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A review of Ethnoveterinary Botanicals Used for Tick Control in Wukari, Taraba State, North Eastern Nigeria

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THE use of traditional methods to control ectoparasites in livestock is a common practice among Fulani herdsmen. Such methods involve manual removal of ticks, avoidance of tick-infested areas, pasture burning and the use of plants with acaricidal activity. The aim of this study was to document and review acaricidal plants used for the control of ticks by Fulani herdsmen in Wukari Local Government Area (LGA), Taraba State, Nigeria. Open-ended questionnaires and guided dialogue techniques were used to interview 58 Fulani herdsmen across five districts in Wukari LGA. Information collected included the common/vernacular names of the plant species, parts used, methods of preparation and administration and toxicity of the plant species. Extensive literature search was conducted to find extra information on what is known about the identified plants. A total of 22 plant species belonging to 16 plant families were documented as being used for the control of ticks in livestock by the herdsmen interviewed. Information obtained from literature indicate that 86% of the plant species already have documented acaricidal and/or tick repellent properties and 50% have similar ethnomedical uses in other parts of the world. Most of the plants employed by the Fulani herdsmen for tick control appear promising as alternative source to commonly used synthetic acaricides.

Keywords: Acaricidal, Ticks, Livestock, Fulani herdsmen.

Introduction

Animal parasites and diseases are two of the greatest threats to the realization of full productive potential of livestock [1]. About 1.4 billion cattle are infested by ticks worldwide [2]. The major losses caused by ticks are due to their ability to transmit protozoan (e.g. theileriosis and babesiosis), rickettsial (e.g. anaplasmosis) and viral diseases (e.g. Louping ill), which are of great economic importance worldwide [3]. Tick-associated dermatophilosis, a skin disease, is also a major health and management problem of livestock in many developing countries [4].

Chemical control of ticks using synthetic acaricides applied on the animal and/or the environment is the most used method in many parts of the world. However, the indiscriminate use of these acaricides has resulted in resistant tick populations [5]. The intense use of acaricides has also raised public health concerns (presence of chemical residues in meat and milk products) and environmental contamination [6]. These issues have prompted the need for the exploration of alternative measures such as the use of acaricidal plants/herbs and other natural products for tick control in livestock [7].

The Fulani is an ethnic group, present in about 21 countries in Africa, cutting across Nigeria, Niger, Senegal, Guinea, Mauritania, Mali, Burkina Faso, Ghana, Benin, Côte D'Ivoire, Cameroon,

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Sudan, Mauritania, Ethiopia and Kenya [8]. They are mostly shepherds and cattle herders and hardly occupy a territory for a long time before migrating [9]. Due to their dependency on natural environment, Fulani herdsmen have a considerable understanding of herbal remedies and their application in disease management [10]. They are also quite knowledgeable of the negative effect of ticks on the health and productivity of their livestock [11]. Over the years, they have devised environmentally friendly means of controlling ticks in their livestock using acaricidal plants. Proper documentation of traditional medical knowledge is important to assist discovery of new sources of drugs and to prevent the extinction of this knowledge [12]. This study aims to document and review ethnoveterinary plants used by Fulani herdsmen in controlling ticks of livestock.

Materials and Methods

Ethical consideration

The research was approved by the Nigeria Natural Medicine Development Agency (NNMDA) Research Ethics Committee. A letter of introduction was also sent to the chief of the Fulanis. We conducted the survey after informed consent by the respondents. All personal information of the respondents has been kept confidential.

Description of the study site

Taraba State is in North-east Nigeria, consisting of undulating landscape dotted with a few mountainous features. Wukari Local Government Area (LGA) is one of the sixteen LGAs in Taraba State (Fig.1). The LGA is divided into fifteen traditional administrative districts namely: Wukari, Avyi, Matar-Fada, Gidan-Idi, Tsokundi, Nwokyo, Rafin-Kada, Chonku, Kente, Chinka, Jibu, Assa, Bantaje, Arufu and Akwana.

