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Preference and Suitability of Nigerian Grown *Gmelina arborea* Linn. Roxb. and *Vitex doniana* Sweet Woods for Beekeeping in Imeko, Nigeria

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Abstract It has been observed that *Apis mellifera* native to tropical Africa has special preferential nesting behaviour for white and yellow woods' cavities in Nigeria. In contrast, the use of brown coloured wood like *Milicia excelsa* for beekeeping on the ground of its durability has been recommended in Ghana. In response to this, the study investigated the suitability of one exotic white coloured wood species (*Gmelina arborea*), one indigenous white coloured wood species (*Vitex doniana*) and one indigenous brown coloured wood species (*Erythrophleum suaveolens*) for beekeeping in Imeko between February, 2009 and April, 2012. A total of 9 hives comprising 3 each of *Erythrophleum suaveolens, Gmelina arborea* and *Vitex doniana* woods were placed at three different sites (1,2,3) within Nazareth High School Compound Imeko. At each site, 3 hives placed comprised the mixture of the 3 wood species' hives. Colonisation of hives made of *G. arborea* and *V. doniana* woods within two months of placement at the 3 sites were observed. Honeybees colonized *E. suaveolens* wood hive at site 3 and absconded in the same month of colonisation (October, 2010). Quantitative analysis of the wood samples' extracts indicated the presence of 39.62mg/g total alkaloids, 1.38mg/g total flavonoids, 84.19mg/g total phenol, 366.52mg/g total Saponins and 101.18mg/g total tannins in *E. suaveolens*; 35.19mg/g total alkaloids, 1.24mg/g total flavonoids, 3.98mg/g total phenol, 5.69mg/g total Saponins and 4.49mg/g total tannins in *G. arborea*; and 4.52mg/g total alkaloids, 0.42mg/g total flavonoids, 1.00mg/g total phenol, 0.66mg/g total Saponins and 1.59mg/g total tannins in *V. doniana*. The results suggested that colour and non-structural chemical composition might be involved in choice and colonisation of cavities (hives) by honeybees. Colonisations were reliably stable in white wood hives within the 3 sites with quantifiable honey production. The colonisations choice of white woods' hives and rejection of brown wood hives confirmed the suitability of *G. arborea* and *V. doniana* woods and non-suitability of *E. suaveolens* wood for beekeeping in Nigeria.

Index Terms: Apis *mellifera* S., Beekeeping, Colonisation, *Gmelina arborea*, Hives and *Vitex doniana.*

1. INTRODUCTION

Apis mellifera native to tropical Africa has been observed to have special higher degree of preference for nesting in white and yellow coloured wood cavities in the wild in Nigeria. Honeybees preferred cavities in trees like *Gmelina arborea, Vitex doniana, Vitex ferruginea, Adansonia digitata, Ceiba pentandra, Bombax buonopozense Pycnanthus angolensis* etc.

Brown coloured wood trees' cavities were not usually used in the wild for nesting probably because of the chemical composition of brown wood [1]. A survey of available literature revealed the paucity of documented information on the suitable (quality) woods for beekeeping in Nigeria. In particular, no information could be found on the nexus between the natural wood species cavities preferred in the wild and test of such woods for suitability of modern beekeeping in Nigeria. Evidences abound to suggest such link for using Cedar and Pine woods as honeybees hive materials in America and other temperate regions having tropical forests [2,3,4,5,6,7,8,9 and 10]. *Apis mellifera* has been globally managed and more appreciated in other continents than Africa where it originated from. *Apis mellifera* L., a hybrid of *Apis mellifera* from Africa has been extensively studied in America [2,3,4,5,6 and 7]. The outcomes of its extensive studies in the wild might have informed the recommendation and utilisa

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tion of cedar and pine woods in nearly all the continents except Africa. Toon and Kail woods that are widely used in Asia for beehives construction are synonymous with Cedar and Pine respectively [11,12]. However, many literatures in Africa had recommended the use of brown woods for beekeeping on the account of their durability without any scientific linkage approach between the woods preferred in the wild and the brown woods recommended.

