INVESTIGATING POLLEN PELLETS AND HONEY SAMPLE FROM AN APIARY IN IBADAN, SOUTHWEST NIGERIA

P. A. Adeonipekun
Palynology/Palaeobotany Unit, Department of Botany
University of Lagos, Nigeria,
p1adeonipekun@yahoo.com and aadeonipekun@unilag.edu.ng

ABSTRACT

To further characterise Nigerian honey samples and bee pollen pellets, three modern beehives in an apiary at the International Institute of Tropical Agriculture {IITA} Ibadan were studied. Pollen pellets and a sample of the produced honey were palynologically studied. Pollen from 43 species of plants belonging to 24 families was recovered from the pellets and honey sample studied. Within the first two months of collection, 24 species were recorded for the pellets, out of which only nine were recovered from the honey sample analysed. Size seems significant in determining which pollen grains are found in honey samples even though they are abundantly collected by bees. The average size of pollen grains found in the honey sample in this study is 47.2 µm while that in pollen pellets is 96.14 µm. This size differential may mean that the larger pollen might have been destroyed through the sieving and other production processes or possibly as a consequence of the bees' digestive process. The pollen of Elaeis guineensis, Tridax procumbens, Nymphaea lotus, Combretum spp. and Chromolaena odorata were the commonest in the pollen pellets. The results obtained here are comparable with those from others who have carried out similar studies.

KEY WORDS: Apiary, Honey Bees, Pollen Pellets, and Honey Pollen.

INTRODUCTION

It is no longer news that pollen grains and other microscopic constituents are found in honey. These palynological components of honey have been used to recognize the botanical and ecological origins of honey samples.

Sowunmi {1976} cited the works of Louveaux, *et al*., 1970, who analyzed the scope and application of melissopalynology and noted the problems of over- and under- representation of palynological constituents in honey. They made recommendations towards solving these problems. Most of the published works on the ecological and botanical origins of honey as deduced from its palynological constituents have come mainly from European countries. Not much has come from Africa probably due to shortage of manpower or because apiculture is yet to be fully commercialized in Africa. The first melissopalynological study from Africa was that of Smith 1956 as reported by Sowunmi {1976}. Smith identified the botanical and ecological origins of honey samples from Tanzania. Also quoted by Sowunmi {1976} was the work of Zander, 1941 who in a study of fossilized honey from an Egyptian tomb recovered the pollen of some extant Egyptian plants known to be visited by bees. Afolabi {1974}, in the first study of Nigerian honey samples pointed out the significance of the Arecaceae (Palmae) and Asteraceae (Compositae) families in the foraging habits of bees because species in these two families were most frequently foraged by bees. Sowunmi {1976}

ascertained the botanical and ecological origins of Nigerian honey samples. The pollen recovered, as pointed out by Sowunmi {1976}, showed the characteristic species diversity of the tropics relative to the temperate countries with low diversity. Sowunmi {1976} indicated that most honey produced in Nigeria come from the savanna regions which are characterized by open vegetation dominated by grasses, with scattered shrubs and trees. Agwu and Akanbi {1985} indicated that the period of honey production by bees in Nigeria was during the dry season i.e. September to April. This is because that period coincides with the flowering periods of many plants the bees forage.

Adeonipekun {1989} revealed that the nature and age of bee colonies determine the activities of bees in pollen collection. Bees from an old and defensive colony collected a higher number of pollen grains than a young and gentle colony. Bees from an old colony were more specific in the pollen types collected, while those from a young colony showed a higher diversity of pollen. Adeonipekun {1989} also indicated that bees tend to show a preference for the pollen of weeds. Stanley and Linskens {1974} have shown that bees collect pollen for food because of its essential elements for reproduction. Proteins and lipids contained in pollen also make it essential for normal growth and development. Stanley and Linskens {1974} also cited the works of other workers such as Kropacova *et al.*, 1968, and De Groot, 1958 which have shown the significance of pollen in the diets of bees. Mutsaers {1988} reiterated that only nectar was used in honey making by bees while pollen was used as food due to its protein content. The work of Ayodele *et al*. {2006} on honey samples revealed that there is a relationship between size and pollen population where they are inversely proportional, and no relationship between population and viscosity, and density. Adekanbi e*t al*. {2009} applied melissopalynology to decipher the nectar sources of African honey bees - *Apis mellifera adansonii.* They reported the predominance of pollen of *Elaies guineensis* and *Tridax procumbens* in their melissopalynological preparations.

This study is another contribution to melissopalynology in Nigeria, and is aimed at establishing further the plants visited by bees, both through the pollen found in honey and those in bee pollen pellets/loads. An attempt will also be made to ascertain possible factors that influence the presence or absence of pollen in honey.

MATERIALS AND METHODS

The materials used in this study -- beehives, pollen pellets and one honey sample -- were supplied by the courtesy of Mrs Marieke Mutsaers (a beekeeper). They were obtained from the apiary of *Apis mellifera* bees in the forest of The International Institute for Tropical Agriculture (IITA), Ibadan, managed by her. Three beehives at two different locations, namely A (1A and 2A) and B (3B) were sampled. Hives at locations A and B are approximately 1 km apart in the northern part. (Fig. 1)

Location A is closer to a cocoa and colanut farm, while location B was directly under a *Berlinia grandifolia* tree. This tree was in bloom almost throughout the sample collection period. Other plants which bloomed within the experimental areas included *Triplochiton*

scleroxylon, *Milicia excelsa*, *Ceiba pentadra*, *Combretum* spp, *Tridax procumbens*, *Synedrella nodiflora*, *Nymphaea lotus*, grasses and sedges.

