FORAGING OF THE AFRICAN HONEYBEE, *APIS MELLIFERA ADANSONII*, IN THE HUMID SEMI-DECIDUOUS FOREST* ENVIRONMENT OF GHANA

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ABSTRACT
The relative abundance, the foraging pattern and rate of Apis mellifera adansonii were studied, particularly in relation to weather for three flowering seasons.

Twenty-four plant species were identified in three study sites as melliferous plant species. Most of them grow sympatrically and flower sequentially. Their flowering seasons are sharply defined, but few of them showed some overlaps. Some of them provided nectar and pollen while others provided either nectar or pollen. Peltophorum pterocarpum, which was the most conspicuous plant species during the early part of the year, recorded the maximum hourly visits of bees although it presented only pollen as a floral reward. Generally, however, the bee visited more frequently nectar-producing plants than those, which offered only pollen.

The foraging rate of the bee depended on the plant species they worked on. As observed for other species of Apis, the Apis mellifera adansonii worked much more slowly when collecting pollen than when foraging for nectar. It did not differ from other races of honeybees in its response to change in weather conditions.

Keywords: *Melliferous plants, Foraging rates, Diurnal pattern, Floral phenology, Relative abundance, Apis mellifera adansonii*

INTRODUCTION

Beekeeping is a viable agricultural industry in Ghana, a country that shows great potential for future development in this field. In most parts of Ghana, beekeeping is still practiced in a traditional form using different types of hives. The economic benefits of beekeeping, however, cannot be over emphasized. Honeybees constitute a major pollinator of the entomophilous plant species and thus plays an important role in the regeneration of forest. At no stage of its complete life cycle does the honeybee attack the plants. The honey that is produced by the honeybee has antibiotic properties and has ready market both locally and abroad.

To capitalize on the opportunities presented by the favourable natural conditions of the country, beekeepers must shift from traditional beekeeping to the usage of honeybees as a manageable and renewable resource. This can be accomplished by studying the behaviour of the West African race of the African honeybee. A considerable diversity in the characteristics of African races of *Apis mellifera* has been reported. These characteristics have been found to vary with temperature, attitude, humidity and other environmental factors [Kihwele, 1988]. Honeybees are efficient pollinators because of their physical characteristics [Headings, 1984].

The success of beekeeping also depends on the abundance and richness of nectar and pollen sources around an apiary. Abundant forage coupled with favourable ecological conditions such as rainfall, temperature and relative humidity indicate tremendous possibilities for developing modern beekeeping in any country. This study sought to identify melliferous plant species in the study area and evaluate the diurnal foraging pattern of the honeybee in relation to changes in weather conditions. The findings would add to the knowledge needed to improve the management of this aggressive and unpredictable West African race of honeybee.

Materials And Methods

Study Area

The investigations were conducted in the forest areas o the University of Science and Technology, Buadi and Anwomaso, all in Kumasi. Kumasi is located between latitudes 7°00' and 6° 30' N and longitudes 2° 00' and 1° 30'E It is in the humid region of the tropics having moist, semi-deciduous forest. The annual rainfall varies between 127 and 165 cm. Although there may be short dry periods (called the harmattan) when rain does not fall, there is no season in which the soil dries out and plant growth ceases. Temperature is relatively constant ranging from a minimum of 20.2°C to a maximum of 37.1°C. The climate is marked by high incidence of solar radiation and relatively little variation in day length.

All the sites were remote natural habitats of wild honeybees and human interference was minimum. They were abandoned farms, which had been left to fallow for period between 3 to 5 years and were undergoing succession. The areas were covered with dense thickets in which fast growing species such as *Trema guineansis* and *Anthoclesta nobilis* were dominant.

Melliferous Plant Species

A survey to identify the melliferous plant species was conducted through three flowering seasons (1989-1991). Preliminary observations were made before the survey to determine the time when bee activity began and ended. Based on the result of these observations, 06.00 to 18.00 hours GMT were chosen for counts of the bee. For forty minutes each hour, we walked slowly and continuously along clumps of plants and counted the number of bees foraging on flowers of the plant species in the study sites. These plants were identified as melliferous plant species. The data were used to assess the foraging frequency and rate of the bee on the various plant species, and their diurnal foraging patterns.

The flowering phenology of the plant species was quantified during these seasons. During each season, records of beginning, peak and end of flowering were kept. Peak flowering was defined as the period during which at least 50% of the plants of a given species were in flower.

