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Review

The potential of Nigerian bioactive plants for controlling gastrointestinal nematode infection in livestock

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Abstract

Bioactive compounds from marine and terrestrial organisms have been used extensively in the treatment of many diseases in both their natural form and as templates for synthetic modifications. This review summarizes present knowledge about anthelmintic effects of the extracts of bioactive plants in Nigeria against helminth parasites of ruminants. Plants traditionally used in livestock production are discussed. The main focus is hinged on *in vitro* and *in vivo* activities of secondary plant metabolites against nematodes of livestock. This review provides insight into preliminary studies of medicinal plants, which can be investigated further to discover promising molecules in the search for novel anthelmintic drugs and nutraceuticals.

Keywords: anthelmintic, nematodes, bioactive plants, Nigeria.

Introduction

Helminthiasis due to gastrointestinal nematodes is a major impediment to livestock production throughout the tropics and elsewhere, including Nigeria (Ademola *et al*., 2009). The principal gastrointestinal nematode genera infecting small ruminants (sheep and goats) in Nigeria are *Haemonchus, Trichostrongylus, Trichuris, Strongyloides, Oesophagostomum, Nematodirus, Gaigeria*, and *Bunostomum*. They are classified in the order Strongylida. The life cycles of these gastrointestinal nematodes follow a similar pattern, with some exceptions (e.g. *Nematodirus* spp., for which larval development occurs within the egg). The risk of infection to grazing animals is associated among other factors with the degree of larval contamination of the pasture. The latter is principally determined by the prevailing weather conditions, namely temperature and rainfall (Soulsby, 1982). If either of these environmental variables is unfavorable (i.e. temperature or relative humidity is low) then egg hatching and larval molting are impaired and availability of infected larvae on pasture will decrease. Rainfall is the only limiting environmental variable in the tropics and subtropics, because temperatures are always high enough to enhance this process. Therefore, in the humid tropics and subtropics, the environmental conditions on pasture are overwhelmingly favorable for egg hatching and larval development.

Parasitic nematodes of livestock are largely controlled with anthelmintic drugs. Even with strategic timely treatments, this type of control is expensive and, in most cases, only partially effective. Since the early 1960s there have been only three major classes of broad-spectrum anthelmintics drugs used for the control of nematode parasites of ruminant livestock, namely the benzimidazoles/probenzimidazoles, the tetrahydropyrimidines/imidazothiazoles (most notable drug being levamisole), and the avermectins/milbemycins or macrocyclic lactones. However, there are novel classes of anthelmintic drugs that have been discovered (e.g. parahequamide and cyclooctadepsipeptides); possibly the greatest constraint in their commercial development are the enormous costs involved (Waller, 1997). The excessive and frequent use of anthelmintics has resulted in anthelminthic resistance in nematode populations. Mba *et al*. (1992) reported thiabendazole resistance in strongyles of sheep in Ibadan, Nigeria. Similarly, anthelmintic resistance to albendazole, levamisole and morantel was reported in bovine

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strongyles in Southwestern Nigeria (Fashanu and Fagbemi, 2003). However, avermectin resistance was absent in strongyles of sheep in Southwestern Nigeria (Ademola, 2002). Ademola *et al.* (2015) also reported the absence of benzimidazole-resistance-associated alleles in *Haemonchus placei* in cattle in Nigeria as revealed by pyrosequencing of β-tubulin isotype 1. Therefore, there is a need for a global interest in the development of improved means of controlling these nematode parasites. More specifically, it is an urgent need for an increased focus on understanding the epidemiology of parasites in order to work toward better strategic and integrated approaches of parasite control in the face of the continued emergence of anthelmintic resistance.

The increased public awareness of drug residues in meat and animal products and the increased resistance of parasites to modern anthelmintics, coupled with the need for a more sustainable system of farming, have resulted in an intensified effort to find alternative endoparasite control options (Rahmann *et al.*, 2002). This has triggered the evaluation of some traditionally used plants for their anthelmintic properties with a view towards finding out more about their potential efficacy in control efforts. Secondary plant substances and metabolites can be beneficial for animal health rather than having an optimized nutritional value (Rahmann, 2004). Secondary metabolites are organic molecules that are not involved in the normal growth and development of an organism. The biosynthesis origin of most secondary metabolites, such as terpenes, phenolic compounds and alkaloids determine their classifications. The various classes of these compounds are often associated with a narrow set of species within a phylogenetic group and are constituents of the bioactive compound in several medicinal, aromatic, colorant, and spice plants or foodstuffs. In this context, a certain group of secondary plant substances, the condensed tannins have been investigated. Condensed tannins are not only included in certain plants, a lot of plants have some condensed tannin content, but only those with higher levels are referred to as 'bioactive forage'.