The methodology adopted for this work was in three major parts: the field work (sample collection in the IITA forest); laboratory work; and microscopic study.

1. *Collection of samples*:
   (a) Pollen Loads – Collection was done fortnightly by fixing at the entrance of hives pollen traps made of perforated rectangular plastics with holes small enough to allow only the bees with few pellets in, but not all the collected pollen pellets packed as loads in the concave-shaped femur on their legs. (See Plates 1 and 2). The modified entrance was in place between 5 pm and 6 pm each day for a period of four months. The dropped pollen pellets were collected at the same time the following day. A total of 20 samples of pollen pellets were collected.

   (b) One honey sample collected from Hive 2A produced about one and halve months after the commencement of collection was used as guided by the beekeeper.

2. *Laboratory work*:
   (a) Pollen pellets - Each sample was subjected to Ertdman's {1969} acetolysis process.

   (b) Honey Sample - Two to three mls of glacial acetic acid was introduced into a centrifuge tube containing a bit of the honey sample. The resultant mixture was centrifuged and the residue acetolysed as in (a) above. The treated residue was washed thoroughly with distilled water. 50% glycerine was added to the residue in the final washing and the mixture was centrifuged. 100% glycerine was added to the final residue which was then stored in a vial.

3. *Microscopic Analysis*:
   The stored sample was centrifuged to remove the 100% glycerine and drained over filter paper for 30 minutes. Mounts in glycerine jelly were made on glass slides. Two small pieces of plasticine balls were placed on the slides before the cover slips were lowered to reduce the pressure on the pollen grains. The mounts were sealed with paraffin wax to prevent the entry of contaminants. A light microscope was used for analysis and identification was done with the aid of the over 3000 pollen reference slides of present day Nigerian species at the Palynology Unit of the Department of Archaeology and Anthropology, University of Ibadan and published photomicrographs of extant pollen grains.

For the quantitative study, 20 microlitres of each stored pollen pellets sample solution was mounted on slides. A random sampling of six different fields of view was undertaken because of the abundance of pollen grains, and the pollen types and numbers were noted. The average number of each species per field of view was obtained from the six sampled fields of view. The total number of each species was then calculated based on the total number of fields of view. Identification was possible to species level in most cases while some remained unidentified. The pollen constituents of pollen pellets and honey were then compared.

RESULTS

The highest values of density, frequency and abundance were recorded for *Elaies guineensis*, *Tridax procumbens, Nymphaea lotus, Combretum* spp. and *Chromolaena odorata* from the treated pollen pellets (Table B).

Pollen grains from 43 species belonging to 24 plant families were recovered from the pollen pellets and the honey sample. Within the first six weeks, 24 species of pollen grains were recovered from the pellets, while only nine of these were found in the honey sample produced from that pollen collection (Table D).

Large grains, with average size of 96.1 µm, were found only in pollen pellets while smaller grains, with average size of 47.2 µm, were recovered from the honey. However, *Triplochiton scleroxylon* pollen was not recovered from the honey sample but found in the pellets despite its small size of 17.4 µm.

A very significant pollen grain – *Motandra guineensis* – was found in the honey but absent from the pollen pellets.

Highest percentages of pollen grains were recorded during the driest period, being 18.2% and 23.8% respectively in late December and early January. Lowest values, 2.0% and 2.2 % were recorded in early March. (Table C and Fig. 2) The *Apis mellifera* bee was observed to forage close plants such as *Triplochiton scleroxylon*, *Melicia excelsa*, *Ceiba pentandra* and *Combretum* spp. blooming around location **A** and *Berlinia grandifolia* growing on top of location **B**. No recovery of pollen of cocoa and colanut trees from their plantations within the experimental sites was recorded.

DISCUSSION

The high abundance, frequency and density values of *Elaies guineensis*, *Tridax procumbens, Nymphaea lotus, Combretum* spp. and *Chromolaena odorata* from the pellets show that these plants are the most frequently visited by bees in the study area in Southwest Nigeria.

E. guineensis – in spite of being a tree and mainly anemophilous was foraged by bees most probably because they were attracted by the sweet odour of the pollen. Rajesh *et al*., {2001} reported that weevils were found to mediate the pollination of *E. guineensis* because of its "fennel-like fragrance" together with wind. Ige *et al*. {2010} reported that *E. guineensis*

dominated four of the 20 honey samples from central Nigeria they worked on. *Tridax procumbens* – a road side, cultivated land and waste places' weed - was foraged because it flowers all-year round and bees are attracted by its creamy inflorescences. *Combretum* spp. – were abundant in the experimental area as ornamentals and weeds. The liane flowers borne in horizontal orientation form a bunch-like inflorescence with pink colour that is very attractive to bees. It is therefore not necessarily the abundance of this plant in the experimental area that accounts for its high pollen values in the pellets and honey. This is because both *Glyricidia sepium* and *Cola* sp. which were also abundant and flowered profusely in the area were not foraged as their pollen were not recovered from either the pollen pellets or honey. Their (*Combretum* spp.) abundance might be due to their well displayed inflorescence and fragrance. This genus was also second most prominent among pollen recovered by Ige *et al*. {2010}. *Combretum paniculatum* which flowers in December and January; *C. hispidum* – January; *C. racemosum* – January; and *C. smeathmanii* - December {Hutchinson and Dalziel, 1954} are the likely species represented in this collection due to their coinciding flowering periods. *Nymphaea lotus* – is an abundant aquatic weed in the nearby lake. It has conspicuously held large flowers with abundant pollen production. The bees were attracted to the brightly white flowers held upright above the surface of the water. *Chromolaena odorata* - a road side and path weed in the rain forest - is foraged due to its brightly whitish disk floret flowers and the preference of its nectar by bees. Crane *et al*. {1984} reported that *C. odorata* is a good nectar source for bees in Burma and Thailand, but its pollen are not collected by bees. Souza Novello, 1981 was quoted as listing *C. odorata* as an important source of pollen and/or nectar for bees Anonymous {2010}. Its high recovery in the pollen pellets and presence in the honey sample studied in this work therefore indicate that they were deliberately collected by bees and not accidental.

