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THE FLORAL BIOLOGY OF *Bauhinia tomentosa* Linn. in Ibadan, Southwestern Nigeria

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ABSTRACT: Flowering in *Bauhinia tomentosa* L. including the duration as well as the morphology of the flower were studied. Pollination method including the breeding system and the pollinators of the flowers were examined. Investigations on the pattern of fruit growth and development, and the extractions of the pigmentations of the flowers were also carried out.

The results showed that flowering occurs throughout the year. Bud initiation to flower opening took between twelve and twenty-one days whilst bud initiation and abscission took between sixteen and twenty three days on the three sample plants. The flowers of *B. tomentosa* are solitary and hermaphroditic. The ovary is superior and elongated. The reproductive organs (pistil and stamens) are almost the same lengths. The mean length of pistils was 3.20±0.07 while stamens had a mean of 2.08±1.11. There was a slight variation in the number of seeds per pod. The mean number of seeds/pod was 8.40±0.11, 8.20±0.37, and 9.40±0.31 for sample plant 1, 2 and 3 respectively. Fruit growth from fruit set to maturity took between forty-two to seventy days. There was an initial rapid growth both in length and breadth shortly after fruit set, then a more or less uniform growth followed by a gradual increase until fruit maturity. The yield of the extract of purple flowers (35.6%) was more than that of yellow flowers (8.2%). The pigment separated differently with thin layer chromatography. Yellow pigments moved higher than the purple pigments. Six insect families were identified on the sample plants and these basically belong to the families Apidae, Vespidae, Tettigoniidae, Formicidae, Scarabacide and Acraeidae. The Formicidae represented by *Oecophylla longinoda* and Apidae represented by *Apis mellifera adansonii* were the major pollinators. All the flower buds enclosed with different bagging methods did not set fruit, however when hand pollination was carried out substantial fruit set were obtained under the four different bagging methods. Fruit set was 77.8%, 72.7%, 50.0% and 55.6% in the flowers bagged with transparent nylon, white tissue paper bags, brown envelopes and fine-meshed silk pollination bag respectively.

Keyword: *Bauhinia tomentosa, morphology*, fruit growth, development, pollinators.

INTRODUCTION

Bauhinia tomentosa L., commonly known as 'Napoleon Hat' belongs to the family Caesalphiniodeae which is a large woody tropical family represented by 60 genera, mainly trees (Irvine, 1961). It is a bushy shrub, 2.8 - 3.9m high with drooping branchlets. It is a native of India but widely grown in the tropics. It is useful as a hedge plant and as an ornamental. It improves soil fertility through symbiotic nitrogen fixation process in the plant's root nodules (Woomer and Swift, 1994).

In tree improvement, knowledge of the flowering and fruiting of a tree species is vital for the efficient planning and formulation of a breeding strategy (Oni, 1990). Flowering is a fundamental process in plant development. It is important, not only for the continued propagation of the plant species but also for human life, which is totally dependent on the products of plants for food, medicine etc. Seeds and fruits are either themselves consumed directly or provide the essential starting ingredients for crop growth.

It is an ornamental plant. Although do not have any direct relevance to food production, it adorns and enhances the aesthetic value of our environment through their beauty and varieties. It may, however, have fodder/forage potentials. An understanding of what determines the flowering behaviour of plant is the pivot of agricultural and horticultural production and is, therefore, of considerable economic importance (Jordan, 1993).

Adequate knowledge of the floral biology of a plant is a pre-requisite for overcoming the morphological and genetic barriers to successful hybridization. Furthermore an understanding of the time from fruit set to maturity will enable the breeder to project the possible harvest time from seed orchards. Such information on time of fruit maturity and the quantity of probable harvests will allow the forester to project the extent and magnitude of nursery and plantation operations required for every planting season.

Bauhinia tomentosa has great aesthetic and soil improvement values thereby necessitating the design of an improvement programme to make the plant genetic resources available for present and future use. Also, the current level of development and standard of living in Nigeria has increased the demand for ornamental trees/flowers. The objective of this study was to determine the floral biology of *Bauhinia tomentosa* through investigations on the flower morphology, breeding systems and pollinators. Also, the pattern of flowering and fruit growth in *B. tomentosa* was studied.

MATERIALS AND METHODS

Study site

Three matured plants of *B. tomentosa* located on the ground of the Department of Forest Resources Management, University of Ibadan ($7^0$18'N and longitude $3^0$54'E) were used for the study. The site has an elevation of 250 metres above sea level and a mean annual rainfall of 1,250 mm most of which falls between March and October with a dry spell in August. The maximum temperature is between 30^0 and 36^0C and minimum between 20^0 and 25^0C. It is situated in the lowland rainforest zone of Nigeria.

