represent 53 % and 49 % respectively of the taxa known to be visited by bees in the gardens of the Bioscience Institute (FUKUSIMA-HEIN, pers. inf.). Some species, however, and possibly the respective families, are not part of this list, especially some representatives of the native forest vegetation (*Alchornea sidaefolia* Bail., *Sorocea ilicifolia* Miq., *Cabralea* s.l. — Meliceae, of the *Serjania* type — Sapindaceae, *Trema micrantha* Blume - Ulmaceae).

The analyses frequently found many pollen types with a very low level of representation. This observation had already been confirmed for *Apis mellifera* Linné and *Trigona spinipes* Fabricius (CORTOPASSI-LAURINO, 1982), *T. (Tetragonisca) angustula angustula* Latreille (IMPERATRIZ-FONSECA *et al.*, 1984), *Melipona marginata* Lepelletier (KLEINERT-GIOVANNINI, 1984), *Paratrigona subnuda* Moure (MOUGA, 1984) and *Melipona quadrifasciata* Lepelletier (GUIBU, pers. inf.) in pollen analyses performed over a one-year period at the same site.

The families Compositae and Leguminosae have the largest numbers of species visited by eusocial bees — 12 % and 11 % respectively of all the taxa observed in the above mentioned gardens (FUKUSIMA-HEIN, pers. inf.). Except for some species of Leguminosae, however, they are scarce sources owing to the small number of exemplars and to their life cycles and habits. Some representatives of Compositae in particular are annual invaders or ruderals which appear scattered around the gardens or on the edge of the forest for short periods of time.

With the exception of some cases of contamination by airborne transport of pollen grains, which is especially probable among Compositae and Leguminosae (MELHEM & MAKINO, 1978), it was considered that many species and even families were potential sources in the area but with limited availability or attractiveness. However, visits to these flowers reflect the degree of dispersion of the individual members of colonies and will determine the degree of polylecty of the species.

SOMMEIJER *et al.* (1983) recognize the possibility that foraging diversity may be related to the population of a colony, rather than the size of the bees. This conclusion was reached after evaluating the sources exploited by 4 species of stingless bees and *Apis mellifera*.

A similar relation was observed between the Apidae studied on the campus of the University of São Paulo (*Apis mellifera* and 9 species of stingless bees) (IMPERATRIZ-FONSECA, pers. inf.). The highest values for foraging diversity were found for *Apis mellifera*, *Trigona spinipes* and *T. (Tetragonisca) angustula*, with nests containing from 5 000 to 100 000 individuals. At the opposite extreme were two species of *Melipona*, with colonies of 500 individuals on average.

Although *P. remota* nests were not highly populated (with about 2 500 individuals), there seems to have been considerable dispersion of individuals over the area, but many foragers visited the same sources.

Other factors must be considered in addition to the colony's population : diversity and distribution of local resources, and the existence of an abundance of attractive sources ; efficiency of the communication system, individuals' capacity of orientation and foraging strategies ; foragers' susceptibility to abiotic factors.

The distribution of resources in relation to a colony may facilitate their location and exploitation even when they are not highly attractive, whereas the identification of highly productive sources is likely to mask the species' degree of polylecty for fairly long periods.

Visits to *Impatiens balsamina* L. and *Tipuana speciosa* Benth. were made easier by their proximity to the colonies, although they were apparently unattractive to the foragers, since availability was greater than demand.

*Eucalyptus* spp and *Archontophoenix* sp are very attractive sources for bees and supply plenty of pollen and honey (FUKUSIMA-HEIN, pers. inf.). The large numbers of long-lasting flowers in the crowns of *Eucalyptus* spp and the abundance of species of this genus in the area may mean that this resource can be used by many social bees with different needs and foraging strategies.

The flowers borne by *Archontophoenix* sp, on the other hand, reach their maximum concentration in inflorescences located close to the stipe, covering an area of about 1 square metre. In this case, the pronounced floral discontinuity between crowns, the large number of exemplars and the asynchronous flowering are factors which provide the condition for visiting bees to be spatially segregated.

