 doi:10.20944/preprints202208.0175.v1

Article

Ethnobotany Survey of Plants used as Biopesticides by Indigenous People of Plateau State, Nigeria

Ahmed Difa Ali [1], Lydia Doosuur Ior [2,3,*], Goni Abraham Dogo [4], John Israila Joshua [5] and John Stephen Gushit [5]

[1] Department of Plant Science and Biotechnology, University of Jos
[2] Department of Pharmacology, University of Jos
[3] Department of Veterinary Parasitology and Entomology, University of Jos
[4] Africa Centre of Excellence in Phytomedicine Research and Development, University of Jos, Jos Nigeria
[5] Department of Science Laboratory Technology, University of Jos
*Corresponding author: shalhonal@unijos.edu.ng; TEL.: +2348036098383

Abstract: The quest for sustainable health, environmental protection and conservation of beneficial organisms makes the use of biopesticides a desirable option. This research aimed to identify botanicals used in the management of farm and household pest in Plateau State, Nigeria. A cross sectional study was carried out using semi-structured questionnaires and on the spot face-to-face interviews. The main issues captured include the pest, plants used to managed the pest, parts used, cultivation status, availability, effect on pest, formulation methods and modes of application. The quantitative data were analyzed using the Frequency of Citation (FC), Relative Frequency of Citation RFC (%) and Use Value (UV). A total of 45 plant species belonging to 42 genera, 20 orders and 30 families were found to be useful in the management of 15 different pests. The FC, RFC(%) and UV values identified the most popularly used plants as: *Hyptis suaveolens, Vernonia amygdalina, Azadirachta indica, Canarium schweinfurthii* and *Euphorbia unispina* and *Erythrophloem africanum*. Plants that showed broad activity include *Azadirachta indica* (7 uses), *Erythrophloem africanum, Khaya senegalensis* and *Vernonia amygdalina*. The perception of the respondents indicated that most of the biopesticides are available, affordable, effective, eco-friendly and safe. This survey provides a pathway for formulation of biopesticides.

Keywords: biopesticides, ethnobotany; survey; indigenous people; Nigeria

1. Introduction

Highly hazardous pesticides (HHPs) have continued to pose unacceptable risks and disproportionately account for the negative impacts of pesticides on human health and environment, particularly in low and middle-income countries (LMICs) including Nigeria [1]. The challenge of HHPs management in Nigeria is enormous because of indiscriminate use, over reliance on pesticides and lack of control measures leading to increase risks to food safety, health of consumers and agricultural workers. Furthermore, the use of synthetic chemical pesticides has affected both the living and non-living components of the environment, as evidenced by diseases, mortalities, population changes, genetic disorders, physiological deformities, phytotoxicity, gene erosion in plants, mammals, avian, insects and other organism as well as pesticide residues in soil, air, and water [2].

The use of natural plant has been found to be humanly safe, ecofriendly, biodegradable, affordable and largely affect only the target pest in the management of pest of stored products especially in the tropics [3-7]. Thus, modern-day quest for sustainable health, protection of the environment and conservation of beneficial organisms makes biopesticides as more desirable options to synthetic chemicals in agriculture and household pest management [8]. For this reason, various indigenous communities in Nigeria use these botanicals to solve their unique recurring pest problems. It has been discovered that many of the botanicals from *Azadirachta indica*, *Alstonia boonei*, *Annona squamosa*, *Capsicum frutescens*, *Eucalyptus camaldulensis*, *Garcina kola*, *Justicia adhatoda*, *Lantana camera*, *Moringa*

 doi:10.20944/preprints202208.0175.v1

oleifera, *Nicotiana tabacum*, *Ocimum* spp and *Zingiber officinale* have been reported as potential alternatives in the control of maize weevil (*Sitophilus zeamais*) [9-11].

There are a lot of projects constituted to research the use of biopesticides in Nigeria and to complement the existing pest management and control strategies of the Nigerian Government. These government Agencies include Federal Ministry of Environment (FMEV), Federal Ministry of Agriculture and Rural Development (FMA & RD), National Agency for Food and Drug Administration Control (NAFDAC) and National Environmental Standards and Regulations Enforcement Agency (NESREA). Most of these programs have been going on but are yet to sufficiently achieve the desired impact as more still need to be done [1]. Thus, there is need to conduct more research towards providing convincing data on biopesticides that will enhance their usage, enable the development of safe alternatives to unacceptable HHPs and the enactment of national biopesticide policies. The increasing awareness on the need for food safety and quality control on residual pesticide concentrations in harvested/stored produce and demand for safe and affordable alternatives from indigenous bioresource serves as the motivation for this survey. Therefore, the aim of this study is to document the knowledge of indigenous people on usage of plants in the management of pests.

2. Materials and Methods

2.1. Study Area

Plateau State is located in the north central part of Nigeria with a land mass of about 30,913 km^2 and an average population of 4,200,442 as at 2016 projected population figures [12]. The State is situated between latitude 8°24'N and 10°46'N, longitude 8°32'E and 10°34'E as shown in Figure 1. It is generally mountainous with rock formations scattered across the guinea savannah. The altitude of the entire state ranges from 300 to 1,829 meters above sea level. The high altitude in the northern part gives it a near temperate climate with an average temperature between 18 and 22°C. On the other hand, the southern part has a slightly different climatic condition which is generally more humid and warmer. The variation in the climatic conditions of the state explains why biodiversity is high. The dominant occupation of the people in the area is farming which occurs mainly in the rainy season. The major ethnic groups in the state include: Berom, Afizere, Amo, Bache, Irigwe (located in northern part of the state), Ngas, Mwaghavul, Boghom, Mushere (found in the central part of the state) and Taroh, Ankwai, Pan, Doemak (found in the southern part of the state) located in the 17 local government areas. The major crops grown include maize, rice, soya bean, groundnuts, acha, yam, iris potato, and temperate vegetables.

2.2. Selection of Study Sites

In this study, the state was divided into three (3) zones namely: Northern, Central and Southern zone. The sites were purposely selected based on ethnic representation to ensure effective coverage of the various ethnic/cultural groups that are either indigenous to or reside within the state. Site coordinates of sampling locations were determine using the Global Positioning System (GPS), G-PORTER GP-102+ model.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