Data collection and analysis

The total number of plants on site at the commencement of project were eight. From this population three that had attained the reproductive age were selected for the detailed study.

Monitoring of flowers and fruits commenced on 21st April 2000. Sample flowers and fruits were selected from among sample plants and the flower and fruit development was monitored. Fruit development from fruit set to fruit browning which signified the onset of maturity were monitored. The breadth and length of flowers were measured twice a week using vernier caliper and 30-cm ruler respectively while fruit length and breadth were measured once a week using the same instruments. The flowers and fruits monitored for assessment was distinguished by tags to make measurements and recording as well as relocation easy.

Flowering

Duration of flowering which refers to the length of the blooming period of a plant species was monitored in the sample plants. Constant observations of the sample plants were carried out daily for incidence of floral bud formation. On each occasion, a thorough check was made on each sample plant to see if there were new buds formed for monitoring. The length and diameter of the flowers were taken with the aid of the ruler and vernier caliper respectively.

Fruit development

Data were also collected to determine the pattern of fruit growth and development. The width and length of fruits from the time of flower abscission to time of fruit browning were taken with the aid of ruler and vernier caliper. The data collected were later presented in tables to obtain the pattern of growth on the species.

Floral morphology

Flowers were collected from the three sample plants and visual morphological examinations made. The flowers were also dissected and drawings of floral structures were made. The lengths of the reproductive parts such as stamens and pistils were measured and recorded. The data obtained were subjected to descriptive statistical analysis.

Determination of the insect pollinators and breeding system

Insect visitors of *B. tomentosa* flowers were observed visually on site. Observations of the insect visitors were made on each day of data collection. However, in order to identify the regular visitors of the plant, observations were made on site for the insect visitors of the plant species between the hours of 0700 hours to 1800 hours. Samples of the insects were caught with trap net and kept in kilner jars containing chloroform. The insects were identified at the insect reference and identification section of the Department of Crop Protection and Environmental Biology, University of Ibadan.

The study of the breeding system of *B. tomentosa* lasted for a week. For each sample plant, four types of bagging methods were used to control pollination in order to know the breeding system of the plant species. These methods were:

i. Fine meshed silk pollination bags
ii. Brown-paper envelopes
iii. White tissue paper
iv. Transparent nylon.

Twenty-four matured unopened flowers that have attained a length of 3.0 cm and diameter of 0.6 cm from the three sample plants were subjected to each of the bagging method earlier mentioned. The bags were removed after a week and each flower was inspected to see if there were fruits set or not. Twenty-four opened flowers were also bagged after they were hand pollinated with the aid of Pin brush. Another 24 opened flowers were cross pollinated by the pollen grains of other plants and were subjected to each of the bagging method earlier mentioned.

Flower pigmentation extraction

Pigments were extracted from the yellow and purple flowers obtained from the sample plants. 600 g of yellow and 195.8 g of purple flowers were separately ground. Using methanol as the solvent and

electrothermal water bath at 100^0C for 12 hours, fractional distillation of the pigment was carried out. Adsorption chromatography method was used to separate the particles of substances by filteration of the solution through a column of cotton wool. The substances are absorbed at the top of the column and move slowly down the column while the one that have affinity for the solvent move quickly downward, so the compound emerged and appear in the filterate. The filterate was then distilled in order to get the extract. The percentage yield in yellow and purple flowers were determined by:

$$\% \text{ Yield} = \frac{\text{Extract}}{\text{Weight of ground flower}}$$

Thin layer chromatography (TLC) was carried out on the extracts. Standard grade silical gel was used to separate the anthocyanidins (Harborne, 1991).
Retention factor were determined by:

$$RF = \frac{\text{distance traveled by the solute}}{\text{Distance traveled by the solvent}}$$

60 g of silical gel and 120 ml of distilled water (1:2) were used to make slurry of 0.25 mm thickness on the plate.

RESULTS

Table 1: Rate of flower bud growth (increase in length, cm)
in *Bauhinia tomentosa* in Ibadan, Nigeria.

