



Ethnobotanical Survey of Plants Used for Insect Repellence in Katsina Local Government Area, Katsina State, Northwestern Nigeria

Gidado S. M² and Samaila S. Y. *^{1, 2}

¹ Department of Basic Science, Faculty of Science and Technology, Kampala International University, Uganda.

² Department of Biology, Umaru Musa Yar'adua University, Katsina, Nigeria

ABSTRACT

This study was conducted to document and evaluate plants species that have the ability to repel insects in Katsina. A semi-structured questionnaire was used to obtain the data of the plant species with the repellence activity. A total number of 50 respondents were interviewed among which the majority were males 56% and above 60 years 30%. The result reported a total number of 20 plants species with insect repellence activity that were distributed in 15 families with Lamiaceae being the family with highest number of species. The leaves of the plants are the most plant part used for the repellence (42 %), the mode of preparation of the plants materials varies with burning to generate smoke being the most adopted mode of preparation. The 20 plants species were found to repel 12 different insects species which are distributed in 7 orders, Diptera having the greatest number of insects (3) and plants species that repel them (15) with mosquito being repelled most by the plants species in the order. It was observed from the study that plants species from different families have the ability to repel a particular insect. The results obtained could provide a baseline information for further scientific investigation to strengthen the concept of plant-based insects repellents.

Keywords: Ethnobotany, Insect, Insect repellence, Katsina, Plants

INTRODUCTION

Insects like mosquitoes, housefly, leeches, weevils, ticks, lice, and bees can pose detrimental issues for humans. They bite individuals and their stings can cause diseases, infections blisters, necrosis, or allergic reactions (Lavaud *et al.*, 1999). Insects which are parasites causes a significant problem for livestock and farm produce, causing substantial economic and financial losses (Booppha *et al.*, 2010; Campbell and Thomas, 1999). Furthermore, insect vectors play a crucial role in transmitting infectious pathogens between humans, which leads to the spread of vector-borne diseases. Globally, there are more than 700,000 deaths caused by these diseases each year including; malaria, dengue fever, Zika fever, yellow fever, chikungunya fever, Chagas disease and Japanese encephalitis (WHO, 2020). In addition to the potential fatalities, these illnesses can also cause significant harm and hardships for humans. Many survivors of these infections are left permanently debilitated, disfigured, injured, or blind (Pialoux *et al.*, 2007; Chu *et al.*, 2010). Moreover, the economic burden of vector-borne diseases is substantial, affecting both governments and households, and has been linked to lower economic development (WHO, 2017). The

presence of insect vectors in our environment brings more harm than good to us therefore finding ways to repel/kill these insects is a necessity.

Through history, humans have employed various methods to combat insects and vectors. Following a traditional approach involves using local plants to protect against stings. For example, oils extracted from plant materials have been applied to the body for this purpose (Roberto *et al.*, 2001). Burning plant materials such as wood and leaves is indeed a common method used to repel insects (Bockarie *et al.*, 1994; Yang *et al.*, 2006). This practice is known to help deter insects from the area. Additionally, toxic solutions can be made by adding specific plant materials to water, which can further aid in repelling insects (De Boer *et al.*, 2010). Since the 1940s, synthetic insecticides and repellents have been discovered and widely used, replacing traditional methods in many regions. Insecticide-treated nets and indoor residual spraying of insecticides are two key interventions that help prevent and control vector-borne diseases (WHO, 2017). However, over the years, more than 550 pest insect species have developed resistance to one or more existing insecticides (Whalon *et al.*, 2008). For example, mosquitoes have developed tolerance to