The Effect of Weather Conditions on the Foraging pattern of *Apis mellifera adansonii*

The shade temperature and humidity were measured at hourly intervals from 06.00 to 18.00 hours GMT. Temperature was measured with a thermometer hung from a branch of the plant and close to the flowers. Relative humidity was recorded with an aspirated psychrometer (Atkins Technical Inc., Gainsville, Florida, U.S.A.) held close to the flowers.

The effect of cloudy and clear weather conditions on the foraging of the bee was also studied. Counts lasting 10 minutes were taken of the foraging bee whenever weather conditions changed.

Results

Melliferous Flowering Plant Species

Twenty-four flowering plant species belonging to the families of Caesalpinaceae, Polygonaceae, Rutaceae, Thunbergiaceae, Acanthaceae, Rhamnaceae, Graminaceae, Solanaceae, Compositae, and Myrtaceae were identified as melliferous plant species in the study sites (Table 1).

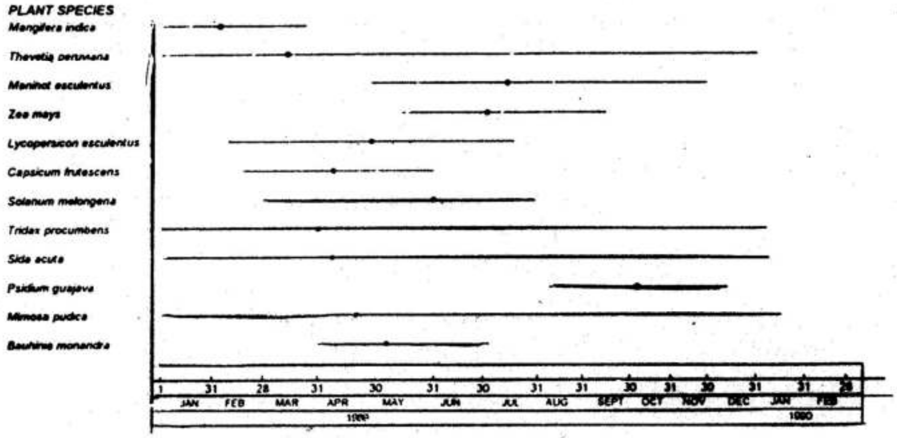
Most of these plant species occurred in the same area with some flowering sequentially, while other flowered synchronously (Fig 1 a,b). The flowering periods of *Antigonon leptopus, Ceiba pentandra, Mangifera indica, Citrus aurantifolia* and *Citrus sinensis* were sharply distinct from each other, but the flowering periods of other species like *Peltophorum pterocarpum, Parkia clappertonia ,Antigonon leptopus, Mangifera indica* broadly overlapped. Some of the plant species, *viz Mimosa pudica, Sida acuta, Tridax procumbens, Justicia flava and Thevetia peruviana* flowered throughout the year.

Frequency of *Apis mellifera adansonii* visits to melliferous plants.

Table 2 provides a summary of frequency visits by *Apis mellifera adansonii* on the melliferous plant species. The results indicated that plant species which provided nectar or nectar and pollen had more bee visits than those which provided only pollen. However, some flowering plants with relatively less conspicuous flowers such as *Tridax procumbens, Sida acuta, Lycopersicon esculentus, Solanum melongena,* were amongst the least attractive. *Peltophorum*

