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## NOCTURNAL BEE ABUNDANCE AND SEASONAL BEE ACTIVITY IN A PANAMANIAN FOREST<sup>1</sup>

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**Abstract.** Bees were monitored weekly for 7 yr at light traps in the tropical monsoon forest of Barro Colorado Island. Fifty species and 17 genera were recorded, including nocturnal *Megalopta* and crepuscular *Rhinetula* (Halictidae) and *Ptiloglossa* (Colletidae). Twenty-eight native meliponines and African *Apis mellifera* in traps increased the known resident highly social bees to 32 species. Most of the 11,860 bees were *Megalopta*; these species were present throughout the year, as were *Rhinetula* and *Ptiloglossa*.

Abundance of *Megalopta* was lowest during the dry season; this was its only consistent seasonality. Peak abundance occurred at various times during dry-to-wet-season transition and in the first half and the end of the wet season. *Centris* and *Epicharis*, large, solitary anthophorid bees, were present in the early wet season and absent in the late wet season and most of the dry season. The highly social bee *Trigona* aff. *cupira* was aseasonal but had abundance peaks during all but the mid-to-late wet season. *Megalopta genalis* abundance and *M. ecuadoria* abundance were highly positively correlated within years, and weakly correlated with abundances of other bees. Pairwise correlations between years were low for each *Megalopta* species and for combined bees of other genera. A singularly large catch of *Megalopta genalis* in 1978 corresponded to flowering of the monocarpic tree *Tachigalia versicolor* near light traps. Fluctuation of bee abundance at light traps probably indicates local flower availability for this species and, to a lesser extent, for the other bees. The data suggest large year-to-year variation in seasonal abundance of resources used by nocturnal bees and by bees in general, but are limited to indicating the presence or absence of most other bee species. The yearly variances in abundance of a stingless bee species and of *Megalopta* in Panamá are comparable to those of eight temperate bumble bee species studied in England, but combined diurnal and crepuscular bee abundance is considerably less variable. The African honey bee arrived on Barro Colorado Island in mid-1982 and has produced no noticeable changes in abundance of other bees but has yet to reach its potential numbers there; light-trap studies could provide perhaps the most reliable information on its impact.

**Key words:** African *Apis*; Barro Colorado Island; bee population dynamics; black-light traps; *Megalopta*; nocturnal bees; Panamá; stingless bees; tropical seasonality.

### INTRODUCTION

Bee abundance in both tropical and temperate areas fluctuates seasonally (Linsley 1958, Sakagami et al. 1967, Sakagami and Fukuda 1973, Heithaus 1979, MacKay and Knerer 1979, Ackerman 1983, Camargo et al. 1984), yet few published studies have assessed population fluctuation during several years or flowering seasons (Anasiewicz 1972, 1975a, b, 1976, Owen 1978). Due to major difficulties in replicable yearly sampling of bees in flight or at flowers, particularly at trees and canopy vegetation, there has been no documentation of the degree to which bee abundance changes from year to year in tropical habitats. We sought to develop baseline data on tropical bee populations through use of light traps, at which nocturnal and crepuscular bee species are known to arrive (Janzen 1968). Our study had particular relevance in establishing normal population levels within tropical forest prior to and after the arrival of immigrant African honey bees, which have steadily colonized South America and, more recently, most of Central America. Such studies can be used to assess the impact of this abundant invading

social bee species on native organisms (Roubik 1978, 1980, 1982, 1983a, Boreham and Roubik, *in press*). In lowland forest of central Panamá, the abundance of African honey bee colonies has continued to increase since the first swarms arrived in early 1982; >800 swarms and nests have been removed from an area of 52 km<sup>2</sup> along the Canal, and >5000 had been removed in the Panamá City metropolitan area as of December 1984 (Boreham and Roubik, *in press*). This paper provides information on the seasonality, diversity, and abundance of bees on Barro Colorado Island, from 1977 through 1983. African honey bees first arrived on the island in July 1982 and were found in natural nests there in December of that year.

### METHODS

Two modified Pennsylvania black-light traps were operated in the forest of Barro Colorado Island, Panama Canal Area, one in the canopy at 27 m and one below it at 3 m above the ground. The funnel traps were positioned on a ridge at 120 m elevation. Traps functioned for 24 h each day during the 7-yr period reported here. All bees were removed from the general insect samples collected in the traps. Daily samples were combined to obtain weekly information, and data

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TABLE 1. Bees from light traps operated 24 h/d on Barro Colorado Island (1977–1983).