From this revelation of the importance of our so-called weeds in honey production by bees, farmers need to be encouraged to practice beekeeping on their farms during the dry season when farming activity ceases. The income generated from beekeeping will sustain them before the rains come and be useful in meeting the costs of weeding and land clearing.

The high diversity of pollen types recovered from the pollen pellets and honey sample studied is unequivocally an indication of the high species diversity of tropical vegetation in contrast to that of temperate regions as earlier reiterated by Sowunmi {1976}. Sowunmi {1976} reported that 50 pollen types were identified in only six honey samples she worked with. This finding according to Sowunmi, {1976}, contrasts with figures from some temperate countries such as 58 pollen types in 54 Louisiana honey samples Lieux, 1972 and 67 types in 130 Luxemburg samples Maurizio, 1971. The availability of these varieties improves the efficiency of the bees for they need not travel far for pollen and nectar and it also increases the nutritional richness of the food sources for both the brood and the adult bees. Thus the honey is multifloral. By the same token, tropical honey has high nutritional value since pollen contains a variety of essential elements, proteins and lipids {Stanley and Linskens, 1974}. Also trado-medically, honey samples from certain areas are preferred by users and raw honey still in honeycombs are most times preferred in making herbal concoctions. This is believed to be natural, hence the search for wild bees by traditional

healers in Nigeria. This belief is given credence by the scientific report of Efem *et al*. 1992 that unprocessed honey i.e. raw honey "inhibited most of the fungi and bacteria" that cause surgical and wound infections Challem {1995}. They however, did not give the result of processed honey. A disadvantage of multifloral honey however, is the difficulty in detecting the "culprit" pollen in an allergy case suspected to be caused by a honey sample. A biochemical test of pollen pellets or loads of the used hives or foraged plants is therefore desirable to verify which has the allergy causing substance. Evidently, the problem is less likely to arise with a unifloral honey since a particular species dominates.

The nine species of pollen recovered from the honey out of the 24 species in the pellets indicate that the size of a pollen grain is one of the significant factors determining its preservation, presence and eventual recovery in honey. This is because the average size of pollen as found in the studied honey is 47.2 µm while that of the pollen pellets is 96.1 µm. The average pollen size in honey samples studied by Adekanmbi *et al.* {2009} is 47.7 µm. Ayodele *et al*. {2006} also made similar observation when they found that in honey samples they worked on, there was an inverse relationship between pollen size and population and no relationship between population and viscosity, and density. Small-sized grains were more in population than large-sized grains in their honey samples. In the present work, the large-sized pollen grains of *Nymphaea lotus* with average size of 58µm, and the third most frequently collected by the bees were abundant in the pollen pellets but were not recovered from the honey. Similarly, the gigantic grains of *Manihot* sp. (290µm diameter) and *Sida* sp. (145 µm diameter) also occurred frequently in the pollen pellets but were not recovered from the honey. This does not mean that large-sized pollen was not originally present in the honey, but they probably had been destroyed beyond recognition during the extraction of honey by the beekeeper. The recovery of the fragmented pollen of *Dombeya buetneri*, which has an average diameter of 87 µm in the studied honey in this work, lends support to this view. The general belief therefore, that size determines the abundance of pollen in honey {Domianowics 1964 cited by Agwu and Akanbi, 1985} may not be totally correct. Rather, size only determines the recovery and not the abundance of pollen in honey.

Another important observation in this work is the non-recovery of the small-sized pollen grains of *Triplochiton scleroxylon* (17.4 µm diameter) from the honey sample though they were very abundant in the pellets. This shows that obviously not all pollen types collected by bees are contained in the honey, indicating that the pollen content of honey is only a partial, though important reflection, of plants visited by bees.

It is significant to note that the pollen grains of *Motandra guineensis* - were found in the honey but absent from the pollen pellets. The absence of this pollen in the pellets is due to its flowering period not coinciding with the time pollen pellets were collected. This is because Schmelzer and Gurib-Fakin {2008} indicated that the flowering period falls between the end of dry season and beginning of wet season. Meanwhile, the collection period was mainly during the peak of dry season which precluded its being collected by bees during this time. Despite its small size (29µm), its inclusion in the honey may likely be due to contamination by wind during extraction process and/or transportation by the beekeeper. This is because a

reconnaissance of the area of study showed that the plant grows in the vicinity. If indeed this is a contamination, it means that beekeepers should take extra caution such as processing in air-conditioned room to prevent poisonous or allergenic pollen from polluting the processed honey. It is also possible to have been collected by bees during its flowering period and kept in the hive since bees store pollen in some of their comb cells as observed by this author. This is because *M. guineensis* flowers are fragrant and have a white to greenish corolla tube {Schmelzer and Gurib-Fakin, 2008} which are attractive features to bees and therefore make its pollen a candidate bee favorites.

The foregoing confirms earlier reports that pollen is collected by bees for food and not for honey production. Even the pollen collected and kept in the comb, as observed by this author, was sealed with nectar probably to prevent them from mixing with the produced honey.