The long standing relationship between Honeybees and trees before the interference of Man was enough for the bees to have known what is desirable for them. Wood being an important biological raw material, the properties of the wood determine its best industrial application. Therefore, it becomes imperative that a thorough knowledge of its physical and chemical properties should precede choice and selection of wood species for beekeeping. The study investigated the suitability of one (1) exotic wood species (*Gmelina arborea*) and two indigenous wood species *Vitex doniana*, a white coloured wood and *Erythrophleum suaveolens*, a brown coloured wood for beekeeping in Imeko – predominantly a derived savannah in Ogun State, Nigeria. Emphases were placed on the colours and non-structural chemical properties of the woods to ascertain honeybee's wood preference for their nesting.

2. Materials and Methods

2.1 Study Area

Wood preference and suitability of *Erythrophleum suaveolens, Gmelina arborea* and *Vitex doniana* wooden hives for beekeeping were investigated in Imeko (Latitude 7^0 22′ 08″ and 7^0 30′ 05″ N and longitude 2^0 44′ 22″ and 2^0 53′ 03″ E) from February, 2009 to April, 2012. The vegetation is mixture of savannah belt and sparse forest suitable for beekeeping. The climate is tropical with two seasons, the dry season (November to March) and wet season (April to October) with average annual temperature of 27.4^0C. The study was conducted in Nazareth High School Compound, Imeko in Imeko/Afon Local Area of Ogun State, Nigeria.

2.2 Construction of hives

Erythrophleum suaveolens, *Gmelina arborea* and *Vitex doniana* wood samples of 1x12x12 and 2x6x12 sizes were purchased from Emilandu sawmill in Imeko. All purchased wood samples (lumbers) were free of blemishes and showed good physical colour property. For each tree species, 3 Kenyan hives samples of 80cm length by 30cm in depth with 22 top bars (40cm length by 3.3cm in width) were constructed and used at 3 different strategic sites within the school compound. Correct $2^1/_2$″ nails and nailing practices were applied for the wood edge to edge joints. The covers of the hives were reinforced using ¾″ tacks with thick water proof nylon to prevent weathering effects.

2.3 Baiting and placing of hives

Three sites named site 1, site 2 and site 3 were strategically selected half kilometre or less apart from one another in the month of February, 2009. All the hives were rubbed with beeswax and some pieces were placed inside as bait. At site 1, *E. suaveolens* wood hive was placed first at left side followed by *G. arborea* wood hive at the middle and then *V. doniana* wood hive with 2m distance apart on iron stands. At site 2, *G. arborea* wood hive was placed first at left side followed by *V. doniana* wood hive at the middle and then *E. suaveolens* wood hive with 1.2m distance apart. At site 3, *V. doniana* wood hive was placed first at left side followed by *E. suaveolens* wood hive at the middle and then *G. arborea* wood hive with 2m distance apart. *Elaeis guineensis* was the predominant palm tree that provided shade for the hives at site 1. *Anogeissus leiocarpus* and *Zanthoxylum zanthoxyloides* were the predominant trees that provided shade for hives at site 2 while *Azadirachta indica* was the predominant tree that provided shade for hives at site 3. These plant species were honeybees foraging trees dominant in the area. Honeybees visited these plants for pollination and collection of food. The hives were examined once every week for evidence on nesting by honeybees until colonisation became remarkably stable.

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TABLE 1

THE LAYOUT OF BEEHIVES AT THE 3 SITES

Site1 1.2m	***E. suaveolens*** →	***G.arborea*** →	***V. doniana***
Site 2	***G. arborea*** →	***v. doniana*** →	***E. suaveolens***
Site 3	***v. doniana*** →	*E. suaveolens* →	G. arborea

2.4 Phyto-chemical screening of the wood samples' extracts

Quantitative analysis of alkaloids, flavonoids, phenol, tannins and Saponins compounds were carried out by using the methods of [13,14,15,16,17 and 18]

2.5 Procedure

Methanolic extract of the samples was prepared following the method of [16], by adding 25 mL of methanol to 0.5g of sample contained in a covered 50 mL centrifuge tube, and shaking continuously for 1 hour at room temperature. The mixture was centrifuged at 3,000 rpm for 10 min, and then the supernatant was collected and store at -20^{o}C until analysis was done.