*Corresponding author. E-mail: dryaradua@gmail.com

DEET (N, N-diethyl-3-methylbenzamide) (10%), a repellent that provides protection against insect bites for up to 9 hours (Tawatsin *et al.*, 2006). Insects are major vectors for several human and animal diseases, yet their control is often neglected (Kumar *et al.*, 2013). Currently, the control of insects heavily relies on chemical pesticides. However, the use of pesticides can have adverse health and environmental effects, be costly, and there's a risk of developing insect resistance and bioaccumulation through the food chain (Ashgar *et al.*, 2016). This emphasizes the need to search for low-cost and environmentally friendly alternatives that can complement existing interventions. In developing countries like Uganda, where inhabitants and health and sanitation standards are poor, the use of repellents is often the only viable protection against vectors (Benelli *et al.*, 2016). Over the past few years, researchers have been exploring the potential of locally available botanicals as alternatives to synthetic compounds for insect control (Moore *et al.*, 2006). Plant-based repellents are typically less toxic, less expensive, easily accessible, and still widely used traditionally as an affordable control option against insects in various African communities (Karunamoorthi *et al.*, 2009). Also, looking into environmental concerns, there is a need for ongoing research and development of new insecticides and repellents. In today's world, while traditional plant-based insect repellents may not be feasible for widespread use in urban settings, they can still serve as valuable sources for the development of modern insecticides and repellents. Researchers have been screening plants for their potential as natural repellents and studying their activities and toxicities over several generations (Debboun *et al.*, 2006).

Some successful examples of modern products derived from traditional plants include pyrethrum and neem. These products have proved to be effective in controlling mosquitoes and other blood-sucking insects (Debboun *et al.*, 2006).

It's worth noting that in remote rural areas, a small number of people still rely on traditional methods to control insects, mainly due to their low cost (Gakuya *et al.*, 2013). However, with improvements in living standards and the undervaluation of traditional knowledge, this valuable knowledge of insect control is being rapidly lost (González *et al.*, 2012)

Therefore, the indigenous knowledge and use of plants as repellents should be documented and preserved as a cheap and sustainable way of preventing insects that are vectors of many diseases. This documentation represents a prerequisite for future research on efficacy and safety as well as identification of single chemical entities with mosquito repellent activity which could lead to the development of standardized bio-pesticides. So far, only a limited number of studies

have been conducted in Katsina on traditional use of medicinal plants to repel insects. The question is therefore to know if there is a consensus extent in indigenous use of plants from Katsina metropolis biodiversity to repel insects.

MATERIALS AND METHODS

Study Area

Katsina Local Government Area (12° 59'N, 7° 36'E); with a total area of 142 km²; is a city (formerly a city-state), and a Local Government Area in Katsina State, and is the capital of Katsina State. It is located some 256,50 km east of the city of Sokoto, 135,18 km northwest of Kano, close to the border with Niger. As of 2007, Katsina estimated population was 459,022 (2006 population census). Demographically, the Hausa people are the largest ethnic group in the state, and Islam is the most practiced religion. The State is the largest producer of cotton in Nigeria. The city is the centre of an agricultural region production of groundnuts, cotton, hides, millet and guinea corn and also has mills for producing peanut oil and steel, it was also a centre for large scale poultry farming of cows, goats, sheep and chickens. The city is the centre of an agricultural region, producing groundnuts, cotton, hides, millet and guinea corn, and also has mills for producing peanut oil and steel. The survey was carried out in 3 wards which are Wakilin Kudu ward, Wakilin Gabas Ward, Wakilin Arewa. Basically, there are two distinct seasons in the emirate: wet and dry season. The wet season is cruel and last for about 3 to 4 months, from June to October and it is characterized by rainfall. The raining season lasts for about 4 to 5 months, which starts from May and ends in October and the average rainfall in the emirate is 5.5 inches. The dry season on the other hand is hot and lasts for 9 months, starting in September and ends in June with about 0.04 inches of precipitation. The cultural activities in the emirate are mainly farming, hunting, fishing and herbalism.