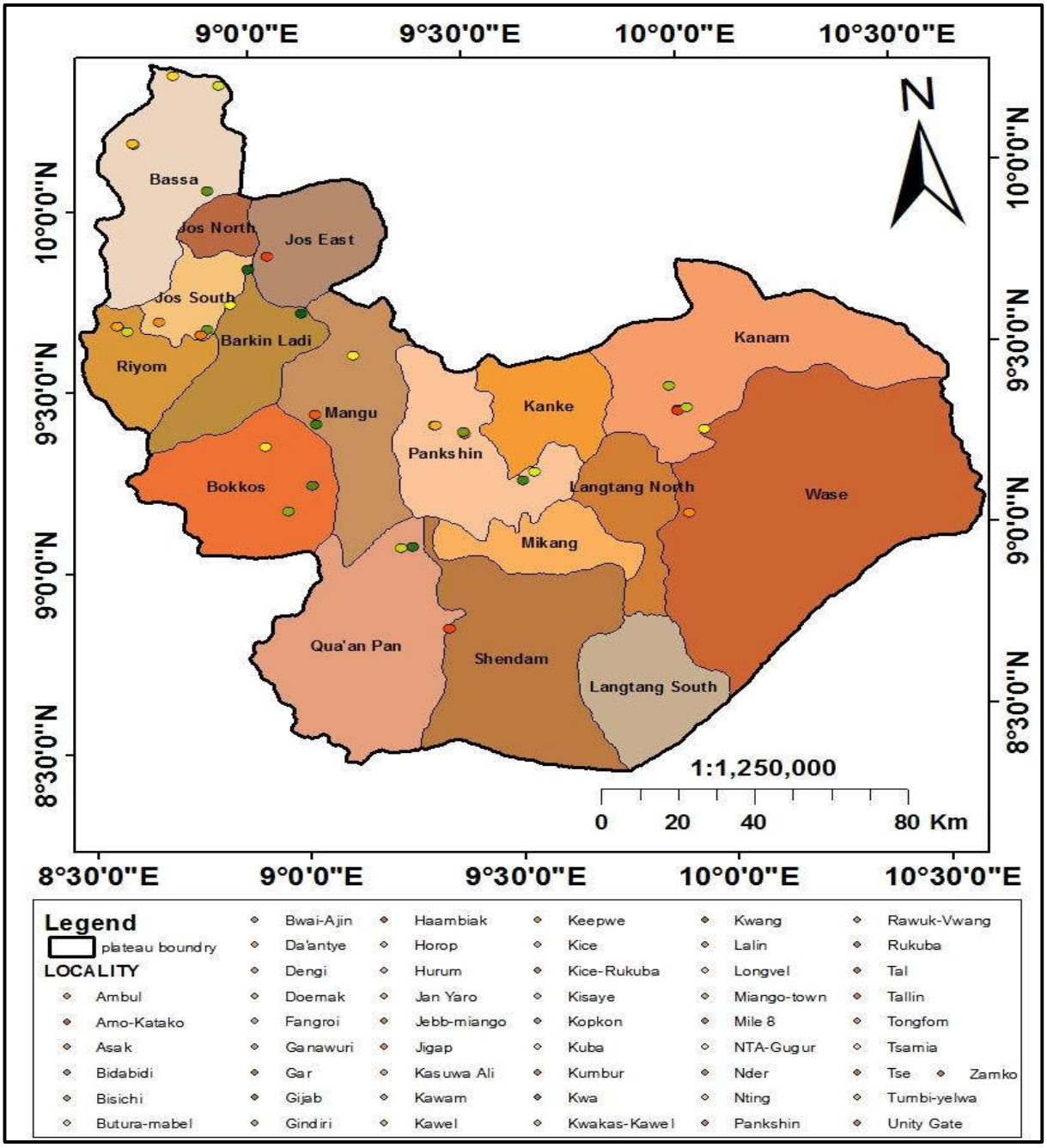

Figure 1. Map of Study Area (Plateau State).

2.3. Ethnobotanical Data Collection

Ethnobotanical data were collected between August and September, 2020. A cross sectional study was carried out using semi-structured questionnaires to obtain information on pesticidal plants amongst the various ethnic groups. We obtained information in the field from both men and women in all communities visited according to the method of [13] and [14]. The main issues captured in the questionnaires include locations, target pest, plants/plants' product for managing pest, parts used, cultivation status, availability in the locality, formulation methods and modes of application.

To ensure maximal retrieval of the questionnaires, we carried out the exercise by on-the-spot administration of questionnaire which further allowed room for wide interaction with the target groups and helped to bring up other necessary salient issues the questionnaire was unable to address. Mindful of the diversity of the culture and tradition of the various ethnic groups in the study area, we used the common languages spoken by the

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

people for communication at the point of sampling. In the event where the spoken language is strange, we overcame this barrier with the aid of interpreters whom we guided on what the study aimed to achieve. Samples of plants referred to by respondents were collected by volunteers from the locality, farmlands and nearby bushes for further identification.

2.4. Voucher Specimen Collection

Voucher numbers were assigned to the preserved specimen and deposited in the herbarium of the Department of Plant Science and Biotechnology, University of Jos. The plants were identified using keys and description given in [15-16] and arranged according to the classification of [15].

2.5. Data Analysis

The data collected was summarized using descriptive methods such as frequencies, percentages, graphs and tables with the help of excel 2010 and SPSS 2019. To statistically analysed the data collected, the following quantitative indices were evaluated:

i. Frequency of Citation (FC)

The FC was calculated as follows:

$$FC = \frac{Number\ of\ times\ a\ particular\ species\ was\ mentioned}{Total\ number\ of\ times\ that\ all\ species\ were\ mentioned} \times 100$$

ii. Relative Frequency of Citation (RFC)

The RFC index describe by [18] was used as the number of informants who mentioned the use of the species (FC) divided by the total number of informants participating in the survey (N). The RFC index ranges from "0 - 0.99", when nobody referred to a plant as useful, and "1" when all informants referred to a plant as useful.

$$RFC = \frac{FC}{N}$$

iii. Use Value (UV)

The Use Value (UV) demonstrates the relative importance of plants known locally as pesticide remedy. We calculated the UV using the following formula (14):

$$UV = \frac{\sum Ui}{N}$$

Where Ui is the number of uses mentioned by each informant for a given species and N refers to the total number of informants interviewed. If a plant secures a high UV score, that indicates there are many use reports for that plant, implying that the plant is important, while a low score (approaching zero) denotes few reports related to its use.

3. Results

3.1. Socio-Demographic Data of the Respondents

A total of 212 participants in 55 localities from 15 Local Government Areas of the state were interviewed during the survey. The profile of the respondents showed 46 (21.70%) female and 166 (78.30%) males. The age of the respondents ranges between 20 to 105 years, and majority them were within 40 to 59 years (41.98%). The vast majority of the respondents were farmers 72.3% (153) and only 7.98% (16) were formally employed (Table 1).

 doi:10.20944/preprints202208.0175.v1

Table 1. Statistics on the usage of Plants as pesticide in Plateau State Nigeria.

Parameter	Count	Percentage (%)
GENDER		
Female	46	21.70
Male	166	78.30
OCCUPATION		
Business	12	5.63
Civil servant	17	7.98
Clergy	9	4.23
Community Leader	1	0.47
Driver	1	0.47
Farmer	153	72.30
Herdsman	2	0.94
Hunter	1	0.47
Security	5	2.35
Student	7	3.29
Trade man	4	1.88
AGE (Years)		
20 – 39	64	30.19
40 – 59	89	41.98
60 – 79	52	24.53
80 – 99	6	2.83
100 – 119	1	0.47

3.2. Plant species used as biopesticide in the study area

The survey revealed that 45 plant species belonging to 42 genera, 20 orders and 30 families were used in the management of 15 different pests in Plateau State (Table 2). Families with the highest number of species are: Euphorbiaceae, Fabaceae and Malvaceae with 4 species each, Amaryllidaceae, Solanaceae and Meliaceae with 3 species each and the remaining families were represented by one species each.

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

Table 2. Plants used as Pesticide in Plateau State, Nigeria.

S/NO	VOUCHERS NUMBERS	FAMILY	SPECIES	ENGLISH NAME	LOCAL NAME	PARTS USED	TARGET PEST
1	JUHN21000366	Amaryllidaceae	*Allium cepa* L.	Onions	Albassa (Hausa), Leh zipir (Mushere)	Bulb	Snake
2	JUHN21000368	Amaryllidaceae	*Allium sativum* L.	Garlic	Tafarnuwa (Hausa)	Rhizome	Snake
3	JUHN21000369	Amaryllidaceae	*Crinum jagus* (J.Thomps.) Dandy		Gadali/Albassan machiji (Hausa), Dau (Doemak), Girime (Irigwe),	Bulb; Leaf; Whole	Snake
4	JUHN21000370	Annonaceae	*Uvaria chamae* P. Beau	bush banana/ Finger root	Rikuki (Hausa)	Seed	Human lice, Lice
5	JUHN21000407	Apocynaceae	*Calotropis procera* (Aiton) Aiton fil.	Calotropis	Tumfafia/Tumphafia (Hausa)	Latex	Fungi
6	JUHN21000371	Asphodelaceae	*Aloe vera* (L.) Burm. F.	Aloe vera		Latex	Fungi
7	JUHN21000372	Asteraceae	*Vernonia amygdalina* Delile	Bitter leaf	Shuwaka (Hausa), Munaan (Mwaghavul), Limtii (Mushere), Chulup(Berom), Gwanye, Manineng, NaF(Ron), Riti, Sudul	latex; Leaf; fruit	Aphid, Bird, Fungi, Insect, Lice, Mite, Rodent, Termite, Weevil
8	JUHN21000373	Bignoniaceae	*Kigelia africana* (Lam.) Benth.	Sausage tree	Hantsargiiwaa (Hausa)	Fruit	Termite
9	JUHN21000374	Bombacaceae	*Ceiba Pentandra* L.		Bwas (Doemak), Dadawan Remi (Hausa)	Seed	Snake
10	JUHN21000375	Burseraceae	*Canarium schweinfurthii* Engl.	African olive/Canarium	Atile (Hausa), Paat (Mushere, Mwaghavul), Toeng paat (Ngas) Ting fwat (Birom)	latex; Leaf; Seed; Stem Bark	Mosquito, Snake, Termite, Weevil
11	JUHN21000376	Chenopodiaceae	*Dysphania ambrosioides* (L.) Mosyakin & Clemants		Kafi Gwano Wari (Hausa)	Leaf	Mosquito, Snake
12	JUHN21000367	Clusiaceae	*Garcinia kola* Heckel	Bitter Cola	Namijin goro (Hausa)	Fruit	Snake
13	JUHN21000377	Cucurbitaceae	*Lagenaria siceraria* Molina		kwarya duma (Hausa)	Leaf	Weevil
14	JUHN21000379	Euphorbiaceae	*Euphorbia tirucalli* L	African milkbush	Kaampaar(Mushere, Mwaghavul)	latex; Leaf; Stem	Termite
15	JUHN21000380	Euphorbiaceae	Euphorbia *unispina* NE Br.	White cactus	Ngaar (Mwaghavul, Mushere), Tinya (Hausa), Bango (Bache), Tulup(Berom)	latex; Leaf; Stem	Ants, Bird, Intestinal Worm, Rodent, Snake, Termite
16	JUHN21000378	Euphorbiaceae	*Jatropha curcas* L.	Jathropha	Binidazugu/Irumu (Hausa), Moor biring (mushere, Mwaghavul)	latex; Leaf; Leaf & stem; Seed; Stem Bark	Fungi, Lice, Lice, Mite
17	JUHN21000409	Euphorbiaceae	*Manihot esculenta* Crantz	Cassava	Rogo (Hausa)	Leaf	Fungi
18	JUHN21000381	Fabaceae	*Arachis hypogea* L.	Groundnut	Gyadda (Hausa), Khom (Mushere, Mwughavul), Abwai (Amo), Yaba (Birom),	Fruit Peel, Seed	Termite