The bees studied on this site visited *Eucalyptus* spp intensily for a number of months of 1981, especially *Apis mellifera*, *T. spinipes* (CORTOPASSI-LAURINO, 1982), *Melipona marginata* (KLEINERT-GIOVANNINI, 1984), *T. angustula* (IMPERATRIZ-FONSECA *et al.*, 1984), and in 1979-1980 *P. subnuda* (MOUGA,

1984). *Archontophoenix* sp was present at levels of over 10 % in samples from *T. spinipes* for January-May, 1981.

During the long period when bees were collecting from *Eucalyptus* spp and *Archontophoenix* sp, there were occasions when the number of pollen types found in samples was seen to fall sharply, as the intensity of visits to these sources increased. However, there were variations in the pollen diversity among samples even when the monthly representativity of the main resources was close to 100 %.

The situation was somewhat similar for *Cecropia* sp, with very compact inflorescences but which are more spread out under the crowns, although they occupy about 0.5 sq. m. altogether. Pollen from *Cecropia* sp appeared in samples from *Apis mellifera* in January (CORTOPASSI-LAURINO, 1982) and from *T. angustula* in various months, also at levels of over 10 %.

It was therefore concluded that plentiful productive sources limited visits to other resources, while a diversity of flowering plants, associated to the dispersion of foragers over the area, determined the very small number of sources visited by *P. remota*.

Among Leguminosae, *Piptadenia* sp and *Mimosa daleoides* were visited for pollen and nectar. These species belong to the sub-family Mimosoideae, good pollen producer (ROS, 1952). The same is not true for *Tipuana speciosa* which provides little pollen, since, as occurs with other representatives of the sub-family Faboideae, the petals tend to prevent bees from getting close to the anthers (ROS, *op. cit.*). It is worth stressing that *Apis mellifera* obtained over 50 % of its pollen diet from *T. speciosa* in October 1980 (CORTOPASSI-LAURINO, 1982). *Mimosa daleoides* and *Piptadenia* sp were highly exploited by *T. angustula* in the summer months of 1980-1981 (IMPERATRIZ-FONSECA *et al.*, 1984).

Foraging from *Mimosa daleoides* and *Cabralea* s.l. (Meliaceae) at large distances may also be the result of a lack of sources close to nests. In this case, the extension of the scope of action and orientation capacity would become limiting factors, while the attractiveness of the source and the absence of competitors would determine the foraging strategy.

*Cabralea* s.l. and *Impatiens balsamina* were hardly visited at all by other species of Meliponinae and *Apis mellifera* studied in the area during this period (IMPERATRIZ-FONSECA, *pers. inf.*).

Sources with 1 %-10 % pollen representation can be considered potential or secondary resources with little attractiveness. They may possibly serve as a complement to the food requirements of the colony and become important for the maintenance of its equilibrium for limited periods when the supply of resources is subjects to seasonal variations.

The primitive communication systems and the low orientation capacity of species of the genus *Plebeia*, in addition to the size of the individuals, impose maximum limits on the distance from exploitable sources of food. LINDAUER & KERR (1960) and KERR & ESCH (1965) found that *Plebeia* spp foragers basically utilized the perfume of the flowers to regiment recruits and thus did not give information on the position and distance of sources. Some meliponines mark out routes using pheromones; various species of *Trigona* also travel *en masse* to a source, while *Melipona* uses sound and has scouts accompanying the start of a flight (LINDAUER & KERR, *op. cit.*).

OLIVEIRA (1973) observed that foragers of *P. saiqui* and *P. droryana* were unable to return to the nest when released at distances of 100 to 200 metres. In the case of *P. remota* the colony's scope of action would seem to extend up to about 100 metres. However, visits to some native forest species, although inexpressive in quantitative terms, show that the attractiveness of some blooms determines an extension of the foragers' range. This probably does not occur when productive resources are available without competition closer to the nests, which is all the more frequent when the colony's energy needs are low. If visits to a limited number of sources overlap, however, the pressure of the local bee community on each population may determine a move to more distant sites for foraging.

SCHEMSKE (1983) recognizes that if it were possible to generalize observations that the flying distance of pollenizers is inversely correlated with the quality of the reward from a previously visited flower, the increased quality of the resource would lead to a fall in the average flying distance of the pollenizer in individual terms, but might attract other taxa of pollenizers with greater food requirements. In this context, the speed with which species locate new sources may be a major factor in spatial segregation and in resource sharing (JOHNSON & HUBBELL, 1974). This would seem to be a pronounced feature of less aggressive and non-monopolistic species, such as those belonging to the genus *Plebeia*.