Observation Days	Plant 1	Plant 2	Plant 3
		Length (cm)	
1	0.86 ± 0.34	0.83 ± 0.49	1.09 ± 0.19
3	1.20 ± 0.13	1.32 ± 0.27	1.30 ± 0.29
5	1.33 ± 0.24	1.32 ± 0.27	1.57 ± 0.32
7	1.57 ± 0.20	2.03 ± 0.55	1.89 ± 0.71
9	1.77 ± 0.36	2.58 ± 0.36	2.53 ± 0.71
11	2.13 ± 0.48	2.94 ± 0.28	3.24 ± 0.23
13	2.61 ± 0.57	3.28 ± 0.38	3.47 ± 0.67
15	3.18 ± 0.92	2.90 ± 0.28	2.80 ± 1.90
17	4.10 ± 0.91	3.00 ± 0.18	4.70 ± 0.80

Formation and development of flower buds

Flower buds initiation to anthesis took about 12 – 21 days. Extended blooming is the rule in *B. tomentosa*. The species flowers continuously throughout the year. Tables 1 and 2 show the pattern of growth among the flowers of three sample trees of *B. tomentosa*.
Increase in lengths of the flowers was gradual and almost uniform in all the sample trees between day 1 and 5. There was a steady increase in lengths of the flowers in Tree 1 up to day 9; while growth in lengths of Trees 2 and 3 increased rapidly from day 7 to 17. Rapid increase in flower length did not start in Tree 1 until day 11 to 17. Diameter growth of the flowers of the sample trees showed a regular pattern if increase from the beginning to the end of the growth period in all the sample trees (Table 2).

Table 2: Rate of growth in flower diameter (cm) in *B. tomentosa* in Ibadan, Nigeria.

Observation Days	Plant 1	Plant 2	Plant 3
1	0.23 ± 0.09	0.22 ± 0.07	0.24 ± 0.04
3	0.23 ± 0.03	0.29 ± 0.04	0.28 ± 0.05
5	0.35 ± 0.04	0.33 ± 0.07	0.33 ± 0.07
7	0.39 ± 0.03	0.40 ± 0.08	0.40 ± 0.05
9	0.42 ± 0.08	0.48 ± 0.01	0.45 ± 0.09
11	0.50 ± 0.12	0.49 ± 0.06	0.54 ± 0.09
13	0.62 ± 0.09	0.43 ± 0.12	0.63 ± 0.05
15	0.71 ± 0.09	0.55 ± 0.15	0.51 ± 0.03
17	0.08 ± 0.07	0.70 ± 0.12	0.50 ± 0.02

Pattern of fruit growth

The maximum ovary size before fruit set was 10 – 13 mm long and 1.5 – 2 mm broad. Beyond this size, rapid growth of ovary was evident 2 days after pollination. Most unfertilized flowers eventually shriveled within 1 week. After fruit set most unsuccessful fruits aborted or dropped due to disease or pest attack and adverse weather.
Observation showed that time of fruit maturity (determined by the onset of browning) from fruit set ranged from six weeks i.e. 42 days to ten weeks i.e. 70 days. Tables 3 and 4 showed the trend of length and diameter growth among the fruits of the three sample trees with increase in time. Both the lengths and diameter growth of the fruit of the sample trees followed the general sigmoid curve for biological organisms. There was a rapid growth (increase in length and breadth) from 1st week till the 5th week in all the sample plants. Thereafter, there was a steady growth in all the sample trees until week 8 when the fruits matured and became brown.

Floral morphology

Drawings of the floral structures of the flower *B. tomentosa* are shown in Figure 1. The flower consists of three sepals which are short and fused. The sepals are green in colour while the petals are bell-shaped and imbricate. The petals are five and creamy yellow coloured.
The flower contains ten stamens and one pistil. The stamens are united at the base while the style is long and 2-lobed. The anthers are also 2-lobed. The stamens consist of yellow coloured filaments on which are borne yellow coloured pollen-producing anthers. The pistil

comprised of one stigma with superior ovary, shortly stalked, elongated composed of 1 carpel and 1 celled with numerous ovules with parietal placentation.

The flowers are large and hermaphroditic. The floral formula of the flower is $K_{(3)}\ C_{(5)}\ A_{5+5}\ G_1$. The length of pistils ranged from 1.30 cm to 4.00 cm with a mean of 3.20 ± 0.07 cm. Plant 1 flowers have the length of its pistils ranging from 1.50 cm to 4.00 cm with mean of 3.16 ± 0.13 cm, while plant 2 had the length of its pistils ranging from 1.30 cm to 3.90 cm with mean of 2.90 ± 0.15 cm while the length of pistils of sample plant 3 ranged from 3.20 cm to 3.90 cm with a mean of 3.60 ± 0.03 cm. However the length of stamens of sample plant 1 ranged from 1.30 to 2.40 cm with mean of 1.88 ± 0.07 cm and sample plant 2 had the length of stamens ranging from 1.20 cm to 2.50 cm with mean of 1.90 ± 0.07 cm while in sample plant 3 it ranged from 1.30 cm to 3.10 cm with mean of 2.40 ± 0.10 cm (Table 5).