TABLE 1 MELLIFEROUS PLANT SPECIES IDENTIFIED IN THE STUDY SITES

PLANT SPECIES	COMMON NAME	FAMILY	FLORAL REWARD
Peltophorum pterocarpum (L)	Rush tree	Caesalphinaceae	Pollen
Antigonon leptopus (Hook)	Coral vine (Ahomahoma)	Polygonaceae	Nectar
Citrus aurantifolia (Christina)	Lime	Rutaceae	Nectar, Pollen
Citrus sinensis (Osbeck)	Sweet orange	Rutaceae	Nectar, Pollen
Justicia flava (Vahl)	Aama	Acanthaceae	Nectar
Thunbergia offinis (Lindl)		Thunbergiaceae	Nectar
Parkia clappertonia (Keay)	African Locust bean	Mimosaceae	Nectar, Pollen
Moringa oleifera (Lam)	Horse radish (Drumstick tree)	Moringaceae	Nectar
Ceiba pentandra (L)	Silk cotton tree	Bombaceae	Nectar
Setracreasea purpurea (L)	Purple Heart	Commelinaceae	Pollen
Salanema excelsa (L)	Aposorompo	Rhamnaceae	Nectar
Gradiramus nigruma (Jacq)	Nkasaenkasae	Rhamnaceae	Pollen
Mangifera indica (L)	Mango	Anacardiaceae	Nectar
Thevetia peruviana (Pers)	Yellow oleander (Milk bush)	Apocynaceae	Necta
Manihot esculentus (Crentz)	Cassava	Euphoribiaceae	Pollen
Zea mays (L)	Maize	Gramineae	Pollen
Lycopersicon esculentus (Mill)	Tomato	Solanaceae	Nectar
Capsicum frutescens (L)	Pepper	Solanaceae	Nectar, Pollen
Solanum melongena (L)	Egg plant	Solanaceae	Pollen
Tridax procumbens (L)	Kuryngeal daisy	Compositae	Nectar
Sida acuta (L)	Tweta	Compositae	Nectar, Pollen
Psidium guajava (L)	Guava	Myrtaceae	Nectar, Pollen
Mimosa pudica (L)	Sensitive plant	Mimosaceae	Pollen
Bauhinia monandra (Kurtz)	Pink Bauhinia	Caesalphinaceae	Nectar



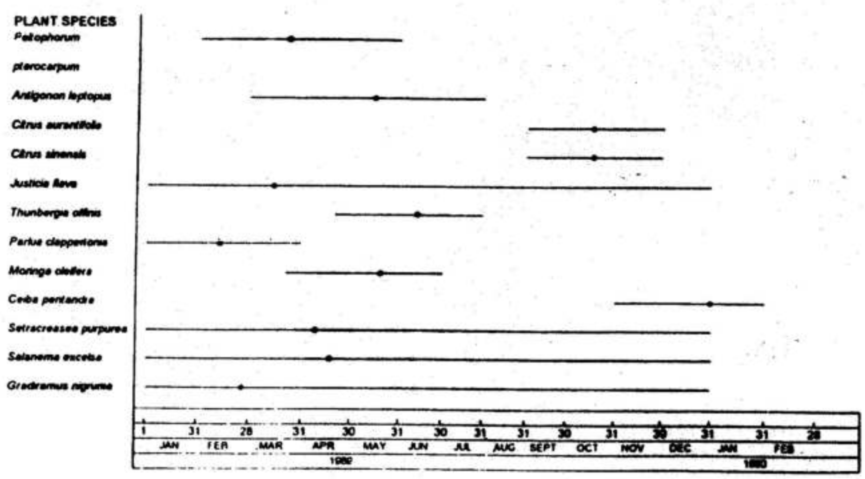


Fig. 2 (a, b) THE FLOWERING PHENOLOGY OF MELLIFEROUS PLANT SPECIES IN THE HUMID FOREST AREA, KUMASI BETWEEN 1989 - 19990. THE SOLID CIRCLES REPRESENT DATES OF PEAK FLOWERING. PEAK FLOWERING WAS DEFINED AS THE PERIOD DURING WHICH AT LEAST 50% OF THE PLANT SPECIES WERE IN FLOWER.

TABLE 2 FORAGING FREQUENCY OF *Apis mellifera adansonii* (JANUARY-DECEMBER, 1990). THE MEANS ARE BASED ON THE TOTAL OF DAILY HOURLY COUNTS BETWEEN 08.00 AND 18.00 HOURS G.M.T. DURING THE FLOWERING PERIOD OF THE PLANT SPECIES. ARRANGEMENT IS BASED ON MANITUDE OF BEE VISITS