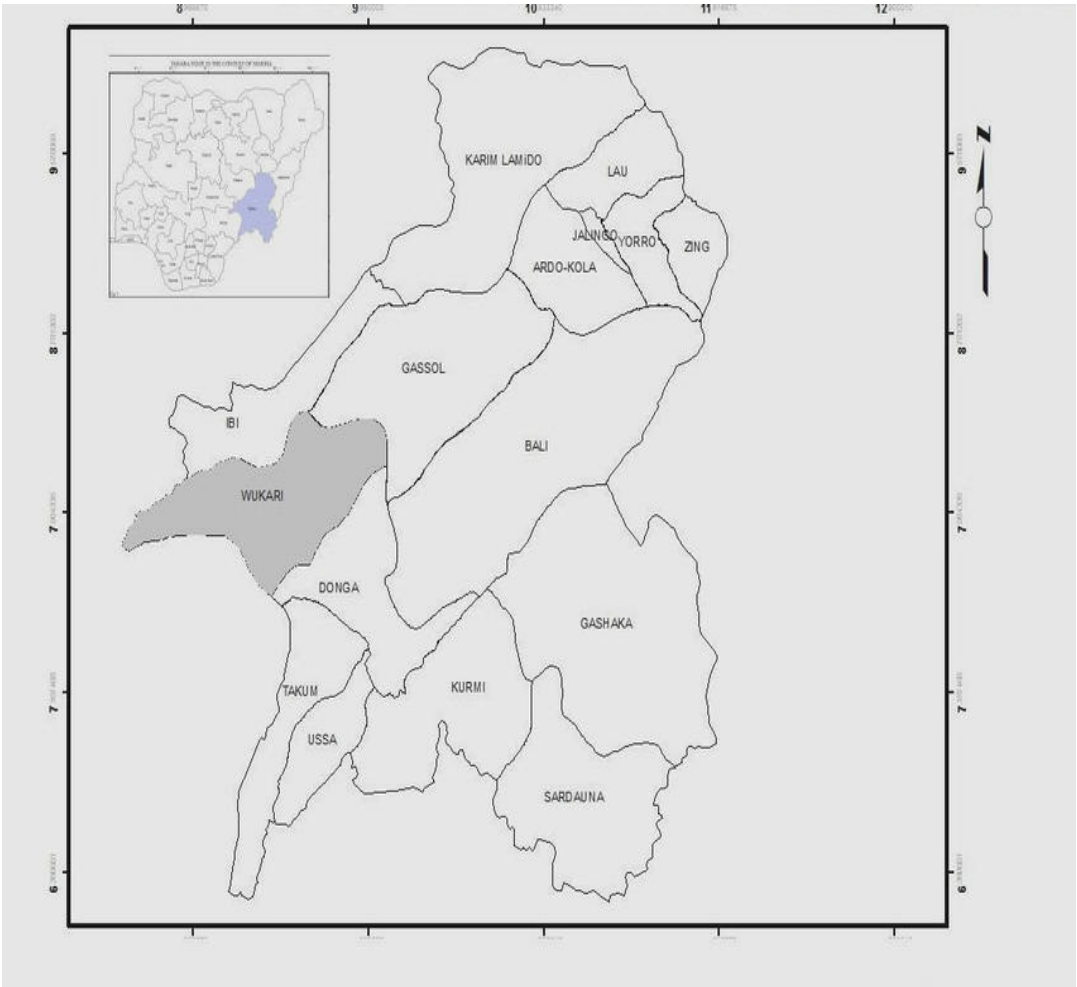

Fig. 1. Map of Taraba State showing the sixteen local government areas [13].

Ethnoveterinary survey and data collection

Ethnoveterinary surveys were conducted in five districts in Wukari LGA namely Wukari, Rafin-kada, Gidan Idi, Bantaje and Tsokundi. Fifteen communities within these five districts were chosen based on their easy accessibility and high concentration of Fulani herdsmen. Courtesy calls to express the purpose of the visit were made to the Fulani chiefs ("*Ardos"*) with kola nut (*Cola nitida*), a highly valued gift to the Fulanis presented. The *Ardos* then arranged meetings with the herdsmen. During the group discussion, herdsmen with vast knowledge in the use of plants to treat livestock diseases were identified. Fifty-eight herdsmen across five districts in Wukari LGA were interviewed.

Interviews were conducted in Hausa and Fulfulde with the help of an interpreter and voice recordings done. The herdsmen that participated in the survey were asked to share their knowledge of ticks, effect of ticks on their livestock and ethnoveterinary knowledge used by them to control ticks. Information collected included plants used to control ticks, parts used, methods of preparation, dosage, frequency, and duration of treatments; mode of administration, effectiveness of the herbal remedy and adverse effects observed. The plants were identified, authenticated and voucher specimens were made and preserved at the Ethno-botanical survey herbarium, NNMDA, Lagos State.

Literature survey

Published journal articles were assessed through Veterinary databases (PubMed, EBSCOhost and Google Scholar). The keywords used for the search were "tick control", "acaricidal plants", "ethnoveterinary" "phytochemical constituents". All documents considered were in English or translated into English. The strength and validity of information obtained from the Fulani herdsmen were evaluated based on similar claims in the literature.

Results

Fulani herdsmen data

A total of 58 Fulani herdsmen were interviewed (Table 1). 81% of them inherited the ethno veterinary knowledge, while 19% acquired the knowledge through training. Approximately 27.58% were between 30-40 years, 32.76% were between 41-50 years and 39.66% were above 50 years. All Fulani herdsmen interviewed were males. 10% had a form of formal education while 90% had no formal education. 39.66% of them have been in husbandry between 11-20 years, while 51.72% of the herdsmen have been in husbandry for over 21 years (Table 1).

TABLE 1. Data of Fulani herdsmen interviewed in Wukari Local Government Area, Taraba State, Nigeria.