The report of Stanley and Linskens {1974} that low temperature and rainfall lower the activity of bees in pollen collection was also confirmed in this work. The driest period of the collection – late December to early January – recorded the highest proportions of pollen. From February to March when the rains set in, pollen collection decreased sharply. The dry periods coincide with the flowering periods of many plants (Fig. 2). With the highest production of pollen and collection by bees during the dry season (September – April) as reported by Agwu and Akanbi {1985} and confirmed by this present work, farmers can conveniently make more money during this period through beekeeping. Beekeepers alike can also plan towards higher yields with this knowledge. From this work also, low humidity tends to enhance pollen collection. The relationship is not as linear as that with rainfall, probably due to the short period covered in this work. However, bees are known to be inactive in high humidity conditions particularly when this coincides with low temperature.

Several workers have reported the wide-range flight by bees. The findings from this work however, show that bees prefer to forage close to their hives rather than at farther distances, as long as flowers in their vicinity have good nectar and pollen sources, appropriate flower-opening period and floral attractiveness as well as upright inflorescence positioning. Such short-distance foraging economises the energy spent in flying, which is a great advantage. The only distant plant whose pollen was collected is *Parinari* sp. *Parinari* spp. are savanna plants. In view of a reconnaissance of the vegetation of the experimental area and the non-availability of a record of the vegetation of the IITA, two possibilities are hereby suggested: (i) Since species of *Parinari* are found in Oyo town, which is about 40km away from Ibadan, the bees probably traveled that distance to collect the pollen, (ii) Alternatively, a species of the genus may occur between Oyo and Ibadan or within the IITA forest. This can only be confirmed by a thorough vegetation study of intervening region and the IITA forest. Nevertheless, 99% of pollen recovered belongs to the rainforest ecosystem, which confirms the bees' preference for nearby pollen and nectar than distant ones when the former are readily available, accessible and nutritive.

CONCLUSION

The abundant recoveries of the pollen of *Elaies guineensis, Tridax procumbens*, *Nymphaea lotus*, *Combretum* spp. and *Chromolaena odorata* both from honey and pollen pellets are unequivocal evidences of the significance of these plants as honeybee pollen and nectar suppliers in southwestern Nigeria. Since four of these plants are weeds farmers who practice bee keeping can make additional and much-needed money to offset the cost of other agricultural activities.

The richness of the tropical vegetation, in which there is also flowering all-year round, is again reflected in the honey and pellet samples studied. This is an advantage to the bees for it will improve the hive economy since bees do not have to travel long distances to forage; furthermore as one plant's flowering period expires, they can change to another. Record of 99% rainforest species recovery from pellets and honey sample further confirm that bees prefer close forage to farther ones.

Though the non-recovery of large-sized pollen grains from the honey sample does not mean that they were not originally in the honey, size is an important factor which influences their recovery from honey but not their presence and abundance. Large-sized grains, which were in the pollen pellets were not found in the honey, most probably because the exine (wall) was fragmented beyond recognition during the process of honey extraction. Consequently, the pollen pellets and loads or pollen of foraged plants may have to be subjected to biochemical treatments in order to ascertain which pollen is allergenic in a particular honey sample, since the cellular components of the destroyed pollen would be in the honey.

The non recovery of certain pollen from the honey sample but contained in the pellets confirms further that pollen are used for food and not for honey production by bees. Moreover, it shows that pollen recovered from honey is only a partial, though important representation of the plants visited by bees. Average pollen size in the honey sample is 47.2 µm while that of the pellets is 96.1 µm.

The dry season is further confirmed as the time for honey production in Nigeria because rainfall lowers bee activity. Beekeepers need to take good precaution during processing to avoid contamination.

ACKNOWLEDGEMENT

The assistance of Prof. M. A. Sowunmi in editing the manuscript and the identification of some of the palynomorphs is appreciated.

REFERENCES

Adeonipekun, A. P., 1989. Palynological study of an Apiary in Ibadan, Nigeria. B.Sc. (Hons) Project. Department of Botany and Microbiology, University of Ibadan, Nigeria. 60pp.

Adekanmbi, O. and Ogundipe, O., 2009. Nectar sources for the honeybee (*Apis mellifera adansonii*) revealed by pollen content. *Not. Bot. Hort. Agrobot. Cluj* 37 (2): 211-217.

Afolabi, A.O. 1974. A palynological investigation of various Nigerian honey samples. B.Sc. (Hons) Project. Department of Botany and Microbiology, Univ. of Ibadan, Nigeria.

Agwu, C. O. C. and Akanbi, T. O., 1985. A palynological study of Honey from four vegetational zones of Nigeria. *Pollen et Spore* 27 (3- 4): 335-348.

Ayodele , M. S.; Folarin , O. M. and Oluwalana, S. A., 2006. Pollen population, viscosity and density of locally produced honey. *Tropical Science*, 46 (4): 192 - 194.

Anonymous, 2010: *Chromolaena odorata* (L.) R. M. King & Robinson (syn: *Eupatorium odoratum* L.) Retrieved on 11 October, 2010 from *http://chalk.richmond.edu/flora-kaxil-kiuic/c/chromolaena_odorata.html*

Challem, J., 1996. Medical Journals Document Value of Bee Propolis, Honey and Royal Jelly. *Nutrition Reporter™* . Retrieved on 7 September, 2010 from *http://www.thenutritionreporter.com/bee_stuff.html.*

Erdtman, G., 1969. *Handbook of Palynology*. Munksgaard, Copenhagen, 209 pp.