Given increased interest in exploiting the anthelmintic activity of plants and their products, there is also a growing interest in finding the best ways of screening for activity. Before embarking on screening program, it is very important that researchers have clearly defined goals which incorporate the needs of their end users because these will influence both the breadth and depth of their research projects. For example, in a situation where there are only a small number of local forages that need to be investigated, it could be possible to meet the anthelmintic activity needs of resource-poor farmers through results obtained from fecal egg count reduction tests in naturally infected animals. On the other hand, it would be impossible to extend this *in vivo* approach to determine the efficacy of products derived from whole plants or their products to moderate sized plant collections, which contain a few hundred different species. The time and financial costs involved in all mass screening programs highlight the importance of the choice of first phase screening technique, which needs to be reproducible, sensitive, and cost-effective. The following phases in the isolation of the active compounds are inevitably more complex and expensive, because as the degree of purification increases so do the costs of discovery, as there is the need to study the compound target, pharmacology, and safety/toxicity.

Traditional use of medicinal plants in livestock production

Before the discovery of commercial anthelmintics, specific plants were used to control worm infections, based more on belief rather than documented testing, and were credited with having specific actions. In traditional medicine, aqueous or powdered parts of plants were usually administered at various dosages and concentrations, which is likely to be the reason for differences in treatment effects reported from different regions.

Many plants and other materials used in traditional medicine have been found to be valuable in western scientific medicine. For instance, in ethnomedical research, quinine, picrotoxine (a stimulant), and acetylsalicylic acid (aspirin) have been produced from very common plants (Ibrahim, 1986). Fulani herders in Northwest Cameroon recognized 33 cattle ailments that can be treated or prevented by traditional methods (Nuwanyakpa *et al.*, 1995). Treatment of parasitic infections with plants by animals may have preceded the used of plant remedies by human beings; sick chimpanzees seek out specific plants such as young leaves of *Aspilla*, a tropical plant which contains thiarubine that cures parasitic diseases (McCorkle and Balazar, 1996). Interest is reviving, especially in developing countries; India, for example, has a thriving medicinal herbal industry, commercial cultivation of medicinal plants, and an annual volume of trade in medicinal plants of over 1 billion rupees (Anjara, 1996). Commercial production of medicinal plants is increasing in many countries.

About 92 varieties of the plants and other materials are used in Nigeria to treat and prevent livestock health problems (Wahua and Oji, 1987). The mode of preparation of different parts depends on the active ingredient to be extracted and the route of administration. In some cases, the same plant in varying doses serves as a cure and a prophylactic, whereas in others different plants are used for treatment and prophylaxis. Fulani herders in Nigeria wash their hands in an infusion of leaves of *Nelsonia competris* and *Guira senegalensis* before collecting and handling herbs. The latter possesses antimicrobial properties (Adebowale, 1997). Many farmers regularly deworm their animals with indigenous herbs. For instance, the seed of *Leucaena leucocephala* makes an effective dewormer. Other leaves commonly used for deworming are *Nauclea latifolia* and *Spondias mombin* (Adebowale, 1997).

Plants with activity against helminthes

Traditional uses of medicinal plants for their anthelmintic efficacy have been well documented. Table 1 summarizes anthelmintic activity evaluated for Nigerian plants. However, their efficacies have not been scientifically validated. Tannin-rich plants have attracted much attention for their effect on internal nematodes in ruminants and Athanasiadou *et al.* (2001) and Hoste *et al.* (2012) discussed this topic in detail in

Table 1. Nigerian plants evaluated for *in vitro* and *in vivo* anthelmintic activity