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

19	JUHN21000383	Fabaceae	*Erythrophleum africanum* (Benth.) Harms	African blackwood	Gwaska (Hausa), Kisom (Mupun), Ravu/iravo (Fyer), Sere (Fyem)	Bark; latex; Leaf; Leaf & Stem Bark; Stem Bark; Whole	Bird, Fungi, Intestinal Worm, Rodent, Snake, Termite, Tick, Weevil
20	JUHN21000382	Fabaceae	*Parkia biglobosa* (Jacq.) Benth	African Locust Bean tree	Dorowa (Hausa), Ting Mess (Mwaghavul), Tsekep Mess (Mushere) Yin furtu (Youm), Din fut (Telh), Nimuum/Fining (Jukun), Jeye/Kuni muun (Mupun), Kuni ribuk(Torak), Mah mur (Mernyang), Nzeing (berom), Sulendhe (Aten), Wok switi (Bokom), Yen Fet (Geomai), Yen fut (Mushere), Yim fut (Tal), Yim mur (Mernyeng),	Fruit, Leaf, Seed	Bird, Mosquito, Rodent, Snake, Termite, Weevil
21	JUHN21000408	Lamiaceae	*Hyptis suaveolens* (L.) Poit.	American Mint		latex, Leaf	Fungi, Mosquito, Snake, Weevil
22	JUHN21000384	Lamiaceae	*Melissa officinalis* L.	Lemon balm	kwili-shuiti (Bogom)	Leaf	Mosquito
23	JUHN21000385	Lamiaceae	*Ocimum americanum* L.	curry like	Daaddooyaa/Gadali/Albasan Machiji (Hausa), Girime (Irigwe), Ihal-soo (Pyem), Ndaw/Gadali (Tarok)	Leaf; Leaf & stem	Butterfly, Mosquito, Weevil
24	JUHN21000386	Lauraceae	*Persea americana* L.	Avocado Pear	Fiya (Hausa)	Seed	Rodent
25	JUHN21000398	Lythraceae	*Lawsonia inermis* L.	Henna Plant	Lalle (Hausa)	Flower	Snake
26	JUHN21000403	Malvaceae	Adansonia *digitata* L.	*Baobab*	Kuka (Hausa)	Leaf	Snake
27	JUHN21000399	Malvaceae	*Bombax ceiba* L.	Bombax sp	Tsap	Leaf	Bird, Rodent,
28	JUHN21000401	Malvaceae	*Elaeis guineensis* Jacq.	African oil palm	Tsekwep Moorbhang(Mushere), Shep Moorbhang (Mwaghavul)	Fruit; Seed	Termite Tick
29	JUHN21000402	Malvaceae	*Hibiscus cannabinus* L.	Kenaf	Rama (Hausa),	Seed/calyx	Fungi Snake
30	JUHN21000400	Malvaceae	*Hibiscus sabdariffa* L.	Sorrel	Yakuwa (Hausa), Diyang,	Seed/calyx	Snake
31	JUHN21000405	Meliaceae	*Azadirachta indica* A. Juss	Neem	Dogon Yaro/Maina (Hausa) Darbagiah,	Bark; Leaf; Seed; Seed, Leaf & Stem bark	Bird, Fungi, Human lice, Insect, Intestinal Worm, Lice, Rodent, Termite, Weevil
32	JUHN21000404	Meliaceae	*Khaya senegalensis* (Desv.) A. Juss.	Mahogany	Madachi (Hausa), Theen (Mushere, Deomak), Nchit (Bache), Tcho (Berom)	Bark; Leaf & Stem Bark; Seed; Stem Bark	Chicken Lice, Fungi, Human lice, Intestinal Worm, Lice, Mite, Termite, Weevil
33	JUHN21000406	Moraceae	*Ficus microcarpa* L.	Ficus	Durumi (Hausa),	Latex	Fungi
34	JUHN21000387	Myrtaceae	*Eucalyptus tereticornis* Smith	Eucalyptus	Rastata/gadina (Hausa), Cyata/Liyata (Irigwe).	Leaf	Mosquito, Weevil
35	JUHN21000388	Opiliaceae	*Opilia celtidifolia* (Guill. & Perr.) Endl.	-	Rupan gadda (Hausa)	Leaf	Bird, Rodent

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

36	JUHN21000389	Pedaliaceae	*Sesamum radiatum* L.	Benniseed	Karkashi (Hausa), Lhem (Mushere, Mwaghavul)	Leaf	Human lice Lice
37	JUHN21000390	Poaceae	*Cymbopogon citratus* (DC.) Stapf	Lemon grass	Kwalunkop (Aten)	Fruit Peel; Leaf; Whole	Mosquito
38	JUHN21000391	Rubiaceae	*Spermacoce verticillata* L.	false buttonweed/African borreria	Gurdudal (Fulani	Latex	Fungi, Mite
39	JUHN21000392	Rutaceae	*Citrus sinensis* (L.) Osbeck	Orange	Lemon zaki (Hausa),	Fruit; Fruit Peel; Leaf	Mosquito
40	JUHN21000393	Sapotaceae	*Vitellaria paradoxa* C. F. Gaertn.	Shea Tree	Kadanya (Hausa)	Seed	Snake
41	JUHN21000394	Scrophulariaceae	*Eremophila oldfieldii* F.Muell.		karara, Kaikayi (Hausa)	Pod; Whole	Intestitnal Worm, Snake
42	JUHN21000397	Solanaceae	*Capsicum frutescens L*	Hot pepper/pepper	Barkono, Chitta (Hausa), Shitaa (Mushere), Njitaa (Mwaghavul)	Fruit; Seed; Whole	Bird, Rodent, Termite, Weevil
43	JUHN21000395	Solanaceae	*Solanum lycopersicum* Lam.	Tomato	Tumatir (Hausa)	Leaf	Fungi
44	JUHN21000396	Solanaceae	*Nicotiana tabacum* L.		Taba (Hausa)	Leaf	Chicken Lice, Mosquito, Snake, Weevil
45	JUHN21000410	Verbenaceae	*Lantana camara* L	Lantana	Kimbar/kashin kuda(Hausa), Tikanahu (Aten)	Leaf	Mosquito

Thirty-three plant species from twenty-one families are used as repellent; fifteen plant species from ten families as insecticide; twelve species from ten families as fungicides; nine species from eight families are used to control rodents. A total of eleven species are used as insecticide and repellent; seven other species are used as avicide and rodenticide (Table 2 & Figure 2).