Characteristics of respondents	Frequency	Percentage
Sex		
Male	58	100
Female	Nil	0
Age		
31-40	16	27.58
41-50	19	32.76
>50	23	39.66
Number of years rearing cattle		
1-10	5	8.62
11-20	23	39.66
>20	30	51.72
Educational Level		
No formal education	52	89.66
Formal education	6	10.34
How the knowledge was acquired		
Inherited	47	81
Learned	11	19

Plant species diversity

A total of 22 plant species belonging to 16 plant families were identified to be used by the Fulani herdsmen for tick control (Table 2). Plants of the Asteraceae, Euphorbiaceae and Fabaceae families had a representation of three plant species each. The remaining 13 families were each represented by one plant species (Table 2). *Tephrosia vogelii* and *Azadirachta indica* were the plant species with the highest percentage of usage by the Fulani herdsmen across the five districts (43% and 36% respectively) (Figure 2). The frequency of plant parts used was highest with the leaves (63%), stem bark (15%), seed and whole plant (7% each), fruit and flowers (4% each) (Figure 3) and herbs were the most used (Figure 4). There was no report of any side or adverse effects from the use of these plants.

TABLE 2. Different plant families and the number of species used to control ticks by Fulani herdsmen in Wukari Local Government Area, Taraba State, Nigeria

Plant family	Number of species
Annonaceae	1
Apocynaceae	1
Asteraceae	3
Balanitaceae	1
Bignonaceae	1
Caricaceae	1
Combretaceae	1
Euphorbiaceae	3
Fabaceae	3
Labiatae	1
Lamiaceae	1
Meliaceae	1
Myrtaceae	1
Poaceae	1
Solanaceae	1
Vitaceae	1

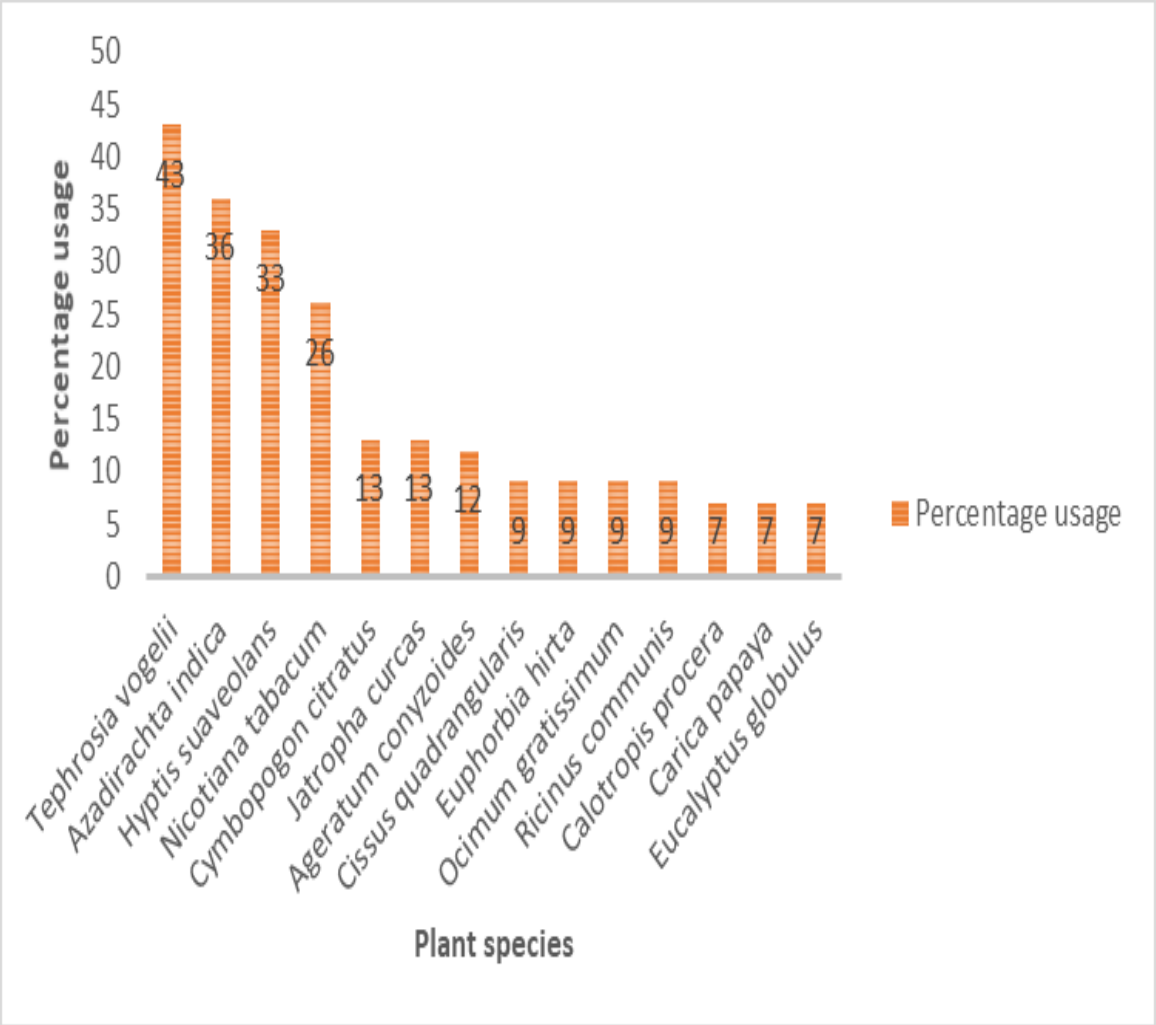

Fig. 2. Percentage use medicinal plants by species in Wukari Local Government, Taraba State, Nigeria