Plant	Part used	Active constituent	Indication cited or activity	Animal species	References
Khaya senegalensis	Bark	Saponins, condensed tannins, terpenoids, flavonoids	*Haemonchus contortus*	Sheep	Ademola *et al.* (2009)
Leucaena leucocephala	Seed	Alkaloids, tannins	*H. contortus*	Sheep	Ademola *et al.* (2005a)
Ficus exasperata	Leaf		*Heligmosomoides bakeri*	Mice	Nweze *et al.* (2013)
Venonia amygdalina	Leaf	Sesquiterpene lactones vernodalin, vernolide, hydroxyvernolide, vernomydin and vernodal, and some novel sigmastane-type steroid glycosides vernonioside A1, A2, B1, B2, and B3 sesquiterpene lactones vernodalin, vernolide, hydroxyvernolide, vernomydin and vernodal, and some novel sigmastane-type steroid glycosides vernonioside A1, A2, B1, B2, and B3	*H. contortus*	Sheep	Alawa *et al.* (2010); Ademola and Eloff (2011a); Nweze *et al.* (2013)
Irvingia gabonensis	Leaf		*H. bakeri*	Mice	Nweze *et al.* (2013)
Salvadora persica	Leaf		Helminth		Datsu *et al.* (2011)
Terminalia avicenoides	Leaf		Helminth		Datsu *et al.* (2011)
Anogeissus leiocarpus	Leaves, roots, trunk bark		*H. contortus*	Sheep	Kabore and Belem (2009); Ademola and Eloff (2011b); Agaie and Onyeyili (2011)
Xylopia aethiopica	Fruits	Alkaloids, tannins, saponins, resins, cyanogenic glycosides, glycosides, and flavonoids	*Nippostrongylus brasiliensis Eudrilius eugeniae*	Rats	Suleiman *et al.* (2005); Ekeanyanwu and Etienajirhevwe (2012)
Aframomum danielli	Seed	Alkaloids, saponins, cardiac glycosides, steroids, and glycosides	*H. contortus*	Sheep	Ajayi *et al.* (2008)
Nauclea latifolia	Leaf, stem bark	Indolo-quinolizidine alkaloids, and glycol-alkaloids	Trichostrongyles	Sheep	Asuzu and Njoku (1996); Ademola *et al.* (2007a)
Cassia alata	Leaf	Alkaloids, lectins, saponins, cyanogenic glycosides, and isoflavones	*H. contortus Heterakis gallinarum*	Sheep, Bird	Ademola and Eloff (2011c); Kundu *et al.* (2014)
Cassia occidentalis	Stem bark	Carbohydrate, glycosides, tannins, saponins, flavonoids, cardiac glycosides, steroids, and triterpenes	*H. contortus*	Sheep	Suleiman *et al.* (2014)
Cassia angustifolia	Stem bark		*Heterakis gallinarum*	Bird	Kundu *et al.* (2014)
Guiera senegalensis	Stem bark	Carbohydrate, glycosides, tannins, saponins, flavonoids, cardiac glycosides, steroids, and triterpenes	*H. contortus*	Sheep	Suleiman *et al.* (2014)
Acanthus montanus	Leaf		Strongyles	Sheep, goats	Adamu *et al.* (2010)
Spigelia anthelmia	Whole plant root		Trichostrongyles	Sheep	Assis *et al.* (2003); Ademola *et al.* (2007b); Shoyibi and Tom Ashafa (2015)
Spondias mombin	Leaf		*H. contortus*	Sheep, goats	Ademola *et al.* (2005b); Wahab and Hiew (2014)
Combretum molle	Leaf	Steroidal acids and saponins, triterpenoids, glycosides	*H. contortus*	Sheep	Ademola and Eloff (2010)
Anacardium occidentale	Leaf		*H. contortus*	Sheep	Varghese *et al.*, (1971); Ademola and Eloff (2011d)
Azadirachta indica					Nwosu *et al.* (2006)
Acalypha wilkesiana			*Fasciola gigantica, Taenia solium*, and *Pheritima pasthuma*		Onocha and Olusanya (2010)

Table 1. (*Cont.*)

Plant	Part used	Active constituent	Indication cited or activity	Animal species	References
Bridelia ferruginae			*Fasciola gigantical*, *Taenia solium*, and *Pheritima posthuma*		Lasisi and Kareem (2011)
Heliotropium indicum	Roots		Strongyles	Sheep	Soyibi and Tom Ashafa (2015)
Senna fistula	Roots		Strongyles	Sheep	Shoyibi and Tom Ashafa (2015)
Monodora myristica	Fruits	Alkaloids, tannins, saponins, resins, steroids, glycosides, flavonoids, cyanogenic glycosides, oxalates, and phytates	*Eudrilius eugeniae*		Ekeanyanwu and Etienajirhevwe (2012)