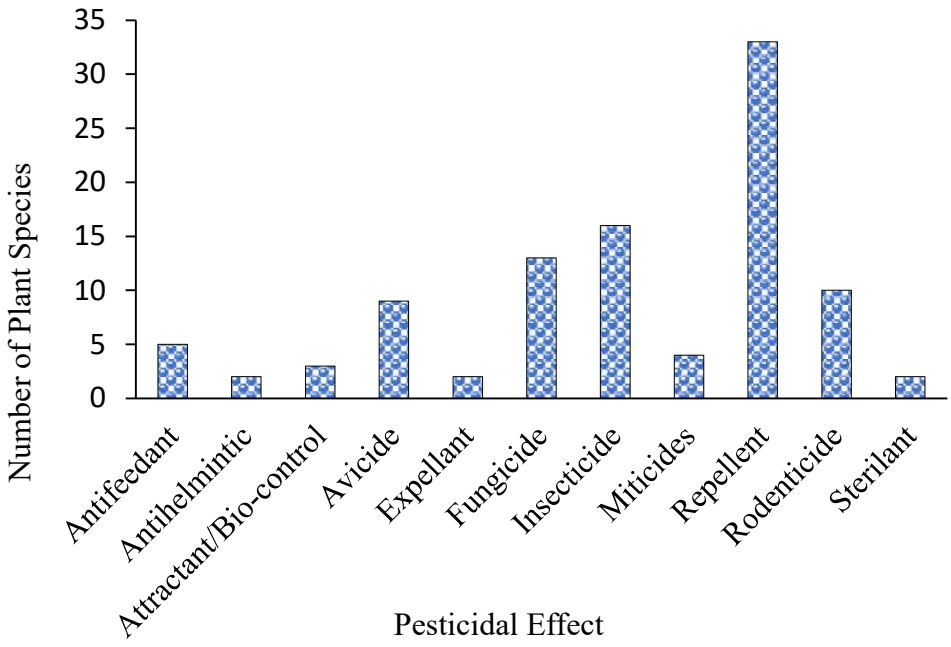

Figure 2. Number of Plants Species distributed for different pesticidal effect .

 doi:10.20944/preprints202208.0175.v1

3.3. Parts used, cultivation status and availability

The frequency of plant parts used by respondents (Figure 3) indicated that the most used plant parts were leaves (26 plants), followed by seeds (14 plants), latex (11 plants), fruit (7 plants), whole (5 plants), stem bark (4 plants), fruit peel (3 plants), while the use of rhizome, flower, leaf/fruit and the combination of seed/leaf/stem bark occurred once.

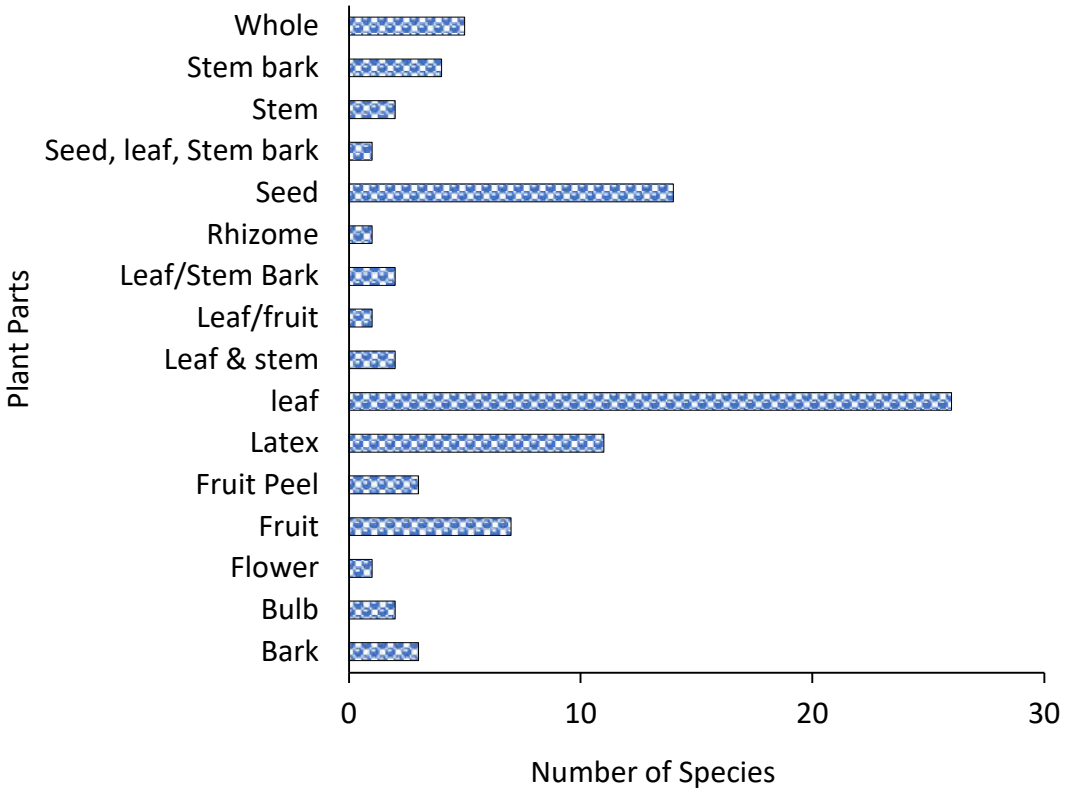

Figure 3. Plant parts used as source of pesticide and their frequency of occurrence.

On the other hand, majority of the plant species occurred domestically (55%), followed by those in the wild (25%) and 20% were found both domestic and in the wild. The perception of the respondents on availability indicated that most of the plants were easily available at all times (93%) and only 7% were difficult to come by (Table 3).

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

Table 3. Method of Administration, Cultivation Status, Availability and Status of Usage of Pesticidal Ethnobotanical Plants in Plateau State.

S/ NO	SPECIES	METHOD OF ADMINISTRATION	CULTIVATION STATUS			AVAILABILITY			STATUS OF USAGE		
			D	O	W	E	A	SY	H	M	IX
1	Adansonia *digitata* L.	SM(1)			1	1					1
3	*Allium cepa* L.	SP(1)		1		1			1		
4	*Allium sativum* L.	SP(1)		1		1			1		
5	*Aloe vera* (L.) Burm. F.	TO(1)		1		1			1		
6	*Arachis hypogea* L.	BA(1),PO(2), SR(1).		4		4			4		
7	*Azadirachta indica* A. Juss	DR(7), OR (1), PO(16), SR(3), SP(1) & TO(3).		29	2	30		1	30		1
8	*Bombax ceiba* L.	DR(2).			2			2	2		
9	*Calotropis procera* (Aiton) Aiton fil.	TO(1).		2		2			2		
10	*Canarium schweinfurthii* Engl.	PO(2), SM(19), TO(3).		16	2	6	22	2	24		
11	*Capsicum frutescens L*	DR(16), PO(3).		19			19		18		1
12	*Ceiba Pentandra* L.	SP(1).				1	1		1		
13	*Citrus sinensis* (L.) Osbeck	PO(2), SM(3).		5			5		3		2
14	*Crinum jagus* (J.Thomps.) Dandy	OR(1), PO(8), SR(2).		10		1	8	3	11		
15	*Cymbopogon citratus* (DC.) Stapf	PO(9), SM(1).		9		1	9	1	10		
16	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	PO(14), SM(2), TO(1).		16	1		17		17		
17	*Elaeis guineensis* Jacq.	PO(1), TO(2).		3			3		3		
18	*Eremophila oldfieldii* F.Muell.	OR(1), PO(1).		2			2		2		
19	*Erythrophleum africanum* (Benth.) Harms	DR(12), PO(4), SM(1), SR(1), SP(4), WS(1).		2	17	4	15	8	23		
20	*Eucalyptus tereticornis* Smith	PO(4), SM(3).		6		1	7		7		
21	*Euphorbia tirucalli* L	PO(9).		6		3	9		9		
22	Euphorbia *unispina* NE Br.	BA(2), DR(10), PO(11), SP(1).		2	1	21	17	7	23		1
23	*Ficus microcarpa* L.	TO(1).		1			1		1		
24	*Garcinia kola* Heckel	PO(1).		1				1	1		
25	*Hibiscus cannabinus* L.	SR(1), SP(1), TO (1).		3			3		3		
26	*Hibiscus sabdariffa* L.	PO(1), SP(1).		2			2		2		
2	*Hyptis suaveolens* (L.) Poit.	PO & SM(7), SM(17), TO(1).		8	60	1	68	1	69		
27	*Jatropha curcas* L.	TO(7).		6	2		8		8		
28	*Khaya senegalensis* (Desv.) A. Juss.	BT(2), DR(1), OR(4), PO(1), SP(2), TO(10).		11	5	4	17	3	19		1
29	*Kigelia africana* (Lam.) Benth.	PO(3).		3			3		3		
30	*Lagenaria siceraria* Molina	PO(1).				1	1		1		
31	*Lantana camara* L	PO(8), SM(9).		13	4		17		16		1
32	*Lawsonia inermis* L.	TO(1).		1			1		1		
33	*Lycopersicon esculentum* Mill.	TO(1).		1			1		1		
34	*Manihot esculenta* Crantz	SR(1).		1			1				1
35	*Melissa officinalis* L.	PO&SM(1).		1			1		1		
36	*Nicotiana tabacum* L.	PO(5), SM(2), SR(1), SP(1).		9			9		9		
37	*Ocimum americanum* L.	DR(2), PO(5).		4	3		4	3	7		
38	*Opilia celtidifolia* (Guill. & Perr.) Endl.	DR(2).				2	2		2		
39	*Parkia biglobosa* (Jacq.) Benth	DR(4), PO(1), SM(1), SP(4), TO(1).		7	1	3	11		9		2
40	*Persea americana* L.	BA(1).		1			1		1		
41	*Sesamum radiatum* L.	WS(10).		10			10		10		
42	*Spermacoce verticillata* L.	TO(7).		5	1	1	7		7		
43	*Uvaria chamae* P. Beau	TO(2).			2		1	1	2		