2.6 Total Alkaloids Determination

The total alkaloid contents in the samples were measured using 1, 10-phenanthroline method described by [15] with slight modifications. 100mg sample powder was extracted in 10ml 80% ethanol. This was centrifuged at 5000rpm for 10 min. Supernatant obtained was used for further estimation of total alkaloids. The reaction mixture contained 1ml plant extract, 1ml of 0.025M $FeCl_3$ in 0.5M HCl and 1ml of 0.05M of 1, 10-phenanthroline in ethanol. The mixture was incubated for 30 minutes in hot water bath with maintained temperature of 70 ± 2^{o}C. The absorbance of red coloured complex was measured at 510nm against reagent blank. Alkaloid contents were estimated and it was calculated with the help of standard curve of quinine (0.1mg/mL, 10mg dissolved in 10ml ethanol and diluted to 100mL with distilled water). The values were expressed as g.100g-1of dry weight.

2.7 Determination of total flavonoids content (TFC)

TFC was determined by Aluminium chloride method as reported by [18]. 0.5 mL of extract was dispensed into test tube, followed by 1.5 mL of methanol, 0.1 mL of aluminium chloride (10%), 0.1 mL of 1M potassium acetate and 2.8 mL of distilled water. The reaction mixture was mixed, allowed to stand at room temperature for 30 minutes, before absorbance was read at 514 nm. TFC was expressed as quercetin equivalent (QE) in mg/g material. The calibration equation for quercetin was $Y = 0.0395x - 0.0055$ ($R^2 = 0.9988$).

2.8 Determination of total phenolic content (TPC)

The total phenolic content of samples extracts was determined according to the Folin–Ciocalteu method used [16]. Briefly, 300 µL of extract was dispensed into test tube (in triplicates). To this was added 1.5 mL of Folin–Ciocalteu reagent (diluted 10 times with distilled water), followed by 1.2 mL of Na_2CO_3 solution (7.5w/v). The reaction mixture was mixed, allowed to stand for 30 min at room temperature before the absorbance was measured at 765 nm against a blank prepared by dispensing 300 µL of distilled instead of sample extract. TPC was expressed as Gallic acid equivalent (GAE) in mg/g material. The calibration equation for Gallic acid was $Y = 0.0645x - 0.0034$ ($R^2 = 0.9997$).

2.9 Total Saponins Determination

Total Saponins (TS) were determined by the method of (Hiai, *et al*., 1976) as described by [17] with some modifications. 0.5 g of sample was extracted with 25 ml of 80% aqueous methanol by shaking on a mechanical shaker for 2 hour, after which the contents of the tubes were centrifuged for 10 min at 3,000 rpm. In a test tube an aliquot (0.25 ml) of the supernatant was taken to which 0.25 ml vanillin reagent (8% vanillin in ethanol) and 2.5 ml of 72% aqueous H_2SO_4 were added. The reaction mixtures in the tubes were heated in a water bath at 60°C for 10 min. Then tubes were cooled in ice for 4 min and then allowed to acclimatize to room temperature. Subsequently, the absorbance was measured in a Uv/Visible spectrophotometer at 544 nm. Diosgenin was used as a standard and the results obtained were expressed as mg diosgenin equivalent per g of sample dry matter.

2.10 Determination of tannin content

Tannin content of samples was determined according to the method of [14] as follows. Sample (0.1g) was extracted with 5 mL of acidified methanol (1% HCl in methanol) at room temperature for 15 minutes. The mixture was centrifuged at 3,000rpm for 20 minutes. 0.1 mL of the supernatant was added with 7.5 ml of distilled water, 0.5 ml of Folin-Denis reagent, 1 ml of 35% sodium carbonate solution and diluted to 10 ml with distilled water. The mixture was shaken well, kept at room temperature for 30 min and absorbance was measured at 760 nm. Blank was prepared with water instead of the sample. Tannin content was expressed as tannic acid equivalent (TAE) in mg/g material. The calibration equation for tannic acid was $Y = 0.0695x + 0.0175$ ($R^2 = 0.9978$).