Family	Genus	Species
Apidae	<i>Melipona</i>	<i>fasciata</i> , <i>compressipes</i> , <i>marginata</i> *
	<i>Apis</i>	<i>mellifera</i> *
	<i>Lestrimelitta</i>	<i>limao</i>
	<i>Trigona</i>	<i>corvina</i> , <i>latitarsis</i> *, <i>fulviventris</i> , aff. <i>cupira</i> , <i>dorsalis</i> , <i>cilipes</i> *, <i>mellicolor</i> *, <i>jatiformis</i> , <i>pachysoma</i> , <i>fuscipennis</i> , <i>frontalis</i> , <i>buyssoni</i> , <i>franki</i> , <i>nigerrima</i> , <i>capitata</i> *, <i>nigra</i> , <i>barrocoloradensis</i> , <i>testaceicornis</i> , <i>mellaria</i> *, aff. <i>minima</i> , <i>perangulata</i> , <i>pallens</i> , <i>angustula</i> , <i>silvestriana</i> *
Halictidae	<i>Euglossa</i>	<i>igniventris</i>
	<i>Eufriesea</i>	<i>surinamensis</i>
	<i>Megalopta</i>	<i>genalis</i> , <i>ecuadoria</i> , near <i>ianthina</i>
Anthophoridae	<i>Augochlora</i>	1 species
	<i>Rhinetula</i>	<i>dentricus</i>
	<i>Centris</i>	<i>dentata</i> , <i>fusciventris</i> , <i>longimana</i> , <i>plumipes</i>
	<i>Epicharis</i>	<i>flava</i> , <i>albofasciata</i>
	<i>Xylocopa</i>	1 species
	<i>Paratetrapedia</i>	2 species
Megachilidae	<i>Mesoplia</i>	<i>azurea</i>
	<i>Ptilomelissa</i>	1 species
Colletidae	<i>Megachile</i>	2 species
	<i>Ptiloglossa</i>	<i>fulvopilosa</i>

\* Not previously recorded among social bees from Barro Colorado Island by Schwarz (1934).

from both traps were pooled. Species were sorted from the material by D. W. Roubik and identified with a reference collection and using keys provided by Michener (1954). Determinations of halictid species were verified by G. C. Eickwort, Cornell University, and the centridines were identified by R. R. Snelling, Los Angeles County Natural History Museum. Voucher specimens are in the collection of D. W. Roubik at the Smithsonian Tropical Research Institute, Panamá.

Barro Colorado Island (BCI) is covered with tropical lowland forest (Croat 1978). Average rainfall is 2500 mm/yr with a pronounced dry season of an average 4 mo, usually from December through April. The dry period may vary from 2 to 6 mo between years (Rand and Rand 1982). Further details of black-light trapping studies on BCI may be found in Wolda (1977, 1982) and Wolda and Fisk (1981).

## RESULTS

### *Bee diversity*

A list of bee taxa encountered in the light-trap samples is given in Table 1. Both female and male bees were caught, but the females of all species were far more common. Fifty species from 17 genera and five families were recorded. In the 7-yr period 11 860 bees were collected; 86% belong to two species of *Megalopta*, a nocturnal genus of halictid bee (Moure 1958). *M. ecuadoria* Friese was the most common bee, with 7713 individuals, and 2487 *M. genalis* Meade-Waldo were also recorded. These bees are readily separated on the basis of diagnostic characteristics given by Michener (1954). A third species, near *M. ianthina* Smith, occurs normally in western Panamá and was collected twice on BCI in traps during 1978. Two species of crepuscular bees came to the black light, *Ptiloglossa fulvopilosa* Cameron (Colletidae) and *Rhinetula den-*

*tricus* Friese (Halictidae). These bees are active from a few hours before dawn until early morning (Janzen 1968, D. W. Roubik, *personal observation*).