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

44	*Vernonia amygdalina* Delile	DR(11), PO(26), SR(1), SP(2), TO(6), WS(2).	39	6	3	47	1	44	4
45	*Vitellaria paradoxa* C. F. Gaertn.	SM(1).					1	1	
	Percentage		**55**	**20**	**25**	**93**	**7**	**97**	**3**

A=Bait, BT=Bathing, DR=Dressing, OR=Orally, PO=Positioning, SM=Smoking, SR=Spraying, SP=Spreading, TO=Topically, WS=Washing, DO=Domestic, WI=Wild.

3.4. Modes of preparation and Application

The respondents employ a variety of methods in the preparation and administration of pesticidal plants (Table 3). The study revealed that the commonest practice for pesticide application employs the use of single species (97%) as compared to the use of mixture of two or more species (3%). Figure 4 depicts that the most common method of application is positioning fresh or dry plant materials to emit fragrance/odor (41.39%), followed by topical application of latex, sap or exudates (24.17%) and smoking of dry or fresh leaves (17.22%).

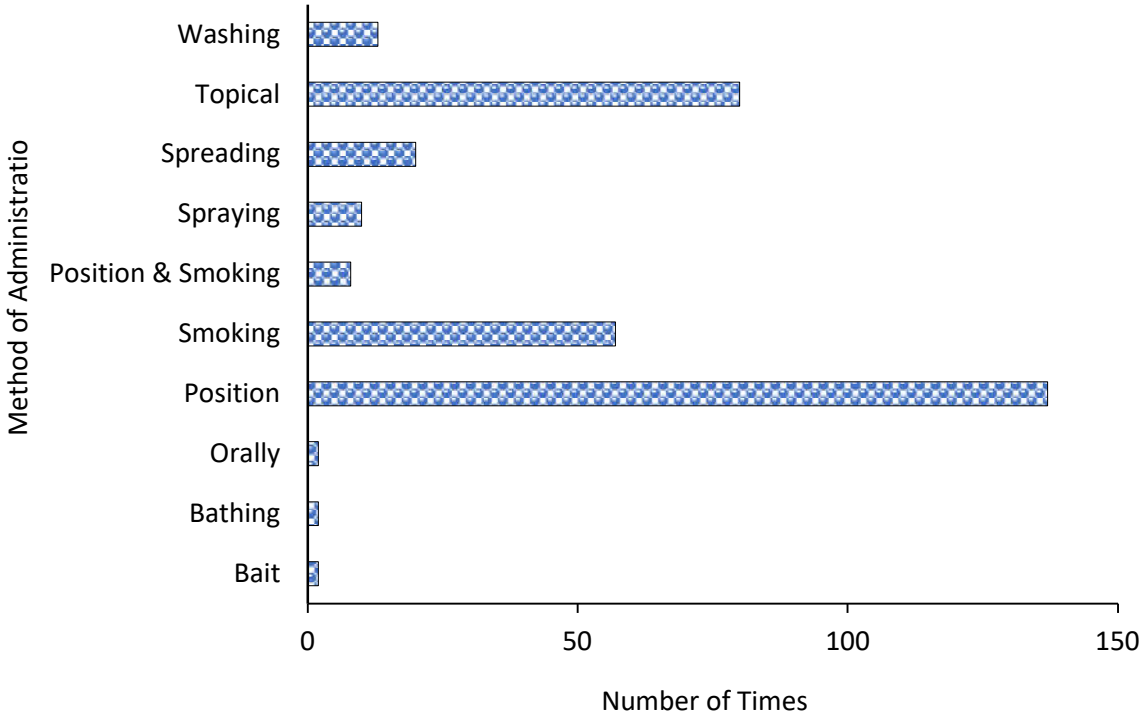

Figure 4. Frequency of mode of application of plants for pest management.

3.5. Uses and Ethnobotanical Indices

The species with the highest number of pesticidal use category (Table 4) were *Azadirachta indica* (7 uses), *Erythrophloem africanum, Khaya senegalensis* and *Vernonia amygdalina* (6 uses), *Euphorbia unispina* and *Capsicum frutescens* (5 uses). The FC, RFC (%) and UV values of identified plant species for the study area ranges from 1-69, 0.47-32.25, and 0.005-0.307 respectively (Table 4). The pesticidal plants reported in this study with high FC, RFC (%) and UV are *Hyptis suaveolens* (L.) Poit. (69, 32.55% and 0.307 respectively), *Vernonia amygdalina* Del. (48, 22.64% and 0.175 respectively), *Azadirachta indica* A. Juss. (31, 14.62% and 0.118 respectively), *Canarium schweinfurthii* Engl. (24, 11.32% and 0.108 respectively),

 doi:10.20944/preprints202208.0175.v1

Euphorbia unispina and *Erythrophleum africanum* (23, 10.85% and 0.071 each respectively). Fourteen of the species mentioned have FC, RFC (%) and UV values of 1, 0.210% and 0.005 respectively.

Table 4. Frequency of Citation (FC), % Relative Frequency of Citation (%RFC) and Use Value (UV) of pesticidal plants in the study area.