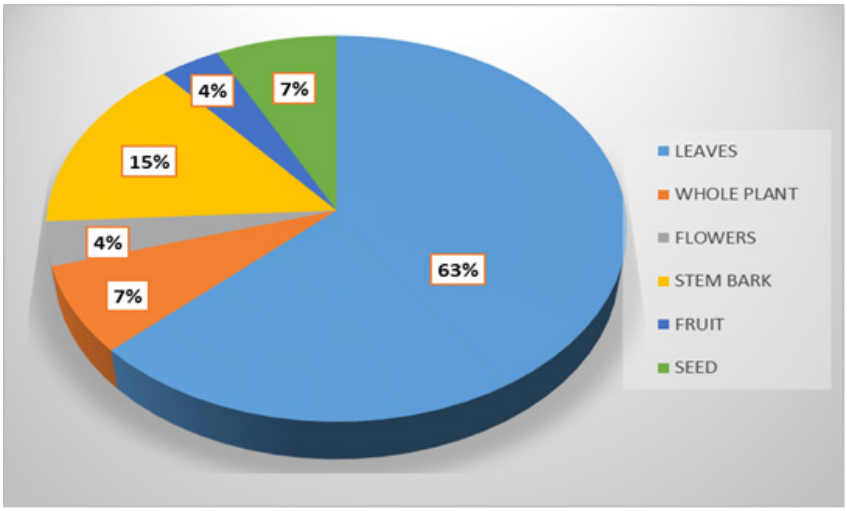

Fig. 3. Plant parts used in controlling ticks by Fulani herdsmen in Wukari Local Government Area, Taraba State, Nigeria

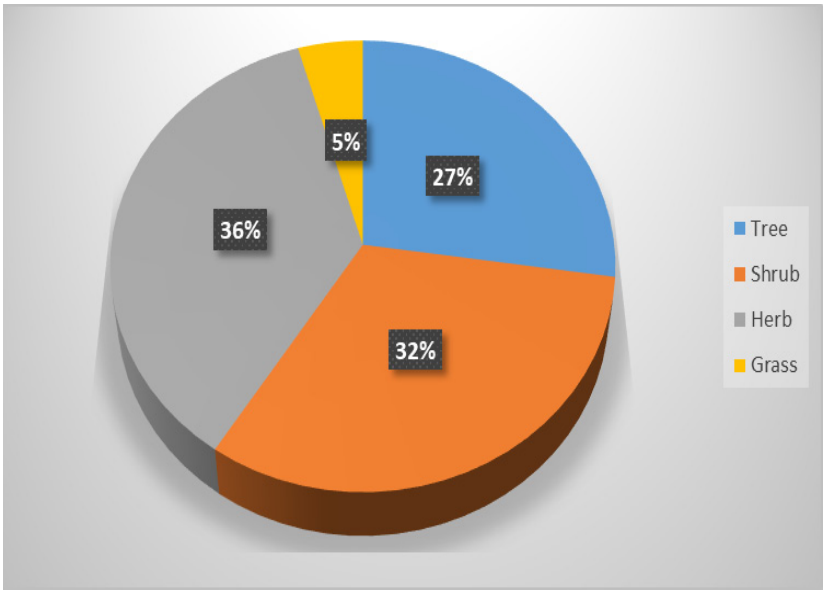

Fig. 4. Plant type distribution for tick control among Fulani herdsmen in Wukari Local Government Area, Taraba State, Nigeria.

Methods used in the preparation and administration of herbal remedies

Herbal medicines used were prepared mainly by pounding, dissolving in water and applying the filtrate as a topical spray. Some were made by squeezing the leaves and then applying the extract directly on the tick. Others applied seed oil from some of the plants topically (Table 3). All the Fulani herdsmen interviewed also used the manual method of hand tick removal as a control measure.

TABLE 3. Plant species used for the control of ticks by Fulani herdsmen in Wukari Local Government Area, Taraba State, Nigeria.