Hutchinson, J. and Dalziel, J. M., 1954. *Flora of West Africa,* vol. I, part 1, 2nd edn. Revised by F. N. Hepper, Crown Agents, London.

Mutsaers, M., 1988. Beekeeping and Palynology. *Third Annual National Conference of the Palynological Association of Nigeria*, Univ. of Ibadan, Ibadan, Nigeria.

Ige, O. E. and Modupe, T. O., 2010. Pollen Characterisation of honey samples from north central Nigeria. *J. Biol. Sci.* 10: 43-47.

Schmelzer, G. H. and Gurib-Fakin, A., 2008. *Medicinal plants*. Plant Resources of Tropical Africa (Program). 792 pp. Retrieved on 6, December, 2010 from *http://books.google.com.ng/motandra guineensis*

Sowunmi, M. A., 1976. The potential value of honey in paleopalynology and archealogy. *Rev. Palaeobot. Palynol*. 21: 71-185.

Stanley, R.G. and Linskens, H. F., 1974. *Pollen: Biology, Biochemistry and Management*. Springerverlag New York, Heidelburg Berlin. 307pp.

TABLE B: SHOWING FREQUENCY, DENSITY AND ABUNDANCE OF POLLEN TYPES

NO	PLANT SPECIES	(Z) FREQUENCY	ABUNDANCE	DENSITY
1.	***Albizia zygia***	**20**	**0.3**	0.1
2.	***Anthonotha sp.***	**5**	**0**	0
3.	***Aspilia africana***	**35**	**1**	0.3
4.	***Berlinia grandiflora***	**25**	**2**	0.5
5.	***Boerhavia diffusa***	**35**	**0.6**	0.2
6.	***Bosqueia angolensia***	**10**	**1.7**	0.3
7.	***Cajanus cajan***	**10**	**1**	0.2
8.	***Cassia sp.***	**5**	**3**	0.2
9.	***Ceiba pentandra***	**5**	**1**	0.1
10.	***Milicia excelsa***	**10**	**16**	0.8
11.	***Chromolaena odorata***	**50**	**1.8**	0.8
12.	***Clausena anisata***	**15**	**1.3**	0.3
13.	***Combretum spp .***	**35**	**7.3**	2.6
14.	***Dombeya buettneri***	**40**	**1.0**	0.4
15.	***Elaeis guineensis***	**85**	**18**	15.3
16.	***Entada abyssinica***	**35**	**0.7**	0.3
17.	***Ipomoea mauritiana***	**5**	**0**	0
18.	***Jasminum sp.***	**10**	**0**	0
19.	***Jatropha sp.***	**25**	**0.2**	0.1
20.	***Jussiaea sp.***	**5.0**	**0**	0
21.	***Manihot sp.***	**35**	**0**	0
22.	***Newbouldin laevis***	**10**	**1**	0.1
23.	***Nymphaea lotus***	**50**	**2.6**	1.3
24.	***Lepistemon sp.***	**5**	**1**	0.1
25.	***Parinari sp.***	**5**	**1**	0.1
26.	***Polygonium sp.***	**40**	**1.1**	1.5
27.	***Paullinia pinnata***	**15**	**1**	0.1
28.	***Potulaca oleraceae***	**15**	**0**	0
29.	***Sapotaceae***	**5**	**3**	0.2
30.	***Sida sp.***	**25**	**0.3**	0.1
31.	***Synedrella nodiflora***	**5**	**1**	0.1
32.	***Talinum triangulare***	**25**	**1**	0.3
33.	***Tridax procumbens***	**75**	**4.7**	3.6
34.	***Triplochiton scleroxylon***	**5**	**3**	0.2
35.	***Vigna unguiculata***	**5**	**5**	0.3
36.	**Type 5**	**5**	**0**	0
37.	**Type 8**	**5**	**0**	0
38.	**Type 9**	**5**	**0**	0
39.	**Type 10**	**5**	**0**	0
40.	**Type 13**	**5**	**2**	0.1
41.	**Type 14**	**15**	**1.3**	0.2
42.	**Type X**	**5**	**2**	0.1
43.	Fungus spore	5	0	0

Abundance = $\frac{\text{Total number of individual pollen grains}}{\text{Number of slides in which contained}}$

Density = $\frac{\text{Total number of individual pollen grains}}{\text{Total number of slides}}$

Frequency = $\frac{\text{Total number of slides in which contained}}{\text{Total number of slides}}$

Table C: Change in Pollen Number Overtime in 20µl of Samples

HIVE NUMBER	COLLECTION PERIOD	POLLEN NUMBER/40 OBJECTIVE LENS	TOTAL NUMBER OF POLLEN GRAINS	% OF POLLEN GRAINS	NO OF SPECIES
2A	WEEK-1	39	45	7.5	20
3B		6			6
2A	WEEK-2	40	48	8.0	13
3B		8			9
2A	WEEK-3	6	14	2.3	10
3B		9			10
2A	WEEK-5	13	109	18.2	8
3B		96			6
2A	WEEK-7	123	143	23.8	12
3B		20			8
2A	WEEK-9	17	79	13.2	16
3B		62			4
1A	WEEK-13	78	91	15.2	3
2A		13			9
1A	WEEK-14	7	13	2.2	5
2A		6			8
1A	WEEK-16	42	46	7.7	6
2A		4			5
1A	WEEK-18	6	13	2.0	6
2A		6			6

Table A1: Species List in Generic and Species Names (Family)