PLANT SPECIES	FAMILY	X NO. PER DAY ± S.E	%
Peltophorum pterocarpum	Caesalpinaceae	142.5±3.50	9.67
Citrus aurantifolia	Rutaceae	134.2±3.65	9.11
Citrus sinensis	Rutaceae	125.8±3.65	8.54
Antigonon leptopus	Polygonaceae	117.5±2.75	7.98
Justicia flava	Acanthacaea	112.5±2.92	7.64
Thevetia peruviana	Apocynaceae	104.2±2.54	7.07
Psidum guajava	Myrtaceae	92.3±2.27	6.26
Manihoi esculentus	Euphorbiaceae	91.6±2.17	6.22
Thunbergia offinis	Thunbergiaceae	84.3±2.35	5.72
Parkia clappertonia	Mimosaceae	77.5±1.15	5.26
Setracreasea purpurea	Commelinaceae	66.7±1.25	4.35
Moringa oleifera	Moringaceae	57.2±1.19	3.88
Gradiramus nigruma	Rhamnaceae	51.6±1.03	3.50
Bauhinia monandra	Caesalphinaceae	42.4±1.18	2.88
Capscicum frutescens	Solanaceae	34.2±0.64	2.33
Salanema excelsa	Rhamnaceae	34.2±0.53	2.32
Zea mays	Gramineae	25.0±0.51	1.70
Mangifera indica	Anacardiaceae	22.5±0.42	1.53
Lycopersicon esculentus	Solanaceae	21.3±0.39	1.44
Solanum melongena	Solanaceae	16.1±0.15	1.09
Tridax procumbens	Compositae	11.5±0.10	0.78
Sida acuta	Compositae	4.2±0.03	0.28
Mimosa pudica	Compositae	3.7±0.01	0.25

pterocarpum, which provided only pollen, was visited most frequently. The maximum hourly count (142.5 ± 4.5) which represented about 10% of all the bees visits was recorded on the flowers of this plant.

The peak period of flowering of *P. pterocarpum* broadly overlapped with *Justicia flava, Setracreasea purpurea, Salanema excelsa, Thunbergia offinis, Thevetia peruviana, Solanun melongena, Sida acuta* and *Mimosa pudica* which flowered earliest. Most of these species provided only nectar as a floral reward.

Diurnal foraging Pattern of *Apis mellifera adansonii*

The data on hourly visits to *Peltophorum pterocarpum, Antigonon leptopus* and *Citrus sinensis* by the bee was plotted to show the diurnal foraging pattern of the honeybee in the tropical environment (Fig 2a,b,c). *P. pterocarpum* and *A. leptopus* offered only pollen and nectar respectively,while *C. sinensis* presented both pollen and nectar. The pattern of foraging, whether foraging for pollen or nectar was bimodal (Fig 3a,b,c) On all plant species the morning peak occurred before mid-day and afternoon peak was between 14.00 and 16.00 hours. Relatively high sustained bee activity occurred between 10.00 and 16.00 hours. Except for *C. sinensis* bee activity was not observed earlier than 08.00 hours.

Foraging Rates

Table 3 gives results of observations made for the bees' visits to *Salanema excelsa, Peltophorum pterocarpum, Gradiramus nigruma, Thunbergia offinis, Justicia flava, Antigonon leptopus, Setracreasea purpurea* and *Thevetia peruviana*. The foraging rate of the bee depended on the plant species they worked on. The bees worked much more slowly when collected pollen than when foraging for nectar. On average foraging rate on the different plant species when collecting pollen appeared very similar, about 10 flowers per minute (Table 3).

The rate of feeding on nectar varied, possibly due to availability of nectar. On *Salanema excelsa, Justicia flava* and *Antigonon leptopus*, where nectar was relatively more abundant and exposed, the bees visited more flowers per minute (between 24 and 25 flowers) than on *Thunbergia offinis* (about 15 flowers per minute) where nectar was less available (Table 3).

The Effect of Temperature and Relative Humidity on the Foraging pattern of *Apis mellifera adansonii.*

The results (Fig 3) indicated that the response to temperature and humidity by the bee did not vary on the different plant species. The general trend was that the proportion of the bees observed foraging increased with rise in temperature and decreased in relative humidity during the day. .

The Effect of Cloudy and Sunny Conditions on the Foraging activity of *Apis mellifera adansonii*

The results of the study are illustrated in Fig 4. The results indicated that *A. mellifera adansonii* was affected by the changing weather situations. Its numbers were substantially reduced during periods of cloud cover even though the temperatures remained high for bee activity during clear weather conditions.

Dicussions

The results of the number of bees visiting the different melliferous plant species in the study generally agreed with the observation that many insects, including honeybees, are attracted to flowers by the nectar they produce than by pollen [Pervical, 1965]. However, for *P. pterocarpum* the greatest cues which could have influenced a greater number of bees to its flowers appeared to be factors such as floral size. Its flowers were relatively large and conspicuous, and was visited most by the bees, even though it provided only pollen as floral reward.