According to IMPERATRIZ-FONSECA *et al.*, (1985), colonies of *P. remota* limit their flying considerably when temperatures fall below 20 °C, and do not leave the nest at all to forage at under 16 °C. *P. remota*'s sensitivity to temperature means that visits to flowers are more intense during the hotter hours of the days, which may reduce the foragers' chances of finding unvisited flowers for collecting.

Considering that bees of the genus *Plebeia* are timid and unaggressive, showing evasive-opportunistic foraging behaviour in the presence of other species (JOHNSON & HUBBELL, 1974), the search for unvisited floral sites must be a relevant condition for exploitation of resources by *P. remota*. JOHNSON & HUBBELL (1974, 1975) and HUBBELL & JOHNSON (1978) observed spatial segregation of

floral foraging sites among stingless bees at the same source. The aggressive monopolistic species kept to the sites with high floral densities.

ROUBIK (1978) also found that *Apis mellifera* obliged stingless bees to abandon flowers, and concluded that leaving or persisting with a source at higher cost could influence individuals to be disposed to look for other activities. A similar interaction was observed by C.F. MARTINS (pers. inf.), studying monocultures, where foragers of *A. mellifera* collected from the sites with higher floral density, while *T. spinipes* looked for more isolated plants or plants with lower floral density.

In the area under study here, *A. mellifera*, *T. spinipes* and *T. angustula*, with many natural nests, stand out as potential competitors of *P. remota*. Thus, extension of the foraging area by *P. remota* may be advantageous if the resources exploited are unattractive to other species of bees.

Prolonged sharing of sources, such as *Eucalyptus* spp, *Archontophoenix* sp, *M. daleoides*, *Cecropia* sp and *Tipuana speciosa*, with *A. mellifera*, *T. spinipes* (CORTOPASSI-LAURINO, 1982) and *T. angustula* (IMPERATRIZ-FONSECA *et al.*, 1984), must have been viable owing to the presence of unvisited foraging sites, despite the occurrence of interactions and sporadic shifting movements. In this case, it can be assumed that supply of these sources surpassed demand.

Throughout the year, the polylecty of *P. remota* was mainly the result of the diversity of the resources included in the colonies' area of action. On the other hand, the quality and quantity of each source, the foraging strategies and the interaction between species determined the fluctuation in the size of the trophic niche.

The supply of *Eucalyptus* spp and *Archontophoenix* sp seems to have had considerable influence on the quantitative distribution of *P. remota* foragers among the blooms, while the diversity of pollen types in the samples was variable and did not depend on visits to these sources.

$H'$  and  $J'$  tended to remain low simultaneously : in other words, the colonies had a certain degree of polylecty but expressed floral preferences when faced with favourable foraging conditions, possibly maximizing gains from more productive sources. The highest values for  $H'$  were obtained when some items, apparently less productive than *Eucalyptus* spp and *Archontophoenix* sp, were included in the diet. At such times, foraging became more uniform, since few sources appeared with a high pollen representativity.

The high values for overlap were the result of the colonies' attraction to few sources. These data demonstrate that floral preferences existed, and possibly that there was a lack of attractive alternatives for the species in question.

Better distribution of foragers among the different blooms, possibly due to scarcity of the main resources, visits to more distant sites or collecting from less attractive sources, led to a degree of divergences in the foraging of the various colonies in some months. The negative correlations between  $H'$  and PS corroborate the assumption that the sources procured at certain periods were less predictable for the foragers or less attractive for the species.

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### RÉSUMÉ

#### EXPLOITATION DES RESSOURCES FLORALES PAR *PLEBEIA REMOTA* HOLMBERG (Apidae, Meliponinae)

Pendant l'année 1981, des échantillons de miel et de pollen ont été prélevés chaque mois, dans trois colonies de *Plebeia remota*.

L'analyse des échantillons de pollen a montré la présence de 64 espèces appartenant à 29 familles botaniques, et celle des échantillons de miel la présence de 97 espèces appartenant à 33 familles botaniques. Les plus représentées sont les Myrtaceae, Palmae, Moraceae et Leguminosae.