Sampling design and informant selection

Two communities in each of the three wards were selected purposively. Series of field trips were made in the selected areas, the informants were interviewed in Hausa at their farmlands, work places, homes and markets. The content, purpose, and the procedure of the study, as well as the expected benefits purpose of the research were explained to the volunteers and their consent was also seek before administering the questionnaire. The criteria for being a respondent are to be an adult, above 18 years and be able to respond to questions independently. In each community, Ward head was firstly interviewed and asked to recommend people that falls within the stated criteria and are familiar with the topic in question were identified as

potential informants and subsequently participated in personal interviews (snowball sampling). The ethnobotanical data of the insect repellent plants was collected using the semi-structured questionnaire following (Martin, 1995; Cotton, 1996; Cunningham, 2001), with slight modification. After the data collection, field observations, general interviews and discussions made on the overall checklist of question with some selected respondents to validate the responses obtained. The information in the questionnaire were divided into two parts: Part A is concern with the socio-demographic information of the respondent which include name, sex, occupation, and level of education. The part B is concern with the information on the use of the plants with insect repellent activity, including parts used, local name, modes of preparation and modes of administration.

Collection and identification of plant specimens

Guided field walk was conducted with some volunteered informant to collect plant with insect repellent activity, plants with the activity were identified by visiting the field with some informants (field interview) cited by the respondent during the data collection. Typical specimens bearing good vegetating and floral parts (leaves, fruits and flowers) were collected for the preparation of voucher specimens. During the collection, habit, GPS location, habitat of each plant was recorded and the specimen was assigned a unique collection number. The collected specimens were pressed immediately following the standard procedure and taken to the herbarium of Umaru Musa Yar'adua University, Katsina (HUMYU). The plant species were identified using various floras, herbarium specimens and with the help of the herbarium curator. The names were further verified and standardized with the aid of database of the plants of the world (POWO) and African Plant Database.

Data Analyses

The socio-demographic information of the respondents and ethnobotanical data collected were organized in Microsoft Excel spread sheet. The socio-demographic information of the respondents was evaluated using simple percentage. Relative Frequency of Citation (RFC) was used to analyzed the ethnobotanical data collected during the survey using $RFC = Fc/N$, where Fc = number of informants who cited a particular plant species and N = total number of informants that participated in the study.

RESULTS

Socio-demographic data of respondents

A total of 50 participants in 3 wards were interviewed during the survey. The profile of the respondents showed 28 (56%) were males and 22 (44%) were females (Table 1). The age of the respondents ranges between 20 to 60 years and above, and majority of them were above 60 years of age (30%). The vast majority of the respondents were farmers (26%). In total, 84% of respondents have knowledge about plants with insect's repellent activity. The level of this knowledge varied from one ward to another with 38% in Wakilin Kudu, 32% in Wakilin Gabas and 30% in Wakilin Arewa. The survey revealed that about 84% of the respondents have awareness on plants, plants parts and their uses towards insect repellent.

Plants species used as insect repellents in Katsina metropolis

This survey attempted to record knowledge about plant species used as repellents against insects in Katsina metropolis to identify outstanding plants that might be formulated as insect repellents. The results achieved indicated 20 plant species to be used to drive off insects, especially mosquitoes. The study showed that the local inhabitants (84%) had knowledge about the insects repellent property of plants and their use. A total number of 20 plants species belonging to genera 18 genera and 14 families were reported to be commonly used against 12 various insects in the study area.

Overall, the majority of the plants species were recorded in Wakilin Kudu. The family Lamiaceae had the highest frequency with three species, Rutaceae, Amaryllidaceae and Meliaceae with two species each, Solanaceae, Fabaceae, Zingiberaceae, Lauraceae, Myrtaceae, Caricaceae, Poaceae, Anacardiaceae, Asteraceae and Piperaceae were represented by one species respectively. The most cited plant was *Citrus lemon* mentioned by 5 respondents in all the wards followed by *Azadirachta indica* mentioned by 4 respondents in all the study area, *Citrus sinenses*, *Piper guineense* and *Mentha piperita* were mentioned by 3 respondents each. Interestingly, *Azadirachta indica* which is used as antifeedant, expellant, fungicide, insecticide, repellent and rodenticide is of economic importance among the plants, the activity of *A. indica* has been related to the presence of Azadirachtin seemingly used in the control of more than 200 insect pests from different insect orders (Alzohairy, 2016). Among the familiar cultures in Africa includes the traditional use of plants parts or products from plants. The insect's repellent activity of these plants can be related to the chemical compositions present in them