The most diverse group was the stingless bees, Meliponinae, which included 28 species of three genera. One species, *Trigona* (*Partamona*) aff. *cupira*, a bee having a manuscript name but never formally described by H. F. Schwarz (J. M. F. Camargo, *personal communication*), comprised over half of the diurnal bees collected at the traps. Of intermediate abundance were *T. (Oxytrigona) mellicolor*, *T. (Plebeia) jatiformis*, *T. (Plebeia) franki*, *T. (Scaptotrigona) barrocoloradensis*, and *T. (Tetragona) dorsalis*. Schwarz (1934) listed 24 stingless bees known from Barro Colorado Island, and Roubik (1983b) reported 37 species from the Atlantic forest of Panamá, 45 km east of BCI. Including the present light-trap information, total meliponine species recorded on BCI number 31. A single worker of the African honeybee, *Apis mellifera scutellata*, was found in a trap in the 1st wk of January 1983. Stingless bees are active on BCI from slightly before dawn until dark, and they probably strayed into traps in the early morning or evening. The additional species listed in Table 1 are normally diurnal bees.

### *Bee seasonality*

There was large variation in abundance of *M. ecuadoria* and *M. genalis* over the 7-yr period, some of which was consistently seasonal (Figs. 1 and 2). Catches tended to be low in the first 10 wk of the year, and relatively high in the second, third, and last 10-wk periods. During the 7-yr period, only 6.4% of *M. ecuadoria* and 5% of *M. genalis* occurred in the first 10 wk of the year. The fractions in the subsequent 20-wk period are 55% and 61%, respectively. However, the seasonality is only meager and much of the pattern of abundance is not repeated over successive years.

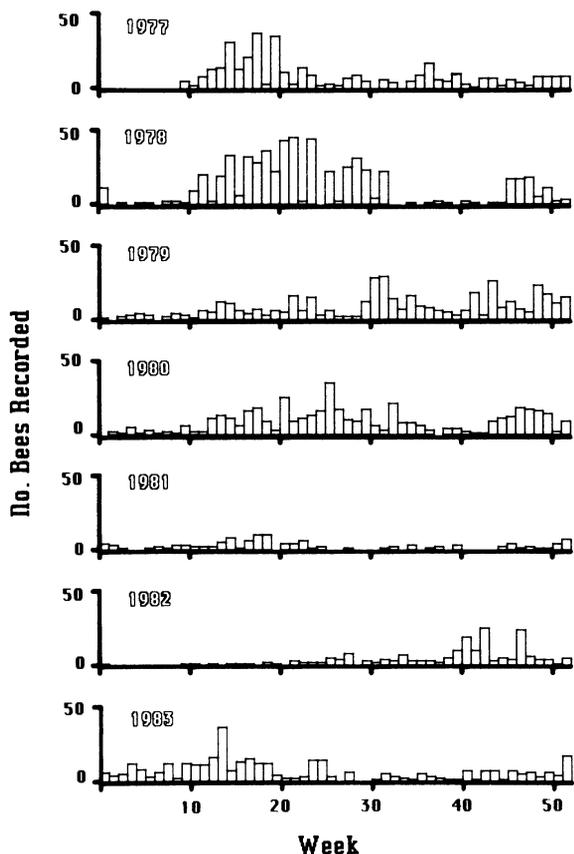


FIG. 1. The number of individuals of *Megalopta ecuadoria* captured per week in two light traps on Barro Colorado Island, Panamá, during seven years.

Different years were compared for abundance of the *Megalopta* using product-moment correlation coefficients. The 52 weekly abundance values in each year were compared with those in the other years. Pairwise comparisons of each of the seven years with all other years produced 21 between-year correlations within each species (Fig. 3A, B). Values tend to be very low, with a tendency toward a preponderance of positive values. This indicates weakly consistent seasonal variation in the abundance of each species from year to year. Correlations between species within each year, however, were much higher (Fig. 3C). Thus the pattern of abundance of a species in one year is very weakly correlated with the pattern in that same species in a different year, but it is strongly positively correlated with the pattern of the other species in the same year. During 1978 the large forest tree *Tachigalia versicolor* (Papilionoideae) on which the traps were hung was in full flower. This species is monocarpic, having but one flowering episode just before death (Foster 1977). A 10-fold increase in *Megalopta genalis* coincident with flowering of *Tachigalia* was seen during the late dry through early wet season of 1978 (Fig. 2).