The diel pattern of insect visits to plants may be directly influenced by environmental factors as well as the fluctuations in availability of food [Corbet, 1978; Willmer, 1983]. Willmer [Willmer, 1982a; 1082b; 1983] has provided evidence to support the view that the interactions between thermal balance and diel rythmicity is responsible for many of the patterns of insects' activity seen in nature. Linsley [1978] has also reported that several species of bees display bimodal (morning and late afternoon) activity patterns, which could also be explained in terms of thermal constraints. The effect of climatic factors on the temporal foraging patterns of *Apis mellifera adansonii* was evident in this study. The bee displayed bimodal foraging pattern on plants regardless of the foraging bee may be due to avoidance of overheating resulting from high ambient temperature and metabolic heat. The high daily tropical temperatures as pertains in the

Fig 3 : TEMPERATURE AND RELATIVE HUMIDITY IN THE VICINITY OF *C.sinensis*, *P. pterocarpum*, AND *A. leptopus*.

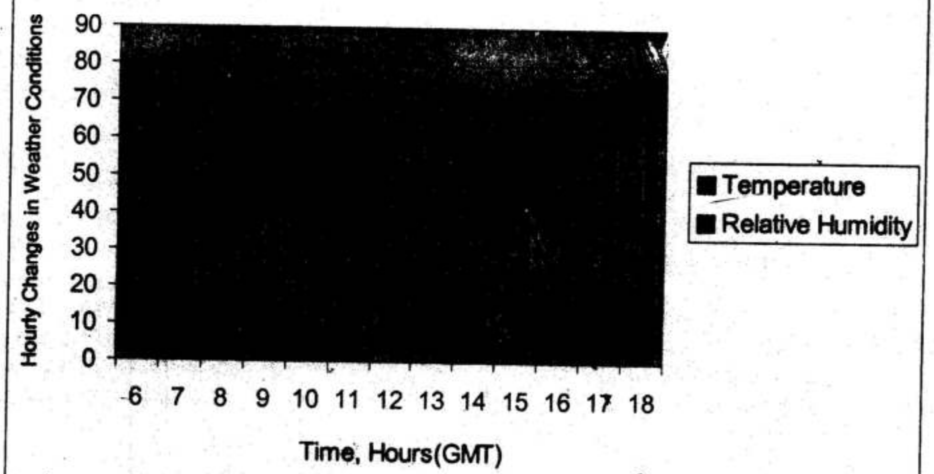


Fig 4 :EFFECT OF WEATHER CONDITIONS ON THE FORAGING OF *Apis mellifera adansonii* ON FLOWER O F *S. excelsa*. THE BEES WERE OBSERVED FOR 10 MINUTES DURING EACH OF THE TMES INDICATED.

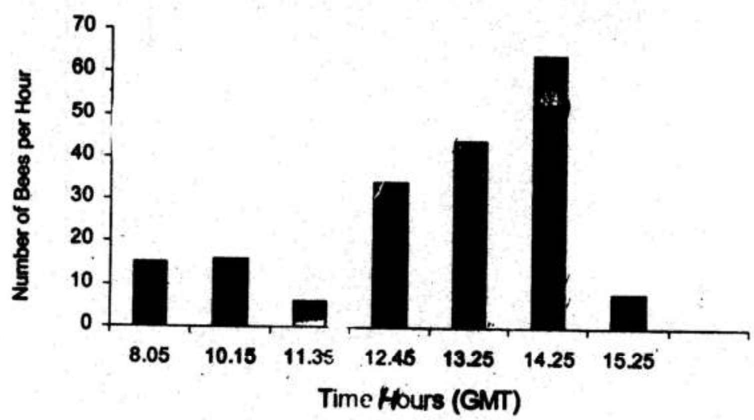


Figure 2abc: Diurnal Pattern of *A.m.adansonii* Visit to *Peltrophorum pterocerpum, Antigonon leptopus, Citrus sinensis*. The Bees were Observed for 40 minutes during each hour