Table 1: Socio-demographic data of the respondents

Gender	No. of Individuals	Percentage (%)
Male	28	56
Female	22	44
Total	50	100
Occupation	No. of Individuals	Percentage (%)
Farmer	13	26
Trader	3	6
Herbalist	10	20
Civil Servant	5	10
Barber	3	6
Driver	2	4
Student	3	6e
Teacher	2	4
Business men	6	12
Gateman	3	6
Total	50	100
Age (years)	No. of Individuals	Percentage (%)
20 – 29	6	12
30 – 39	8	16
40 – 49	9	18
50 – 59	12	24
60 – above	15	30
Total	50	100

Plant parts used

With respect to the parts of the plants used for repelling insects, results from the survey showed that the frequency of plant parts used by respondents indicated that the most used plant parts were leaves (12 plants), followed by fruit (4 plants), fruit peel (2 plants), stem (3 plants), bulb (2 plants), while the use of rhizome, seed oil and the combination of leaf/fruit/stem, leaf/stem and leaf/fruit occurred once.

This preference might be based on the fact that leaves are readily available or more likely that their unstable volatile compounds have the desired activity. This

choice might also result from the desire of the communities to preserve the biodiversity on which they depend for food and remedies and from which harvesting plant barks or whole plants should rather attributed to the extinction of the plants species. Among the repellent plants species recorded in this survey, the main parts used were reported to be the leaves and stem. The use of leaves is remarkable which could be due to the instant accessibility of their active ingredients that are more likely unstable elements. Plants with essential oils are those that are widely used for repellent activity which produce powerful odours when leaves are crushed together many of which are unpleasant to insects.

Table 3: Plants part used in the study area

Plant Part	No. of Species	Percentage (%)
Leave	18	42
Fruit	6	14
Fruit peel	4	10
Stem	6	14
Bulb	4	10
Rhizome	2	5
Seed oil	3	5
Total	43	100

Table 2: Plants species used as insect repellents in Katsina metropolis

S/N	Local Name	Scientific Name	Family	Insect	RFC	Part Used	Mode of Admin
1.	Lemon	<i>Citrus lemon</i>	Rutaceae	Cockroach	5(0.1)	Fruit, peel	Smoking
2.	Neem	<i>Azadirachta indica</i>	Meliaceae	Housefly, Mosquito	4(0.18)	Leaf, fruit	Smoking
3.	Orange	<i>Citrus sinensis</i>	Rutaceae	Mosquito, bee grasshopper	3(0.06)	Fruit peel	Smoking
4.	Mint	<i>Mentha piperita</i>	Lamiaceae	Ant, bee, mosquito	3(0.06)	Leaf	Smoking/positioning
5.	Pepper	<i>Piper guineense</i>	Piperaceae	Bean, weevil, mosquito	3(0.06)	Fruit	Smoking/positioning
6.	Mango	<i>Mangifera indica</i>	Anacardiaceae	Mosquito	2(0.04)	Leaf	Smoking
7.	Tomatoes	<i>Solanum lycopersicum</i>	Solanaceae	Mosquito	2(0.04)	Leaf	Smoking
8.	Tobacco	<i>Nicotiana tabacum</i>	Solanaceae	Mosquito	4(0.08)	Leaf	Smoking
9.	Onion	<i>Allium cepa</i>	Amaryllidaceae	Aphid, Mosquito, Leeches	2(0.04)	Bulb	Skin application
10.	Garlic	<i>Allium sativum</i>	Amaryllidaceae	Bees	2(0.04)	Bulb	Smoking
11.	Eucalyptus	<i>Eucalyptus globulus</i>	Myrtaceae	Spider, ant, lice	2(0.04)	Leaf	Smoking
12.	Lemongrass	<i>Cymbopogon citratus</i>	Poaceae	Mosquito, ant, spider tick	2(0.04)	Leaf	Smoking/positioning
13.	Pawpaw	<i>Carica papaya</i>	Caricaceae	Housefly	1(0.02)	Stem	Skin application
14.	Bitter-leaf	<i>Vernonia amygdalina</i>	Asteraceae	Mosquito, aphid, termite	1(0.02)	Fruit, leaf	Spraying
15.	Rosemary	<i>Rosmarinus officinalis</i>	Lamiaceae	Bugs	1(0.02)	Leaf	Smoking/positioning
16.	Scent leaf	<i>Ocimum basilicum</i>	Lamiaceae	Mosquito	1(0.02)	Fruit, leaf	Positioning
17.	Locust bean tree	<i>Parkia biglobosa</i>	Fabaceae	Mosquito, termite weevil	1(0.02)	Stem, leaf	Spraying
18.	Groundnut	<i>Arachis hypogaea</i>	Fabaceae	Termite	1(0.02)	Seed oil	Spraying
19.	Mahogany	<i>Swietenia mahagoni</i>	Meliaceae	Housefly, termite	1(0.02)	Leaf	Positioning
20.	Ginger	<i>Zingiber officinale</i>	Zingiberaceae	Mosquito	1(0.02)	Rhizome	Spraying