Table 3: Variation in growth sequence (increase in lengths, cm) of fruits of *B. tomemtosa* in Ibadan, Nigeria.

Time of Observation (Weeks)	Tree 1	Tree 2	Tree 3
1	1.41 ± 1.4	1.42 ± 0.97	1.65 ± 1.82
2	2.81 ± 2.08	2.39 ± 1.55	3.67 ± 2.27
3	4.89 ± 4.03	3.94 ± 3.56	11.24 ± 0.75
4	8.97 ± 3.17	7.50 ± 3.56	11.24 ± 0.75
5	12.14 ± 0.49	11.06 ± 1.05	11.99 ± 0.04
6	12.63 ± 0.08	12.11 ± 0.16	12.10 ± 0.02
7	12.71 ± 0.36	12.27 ± 0.14	12.10 ± 0.04
8	12.71 ± 0.28	12.27 ± 0.12	12.10 ± 0.04

Table 4: Variation in growth sequence (increase in diameter, cm) of fruits of *B. tomentosa* in Ibadan, Nigeria.

Time of Observation in Weeks	Plant 1	Plant 2	Plant 3
1	0.18 ± 0.12	0.15 ± 0.12	0.16 ± 0.13
2	0.30 ± 0.15	0.27 ± 0.16	0.29 ± 0.02
3	0.45 ± 0.51	0.43 ± 0.5	0.58 ± 0.08
4	0.96 ± 0.64	0.93 ± 0.64	1.44 ± 0.06
5	1.60 ± 0.04	1.57 ± 0.03	1.60 ± 0.02
6	1.64 ± 0.02	1.60 ± 0.02	1.62 ± 0.01
7	1.66 ± 0.03	1.64 ± 0.02	1.63 ± 0.03
8	1.66 ± 0.21	1.64 ± 0.02	1.63 ± 0.03