	WK-1		WK-2		WK-3		WK-5		WK-7		WK-9		WK-13		WK-14		WK-16		WK-18	
	2A	3B	2A	3B	2A	3B	2A	3B	2A	3B	2A	3B	1A	2A	1A	2A	1A	2A	1A	2A
Albizia zygia	+		+						+	+										
Anthonotha sp														+						
Aspilia africana	+				+	+	+					+		+		+		+		
Berlinia grandiflora								+	+	+	+	+								
Boerhavia diffusa	+		+		+						+					+	+	+		
Bosqueia angolensis				+		+														
Cajanse cajan	+		+					+												
Cassia sp		+																		
Ceiba pentandra											+									
Milicia excelsa			+						+											
Chromolaena odorata			+	+	+	+	+	+	+	+	+			+						
Clausena anisata														+			+		+	+
Combretum sp.					+	+	+	+		+	+	+								
Dombeya buettneri	+		+	+	+		+	+	+											
Elaeis guineensis	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+		
Entada abyssinica	+	+	+	+	+	+					+									
Ipomoea mauritiana									+											
Jasminum sp.																				+
Jatropha sp											+		+	+	+	+				
Jussiaea sp											+									
Manihot sp.	+	+	+	+					+		+	+								
Newbouldia laevis	+	+								+										
Nymphaea lotus	+		+					+	+					+	+	+	+		+	+
Lepistemon sp.	+																			
Parinari sp.				+																+
Polygonium sp.	+	+	+		+		+		+		+								+	
Paullinia pinnata					+						+						+			
Potulaca oleraceae					+											+				
Sapotaceae							+													
Sida sp.	+					+			+	+	+									
Synedrella nodiflora	+																			
Talinum triangulare	+		+	+										+				+		
Tridax procumbens	+	+	+		+	+	+		+	+	+		+	+	+	+	+	+	+	+
Triplochiton scleroxylon						+														
Vigna unguiculata															+					
Type 5	+																			
Type 8	+																			
Type 9	+																			
Type 10	+																			
Type 13																				
Type 14														+			+			+
Type X						+								+						
Fungal spore				+																

Table A2: Pollen Spectrum of the Four Months' Collection (% Composition)

	WEEK-1		WEEK-2		WEEK-3		WEEK-5		WEEK-7		WEEK-9		WEEK-13		WEEK-14		WEEK-16		WEEK-18	
HIVE NUMBER	2A	3B	2A	3B	2A	3B	2A	3B	2A	3B	2A	3B	1A	2A	1A	2A	1A	2A	1A	2A
	B	**C**	**F**	**G**	**J**	**K**	**R**	**S**	**B1**	**C1**	**J1**	**K1**	**M1**	**N1**	**O1**	**P1**	**Q1**	**R1**	**A2**	**B2**
Albizia zygia	1.3		0.8						0.1	1.7										
Anthonotha sp														1.3						
Aspilia africana					7.9		9.4			25.2				6.6		0		16.7		
Berlinia grandiflora								3.6	0.3		2	1.6								
Boerhavia diffusa	1.8		4.5		5.2						2.0					14.7	0.4	0		
Bosqueia angolensis				41.7		1.9					11.1									
Cajanus cajan	5.3		2.0					0.3												
Cassia sp		44																		
Ceiba pentandra											6.1									
Milicia excelsa			6.8						23.7											
Chromolaena odorata			11.8	3.8	5.2	12.8	4.0	0.5	4.3	2.5	1.0			6.6						
Clausena anisata														21.1			2.4		8.6	2.9
Combretum sp.					23.7	9.0	5.4	0.5		9.2	37.4	58								
Dombeya buettneri	0.8		2.5	10.1	10.5		12.0	0.7	1.0											
Elais guineensis	8.8	25	8.3	6.3	2.7	12.8	13.4	94.3	64.9	53.8	21.2	40.1	96.6		12.2	61.8	3.6	4.2		
Entada abyssinica	4.4	20	0.8	15.2	5.2	3.6					3.0									
Ipomoea mauritiana									0.1											
Jasminum sp.																			2.	

																			9	
Jatropha sp											1.0		0.6	1.3	2.5	0				
Jussiaea sp											2									
Manihot sp.	0.5	3	0.8	3.8					0.1		0	0.3								
Newbouldin laevis	1.3																			
Nymphaea lotus	27.8		9.3						0.3	2.5				28.9	14.6	17.7	5.6		25.7	28.6
Lepistemon sp.	1.3																			
Parinari sp.				15.2																
Polygonum sp.	2.2	3	8.3		2.7		8.0		1.8		11.1								2.9	
Paullinia pinnata					23.7												0.8			
Portulaca oleraceae											1.0					0				2.9
Sapotaceae							26.6													
Sida sp.	1.3					1.8			0.1	1.7										
Synedrella nodiflora																				8.6
Talinum triangulare	1.8		6.3	3.8										1.3				16.7		
Tridax procumbens		5.0	37.8		13.1		21.3		3.4	3.4	0		2.8	9.2	4.8	5.8	85.2	62.3	60	34.3
Triplochiton scleroxylon						27.2														
Vignn unguiculata															65.9					
Type 5	0.5																			
Type 8	0.8																			
Type 9	0.8																			
Type 10	0.8													11.8						
Type 13														11.8			2.0			
Type 14						2.7														
Type X						23.7														
Composita e complex	38.6			0.1																
Fungal spore																				