As the only highly social bee species occurring in

large numbers, *Trigona* aff. *cupira* had sporadic abundance peaks through much of the year (Fig. 4). Low numbers did occur consistently, however, during the fourth and early fifth 10-wk period, or the mid to late wet season. The same general pattern existed for all non-*Megalopta* bees combined (Fig. 4), and demonstrates little seasonality and low correspondence with the patterns of *Megalopta* abundance in traps (Fig. 3D, E). It is noteworthy that no abrupt increase in numbers of the other bees occurred during the flowering of *Tachigalia* in 1978 (Fig. 4). Total catches of diurnal and crepuscular bees averaged 242 for the 7-yr period: 279, 206, 326, 216, 265, 164, and 235 in the respective years.

The two crepuscular bees *Rhinetula* and *Ptiloglossa* seem to have been present throughout the year, although *Rhinetula* was more consistently collected in the early wet season (Fig. 5). Six species of the large anthophorid bees *Centris* and *Epicharis* (Centridini) were largely restricted to the early wet season and were conspicuously absent in the mid dry and late wet seasons (Fig. 5). Such bees are known to visit large flowering trees and vines often; they have been characterized as a group typically most active during the dry

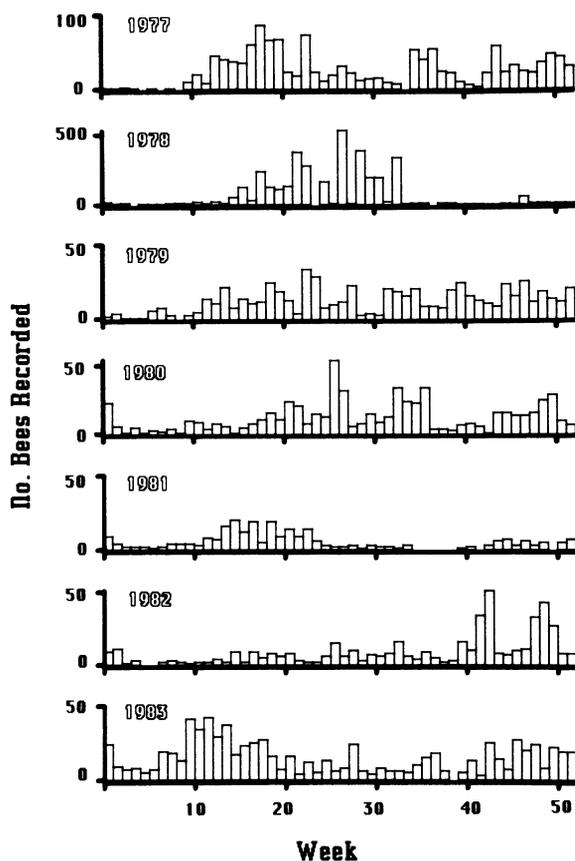


FIG. 2. The number of individuals of *Megalopta genalis* captured per week in two light traps on Barro Colorado Island, Panamá, during seven years. Note different ordinate scales.

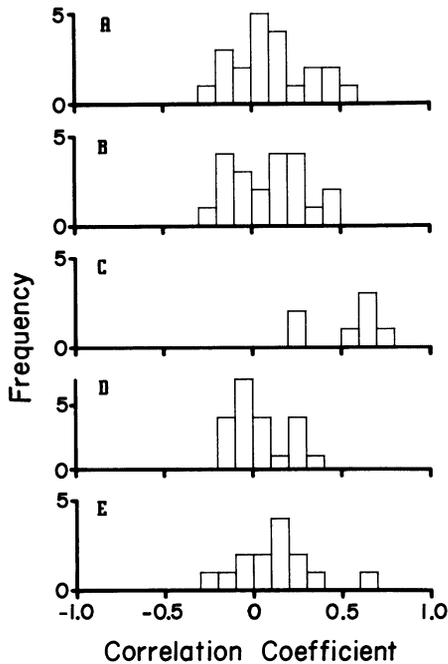


FIG. 3. The distribution of product-moment correlation coefficients: (A) between years in *Megalopta ecuadoria* (all pairwise comparisons for seven years: 21 values); (B) between years in *Megalopta genalis* (21 values); (C) between the two *Megalopta* species in the same year (seven years: 7 values); (D) between years for the rest of the bees combined (21 values); (E) between each of the two *Megalopta* species and the rest of the bees combined for each year (seven years for each *Megalopta* species: 14 values). For the basic data see Figs. 1, 2, and 4.

season (Janzen 1967, Roubik and Michener 1980, Roubik et al. 1982, Frankie et al. 1983).