S/N	SPECIES	EFFECT ON THE PEST	FC	RFC(%)	UV
1	Adansonia *digitata* L.	Repellent (1)	1	0.47	0.005
2	*Allium cepa* L.	Repellent (1)	1	0.47	0.005
3	*Allium sativum* L.	Repellent (1)	1	0.47	0.005
4	*Aloe vera* Mill.	Fungicide (1)	1	0.47	0.005
5	*Arachis hypogea* L.	Attractant/Bio-control (4)	4	1.89	0.019
6	*Azadirachta indica* A. Juss	Antifeedant (1), Avicide (2), Expellant (1), Fungicide (1), Insecticide (11), Repellent (13), Rodenticide (2)	31	14.62	0.118
7	*Bombax ceiba* L.	Avicide (1), Rodenticide (1)	2	0.94	0.005
8	*Calotropis procera* (Aiton) Aiton fil.	Fungicide (1), Repellent (1)	2	0.94	0.009
9	*Canarium schweinfurthii* Engl.	Repellent (24)	24	11.32	0.108
10	*Capsicum frutescens L*	Avicide (1), Antifeedant (1), Insecticide (4), Repellent (12), Rodenticide (1)	19	8.96	0.08
11	*Ceiba Pentandra* L.	Repellent (1)	1	0.47	0.005
12	*Citrus sinensis* (L.) Osbeck	Repellent (5)	5	2.36	0.024
13	*Crinum jagus* (J.Thomps.) Dandy	Repellent (11)	11	5.19	0.047
14	*Cymbopogon citratus* (DC.) Stapf	Repellent (10)	10	4.72	0.047
15	*Dysphania ambrosioides* (L.) Mosyakin & Clemants	Repellent (17)	17	8.02	0.061
16	*Elaeis guineensis* Jacq.	Insecticide (2), Repellent (1)	3	1.42	0.014
17	*Eremophila oldfieldii* F.Muell.	Anthelmintic (1), Insecticide (1)	2	0.94	0.009
18	*Erythrophleum africanum* (Benth.) Harms	Acaricide (1), Avicide (4), Insecticide (11), Repellent (2), Fungicide (1), Rodenticide (4)	23	10.85	0.071
19	*Eucalyptus tereticornis* Smith	Insecticide (2), Repellent (5)	7	3.3	0.028
20	*Euphorbia tirucalli* L	Insecticide (1), Repellent (8)	9	4.25	0.042
21	Euphorbia *unispina* NE Br.	Avicide (3), Fungicide (1), Insecticide (8), Repellent (7), Rodenticide (4)	23	10.85	0.071
22	*Ficus microcarpa* L.	Fungicide (1)	1	0.47	0.005
23	*Garcinia kola* Heckel	Repellent (1)	1	0.47	0.005
24	*Hibiscus cannabinus* L.	Fungicide (1), Repellent (2)	3	1.42	0.014
25	*Hibiscus sabdariffa* L.	Repellent (2)	2	0.94	0.009
26	*Hyptis suaveolens* (L.) Poit.	Antifeedant (2), Insecticide (1), Repellent (66)	69	32.55	0.307
27	*Jatropha curcas* L.	Fungicide (4), Insecticide (2), Miticides (1)	7	3.3	0.019
28	*Khaya senegalensis* D	Anthelmintic (3), Expellant (2), Fungicide (2), Insecticide (5), Miticides (1), Repellent (7)	20	9.43	0.09
29	*Kigelia africana* (Lam.) Benth.	Attractant/Bio-control (3)	3	1.42	0.014
30	*Lagenaria siceraria* Molina	Antifeedant (1)	1	0.21	0.005
31	Lantana camara L	Repellent (17)	17	8.02	0.08
32	*Lawsonia inermis* L.	Repellent (1)	1	0.47	0.005
33	*Lycopersicon esculentum* Mill.	Fungicide (1)	1	0.47	0.005
34	*Manihot esculent* Crantz	Insecticide (1)	1	0.47	0.005
35	*Melissa officinalis* L.	Repellent (1)	1	0.47	0.005
36	*Nicotiana tabacum* L.	Insecticide (1), Repellent (8)	9	4.25	0.042
37	*Ocimum americanum* L.	Insecticide (2), Repellent (5)	7	3.3	0.033
38	*Opilia celtidifolia* (Guill. & Perr.)	Avicide (1), Rodenticide (1)	2	0.42	0.005
39	*Parkia biglobosa* (Jacq.) Benth	Avicide (1), Repellent (9), Rodenticide (1)	11	5.19	0.047
40	*Persea americana* L.	Rodenticide (1)	1	0.47	0.005

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

41	*Sesamum radiatum* L.	Insecticide (10)	10	4.72	0.047
42	*Spermacoce verticillata* L.	Fungicide (4), Repellent (3)	7	3.3	0.033
43	*Uvaria chamae* P. Beau	Repellent (2)	2	0.94	0.009
44	*Vernonia amygdalina* Delile	Avicide (3), Fungicide (4), Insecticide (6), Miticides (3), Repellent (29), Rodenticide (3)	48	22.64	0.175
45	*Vitellaria paradoxa* Gaertn.	Repellent (1)	1	0.47	0.005

FC = Frequency of citation, RFC = Relative frequency of citation, UV = Use value

4. Discussion

4.1. Demographic data

Generally, the study revealed that the indigenous people of Plateau State have sufficient knowledge of the use of plants in the management of pests. The profile of the respondents interviewed in this study indicates that a large section of the population are aware of the use of pesticidal plants from different ethnic groups irrespective of their sex and age. The fact that males are more knowledgeable about the pesticidal plants could be attributed to the men being more engaged in farming compared to women [18]. Interestingly, a considerable number of women were encountered during the interview due to their active roles in subsistence farming and other agricultural activities common to the state. In Plateau State and other reports, the respondents' age of 40 - 59 years, depicts the peak of their productive years (Table 1). [19] indicated a curvilinear relationship between age of respondents and the number of plant species identified in Niger, advocating that knowledge of plant species drops after a certain age.

4.2. Plant Species used as Biopesticide

The 45 pesticidal plants from 30 families used for pest management purposes reported in this study is higher than the 36 plant species from 28 families earlier report on crop protectants in the Federal Capital Territory of North Central Nigeria by [20]. Another report by [21] revealed the use of 31 plants belonging to 22 families for pest management by rural farmers in Ekiti State, Nigeria.

The family with the highest contribution to the species are: Euphorbiaceae, Fabaceae and Malvacea followed by Amaryllidaceae, Solanaceae and Meliaceae (Table 2). Previous studies by [20] have confirmed the prevalence of pesticidal effects of plant species belonging to the family Fabaceae and Lamiaceae followed by Apocynaceae, Cucurbitaceae, Euphorbiaceae and Plantaginaceae. Our results agree with those of [22, 23] who found that the family Euphorbiaceae was one of the most used sources of plant-based pesticides in Southwestern and Northern Uganda respectively. Other studies in sub-Saharan Africa such as [24, 25] also reported that Euphorbiaceae is the family with the highest number of biopesticidal plants. This observation could be attributed to their range of phytochemical compounds, including polyphenols, phenolic acids, flavonoids, saponins, tannins, acetylenes, coumarins and triterpenes in these families [26].

Thirty-two plant species were found to be used as repellent, fifteen as insecticide twelve as fungicide while nine were used to control rodents with several plants having broad pesticidal activities. Interestingly, *Azadirachta indica* which is used as antifeedant, avicide, expellant, fungicide, insecticide, repellent and rodenticide is of economic significance among the plants. For example The activity of *A. indica* has been associated with the presence of Azadirachtin reportedly used in the control of over 200 insect pests from different insect orders [27]. A notable example of avicide and rodenticide in this study is *Erythrophleum africanum* ('Gwaska' in Hausa), reputed for its use as an ordeal poison to kill or scare away stubborn pest like birds and rodents from cultivated farmland as corroborated by [28, 29].

Similarly, *Hyptis suaveolens*, the most frequently cited plant belonging to the family Lamiaceae, was the most represented insect repellent plant family as found also in an earlier study in Kenya [30]. It is used for some ethnobotanical applications in rural

Preprints (www.preprints.org) | NOT PEER-REVIEWED | Posted: 9 August 2022 doi:10.20944/preprints202208.0175.v1

communities in African countries [31] and the plant is readily available close to villages, along roadsides, on farmsteads, etc. In line with our findings, the plant has been reported by many to be a potent herb that exhibits insecticidal properties[32] that include feeding deterrent, insect repellency against mosquitoes and pests of stored grains [33-36].

The data obtained revealed that some plants such as *Azadirachta indica*, *Capsicum frutescens*, *Erythrophloem africanum*, *Euphorbia unispina*, *Khaya senegalensis*, *Vernonia amygdalina* D, had multiple pesticidal properties, as they were implicated in the control of 5 to 7 pest each. Similarly, an investigation on the protectant effectiveness of some Nigerian native plants against the maize and cowpea weevil by [37, 38], recognized that several plants have broad pesticidal activity and are commonly used in traditional agricultural applications in many parts of the developing countries.

4.3. Parts used, Cultivation Status and Availability

Our findings in this study that the most frequently used plant part is the leaves followed by seeds, latex and fruits (Figure 2) is consistent with earlier reports [39-41]. This could be because leaves are readily available, very abundant and very easy to harvest [42]. The harvesting of leaves is relatively more sustainable since the plant can regrow new leaves easily, especially during the rainy seasons. According to the plant defense theory [43], the bioactive compounds or secondary metabolites presumed to be responsible for repelling attackers are more concentrated in the leaves compared to other parts of the plants [23, 41]. Providentially, the preference for leaves might help a lot from the point of conservation of these plants compared to harvesting plant roots, barks or gathering the whole plant. In the same vein, the minimal use of roots and the whole plant for pest control is an added advantage for conservation purposes.