Species	Family	Common names	Vernacular name	Part used	Mode of preparation and & administration
Ageratum conyzoides L.	Astereceae	Goat weed	H- NI F- Kumba-dongul	L	Boiled fresh leaves in water is used as filtrate for topical spray
Annona senegalensis Pers.	Annonaceae	African custard apple	H- Gwándàn dààjì F- Dukuu-hi	L	Leaves pounded, dissolved in water and used as a topical spray
Aspilia africana (Pers.) C.D. Adams	Asteraceae	English haemarrhage plant	H-Jamajina, Kalankuwa F- Nyarki	W	Dried whole plant is grinded in a mortar, dissolved in water and administered as a topical spray
Azadirachta indica A. Juss	Meliaceae	Neem	H- Dóógón yááròò F- Daandi mayo, Ganyeeje	L, Sd	Leaves infusion and seed oil used as a spray
*Balanites aegyptiaca.*Del	Balanitaceae	Desert date	H- Ádúúwàà F- Tannere	L	Fresh leaves pound, mixed with water and applied directly on the ticks
Calotropis procera (Aiton) W.T.Aiton	Apocynaceae	Sugar apple, Sodom apple	H- Bambambele F- Tumpaapahi	L	Pound fresh leaves, dissolved in water, decanted and used as a topical spray
Carica papaya L.	Caricaceae	Pawpaw	H- Gwándâ F- dukku-hi	L	Dry leaves grinded and mixed with neem oil and spray topically
Cissus quadrangularis L	Vitaceae	Devils backbone, Edible stemmed vine	H- Ɗáɗɗòòríí F- Gaadal, Ceembe	L	Both leaves and stem infusion used as a spray
Cymbopogon citratus (DC.) Starf	Poaceae	Lemon grass	H- NI F- Wajaalo, Luɓodî	L	Grinded leaves infusion used as a spray
Eucalyptus globulus Labill.	Myrtaceae	Southern blue gum	H- NI F- Sumsum	L	Fresh leaves pounded, dissolved in water and filtrate used as a topical spray on ticks infested areas
Euphorbia hirta. L	Euphorbiaceae	Asthma plant	H- Noonon kurciya F- Endamyel, Kosam-yel	L	Juice squeezed from the leaves and applied on the ticks
Guiera senegalensis J.F. Gmel	Combretaceae	Guier du Senegal	H- Sabara F- Geelooki	L, SB	Both dry leaves and stem bark soaked in water and filtrate applied topically on tick infested areas
Hyptis suaveolens (L.) Poit.	Lamiaceae	Bush tea, Pignut	H- Maganin sauro F-Kachu- Kachugha	L	Filtrate from fresh leaves used as a spray, dry leaves burnt to repel ticks from the herd
Jatropha curcas L.	Euphorbiaceae	Physic nut	H- Bìì ní dà zúgúú- F- Magalee-hi	F	Extracted oil from the fruits, mixed with ash and applied topically
Kigelia africana (Lam.) Benth	Bignonaceae	Sausage tree	H- Hántsàř gííwáá, Nòònòn gííwáá F- Gillaa-hi	SB	Stem bark boiled in water and filtrate applied as a topical spray
Nicotiana tabacum L.	Solanaceae	Tobacco	H- Táábaà F- Taba-hi	L	Pound and squeezed leaves in water sprayed on the ticks
Ocimum gratissimum L.	Labiatae	Africa Basil, Scent leaf	H- Ɗáddóóyà tá gídáá F- Urngol	WP	Pulverized leaves dissolved in water, filtrate used as a wash
Ricinus communis L.	Euphorbiaceae	Castor oil plant	H- Zúrmâ mutane Cíkà gídáá, Ɗán kwásáré H- Kolakolaa-hi	L	Pound fresh leaves, dissolved in water and sprayed the filtrate topically
Senna occidentalis (L.) Link	Fabaceae	Coffee senna	H- Tárásáá F- Tabsahi, Jambajohi	L, Sd	Leaves and seed infusion sprayed topically
Tamarindus indica L.	Fabaceae	Tamarind	H- Tsamiyaa F- Jatami, Jaɓɓe	SB	Stem bark decoction applied topically
Tephrosia vogelii Hook. F.	Fabaceae	Fish poison bean	H- Jimfaa F- Tokke liɗɗî, Lekki liɗɗî	L	Fresh leaves grinded, squeezed in water and use as a wash
Tithornia diversifolia (Hemsl.) A.grey	Asteraceae	Mexican sunflower	H- NI F-Burum burum	L, F	Dry flowers and leaves are grinded, dissolved in water and used to wash the animal

H-Hausa; F- Fulfulde; L- Leaves; R- Roots; SB- Stem bark; Se- Seed; WP- Whole plant; NI- Nonindigenou

Literature review on the use of identified herbal remedies

Of the 22 plant species used in the control of ticks in Wukari LGA, 50% were found to have similar ethnomedical claims in some other regions (Table 4). Approximately 86% have been pharmacologically reported to have acaricidal and/or tick repellent activity by other researchers (Table 4).

Reported efficacies of the herbal remedies

All the plant species had reported pharmacological activities and/or isolated constituents to support claims of their use (Table 5).

TABLE 4. Plant species used by Fulani herdsmen in Wukari Local Government Area, Taraba State, Nigeria that have demonstrated acaricidal activity from literature.

Plant species	Activity	Country of study	References
Ageratum conyzoides L.	Acaricidal/ repellant	India	[14,15,16]
Azadirachta indica A. Juss	Acaricidal	Pakistan, Côte d'Ivoire, Ethiopia	[17,18,19]
Balanites aegyptiaca Del	Acaricidal	Uganda	[20]
Carica papaya L.	Acaricidal	Zimbabwe, India	[21,22,23]
Calotropis procera (Aiton) W.T.Aiton	Acaricidal	Ethiopia, Pakistan	[24,25]
Cissus quadrangularis L.	Acaricidal	Zimbabwe, South Africa	[26,27,28,29]
Cymbopogon citratus (DC.) Stapf	Acaricidal/ repellant	Benin, Brazil	[30,31]
Eucalyptus globulus Labill	Acaricidal	Algeria, Iran	[32,33]
Euphorbia hirta L.	Repellant	Uganda	[34]
Guiera senegalensis J.F. Gmel	Acaricidal	Sudan	[35]
Hyptis suaveolans (L.) Poit	Acaricidal/ repellant	Benin	[36]
Jatropha curcas L.	Acaricidal	Colombia, India, South Africa,	[37, 26,38]
Kigelia africana (Lam.) Benth	Acaricidal/ repellant	Uganda	[34,39]
Nicotiana tabacum L.	Acaricidal, repellant	Zimbabwe, Uganda, Malawi, India	[40, 41, 42,43]
Ocimum gratissimum L.	Acaricidal, repellant	Benin, Brazil	[36, 44]
Ricinus communis L.	Acaricidal	Bangladesh, India, Zimbabwe,	[41, 45,46]
Senna occidentalis L.	Acaricidal	Jamaica	[47]
Tamarindus indica L.	Acaricidal	Tanzania, Thailand	[48,49]
Tephrosia vogelii Hook.F.	Acaricidal	Benin, Uganda, Tanzania, Zimbabwe	[19, 36,50,51]
Tithornia diversifolia (Hemsl.) A.grey	Acaricidal, repellant	Côte d'Ivoire, Kenya	[18, 52,53]