Table D: Relating Pellet's Pollen To Honey Pollen

S/NO	PLANT SPECIES	PELLETS (WEEK-2 TO WEEK-7)	2A HONEY SAMPLE (WEEK-8)	AVERAGE POLLEN SIZE (µm)
1.	*Albizia zygia*	+	-	69.6
2.	*Aspilia africana*	+	-	52.2
3.	*Berlinia grandiflora*	+	-	87.0
4.	*Boerhavia diffusa*	+	-	104.4
5.	*Cajanus cajan*	+	-	69.6
6.	*Ceiba pentandra*	+	-	87.0
7.	*Milicia excelsa*	+	+	23.2
8.	*Chromolaena odorata*	+	+	46.4
9.	*Combretum* sp.	+	+	32
10.	*Dombeya buettneri*	+	+	87
11.	*Elaeis guineensis*	+	+	58
12.	*Entada abyssinica*	+	-	69.6
13.	*Ipomoea mauritiana*	+	-	127.6
14.	*Manihot* sp.	+	-	390
15.	*Motandra guineensis*	-	+	29
16.	*Nymphaea lotus*	+	-	58
17.	*Paullinia pinnata*	+	-	-
18.	*Polygonum* sp.	+	-	75.4
19.	*Sapotaceae*	+	-	-
20.	*Sida* sp.	+	-	145
21.	*Talinum trinagulare*	+	-	78.3
22.	*Tridax procumbens*	+	+	58
23.	*Triplochiton scleroxylon*	+	-	17.4
24.	*Bosquiea angolensis*	+	+	40.6
25.	*Parinari* sp.	+	-	69.6

*** + = present** *** Average pollen size in Honey sample: 47.22µm**

*** - = Absent** ***Average pollen size in Pollen Pellets: 96.14µm**

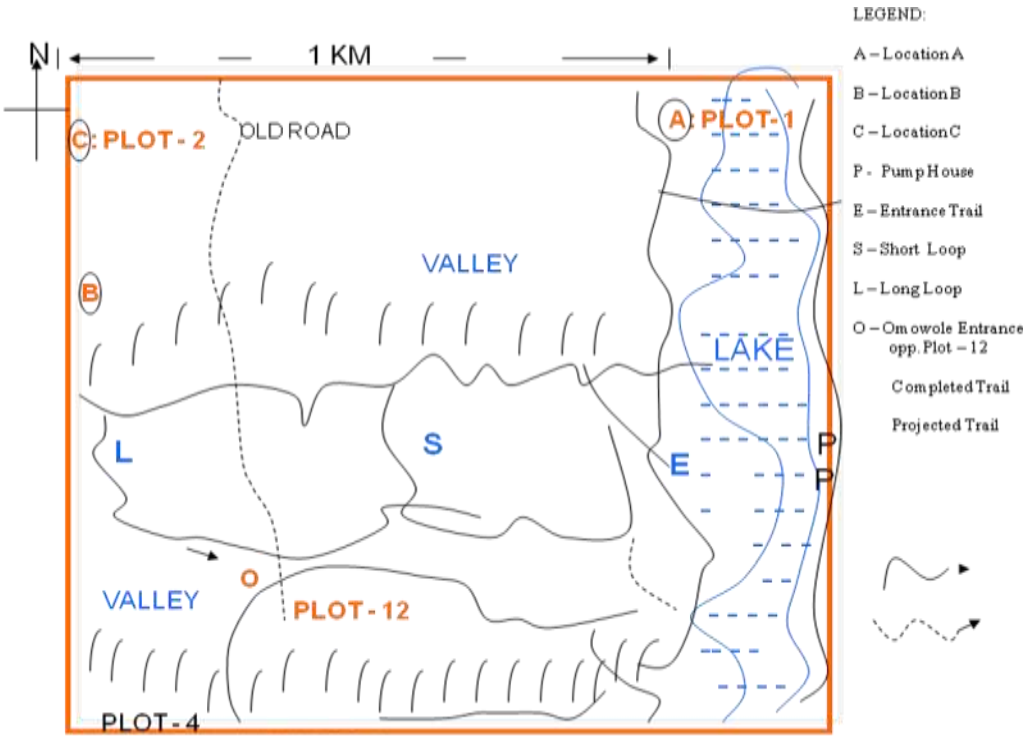


FIG -1: Forest Trail on the IITA West Bank, showing Locations A, B, AND C

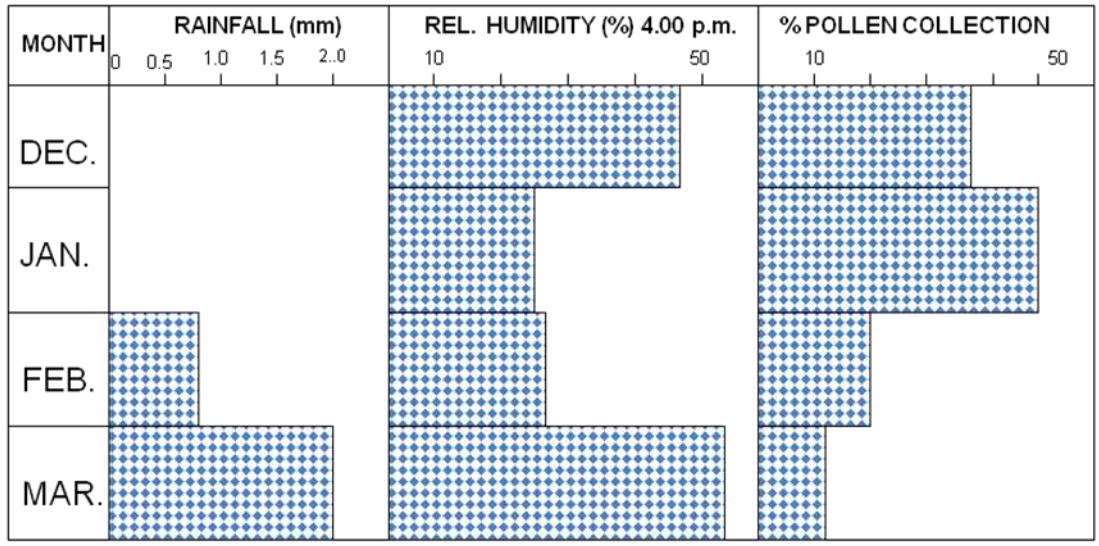
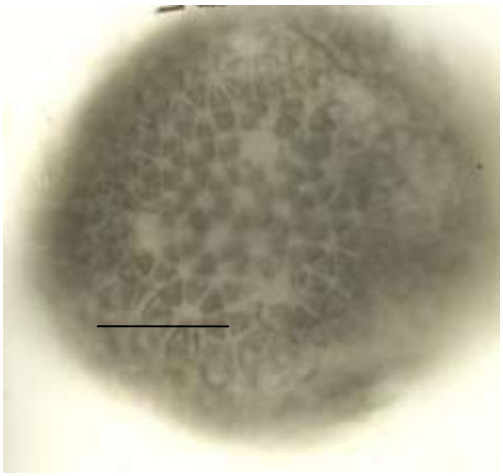