3. RESULTS

3.1 Preference Tests and Colonisation

Within 2 months of placement, all the hives of *G. arborea* and *V. doniana* woods were colonised with *G. Arborea* wood hive at site 1 first colonised in first week. *E. suaveolens* wood hive at site 3 was colonised and abandoned the same month of October, 2010 exactly nineteen months after all the *G. arborea* and *V. doniana* woods hives have been remarkably stable. Honeybees' swarms never returned to the abandoned hive and *E. suaveolens* wood hives at sites 1 and 2 were not colonised till the study was terminated. There was no remarkable difference in the rate of colonisation between the hives of *G. arborea* and *V. doniana* woods in the area. There were evidences of Honeybees abundance in the area scouting for nesting cavities. Honeybees in Nigeria showed high degree of preference for white woods of *G. arborea* and *V. doniana* and rejection of brown wood of *E. suaveolens* as shown in table 2. The rate of colonisation and absconding/rejection percentage was shown in table 3. Hives of *G. arborea* and *V. doniana* woods were 100% colonised and reliably stable in all the sites. While the only colonised hive of *E. suaveolens* wood at site 3 was absconded and completely rejected like others in other sites. The quantitative phyto-compounds screening analysis of major secondary metabolites in woods' samples were presented in table 4. Saponins content was significantly highest with dif ference of 265.34mg/g from Tannin, 282.33mg/g, Phenol, 326.90mg/g, Alkaloids and then 365.14mg/g from Flavonoids in *E. suaveolens* wood. In *G. arborea* wood, the trend differed remarkably as Alkaloids was highest with difference of 29.50mg/g from Saponins, 30.70mg/g from Tannin, 31.21mg/g from Phenol, and 33.95mg/g from Flavonoids. While the trend in *V. doniana* wood equally differed remarkably with lowest values as Alkaloids was also highest with difference of 2.93mg/g from Tannin, 3.52mg/g from Phenol, 3.86mg/g from Saponins, and 4.10mg/g from Flavonoids. Saponins content was highest and Flavonoids was least in *E. suaveolens* sample. Alkaloids and Flavonoids contents were highest and lowest in *G. arborea* and *V. doniana* woods' samples respectively.

TABLE 2

WOOD COLOUR PREFERENCE OF HONEYBEES

Wood species hives	Colour	Attraction	Remark
Erythrophleum suaveolens wood	Brown	Not colonised	Not suitable
Gmelina arborea wood	White	Colonised	Suitable
Vitex doniana wood	White	Colonised	Suitable

TABLE 3

COLONISATION AND REJECTION RATE PERCENTAGE

Wood species hives	Colonisation %	Absconding/rejection %
Erythrophleum suaveolens wood	0%	100%
Gmelina arborea wood	100%	0%
Vitex doniana wood	100%	0%

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TABLE 4

MEAN VALUES OF WOODS NON-STRUCTURAL CHEMICAL COMPOSITION

Wood species' samples	Alkaloids (mg/g)	Flavonoids (mg/g)	Phenol (mg/g)	Saponins (mg/g)	Tannin (mg/g)
E. suaveolens wood	39.62±0.170	1.38±0.020	84.19±0.020	366.52±0.040	101.18±0.020
G. arborea wood	35.19±0.030	1.24±0.015	3.98±0.055	5.69±0.120	4.49±0.120
V. doniana wood	4.52±0.115	0.42±0.015	1.00±0.015	0.66±0.025	1.59±0.120

3.2 Economics of Hives, Machining and Nail joint compatibility

Table 5 showed the relative cost of production, the nail joint compatibility and the weight of the honeybees' hives. *G. arborea* wood hive cost highest with a difference of ₦544.00 from *E. suaveolens* wood hive and ₦1030.00 from *V. doniana* wood hive. Considerable effort was applied to cut *G. arborea* and *V. doniana* woods into desirable sizes while much effort was applied for the construction of *E. suaveolens* wood hives. Gmelina wood was very compatible with $2^{1}/_{2}$″ nails without any split observed in its edge to edge grain joints. Little splits were developed in *V. doniana* wood hives while pronounced splits were developed in *E. suaveolens* wood hives