DISCUSSION

*Abundance patterns*

Abundance of bees in the light traps is likely determined by proximate factors such as the location of flowers and nests, and general bee abundance in the habitat. That 86% of all bees collected during our study belonged to the only two common nocturnal species on BCI indicates that these has the greatest chances for capture. There can be no comparison of absolute abundance with the other bees in the study. Two crepuscular species, *Ptiloglossa* and *Rhinetula*, were sampled for little more than an hour each day, corresponding to their known foraging period, although *Rhinetula* has been collected in full sunlight during early morning (Janzen 1968, D. W. Roubik and R. W. Brooks, *personal observation*). The remaining 45 species of diurnal bees were probably effectively sampled for a period of only several minutes each day. Combined information for several years, however, does reveal trends in their abundance and seasonal activity. The numbers of *Trigona* aff. *cupira* arriving at traps were large relative to

those of the 29 highly social bee species that were found, which may show that the *Trigona* nested nearby. Their nests, each containing an average of 2000 adults, are often aggregated; their foraging period is, as for most stingless bees, from dawn until dusk (Roubik 1983a, Roubik and Buchmann 1984), but their nests are exposed and vulnerable to predators. Thus if a colony is disturbed at night, defending bees will fly from the nest and then to a light source (D. W. Roubik, *personal observation*).

The bees for which we feel there are adequate data to discuss both seasonal activity and local abundance are the two nocturnal *Megalopta*. Like many augochlorine bees, these may be primitively eusocial, with reproductive castes (Michener 1974). There were large differences in size among females, suggesting a caste structure (Brooks and Roubik 1983). *Megalopta* live in small excavations in tree branches with few (<20) brood cells and fewer active adults, but data on their foraging preferences are virtually nil (Sakagami and Moure 1967, Janzen 1968, Eickwort and Sakagami

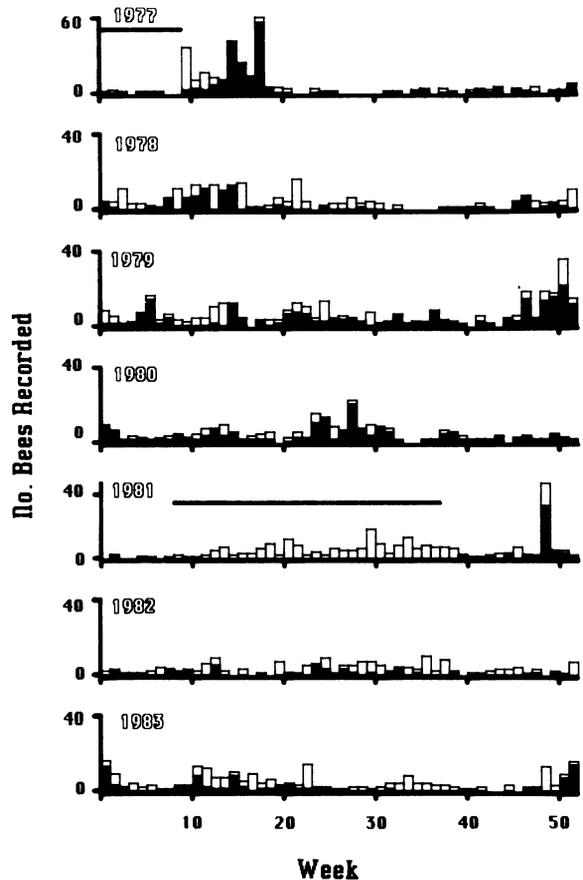


FIG. 4. The number of individuals of the diurnal and crepuscular (non-*Megalopta*) bees in two light traps on Barro Colorado Island, Panamá, during seven years. ■ the species *Trigona* aff. *cupira*. Horizontal bars in 1977 and 1981 indicate periods for which individuals of *T.* aff. *cupira* were not recorded. Note different ordinate scale for 1977.