TABLE 5. Other pharmacological studies and isolated compounds present in plant species used for the control of ticks by Fulani Herdsmen in Wukari Local Government Area, Taraba State, Nigeria

Plant species	Some reported pharmacological activities	Some isolated compounds	References
Ageratum conyzoides L.	Insecticidal, antitumour, antifungal, antiviral, and anti-inflammatory reproductive, anti-depressant, antibacterial, antioxidant, ulcer, wound healing	Precocene I, precocene II, chromenes, kaempferol, 5-hydroxy tryptamine, Polymethoxy flavones, antiulcerogenic compound-1(AC-1)	[54,55]
Annona senegalensis Pers.	Antidiarrhoeal, antimicrobial, antimalarial, toothache, snake bite, anticonvulsant, antioxidant	Kaurenoic acid, 1, 2 benzenediol, butylated hydroxytoluene (BHT), Phenol, 2, 6 bis (1, 1-dimethylethyl-4methyl, methylcarbamate, n hexadecanoic acid, hexadecane, 13hexyloxacyclotridec-10-en-2one, oleic acid, tetracosane, 9- octylheptadecane, heneicosane, 12-mehtyl-E, E-2, 13octadecadien-1-ol, octadecanoic acid, 9, 17-octadecandienal, pentadecane, tetratriacontane	[56.57,58]
Aspilia africana (Pers) C.D.Adams	Antimicrobial, antinociceptive, wound healing, antiulcer, growth and egg laying promotion in quails	Terpenoids, β-caryophyllene, germacrene D, α-pinene, carene, phytol, linolenic acid	[59,60,61]
Azadirachta indica A. Juss	Antibacterial, antifungal, anti-inflammatory. antiarthritic, antipyretic, hypoglycemic, antiulcer, antifungal, antibacterial, antitumour, insecticidal	Azadirachtin, nimbin, nimbidin, nimbolide, limonoids,quercetin and ß-sitosterol, ascorbic acid, n-hexacosanol and amino acid, 7-desacetyl-7-benzoylazadiradione, 7-desacetyl-7-benzoylgedunin, 17-hydroxyazadiradione, nimbiol	[62,63,64]
Balanites aegyptiaca Del.	Antibacterial, cardioprotective, antioxidant, anthelminthic, antivenin, anticancer, anti-inflammatory, hepatoprotective, antidiabetic, antiviral, wound healing, antinociceptive, insecticidal	Quercetin 3-glucoside, quercetin-3-rutinoside; 3-glucoside, 3-rutinoside, 3-7-diglucoside and 3-rhamnogalactoside of isorhamnetin, Balanitins- 1, Balanitins- 2, Balanitins- 3, furanocoumarin bergapten and dihydrofuranocumarin D- marmesin, beta-sitosterol, bergapten, marmesin, β-sitosterol glucoside	[65,66,67]
Carica papaya L.	Anthelminthic, antioxidant, antimicrobial, antifungal, larvicidal, antiplasmodial, immunomodulatory, anticonvulsant, antifertility, antihypertensive	Papain, trypsin inhibitors, phytic, oxalate, carpaine, caricin, glucotropacolin, pseudocarpain, dehydrocarpaine I and II, choline, vitamin C and E, carposide.	[68,69]
Cassia occidentalis L.	Antimicrobial, antioxidant, hepatoprotective, antipyretic, antidepressant	Achrosin, aloe-emodin, emodin, anthrones, apigenin, aurantiobtusin, campesterol, cassiollin, chryso-obtusin, chrysophanic acid, chrysarobin, chrysophanol, chrysoeriol	[70]
Cissus quadrangularis L.	Antiplasmodial, anti-inflammatory, estrogenic, antinociceptive, antitumour, osteoblastogenic, hepatoprotective, antioxidant, antihaemorrhoidic, antibacterial, antiviral, antifungal	A and β-amyrins, β-sitosterol, ketosetosterol, phenols, tannins, vitamin, carotene 7-Oxo-Onocer-8-ene-3 β 21 α diol, 31 methyl tritiacontanoic acid, taraxeryl acetate, taraxerol, iso-pentadecanoic acid, resveratrol, piceatanon, pallidol, parthenocissus, alicyclic lipids	[71,72]
Cymbopogon citratus (DC.) Stapf	Anti-amoebic, antibacterial, antifungal, antimalarial, antimycobacterial, antioxidants, hypoglycemic, insecticidal, miticidal	Elimicin, catecol, chlorogenic acid, quercetin, kaempferol, citral, apigenin, cymbopogone, cymbopogonol, luteolin	[73,74]
Eucalyptus globulus Labill	Anti-inflammatory, antinociceptive, antimicrobial, musculorelaxant, antimycotic, sedative, neuroprotective, insecticidal, antidiabetic, anthelminthic, antioxidant, anticancer	1-8 cineole, spathulenol, aromadendrene	[75,76]

TABLE 5. Cont.