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TABLE **5**

ECONOMICS OF BEEHIVES, 2009

Wood species' samples	**Cost of production (₦)**	**Qty**	**Total cost (₦)**	**Nail joint compatibility**	**Weight**
E. suaveolens wood	3,660	3	10,980	Poorly compatible	Heavy
G. arborea wood	4,210	3	12,230	Very compatible	Moderate
V. doniana wood	3,180	3	9,540	Compatible	Light

TABLE 6

ECONOMICS OF HONEY PRODUCTION FOR WOOD SPECIES HIVES AT DIFFERENT SITES

Site 1				
Wood species hive type	Harvesting periods	Dates	Quantity (litre)	Revenue or Monetary value (₦)
E. suaveolens	1st harvest	December, 2009	0	0x1000=0.00
	2nd harvest	February, 2011	0	0x1200=0.00
	3rd harvest	April, 2012	0	0x1500=0.00
Total			0	0.00
G. arborea	1st harvest	December, 2009	8.50	8.5x1000=8,500.00
	2nd harvest	February, 2011	10.50	10.5x1200=12,600.00
	3rd harvest	April, 2012	8.00	8.0x1500=12,000.00
Total			27.00	33,100.00
V. doniana	1st harvest	December, 2009	9.00	9.00x1000=9,000.00
	2nd harvest	February, 2011	10.75	10.75x1200=12,900.00
	3rd harvest	April, 2012	7.75	7.75x1500=11,625.00

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Total			27.50	33,525.00
Site 2				
E. suaveolens	1st harvest	December, 2009	0	0x1000=0.00
	2nd harvest	April, 2011	0	0x1200=0.00
	3rd harvest	April, 2012	0	0x1500=0.00
Total			0	0.00
G. arborea	1st harvest	December, 2009	9.25	9.25x1000=9,250.00
	2nd harvest	April, 2011	10.00	10.00x1200=12,000.00
	3rd harvest	April, 2012	8.00	8.00x1500=12,000.00
Total			27.25	33,250.00
V. doniana	1st harvest	December, 2009	8.00	8.00x1000=8,000.00
	2nd harvest	April, 2011	9.75	9.75x1200=11,700.00
	3rd harvest	April, 2012	7.50	7.50x1500=11,250.00
Total			26.25	30,950.00
Site 3				
E. suaveolens	1st harvest	December, 2009	0	0x1000=0.00
	2nd harvest	February, 2011	0	0x1200=0.00
	3rd harvest	April, 2012	0	0x1500=0.00
Total			0	0.00
G. arborea	1st harvest	December, 2009	10.50	10.50x1000=10,500.00
	2nd harvest	February, 2011	12.25	12.25x1200=14,700.00
	3rd harvest	April, 2012	8.75	8.75x1500=13,125.00
Total			31.50	38,325.00
V. doniana	1st harvest	December, 2009	10.00	10.00x1000=10,000.00
	2nd harvest	February, 2011	12.00	12.00x1200=14,400.00
	3rd harvest	April, 2012	8.50	8.50x1500=12,750.00
Total			30.50	37,150.00