This study and other similar studies [44, 45] revealed that the majority of the respondents believed that most of the plants are available, effective, dependable, eco-friendly and have low toxicity. The level of respondent's awareness, confidence, and acceptability may be a strong impetus for the launch of biopesticide utilization and development in the region. This also emphasizes the significance of indigenous knowledge and practices in the promotion of the use of biopesticide production in Nigeria.

4.4. Modes of preparation and Application

The practice of using a single plant for pesticide preparation compared to the use of mixture of two to three plant species is very evident in this study. On the contrary for ethnomedicinal studies, most of the reported remedies [46] involved the use of concoctions of two to three plant species.

For most insects, positioning fresh or dry plant materials was the most popular method of application for repelling insects like mosquitoes. Positioning by hanging of repellent plants on the walls, roofs or by the entrance was consistent with previous studies in Ethiopia [47], Guinea Bissau [48] and Uganda [39]. In addition [48], reported that hanging fresh leaves gave a repellent activity of greater than 70% against mosquitoes. The practice of positioning *H. suaveolens*, *A. indica*, *E. africanum*, *E. tereticornis*, *K. senegalensis*, *L. siceraria*, *O. americanum* and *V. amygdalina* in between grains during storage have been observed in many localities. It is expected that these plants naturally provide several organic bioactive compounds which in turn provide an odor that is typically volatile in nature that was found to be offensive, especially against insect pests of stored grain, mosquitoes and flies [49, 50].

The common practice of smoking or smoldering of both fresh or dry leaves inside the house to repel mosquitoes and other insects of veterinary importance agrees with reports from Guinea Bissau [48], Kenya [45] and Ethiopia [47]. In Guinea Bissau, it was demonstrated that smoldering leaves of *H. suaveolens* showed repellent activity beyond 80% [48]. It was documented that the repellent activity of burned plants might be due to the release of specific volatile compounds (e.g., β-ocimene) created during combustion or from the plant materials themselves [39, 51].

 doi:10.20944/preprints202208.0175.v1

4.5. Uses and Ethnobotanical Indices

Demonstrated by FC, RFC (%) and UV values of identified plants species *Hyptis suaveolens*, *Vernonia amygdalina*, *Azadirachta indica*, *Canarium schweinfurthii*, *Euphorbia unispina*, and *Erythrophloem africanum* are the most popular pesticidal plants in this study (Table 4). The RFC (%) and UV values are indicators of the frequency of mention by the informants and that they are the most recognized plant in the study area. In agreement with this, UV in our study is driven by species with the greatest number of uses rather than those cited by more informants. However, intensive use and excessive exploitation of these species can threaten their existence and consequently the biodiversity of the region, since 25% of the species used by the local population are from the wild. It is therefore necessary to take protective measures and regulate their harvesting to preserve the plant species of the region and ensure their sustainability.

5. Conclusion

This study reports the first ethno-biopesticides survey in Plateau State, from which, forty five (45) plants belonging to twenty eight (28) families were reported by the respondents for local management of common pest affecting human, animals and plants. However, the efficacy and safety of all the reported plants will be verified in our further work.

Author Contributions: Conceptualization, John Gushit; Data curation, John Joshua; Formal analysis, Ahmed Ali and John Joshua; Funding acquisition, Ahmed Ali, Lydia Ior, Goni Dogo, John Joshua and John Gushit; Investigation, Lydia Ior, Goni Dogo, John Joshua and John Gushit; Methodology, Ahmed Ali and Lydia Ior; Project administration, John Gushit; Supervision, Ahmed Ali and John Gushit; Validation, Lydia Ior; Visualization, Goni Dogo; Writing – original draft, Ahmed Ali; Writing – review & editing, Lydia Ior and Goni Dogo.

Funding: This research project was supported by grants from the National Research Fund-TETFund/DR&D/CE/NRF/CC/21/VOL1.

Data Availability Statement: All data generated or analyzed during this study are included in this published article.

Acknowledgments: We are grateful to the management of the University of Jos, Nigeria, for hosting the research and providing necessary infrastructure to carry out this research. We also appreciate all our informants who have graciously collaborated with us and made their knowledge available to our research.

Conflicts of Interest: The authors declare no conflict of interest.

Abbreviations: FC: Frequency of Citation; RFC: Relative Frequency of Citation;FUV: ICF: Informant Consensus Factor; UI: User index; UV: Use value; Fund; BA: Bait; BT: Bathing; DR: Dressing; OR: Orally; PO: Positioning; SM: Smoking; SR: Spraying; SP: Spreading; TO: Topical; WS: Washing; DO: Domestic; WI: Wild; GPS: Global Positioning System; LGAs: Local Government Areas; NRF: National Research Fund; TETFund: Tertiary Education Trust.

References

1. Sustainable Environment Development Initiative (SEDI), Report on Pesticides and Highly Hazardous Pesticides (HHPs) in Nigeria. G20123 SEDI Nigeria HHPs Report. 2021, Pp 51
2. Kumar, S. Biopesticides: A Need for Food and Environmental Safety. J Biofertil Biopesticide. 2012, 3-14
3. Lale, N.E.S. A Laboratory study of the comparative toxicity of products from three spices to the maize weevil. Postharvest Biol. Technol., 1992, 2, 61-64.
4. Adedire, C.O.; Akinkurolere, R.O.; Ajayi, O.O. Susceptibility of some maize cultivars in Nigeria to infestation and damage by maize weevil, *Sitophilus zeamais* (Motsch.) (Coleoptera Curculionidae). Nig J Entomol. 2020, 28, 55-63.
5. Emeasor, K.C.; Uwalaka, O.A. Uwalaka. Control of fruit borer of garden egg, *Leucinodes orbonalis* (Lepidoptera: Pyralidae) using organic and inorganic pesticides. Net J. Agric. Sci. 2018, 6(2): 16-19
6. Lengai, G.M.W.; Muthomi, J.W.; Mbega, E.R. Phytochemical activity and role of botanical pesticides in pest management for sustainable agricultural crop production. Scientific African, 2020, 7, e00239.
7. Ugwu, J.A.; Nwaokolo, V.M. Biocidal activity of selected botanicals and *Beauveria Bassiana* on oriental fruit fly, *Bactrocera Dorsalis* (Diptera:Tephritidae). Journal of Research in Forestry, Wildlife & Environment, 2020, 12(1), 53–61