Plant species	Some reported pharmacological activities	Some isolated compounds	References
Euphorbia hirta L.	Anxiolytic, analgesic, antipyretic, anti-inflammatory, antitumour, antibacterial, anti-fungal, antidiabetic, nephroprotective, acetyl cholinesterase inhibitor, antioxidant, immunomodulatory, molluscicidal, anthelminthic, antiviral	euphorbin-A,euphorbin-B, euphorbin-C, quercitrin, Rutin, euphorbin-D, 2,4,6-tri-O-galloyl-β-d-glucose, 1,3,4,6-tetra-Ogalloyl-β-d-glucose, kaempferol,gallic acid,and protocatechuic acid, β-amyrin,24-methylenecycloartenol,β-sitosterol,heptacosane, shikmic acid, tinyatoxin, choline	[77,78]
Guiera senegalensis J.F. Gmel	Anticancer, antiplasmodial, anti-inflammatory, antioxidant, antibacterial	Harman, tetrahydroharman, dihydroharman, Guieranone A, hyoscyamin solanine, quercetin	[79,80]
Hyptis suaveolans (L.) Poit	Antibacterial, antiplasmodial, antinociceptive, anti-inflammatory, antifungal, antioxidant, anti-ulcer, immunomodulatory, antidiabetic, insecticidal	Suaveolic acid, suaveolol, methyl suaveolate, β-sitosterol, ursolic acid, rosamarinic acid ,methyl rosmarinate , oleanoic acid, 3β-hydroxy lup-12-en-28-oic acid, urs-12-en-3β-ol-27-oic acid, 1,19adihydroxy-urs-2(3),12-dien-28-oic acid and 3β-hydroxyl lup-20(29)-en-27-oic acid	[81,82,83]
Jatropha curcas	Antitumour, anti-inflammatory, anticoagulant, anthelminthic, insecticidal, wound healing, antidiarrheal, immunomodulatory	Curcusone-B, palmitic acid, stearic acid, arachidoleic acid , beheric acid, arachidic acid, linoleic acid , 6,6″-diC-β-D-$^{4}C_{1}$-glucopyranoside-methylene-(8,8″)-biapigenin, apigenin 7-O-β-D-neohesperidoside , apigenin 7-O-β-D-galactoside , orientin , vitexin , vicenin II, apigenin	[84,85]
Kigelia africana (Lam.) Benth	Antibacterial, antifungal, antineoplastic, analgesic, anti-inflammatory, antimalarial	Kigelin, 6-methoxymellein, stigmasterol, lapachol, β-sitosterol, 3-dimethyl kigelin, ferulic acid, norviburtinal , pinnatal, specioside, verminoside, minecoside.	[86,87]
Nicotiana tabacum L.	Antibacterial, antinociceptive, anthelminthic	Nicotine, solanesol, citric acid, nicoteine, nicotimine, anabaine anatalline, anatabine, nornicotine., tahacinin, tahacilin and isoquercitrin, 1-quinic, chlorogenic, caffeic and oxalic acids	[88,89]
Ocimum gratissimum L.	Anthelminthic, insecticidal, wound healing, antifungal, antibacterial, anti-inflammatory, insecticidal, antimalarial	Rosmarinic acid, apigenin, myretenal, luteolin, ß-sitosterol, carnosic acid, thymol, eugenol, β-Caryophyllene, γ-terpinene, α-terpinene, p-cymene, terpin-4-ol, carvacrol, α-humulene	[90,91]
Ricinus communis L.	Antioxidant, antihistaminic, antinociceptive, antiulcer, immunomodulatory, antidiabetic, hepatoprotective, antifertility, anti- inflammatory, antimicrobial, lipolytic, wound healing, insecticidal	Ricinine, N-demethylricinine, rutin, epicatechin ellagic acid, β-caryophyllene,gallic acid, quercetin, gentisic acid, ellagic acid, rutinoside, kaempferol-3-O-β-D-glucopyranoside, indole-3-acetic acid	[92,93]
Tamarindus indica L.	Hypolipidemic, weight reducing, antimicrobial, hepatoprotective, anthelmintic, antioxidant, analgesic, anti-inflammatory, antivenom, wound healing, antidiarrheal, immunomodulatory, antiemetic, antimalarial, cytotoxic	Geraniol, limonene, pipecolic acid, lupeol, orientin, vitexin, phenylalanine, leucine, campesterol, β-amyrin, β-sitosterol	[94,95]
Tephrosia vogelii Hook.f.	Antidiabetic, antiulcer, antidiarrheal, wound healing, anti-inflammatory, insecticidal, antiviral, antiprotozoal, anti-fungal, antiplasmodial	6-hydroxy-kaempferol 6-methyl ether, rotenoids, deguelin, rotenone, sarcolobine, tephrosin, α-toxicarol, 8 (4, 5-dihydro-5, 5-dimethyl4-oxofuran-3yl)-5-hydoxy-7-methoxy-2-phenyl-4H-chrome-4-one	[96,97]
Tithornia diversifolia (Hemsl.) A. Gray	Cytotoxic, anti-malarial, anti-inflammatory, anticancer, anti-amoebic, antiviral, antifeedant, antidiarrhoeal, anti-amoebic, spasmolytic, analgesic	α-pinene, β-pinene, isocaryophyllene, nerolidol, 1-tridecanol, limonene, sabinene, α-copaene, cyclodecene, germacrene D, β-caryophyllene, 1, 8-cineole, tagitinin C	[98,99]