3.3 Health of the Bees and Economics of Honey production

The honeybees showed evidence of sound health through their agility actions, responses and activities towards colonies sustainability throughout the duration of the study. Hives were routinely inspected and kept in most sanitary conditions. The colonies were large and strong with high defensive characteristic. Table 6 showed the harvesting periods, quantity produced and monetary values of the honey produced. The first harvesting was done exactly 8 months after the colonisation (December, 2009). The honey production ranged from 8.50 to 10.50 litres and 8.00 to 10.00 litres for *G. arborea* and *V. doniana* wood hives respectively for the 3 sites. Second harvesting was done when the honey was fully ripped a year and one month after the first harvesting (February, 2011). The honey production ranged from 10.00 to 12.25 litres and 9.75 to 12.00 litres for *G. arborea* and *V. doniana* wood hives respectively for the 3 sites. And the last harvesting was done one year and two months after the second harvesting (April, 2012). The honey production ranged from 8.00 to 8.75 litres and 7.50 to 8.50 litres for *G. arborea* and *V. doniana* wood hives respectively for the 3 sites. The quantity of honey production has a zig zag trend with peak in 2011 in all the sites. The quantity of honey produced and sold from the first har vesting settled the investment capital with regard to *G. arborea* and *V. doniana* wood hives. This suggested that beekeeping using *G. arborea* and *V. doniana* woods is a viable and sustainable enterprise. The price increase from ₦1000.00 in 2009 to ₦1200.00 in 2011 and ₦1500.00 in 2012 was discretional. There are ready made markets for honey because there is a wider gap between the demand and the supply of quality honey locally in Nigeria.

4. DISCUSSION

This study succeeded a preliminary survey of wood cavities preferred by honeybees in the wild in Nigeria to determine the suitability of specific indigenous/exotic wood species for beekeeping. This approach was adopted to comprehensively elucidate the underlining reasons that dictate the choice of specific wood types for the construction of hives for beekeeping rather than the general view of using any wood on the account of its durability. The colonies of *Apis mellifera* reliably preferred white wood hives. The hive of *G. arborea* wood at site 1 colonised first within the first week of setting while the rest hives except *E. suaveolens* wood hives colonised within 2 months of setting. The fast colonisation at site 1 may be attributed to attraction of *Elaeis guineensis* fruiting and in particular may be due to higher Flavonoids content of *G. arborea* wood over *V. doniana*. The hives of *G. arborea* and *V. doniana* woods colonised while *E. suaveolens* wood hives did not colonise. This may be due to the high deleterious wood phyto-constituents (Saponins, Tannin and Phenol) in *E. suaveolens* as compared to *G. arborea* and *V. doniana* (Table 4). This confirms the suitability of *G. arborea* and *V. doniana* woods and non-suitability of *E. suaveolens* wood for beekeeping. The criteria for preference are strongly based on multiple attributes which include colour, density, texture, concentration of extractives etc. Colours and extractives were consideration that seemed to have informed these preferences. The extent of awareness of chemical hazards associated with the choice of specific wood species for beekeeping is not well understood in Nigeria. Most species that are used for beekeeping have scanty or un known phytoconstituents bioactivity and uncertain chemical safety. And their uses for beekeeping purposes have potential implications for bees wellbeing and consumers safety as well. Honey is more hygroscopic than woods. It has ability to absorb moisture and extractives from hive woods, hence contaminating the honey. High concentrations of secondary metabolites are known for defensive mechanism against insects. It can be reasonably assumed that *E. suaveolens* woods may possess insects' repellent activities. It is very clear that the two wood species colonised have intrinsic non-insects repellent properties. These observations emphasize the relevance of chemically safe woods for beekeeping and discontinuing use of brown woods for beekeeping.

Generally, the high colonisation and stability of *G. arborea* and *V. doniana* wood hives by natural swarms could have been due to a high population of the natural/feral swarms present in the neighbourhood of the study sites. In Nigeria, most research on beekeeping that was supposed to use empirical approach to elicit information employed the descriptive methods (questionnaires and interviews) on farms with scanty historical records. The colonisation rate was 100% in *G. arborea* and *V. doniana* wood hives within two months of setting while *E. suaveolens* wood hives colonisation was 0%. This 100% colonisation rate was in conformity with what was obtained by [19] in Ogbomoso, South Western Nigeria but almost doubled the 55.6% and 44.4% colonization rates registered within three months by [20] in Moyo and Koboko Districts of Uganda, respectively. This again exactly doubled the reported highest colonization rate of 50% by [21] using Kenya Top Bars (KTB) hives in Nigeria. The reported colonisation rates by [21] and [20] were relative low to this present study though the wood species used for the hives were not discussed. These reported low colonisation and high rate of absconding in many literatures in Africa may be attributed to the wrong choice of wood species used for hive construction among other factors. The observations that *G. arborea* and *V. doniana* species were 100% suitable for beekeeping is particularly interesting because neither the strength nor the durability of both species are exceptionally high to justify their usage for high utility construction of which *E. suaveolens* fits.