Les espèces ayant une représentation pollinique supérieure à 10 % dans les échantillons ont été considérées comme étant les sources alimentaires les plus importantes. Ainsi les colonies de *Plebeia remota* trouvent leur nourriture chez un nombre réduit d'espèces botaniques situées dans un rayon d'une centaine de mètres autour des colonies : 7 pour le pollen (*Archontophoenix* sp., *Asparagus* s.l., *Cabralea* s.l., *Cecropia* sp., *Eucalyptus* spp., *Mimosa daleoides*, *Pipta denia* sp. (Figs 3, 4, 5)) et 8 pour le nectar (*Archontophoenix* sp., *Asparagus* sp., *Cecropia* sp., *Eucalyptus* spp., *Impatiens balsamina*, *Mimosa daleoides*, *Pipta denia* s.l., *Tipuana speciosa* (Figs 6, 7, 8)). Il est intéressant de noter que la plupart des espèces bien représentées dans les échantillons sont des arbres.

Les valeurs basses obtenues pour l'étendue de la niche ( $H' < 1$  en général ; Figs 10, 12) et l'uniformité ( $J' < 0,5$  en général ; Figs 11, 13) montrent que *P. remota* récolte de grandes quantités à partir de peu de sources, mais d'une façon très hétérogène d'un mois à l'autre. Les figures 14 et 15 donnent les valeurs du chevauchement des ressources : le chevauchement entre les colonies est élevé ( $PS < 0,5$  en général), résultant du butinage intensif sur quelques sources durant toute l'année 1981.

## ZUSAMMENFASSUNG

AUSBEUTUNG DER BLÜTENQUELLEN DURCH  
*PLEBEIA REMOTA* HOLMBERG (Apidae, Meliponinae)

Während des Jahres 1981 wurden monatlich Proben aus den 3 Bienenstöcken der *Plebeia remota* Holmberg von Pollen und Honig aus den Vorratsbehältern gesammelt. In den Pollenproben wurden Pollenkörner von 64 Pflanzenarten gefunden, die zu 29 botanischen Familien gehören, und bei den Honigproben 97 Pflanzenarten, die zu 33 botanischen Familien gehören. Die am häufigsten vertretenen Familien in den Proben waren: Myrtaceae, Palmae, Moraceae und Leguminosae.

Wir hielten die mit über 10 % vertretenen Gattungen für die wirklich wichtigen Nahrungsquellen. Man kann dabei feststellen, dass die Bienenvölker *Plebeia remota* einen grossen Teil ihrer Nahrung aus nur wenigen Blütenquellen, die sich in einem Umkreis von annähernd 100 m Entfernung von den Bienenstöcken befanden, bezogen haben: 7 für Pollen — *Archontophoenix* sp, *Asparagus* s.l., *Cabralea* s.l., *Cecropia* sp, *Eucalyptus* spp, *Mimosa daleoides*, *Piptadenia* sp (figs. 3, 4, 5) und 8 für Nektar — *Archontophoenix* sp, *Asparagus* s.l., *Cecropia* sp, *Eucalyptus* spp, *Impatiens batsamina*, *Mimosa daleoides*, *Piptadenia* sp, *Tipuana speciosa* (figs. 6, 7, 8). Es ist dabei bemerkenswert, dass der grösste Teil der hauptsächlich vertretenen Gattungen in den Proben zu den Baumschichten gehörten.

Die erhaltenen niedrigen Werte für die Ausbreitung der Nische ( $H'$  im allgemeinen weniger als 1,0; figs. 10, 12) und die Gleichmässigkeit ( $J'$  im allgemeinen weniger als 0,5; figs. 11, 13) zeigen, dass *Plebeia remota* bei vielen Nahrungsquellen, aber auf sehr heterogene Weise in jedem Monat gesammelt haben. Das bedeutet, dass dies zu einer Tendenz der Konzentrierung auf wenige Nahrungsquellen geführt hat, um zu jeder Zeit die Nahrungsvorräte voll auszunützen. Es ergab sich auch ein Zusammentreffen der Trachtbienen der verschiedenen Bienenvölker bei diesen wenigen Pflanzenquellen, woraus sich die hohen Werte der Überbesetzung (PS im allgemeinen mehr als 0,5; figs. 14, 15) innerhalb der gleichen Gattungen erklären lassen.

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