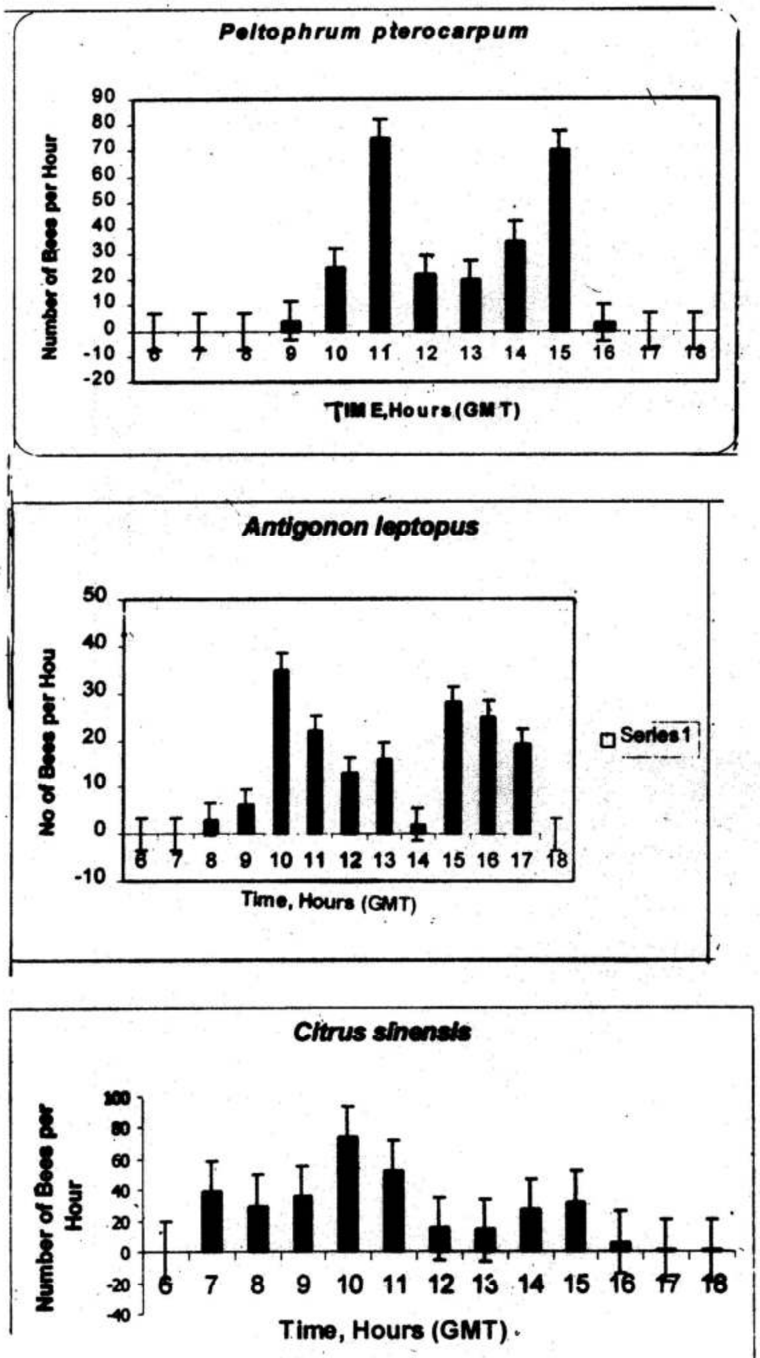


TABLE 3 FORAGING RATES OF *Apis mellifera adansonii* ON MELLIFEROUS PLANT SPECIES. ARRANGEMENT BASED ON FLORAL REWARD

PLANT SPECIES	FLORAL REWARD	X ± S.E. TIME (SECS) SPENT PER VISIT PER FLOWER	X NO. OF FLOWERS PER MINUTE
Salanema excelsa	Nectar	2.0 ± 0.05	24.5
Thunbergia offinis	Nectar	2.1 ± 0.03	15.0
Justicia flava	Nectar	2.2 ± 0.01	25.6
Antigonon leptopus	Nectar	2.5 ± 0.01	25.4
Thevetia peruviano	Nectar	7.5 ± 0.24	10.0
Peltophorum pterocarpum	Pollen	7.6 ± 0.20	8.5
Gradiramus nigruma	Pollen	6.02 + 0.3	10.0
Setracreasea purpurea	Pollen	7.2 ± 0.21	10.5

study may often limit bee activity to early and later parts of the day. Low temperature, wind, rain, wet conditions and low light intensity, have been associated with below average numbers of European honey bees foraging on flowers [Free, 1970; Willmer, 1983]. Data from our study agree with these observations.

Conclusion

This study has revealed that in humid forest zone of Ghana many melliferous plant species are annual and perennial weed plants found in cultivated or abandoned farm areas. These plant species, which grow sympatrically and flower sequentially, make pollen and nectar and pollen throughout the year coupled with good weather conditions demonstrates the tremendous beekeeping potential of the forest zone of Ghana.

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