The colonies showed evidence of sound health withy remarkable stability in the hives with quantifiable honey production. Results showed an average honey production of 9.4 litres with an appreciable increase in production from 2009 to 2011 and slight decline in 2012. Variations in honey production from 2009 to 2012 were greatest in site 3. This could be attributable to influence of climatic changes and proximity of site 3 to more foraging food plants. Total revenue accrued from sale of honey alone for *G. arborea* and *V. doniana* wood hives ranged from ₦33,100 to ₦38,325 and ₦30,950 to ₦37,150 per annum respectively. With this immediate gain, beekeeping using suitable woods has great potential for economic returns. *G. arborea* wood not only has a beautiful white fine texture grain but is moderately resistant to insects and rot too. The wood is stronger compared to *V. doniana*. This study revealed some vital practical suggestions to guide regional policy development on beekeeping management and development in Africa.

4.1 Pest Situation

Small hive black beetles (*Aethina tumida*) were scantly found in all the hives during the dry season. This is in conformity with the finding of [22] in Central Uganda that *Aethina tumida* prefers warmer micro-climate. Though the presence of the beetles was reported to have implication on the stressful workers to become more housekeepers because of the likelihood of the beetles attacking the queen [23]. It seemed *A. Tumida* is honey eater and not combs destroyer like moth wax. Moth wax was once a notable threat pest that caused high rate of absconding in the study area when hives' covers were not properly reinforced more importantly during rainy season. Pest situation can be controlled to minimal when hives' environments are kept in most sanitary conditions.

5. CONCLUSIONS

- The continued use of specific wood species for beekeeping must be dictated by historical precedents, distinct species physical, chemical and aesthetic features and by species availability. The observed dearth of beekeepers/consumers appreciation for potential likely chemical hazards via the possible absorption of wood phyto-constituents to honey or causing low rate of colonisation and high absconding rate offers an interesting dynamics that need to be addressed if sustainable beekeeping development is desired in Nigeria and Africa at large.
- The study confirmed the acceptability of white woods (*Gmelina arborea and Vitex doniana*) as suitable cavities' materials for honeybees nesting over brown wood (*Erythrophleum suaveolens*).
- The study is of great value to beekeepers in Nigeria and Africa at large because a study of woods in Nigeria could be applied in most instances in many other parts of Africa.
- The study has revealed that durability does not mean suitability. The findings counters the views of using brown woods on the account of durability and more importantly the use of *Milicia excelsa* for hives construction in Ghana as recommended by [24]. Hence, durability alone should not be used as a criterion for selecting woods for beekeeping.
- Observations and measurements showed that these hives too can sustain the bees for more than 10 years.

6. RECOMMENDATIONS

1. Massive plantations of *Gmelina arborea* and *Vitex doniana* should be embark on for the development of suitable habitat for bees (both in the wild and captivity) and other cavity inhabiting animals
2. The use of inorganic herbicides for weeding should be discouraged because this is one of the most anthropogenic threats to genetic honeybee's resource conservation in Nigeria.

3. As Pine and Cedar are highly recommended for beekeeping in temperate region, so It is strongly recommended that *Gmelina arborea* and *Vitex doniana* should be used for beekeeping in Nigeria and Africa at large.
4. Intending beekeepers must seek advice from wood scientists for choice of quality wood species.
5. Further research should be conducted to compare more brown woods with white and yellow woods.
6. Nigeria government should give more priority to funding Forestry related research. The recent delisting Nigeria from eligible countries to benefit from ITTO is a disservice to forestry education and research simply because Nigeria failed to fulfil her counterpart funding component.

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Figure 1. Ripped comb honey half capped from *Vitex doniana* Hive