FIG. 2: Monthly Pollen Collection Related to Rainfall and Rel. Humidity

PLATE-1 PHOTOMICROGRAPHS



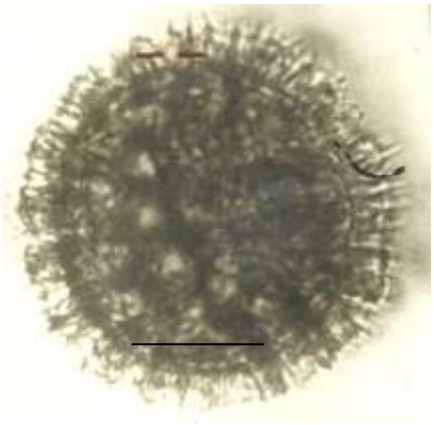
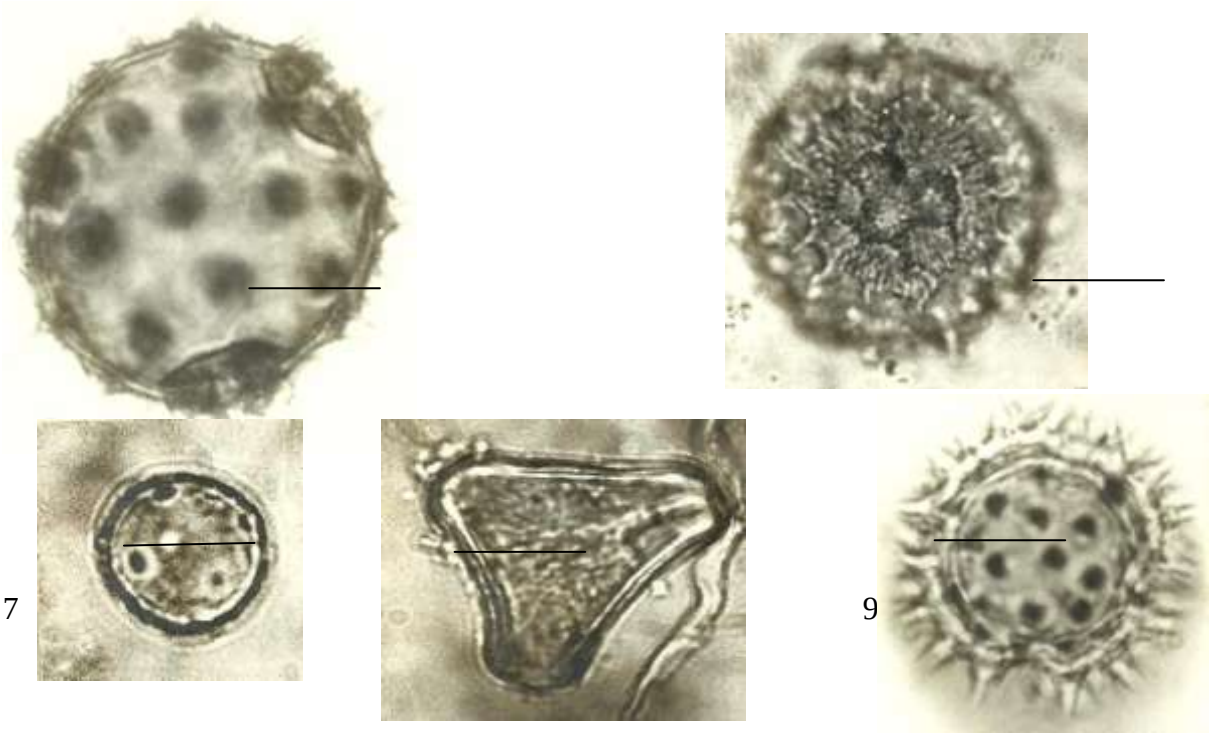


PLATE-2 PHOTOMICROGRAPHS



PLS. 1&2

1. *Manihot* sp., Euphorbiaceae (Mag. x625); 2. *Lepistemon* owariense, Convolvulaceae; 3. *Sida* sp., Malvaceae; 4. *Albizzia zygia*, Mimosaceae; 5. *Dombeya buetnerii*, 6. *Polygonum* sp., Polygonaceae; 7. *Bosquiea angolensis, Moraceae; 8. Paullinia pinnata*, Sapindaceae; 9. *Tridax procumbens, Asteraceae.* Bars = 38 μm