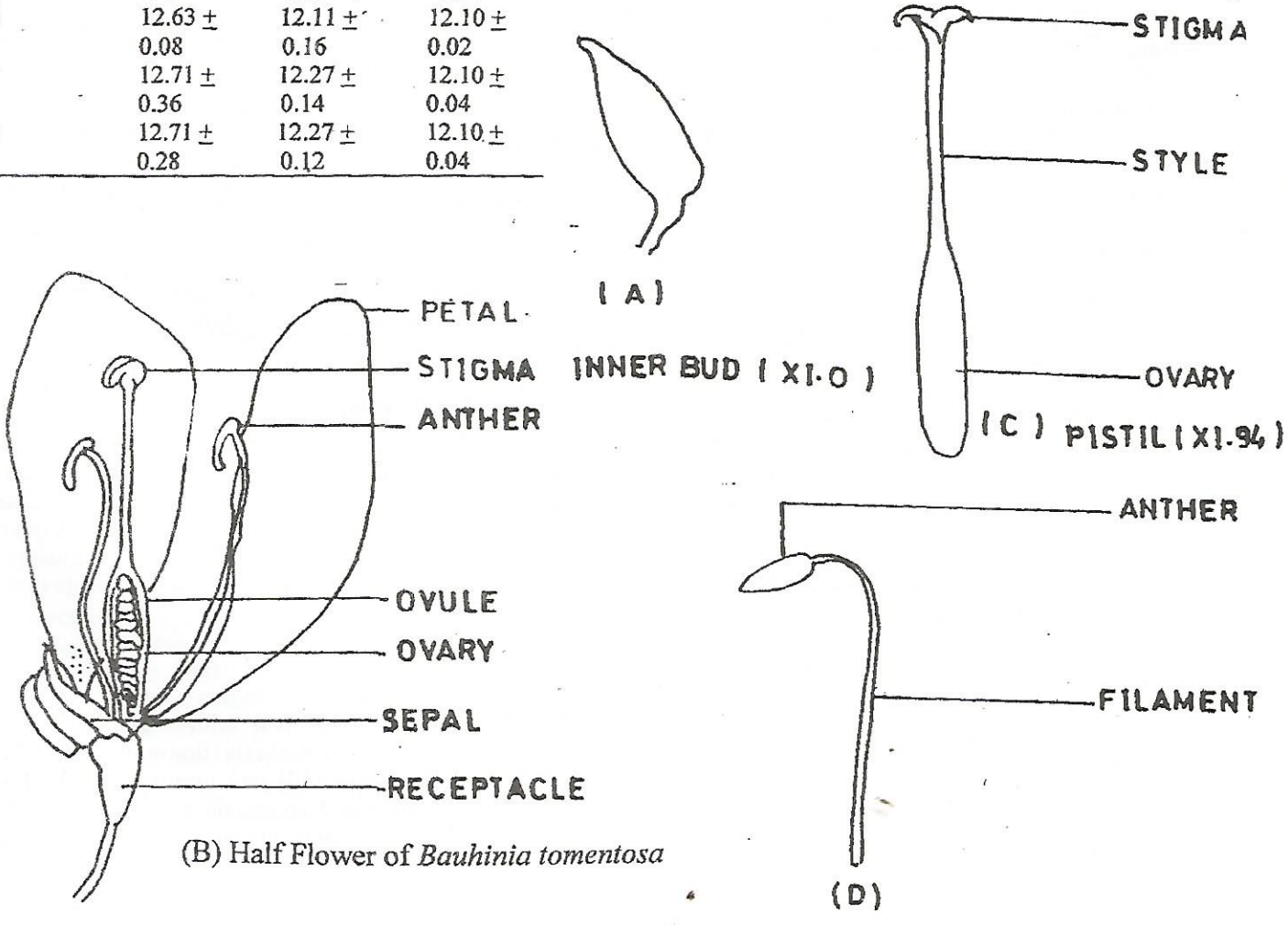

Figure 1. Floral structures of *Bauhinia tomentosa*

Breeding System

All the 24 flower buds that were bagged with four bagging methods (6 flowers/method) opened, but set no fruit. However, when hand pollination was carried out, substantial levels of fruit set were obtained with the different bagging methods. In flowers enclosed with fine meshed silk pollination bags, fruit set ranged from 8.3% to 16.7%. Those enclosed with brown paper envelope had fruit set of 12.5%, while fruit set ranged from 16.7% to 20.8% in flowers enclosed with both white tissue paper and transparent nylon bags. Transparent nylon bags gave the greatest fruit set with an overall pooled mean fruit set of 77.8%, followed by white tissue paper which had a pooled mean fruit set of 72.2%, then the fine meshed silk pollination bag had a pooled mean fruit set of 55.6%. The lowest overall pooled mean fruit set of 50% was obtained under the brown paper envelope bag.

Number of Seeds Per Pod

The number of seeds per pod at maturity ranged from 4 to 14. In sample plant 1 number of seeds/pod ranged from 4 to 14 with a mean of 8.4 ± 0.11 and co-efficient of variability of 7.1%. In sample plant 2, number of seeds/pod ranged from 4 to 12 with mean of 8.2 ± 0.37 and coefficient of variability of 24.7% while it ranged from 6 – 12 with mean of 9.4 ± 0.31 and a coefficient of variability of 18.3% in sample plant 3.

Insect pollinators

Six insect families were identified; they were Apidae, Vespidae, Tettigoniidae, Formicidae, Scarabacidae and Acracidae. The insects associated with flowers were (1) *Pharneroptersa nana sparsa* (grasshopper) family Tettigoniidae, order Orthoptera, (2) *Apis mellifera andansonii* (bee) family Apidae, order Hymenoptera (3) *Belonogaster juncen* (Wasp) family Vespidae order Hymonoptera (4) *Acraea orestia* (butterfly) family Acraeidae order Lipidoptera (5) *Occophylla longinoda* (ant) family Formicidae (6) *Apogonia sp* (beetle) family Scarabaeidae, order Coleoptera.

The most abundant insect pollinator was *Oecophylla longinoda* with a total of 90 visits per day and a mean insect visit of 8.2 ± 1.21 per hour. *Apis mellifera adamsonii* was the next most frequent pollinator with a total of 64 visits per day and mean of 5.8 ± 1.17 per hour. Both *Belonogaster juncen* and *Apogonia sp* recorded a total of 42 visits per day and mean insect visit per hour of 3.8 ± 0.5 and 3.8 ± 0.98 respectively. *Acraea orestia* recorded a total of 24 visit per day and mean of 2.2 ± 0.55 per hour, while *Phaneroptersa nana sparsa* recorded a total of 4 visits per day and mean insect per hour of 0.36 ± 0.15. The frequency of insect pollinators of the flowers attained its peak between 1100 and 1200 hours and gradually declined till 1800 hours.