8. Ugwu, J.A.; Alabi, O.Y.; Aluko, O.J. Insecticidal activity of crude extracts of three spices and commercial botanical pesticide on oriental fruit fly under laboratory conditions. The Journal of Basic and Applied Zoology 2021, 82:26
9. Yusuf, S.R.; Ahmed, B.I.; Chaudhary, J.P.; Yusuf, A.U. Laboratory evaluation of some plant products for the control of maize weevil *S. zeamais* (mots) in stored maize. ESN Occasional Publication. 1998, 31:203-213.
10. Ileke, K.D.; Oni, M.O. Oni. Toxicity of some plant powders to maize weevil, *Sitophilus zeamais* (Coleoptera: Curculionidae) on stored wheat grains. Afr. J Agricul. Res., 2011, 6(13): 3043 - 3048. 2011
11. Karunakara, S.; Arulnandhy V. Insecticidal activity of selected botanicals on maize weevil, *Sitophilus zeamais* L., in stored maize grains. AGRIEAST: Journal of Agricultural Sciences, 2018, 12, (1), 1-6.
12. Population Forecast, National Population Commission and National Bureau of Statistics Estimates. 2016
13. Rao, D.N.; Karmeshu, V.P. Dynamics of Urbanization: The Empirical Validation of the Replacement Hypothesis. Environ. Plann. B: Plann. Des. 1989, 16(3), 289-295
14. Ior, L.D.; Otimenyin, S.O.; OKwori, V.A.; Umar, D.M.; Azila, J.J. Ethnobotanical survey of plants used in the management of mental illnesses in some selected local government areas of Plateau State, Nigeria. J Pharmacog and Phytother. 2017, 9(10), pp. 146-156
15. Hutchinson, J.; Dalziel, J.M. Crown Agents for Oversea Governments and Administrations. London. Volume One, Part One. 1954.
16. Burkill, H.; The Useful Plants of West Tropical Africa. 1986, 2 (1), Families A-D Royal Botanic Gardens
17. Cook, A.M. The Evaluation of Disinfectants. R. Soc. Health J. 1967, 87(4), 199-203
18. Bello, S.; Jamaladdeen, M.T.; Elder, S.S.; Yaradua, S.S.; Kankara, N.H.; Wagini, C.H.; Stirton, M.H.; Musaya, M. Threatened medicinal and economic plants of the Sudan Savanna in Katsina State, northwestern Nigeria. Bothalia-Afr Biodivers Conserv. 2019, 49(1):1–7
19. Ayantunde, A.; Briejer, M.; Hiernaux, P.; Udo, H.M.J.; Tabo, R. "Botanical knowledge and its differentiation by age, gender and ethnicity in Southwestern Niger," Human Ecology. 2008, 36, (6), 881–889
20. Salako, E.A.; Anjorin, S.T.; Omaliko, C.P.; Oyerinde, A.A.; Abdullahi, I.N. Pesticidal plants diversity, status and uses in North Central Nigeria. Academ Arena. 2014 6(3), 48-57
21. Kayode, J.; Odesola, A.F.; Ayeni, M.J.; Awoyemi, S.B. Survey of Botanicals Used as Pesticides by the Rural Farmers of Ekiti State, Nigeria. Int. J. Biol. Papers. 2016, 1(2), 12-17
22. Mwine, T.J.; Van Damme, P.; Gerard, K.; Charles, K. Ethnobotanical survey of pesticidal plants used in South Uganda: Case study of Masaka district. J. Med Plant Res. 2011, 5(7):1155–63
23. Okori, C.; Oryema, C.; Opiro, R.; Amos, A.; Obici, G.I; K. Rutaro.; G.M. Malinga.; E. Sande. Ethnobotanical survey of plants locally used in the control of termite pests among rural communities in northern Uganda. CABI Agric. Biosc. 2022, 3:37.
24. Adebayo, S.E.; Samue, A.T.l.; Jessica, U.A. Ethnobotanical survey of pesticidal plants used in Edo State, Nigeria. Afr. J Agric Sci. Technol. 2015, 3(11):448–60
25. Qwarse, M.; Mihale, M.J.; Sempombe, J.; Mugoyela, V.; Henry, Sunghwa L. F. Ethnobotanical survey of medicinal and pesticidal plants used by agropastoral communities in Mbulu District, Tanzania. Tanzania J. Sci. Technol. 2018, 1(1):22–35
26. Olas, R. B. The plants of the asteraceae family as agents in the protection of human health. Int J Mol Sci. 2021, 22(6):3009
27. Mondal, T.; Monda, D. l. A review on efficacy of A. indica. A Juss based biopesticides: An Indian Perspective. Research Journal of Recent Sciences. 2012, 35:445-516
28. Dalma, G. The Eerythrophleum alkaloids. In "The A1ka1oids" Ed. Manske, H. F. Academic Press, New York. 1970. 4, 265-273
29. Loder, N.J.; . Culrenor, C.C.J.; Nearn, R.H.; Russel,nG.B.; Stanton, F.W. Tumor inhibitory plants New Alkaloids from the bark of *Erythrophleum chlorostachys* (Leguminosaea). Aust J Chem. 1974, 27, 179-185.
30. Kariuki, J.M; SKariuki, T.; Muchiri, D.R.; Njoka, E. Field evaluation of naturally occurring mosquito repellents in Mt. Kenya region, Kenya. Int J Biodivers Conserv.2016, 8(2). 55-9
31. Edeoga, H.O.; Omosun, G.; Uche, L.C. Chemical composition of *Hyptis suavelens* and *Ocimum gratissimum* hybrids from Nigeria. Afr J Biotechnol.2006, 5(10), 892-895
32. Peerzada, N. Chemical composition of the essential oil of *Hyptis suaveolens*. Molecules. 1997.; 2:165-168
33. Simmond, M.S.J.; Blaney, W.M. Labiate-insect interaction: Effect of Labiate derived compounds on insect behavior. In: Harley, R.M. and Reynold, T. (Ed.). Advances in Labiate Science. Royal Botanical Garden Kew, 375-392.
34. Oparaeke, M.; Dike, M.C.; Amatobi, C.I. Evaluation of Botanical Mixtures for Insect Pests Management on Cowpea Plants J. Agric Rural Develop in the Tropics and Subtropics 2005, 13:178–181.
35. Mudgal, V.; Khanna, K.K.; Hazra, P.K. Flora of Madhya Pradesh II. Botanical Survey of India, 1997, 403-404.
36. Ijeh, I.; Edeoga, H.O.; Jimoh, M.A.; Ejeke, C. Preliminary phytochemical nutritional and toxicological studies of leaves and stems of *Hyptis suaveolens*. Res J Pharm. 2007, 1(2), 34-40.
37. Lajide, L.C.; Adedire, O.; Muse, W.A.; Agele, S.O. Insecticidal activity of powders of some Nigerian plants against the maize weevil (*Sitophilus zeamais* Motsch). Entomol. Soc. Nig. Pub. 1998, 31: 227-235.
38. Fatope, M.O. Cowpea weevil bioassay: a simple prescreen for plants with grain protectant effects. Int J Pest Manag.1995, 41: 84-86.
39. Baana, K.; Angwech, H.; Malinga, G. Ethnobotanical survey of plants used as repellents against housefly, *Musca domestica* L. (Diptera: Muscidae) in Budondo Subcounty, Jinja District, Uganda. J Ethnobiol Ethnomedicine. 2018, 14:35.
40. Adetoro, N.A.; Adekunle, M.F.; Momoh, S. The use of biopesticides in indigenous cropping systems in Ogun State, Nigeria. The Bioprospertor. 1991, 1 (2), 1-10.

41. Youmsi, R.D.F.; Fokou, P.V.T.; Menkem, E.Z.; Bakarnga-Via, I.; Keumoe, R.V.; Nana, Boyom, F.F. Ethnobotanical survey of medicinal plants used as insects' repellents in six malaria endemic localities of Cameroon. Ethnobiol Ethnomedicine. 2017, 13(1), 13-17.
42. Sargin, S.A.; Selvi, S.; Büyükcengiz, M. Ethnomedicinal plants of Aydıncık District of Mersin. J Ethnopharmacol. 2015, 174 (4), 200-216.
43. Massei, G.; Hartley, S.E. Disarmed by domestication? Induced responses to browsing in wild and cultivated olive. Oecologia. 2000, 122(2):225–31.
44. E. Oruonye, E. Okrikata. Sustainable use of plant protection products in Nigeria and challenges. J Plant Breed Crop Sci. 2(9), 267–272. 2010
45. S.K. Okwute. Plants as potential sources of pesticidal agents: a review. In: Soundararajan, R. P. (ed.), Pesticides – advances in chemical and botanical pesticides. InTech: USA. 207–323. 2012
46. Seyoum, P. S. Kung, E. W. Kabiru, W. Lwande, G. F. Killeen, A. Hassanali, B. G. J. Knots BGJ. Trans. R Soc Trop Med Hyg. 96, 225-31. (2002)
47. K. Karunamoorthi, K. Ilango, A. Endale. Ethnobotanical survey of knowledge and usage custom of traditional insect/mosquito repellent plants among the Ethiopian Oromo ethnic group. J Ethnopharmacol. 125 (2), 224-229. 2009
48. K. Pålsson, T. G. Jaenson. Comparison of plant products and pyrethroid-treated bed nets for protection against mosquitoes (Diptera: Culicidae) in Guinea Bissau, West Africa. J. Med Entomol. 36(2), 144-148. 1999. doi: 10.1093/jmedent
49. M. B. Isman. Botanical insecticides, deterrents, and repellents in modern agriculture and an increasingly regulated world. Annu Rev Entomol.51, 45-66. 2006
50. M. E. Maffei, J. Gertsch, G. Appendino. Plant volatiles: production, function and pharmacology. Nat Prod Repr. 28:1359-1380. 2011
51. E. J. Kweka, F. Mosha, A. Lowassa, A. M. Mahande, J. Kitau, J. Matowa, M. J. Mahande, C. P. Massenga, F. Tenu, E. Feston, E. E. Lyatuu, M. A. Mboya, R. Mndeme,G. Chuwa, E. A. Temu. Ethnobotanical study of some mosquito repellent plants in north-eastern Tanzania. Malar J. 7, 1475-2875. 2008