Table 4: Mode of Administration

Mode of Administration	Percentage (%)
Smoking (burning dry leaves to produce smoke)	60
Skin application (smashing leaves to apply on skin)	10
Spraying (spraying mixture of part used)	20
Positioning (Hanging plant part inside the house)	10
Total	100

Mode of administration of plants part

From this survey, it was reported that communities adopt many modes of administration of plants parts or products. Amongst those, 60% were reported to be burnt to produce smokes inside the houses, 10% were mashed and thereafter applied on the body, 20% were made into a mixture and sprayed and 10% were hung in the houses (positioning). Based on informants' reports, the appropriate plant parts were collected only when needed and at any time. The practice of using a single plant for insect repellent 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 (Seyoum *et al.*, 2002) involved the use of concoctions of two to three plant species. The familiar practice of smoking both fresh or dry leaves inside the house to repel mosquitoes and other insects of veterinary importance is much more effective. It was recorded that the repellent activity of burned plants might be due to the release of specific unstable volatile components (e.g., β -ocimene) formed during oxidation or from the plant materials themselves (Malinga *et al.*, 2018). The practice of positioning *Piper guineense* in between grains during storage have been observed in many localities. It is expected that this plant naturally provides several organic bioactive compounds which in turn provide an unpleasant odour that is typically volatile in nature that was found to be offensive, especially against insect pests of stored grain (bean weevil). Most of the plants recorded (60%) were reported to be burnt to produce smokes inside the house, corresponding with the claims of Palsson and Jaenson *et al.* (1999) which showed that a successful way in repelling insects is by burning plant's parts. Biran *et al.* (2007) also recorded mixed proof especially for using firewood smoke to protect against mosquito bite.

Smashed plant parts for skin application (10%) the plant part responsible for the repellent activity is crushed and applied on the skin to keep away insects and prevent bites from the body. Making mixture of the plants parts to be sprayed (20%) where the part of plant that drives away insect is blended to form a mixture and is used as a spray. Hung plants leaves or parts inside the house (10%), the fragment of plant that repels insects will be hung over a place so as to produce its scent to keep off insects. All this repellent mode of administration were also documented during the study as vital administration modes of the plant's parts. These modes of repellent plants administration have been used for thousands of years by human, and are still diversely used all through the developing countries (Hill *et al.*, 2006). Plants have been used for centuries where they are burnt to produce smoke which drives off insects, crushed to apply on the skin to repel insects, hung in the house to keep off insects and spraying mixture of plants parts to fight off insects.

Insects orders repelled by the 20 plants species

For the survey using semi-structured interview and questionnaires 12 different insects from 7 orders which include Diptera, Hymenoptera, Orthoptera, Isoptera, Blattodea, Coleoptera and Hemiptera were identified to be repelled by the plant species from the survey (Table 5). Insects like mosquitoes, housefly, flies belonging to the order Diptera were repelled by 15 plants species; bees and ants belonging to the order Hymenoptera were repelled by 3 plants species; Grasshopper belonging to the order Orthoptera were repelled by 1 plant species; Termites and spider belonging to the order Isoptera were repelled by 7 plants species; Cockroaches belongings to the order Blattodea were repelled by 1 plant species; weevils belonging to the order Coleoptera were repelled by 3 plants species: bugs and aphids belonging to the order Hemiptera were repelled by 4 plants species.