Table 5: Length (cm) of pistils and stamens of *B. tomentosa* in Ibadan, Nigeria.

	Pistil		
	Plant 1	Plant 2	Plant 3
Sum (E)	94.8	85.8	106.4
Mean	3.16	2.86	3.55
S.E ±	0.13	0.15	0.03
C.V (%)	23.19	29.36	4.94
	Stamen		
	Plant 1	Plant 2	Plant 3
Sum (E)	56.4	58.00	72.60
Mean	1.88	1.93	2.42
S.E ±	0.07	0.07	0.10
C.V (%)	20.07	18.73	23.11

Extraction and thin layer chromatography extract from flower of *b. tomentosa*

Tables 6 and 7 showed the results of the extraction and thin layer chromatography of the yellow and purple flowers of *Bauhinia tomentosa* respectively. The weight of the yellow and purple flowers after grinding were 60g and 195.8g respectively while the percentage extract yield were 8.2% for yellow and 35.6% for purple flower. The retention factor (RF) values of the pigments of yellow and purple flowers which lmoved in Ethylacetate and Benzene (5:1) solvent system under thin layer chromatography are shown in Table 7.

Table 6: Extraction of flowers of *B. tomentosa* in Ibadan, Nigeria.

Sample Flower	Yellow	Purple
Weight of Sample (g)	600	195.8
% Yield of Extract	8.2	35.6
Solvent	Methanol	Methanol
Colour of Extract	Yellow	Purple

Table 7: Retention factor of the pigments sof *Bauhinia tomentosa* in Ibadan, Nigeria.

Yellow Pigments	Purple Pigments
0.15	0.09
0.30	0.21
0.58	0.25
0.19	0.25

DISCUSSION AND CONCLUSION

Results of this study has shown that *Bauhinia tomentosa* flowers throughout the year with slight differences among the sample trees Anthesis (flower opening) takes place between twelve (12) and twenty-one (21) days after bud initiation and abscission as from 16th – 23rd day. The flowers of *Bauhinia tomentosa* are solitary and

hermaphroditic and the inflorescence is racemose. Petals are five with three attractive sepals which are fused. Ovary is superior and elongated while the reproductive organs (pistil and stamens) of the plant are almost uniform with slight differences which may be due to the genetic make up of the varieties since no two organisms are the same genetically.

There was an initial rapid rate of fruit growth development both in length and breadth shortly after fruit set in *B. tomentosa*; then a more or less uniform growth followed by a gradual increase until fruit maturity. Fruit maturity from time of fruit set takes forty-two to seventy days. The variation in the pattern of growth might be due to differences in investment in reproductive organs of the species. The differences in the number of seeds/pod can also be explained by the differences in the genetic make up of the plant. Controlled pollination in *B. tomentosa* is only feasible with hand pollination method. The failure of the flowers to set more fruit under the brown envelope bags could be due to temperature build up in the bags. The opaque nature of the envelope could also result into the low fruit set under the method, the hindrance of sunlight might have caused some physiological damage of the pollen and flowers hence their abortion. Thus for a successful controlled pollination of the species, there is need to use transparent bags in order to maintain light similar to the natural environment.

The flowers of *B. tomentosa* is both self and cross pollinated with the help of insect pollinators. The major pollinator is from the family Formicidae represented by *Oecophylla longinoda* which are reported to be strongly sensitive to pungent smell. The family Apidae follows in abundance of pollinators represented by *Apis mellifera andansonii*. The Apidae are reported to be very sensitive to narrowly and widely tubular flowers with long style and short stamens (Weberling, 1989), which might be responsible for their abundance on the flowers. The family Scarabaeidae represented by *Apogonia sp* are known for making use of the pollination chamber formed by the petals for mating and the laying of eggs while pollination occur at the same time (Gottsberger, 1977) while the families Vespidae and Acracidae represented by *Belonogaster juncen* and *Acraea ovestia* respectively are reported to be very sensitive to strong smells and bright colours. While the length and width of leaves are the same with slight differences.

The flowers of *B. tomentosa* contained different pigments due to different retention factor values of the yellow and purple extract. Anthocyanidins is responsible for the pigmentation in the plant and the colour changes of the flowers from yellow at anthesis to purple the following day may be as a result of the alteration in pH value or it may happened that the synthesis of different pigments proceeds during particular stage of anthesis to give different intensities it could also be as result of temperature changes (Harborne, 1976).

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