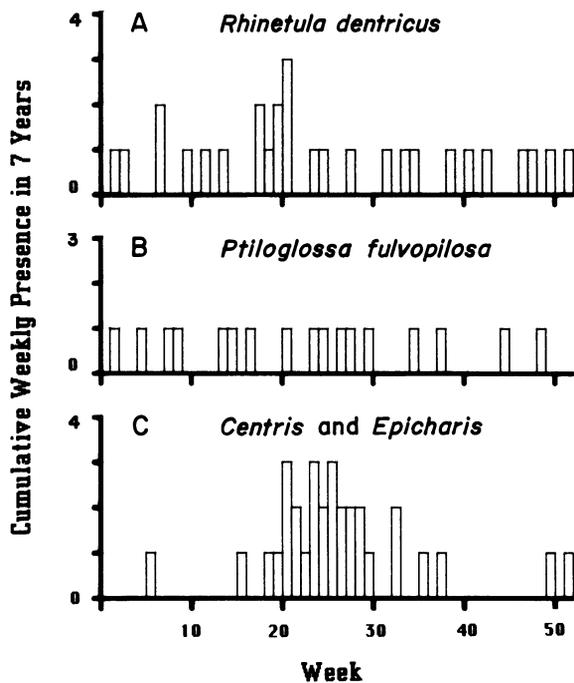


FIG. 5. Cumulative number of times each of three solitary bee groups was recorded in light traps during the indicated week in seven years on Barro Colorado Island, Panamá. (A) *Rhinetula dentricus*; (B) *Ptiloglossa fulvopilosa*; (C) Centridini: *Centris* (4 species) and *Epicharis* (2 species) (see Table 1).

1979). From the unprecedented 1978 catch of *M. genalis* during the flowering time of *Tachigalia versicolor*, the tree from which the traps were suspended, it seems that this papilionaceous legume is a major resource when it flowers, which has been thought to occur every four years (Foster 1977 and *personal communication*). However, there was no widespread flowering of this species nor an increase in *M. genalis* in traps during 1982. While the conspicuous increase of *M. genalis* in 1978 was not observed for the other bees, the light-trap data for all bee species must include some information on seasonal availability of resources near the light trap. Since the *Megalopta* are very large halictid bees, 9–15 mm in length, and tropical forest bees of smaller or comparable size fly more than a kilometre from their nests (Roubik and Aluja 1983, Roubik, *in press*), bees may have arrived at the light traps from a large area. Our captures therefore probably included both bees nesting near the light trap and those flying into the area during the several hours in which they forage each night (Janzen 1968).

Diurnal bee species are probably better indicators of flowers or nests in the immediate area of the light trap, because they will be attracted to the light during a much shorter time period than nocturnal or crepuscular species. However, our combined data suggest that food availability for the bees fluctuated markedly between years. At any time of the year some species of trees

can be found flowering on BCI, but there is a broad community peak of flowering lasting from the dry season through the first half of the rainy season (Croat 1978, Foster 1982). This fits the general seasonality pattern of *Megalopta*. Deviations from that pattern, as they occur virtually every year, probably depend on local flowering phenomena. It is clear from the plotted correlation coefficients of year-to-year abundance (Fig. 3A, B, D) that all bee groups had only weakly consistent seasonal patterns in abundance between years. General abundance of both *Megalopta* species showed seasonal peaks during the dry-to-wet and early-to-mid wet seasons in six of the seven years, with a slight peak in the wet-to-dry transition (Figs. 1 and 2). Many large forest trees that are principal bee resources flower sporadically, usually in connection with water stress or accumulated reserves needed to produce flower, nectar, and pollen (Augsburger 1980, Foster 1982, Reich and Borchert 1984). It is therefore expected that bees that are completely dependent on food immediately available in the environment (all but the Meliponinae and Apinae in this study) are opportunistic in selection of flower species. Abundance phenomena of the nocturnal bees may reflect current flower availability as well as resources during previous bee generations. Consistent positive correlations in numbers of the two *Megalopta* species within years are largely determined by the same general factors, although the example of *Tachigalia* suggests that congeneric bee abundance is not influenced evenly by a given flower species. Differing effects of pathogens, parasites, and predators on the abundance of *Megalopta* cannot be assessed, nor can the availability of their nest sites, which include pithy stemmed plants and excavations made in dead wood by burrowing insect larvae (Sakagami and Moure 1967, Janzen 1968). There may be relatively few nest parasites of *Megalopta*, because apoid parasites usually can enter a host nest only when the host is absent, and seem to use mainly visual cues to locate the nests; if this is indeed true for potential *Megalopta* parasites, the bees should be relatively safe, as they are active and away from their nests only at night. Many of the normal suite of diurnal Mutillidae and confamilial parasites that affect halictids (Michener 1974, Brooks and Roubik 1983) may be absent. Additional visual predators of relatively large bees, such as birds, toads, dragonflies, spiders, robber flies, lizards, and mantids should contribute little to mortality patterns of *Megalopta*.