Table 5: Classification of the insect into their orders

Insect	Order
Mosquito, House fly	Diptera
Bee ant	Hymenoptera
Grasshopper	Orthoptera
Termite, Spider	Isoptera
Cockroach	Blattodea
Weevil	Coleoptera
Aphid, Bug	Hemiptera

Where Nur= frequency of use citation in each insect order

Nuf = number of plants species used to repel insect from that order

Discussion

This survey aimed to document knowledge about plant species used as repellents against insects in Katsina metropolis to recognize prominent plants that might be developed as insect repellents. A total

number of 20 plant species were able to be obtained from the result which are used to eliminate insects particularly mosquitoes. Most of the informants interviewed were men 56% contrary to 44% of women, comparable to the model which was

previously reported by Bekalo *et al.* (2009). Recently, an assessment indicated important diversity in the awareness of men and women in Africa when it comes to ethnobotanical knowledge. More so, women in rural Africa often collect plants for firewood purpose. The survey exhibited that about 84% of the respondents have awareness on plants, plants parts and their uses towards insect repellent.

Most of the plants recorded (60%) were reported to be burnt to produce smokes inside the house, corresponding with the claims of Palsson and Jaenson (1999) which showed that a successful way in repelling insects is by burning plant's parts. Biran *et al.* (2007) also recorded mixed proof especially for using firewood smoke to protect against mosquito bite. Despite the limited data on how repellent smokes or their components work, the repellent activity of burned plants shows to be due to the discharge of specific unstable elements, either present in the fresh/dried plant or created during the oxidation process.

Smashed plant parts for skin application (10%) the plant part responsible for the repellency activity is crushed and applied on the skin to keep away insects and prevent bites from the body. Making mixture of the plants parts to be sprayed (20%) where the part of plant that drives away insect is blended to form a mixture and is used as a spray. Hung plants leaves or parts inside the house (10%), the fragment of plant that repels insects will be hung over a place so as to produce its scent to keep off insects. All this repellent mode of administration were also documented during the study as vital administration modes of the plant's parts. These modes of preparation of the plant with repellence activity in Katsina Local Government Area have been used for thousands of years by human, and are still diversely used all through the developing countries. Plants have been used for centuries where they are burnt to produce smoke which drives off insects, crushed to apply on the skin to repel insects, hung in the house to keep off insects and spraying mixture of plants parts to fight off insects.

Among the familiar culture in Africa includes the traditional use of plants parts or products from plants. The insect's repellency activity of these plants can be related to the chemical compositions present in them. Different active elements with insects' repellency activity have been previously addressed in some of the recorded plants species (Youmsi *et al.*, 2017; Baana *et al.*, 2018; Ahmed *et al.*, 2022). From the plants species with insect repellency activity recorded in this survey, the main parts used were accounted to be the leaves. The use of leaves is remarkable which could be due to the instant accessibility of their active ingredients that are more likely unstable elements. Plants with

essential oils are those that are widely used for repellent activity which produce powerful odors when leaves are crushed together many of which are unpleasant to insects.

Through the interview using a semi-structured questionnaire adopted in this survey, Lamiaceae is the most common represented family among the 14 families recorded with a number of 3 plants species (*Rosmarinus officinalis*, *Ocimum basilicum*, *Mentha piperita*).

The 20 plants species recorded were found to repel a number of 12 various insects belonging to 7 orders. More than 1 plant species can be seen in correspondence towards repelling a particular insect most especially mosquitoes which was documented to be repelled by 13 different species from various orders, this can show that people have more knowledge on plants species that can repel mosquitoes which could possibly be because mosquitoes are of important public health concern among African countries.

Author Contributions

Research concept and design: SSY and MSG; Collection and/or assembly of data: SSY and MSG; Data analysis and interpretation: SSY; Writing the article: SSY; Critical revision of the article: SSY and MSG; Final approval of the article: SSY and MSG

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