Discussion

The use of parasiticidal plants has been a major component of pest management for generations [100]. One of their great advantages is that they can be propagated locally and self-harvested [101]. These plants contain secondary metabolites that have been found to exhibit toxic, repellent, anti-ovipositional, antifeedant and growth-inhibiting effects against many arthropod species [102, 103].

In this study, all the Fulani herdsmen interviewed were males. This may be that since in Fulani culture and most places in Africa, men are the ones responsible for cattle herding, hence the tendency to be more knowledgeable in medicinal plants. The older generation were more knowledgeable about the use of medicinal plants in the treatment of animals. This is in line with the study conducted by Nyahangare et al. [41] in Zimbabwe. This could be as a result of increase in the number of young Fulanis enrolled in western education. Direct and indirect influence of modernization and globalization could also be responsible for the low number of young respondents that participated in the study [104].

Approximately 86% of the plants documented have demonstrated acaricidal and tick repellent properties from studies conducted by other researchers [13, 14, 28, 36, 41]. Plant leaves were the plant part most used by the Fulani herdsmen in the LGA. The use of leaves is consistent with other reported studies [19,39]. This is often attributed to their high pharmacologically active components compared to woody plant forms [105].

Some of the plants reported in this study e.g. *E. hirta, K. africana*, *A. indica, B. aegyptiaca* and *N. tabacum* have similar uses in Uganda [20,39], *C. quadragularis* and *R. communis* in Zimbabwe [41], *A. indica* and *T. vogelii* in Ethiopia [19], *T. indica* in Tanzania [49]. This may be an indication of their effectiveness having been used in different areas and shared cultures. The main mode of application of the plants in this study was topical, which is in line with a similar study conducted by Opiro et al. [39]. This route of administration is easy to administer and safer because topical applications are poorly absorbed into systemic circulation.

Tephrosia vogelii possess known acaricidal activity [36, 50, 51]. Biosynthesized rotenoids (isoflavonoids) from *T. vogelii* have broad spectrum insecticidal and acaricidal properties [106]. In insects and acarines, rotenone exhibits its action by inhibiting the transfer of electrons from Fe-S centers in complex I to ubiquinone in the electron transport chain. This prevents nicotinamide adenine dinucleotide from being converted into usable cellular energy, adenine triphosphate [107]. On the other hand, the main bioactive compound found in *Nicotiana tabacum* is the alkaloid nicotine, which is also commonly found in members of the family Solanaceae. Nicotine exhibits its action by mimicking the excitatory neurotransmitter acetylcholine [108].

Azadirachta indica leaves and stem bark powder have the capacity to adsorb heavy metals like cadmium and lead from aqueous solution [109]. Azadiractin stimulates chemoreceptors on deterrent cells and blocks the firing of phagostimulatory receptors on feeding stimulatory cells [110]. It also inhibits protein synthesis in various insect tissues such as the midgut thereby impairing food protein digestion [108]. Functional impairment of the reproductive system of ticks is usually a consequence of significant morphophysiological alterations that have been detected in ticks exposed to neem oil [111]. Salannin, another active component of *A. indica*, deters feeding, increases the larval stage duration and causes delay in moulting, leading to decreased pupal weight, larval and pupal mortality [112]. Shampoo formulations of neem seed extracts have been developed for veterinary and human use [113].

Monoterpenoids like eucalyptol, linalool and citral isolated from many of the plants exert their effects by reversible inhibition of acetylcholinesterase [114,115]. Citral found in *C. citratus* exhibits a neurophysiological effect on the neuromodulator, octopamine [116]. Thymol affects the $GABA_A$ receptors [117, 118]. This could be responsible for the effect of *O. gratissimum* on ticks. 1,8-cineole from *O. gratissimum* has been found to be effective against *Rhipicephalus* (*Boophilus*) *microplus* [119].

Conclusions

This study documents and reviews the use of 22 ethnoveterinary plants in the control of ticks in Wukari LGA, Taraba State, North eastern Nigeria. Appropriate strategies for the validation of traditional remedies and conservation of natural resource are necessary.

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Conflict of interest

The authors declare that there is no conflict of interest.

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