#### Seasonality patterns

Light-trap data appear to be reasonable indicators of presence or absence of adult bees of most species and higher taxa that came repeatedly to the lights. Our data clearly establish the year-round activity of *Megalopta* and stingless bees. Although few individuals of the crepuscular bees were trapped, similar year-round activity is shown by the cumulative weekly presence

of *Ptiloglossa* and *Rhinotula* plotted in Fig. 4. The former species nests in the ground, as probably does the latter. Distribution of bee catches among the two light traps reveals that 57% of the *Rhinotula* and 81% of the *Ptiloglossa* arrived at the lower trap, while the wood-nesting *Megalopta* were consistently more abundant in the trap 27 m above the ground. For example, in 1977 69% of *M. ecuadoria* and 81% of *M. genalis* were taken at the higher trap; the respective figures for 1978, the year of the largest catches, were 64% and 80%. Such data indicate differences in nesting and foraging locations, but it is difficult to deduce which factor predominates.

Combined data for the centridine bees *Epicharis* and *Centris* suggest that these six species are largely restricted to the early to mid wet season. This is in marked contrast to centridines censused at flowers in the lowland dry forest of Guanacaste, Costa Rica (Heithaus 1979, Frankie et al. 1983). There, all but 3 of 10 *Centris* species were entirely restricted to the dry season (*C. segregata* = *C. inermis* may show seasonal activity of its two color forms; Frankie et al. 1983, Snelling 1984). All four *Epicharis* species showed peak activity in the dry seasons, but were also present during the wet season of May-June. A pattern noted in the six Panamá species and centridines not restricted to the dry seasons in Guanacaste is that these are, with the exception of *C. analis*, the largest bees of those censused (Snelling 1984). Furthermore, the *Epicharis* and most of the *Centris* active in the wet season are dark in color. Nesting biologies of most of these solitary bees are known (Roubik and Michener 1980, Coville et al. 1983) and both the dry-season and the wet-season species nest in the ground and in holes in wood. An hypothesis for some consideration is that larger centridines are most active during cooler periods of higher moisture, and that this pattern is enforced by thermoregulatory attributes dependent on body size and color. Centridine bees have short, thick hair covering the thorax; darker bees probably have a slight advantage in passive heat absorption, which may allow foraging to be initiated earlier than in other species. Darker centridines should also more readily experience overheating from the flight muscles (Heinrich 1979). The light color morph of *Centris segregata* is active only in the dry season, and diurnal bees in cool cloud forest conditions tend to be black (Roubik and Michener 1984), including the highland species *Centris festiva* (Snelling 1984). A tendency toward activity at cooler periods early or late in the day would help to explain both the lack of other species in the traps and the presence of these larger and often dark bees primarily during the wet season. In both Central and South America there are roughly 20-30 centridine species in the lowland forest, and they show a large range in size (Michener 1954, Roubik 1979, Frankie et al. 1983, Snelling 1984). It is conceivable that many of the less well known species are active primarily during the wet season. Since the large flowers visited by

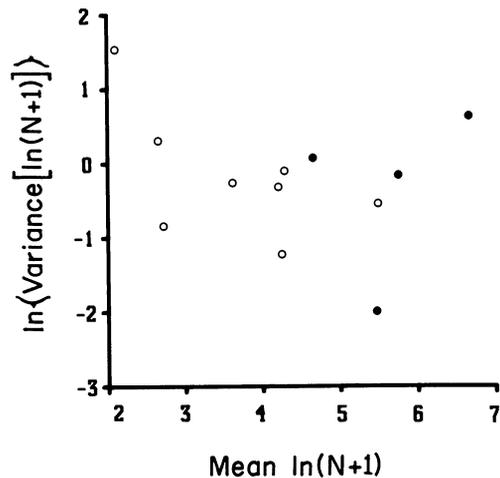


FIG. 6. Variation in abundance during seven years of three tropical bee species and combined diurnal and crepuscular (non-*Megalopta*) bees in light traps on Barro Colorado Island, (BCI), and also eight species of bumble bees during six years in England (Owen 1978). ● on top from left to right: *M. ecuadoria*, *M. genalis*, *Trigona* aff. *cupira*; ● below represents combined bees on BCI. ○: eight species of *Bombus* in England.

centridine bees are most abundant during the dry season (Frankie et al. 1983), some species will be difficult to find during the rest of the year. For this bee group, light-trap data supplement the available information from collections made at flowers.

The addition of seven native species to the list of highly social bees known from Barro Colorado Island (Table 1) demonstrates the utility of light-trap studies for this tropical bee group. A total of 31 resident native highly social bee species is probably a close estimate of the species there, a number which is likely to have declined from roughly 35 species since formation of the island in 1914 (Roubik 1983b, Wille 1983).

*Long-term population stability*

Variation of insect abundance from year to year, usually considering a data set of only two or three years, has been reviewed by Wolda (1978). A variety of bees from Poland were studied for this time interval (Anasiewicz 1972, 1975a, b, 1976) and were analyzed using the Annual Variance (AV) statistic of Wolda (1978) and Williamson (1984). For both tropical and temperate insects, AV ranges from 0.018 for the most stable to the most variable AV of 0.642. The three points for Polish bees, obtained from samples made in flowering crop fields, were 0.087, 0.177, and 0.267. They are intermediate in variability among insects, whether tropical or temperate. Data for a longer term, covering six years, are available only for bumble bees in an English garden (Owen 1978). Compared to other insects, these bees were found to be very stable in their yearly sampled populations, ranking third among 75 surveys which included 2836 tropical and temperate species (Wolda 1983). Our data for the two nocturnal

halictids and one *Trigona* show that they are just as variable in abundance in light traps as the British bumble bees in Malaise traps (Fig. 6). The data point for all diurnal and crepuscular bees combined, however, shows a much smaller variation than for any of the separate bee groups. Such slight changes in yearly abundance of the bees on BCI tend to obscure the diverse abundance trends of individual species, which probably tend to cancel out each others' variation. However, bee activity in foraging and pollination may indeed be highly stable within a given area of Barro Colorado Island, as is true for euglossine bees in other Panamanian forests (D. W. Roubik, *personal observation*).

The present data do not permit conclusions about the effects of African honey bees on seasonality or abundance of native bees (Roubik 1983). The African honey bee had not attained its potential abundance on BCI or in central Panamá in 1983 (Boreham and Roubik, *in press*). These bees live for a short time in cavity nest sites within mature forest, from which colonies often abscond after a few months (D. W. Roubik, *personal observation*). Despite the residence of some African honey bee colonies on BCI, the light-trap data show no unusual changes in the abundance of native bees during 1982–1983.

Bees taken at the light traps appeared little affected by fluctuations in rainfall on BCI (see Rand and Rand 1982). The dry season of 1982–1983 was unusually intense, lasting for nearly 6 mo on BCI, yet there was no obvious drop in bee abundance in that year or the following year. Similar lack of change in bee populations was noted for 45 euglossine bee species (D. W. Roubik, *personal observation*). The apparent stability of these tropical pollinators in the face of changing weather conditions and attendant flowering phenologies may allow the influence of African honey bees to be tested in coming years. Light traps are perhaps the most satisfactory method for sampling such changes, since preferred bee forage at ground level can change drastically from year to year, thus nullifying the value of surveys at flowers for the purpose of monitoring absolute bee abundance (Ginsberg 1979). For a short period near dawn, both *Apis* and *Megalopta* forage; these species may have sufficient overlap in foraging activity and plant resources to compete directly for food. As shown in earlier studies (Roubik 1982, 1983a), the initial effect of African honey bees on native bee populations is insignificant and flower preference of *Apis* is similar to bees of equal or smaller size. The future interaction of African honey bees with *Megalopta*, *Rhinotula*, and the stingless bees should be measurable using information from light-trap studies on Barro Colorado Island.

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