their review. Consumption of such bioactive plants had the therapeutic and nutritional effects on the host and the ability to maintain homeostasis indicated by clinical condition under parasitic challenge. However, the content of condensed tannins should be controlled because of the anti-nutritional effect. Such a diet has also been associated with lethal effects on nematodes and the commonly reported effect was a substantial decrease in fecal egg counts, which was related to effects on female worm fecundity. When using the whole plant extracts, these effects on nematodes can be associated with the presence of one or more plant secondary metabolites with a wide range of biochemical characteristics, of which sesquiterpene lactones and condensed tannins are the most common in these forage legumes (Max *et al.*, 2005). Most *in vitro* studies reported the interference with hatching of eggs and inhibition of larval motility for L_1 and L_3 stages, which can contribute to a gradual decrease in pasture contamination with infective stages (Ademola *et al.*, 2009). Feeding of the extract of *Khaya senegalensis*, which is rich in condensed tannin, was effective against gastrointestinal nematodes of sheep. The LC_{50} of the aqueous and ethanolic extracts was 0.69 and 0.51 mg ml^{-1}, respectively. However, sheep drenched with 500 mg kg^{-1} of *K. senegalensis* ethanolic extract had a mean fecal egg count reduction of 88.82% (Ademola *et al.*, 2004). The other effect seen following incubation with tannin-rich extracts from *L. leucocephala*, for example, was a significant inhibition of the egg hatching and larval development process of *H. contortus* (Ademola and Idowu, 2006). The anthelmintic effect of chromatographic fractions of *L. leucocephala* (Lam.) de Wit seed extract was investigated by Ademola *et al.* (2005a) to determine the relative efficacy of the seed components as anthelmintic against gastrointestinal sheep nematodes.

The fractions of the seed extract are composed of alkaloids and tannins. The tannin fraction was reported to be significantly more active (LC_{50} 40.80 µg ml^{-1}) than all the other fractions. *In vitro Heligmosomoides bakeri* larval assays at concentrations of 500, 250, and 125 mg ml^{-1} of *Ficus exasperata* caused 100% larval mortality; while *Venonia amygdalina* and *Irvingia gabonensis* extracts caused 71.43% larval deaths at the same concentrations (Nweze *et al.*, 2013). Treatment of calves with 1.1 g kg^{-1} body weight of *V. amygdalina* produced 59.5% reduction in eggs per gram of feces in an *in vivo* study (Alawa *et al.*, 2010), while the *in vitro* study of *V. amygdalina* also demonstrated activity, with lethal concentration (LC_{50}) values of 957.0, 76.0, 524.0, 309.0, and 224.0 µg ml^{-1} for the acetone extract, and the butanol, hexane, chloroform, and 65% methanol, respectively, when tested against nematode eggs (Ademola and Eloff, 2011a).

Datsu *et al.* (2011) reported that the aqueous extracts of the leaves and shoots of *Salvadora persica* L., a member of the Salvadoraceae family, and the root bark of *Terminalia avicenoides*, of the family Combrataceae, are used in traditional medicine for the treatment of helminth infections in Northern Nigeria. Their study showed that both plant extracts exhibited *in vitro* anthelmintic activity on strongyles of sheep. Leaves, roots, and trunk bark of *Anogeissus leiocarpus* are used by traditional practitioners for the treatment of helminthiasis. *Anogeissus leiocarpus* acetone extract inhibited egg hatching and larval development in a dose-dependent manner. At the concentration of 100 mg

ml^{-1}, the efficacy of the extract of *A. leocarpus* was comparable with 30 mg ml^{-1} of levamisole (96.8%) but <25 mg ml^{-1} of albendazole (99.8%) (Ademola and Eloff, 2011b; Agaie and Onyeyili, 2011). Kabore and Belem (2009) also reported anthelmintic activity of *A. leiocarpus* from Burkina Faso on eggs and first-stage larvae of *H. contortus* with LC_{50} values of 409.5 and 411.4 µg ml^{-1}, respectively. The anthelmintic effect of the *Xylopia aethiopica* crude methanol extract against *Nippostrongylus brasiliensis* in rats at 0.8, 1.0, 1.2, 1.4, 1.7, and 2.0 g kg^{-1} reduced parasites burden by 21, 47, 51, 50, 63, and 76%, respectively (Suleiman *et al.*, 2005). The anthelmintic activity of aqueous extract of *X. aethiopica* was found to be more potent than the ethanol extract, which had a better anthelmintic activity than the methanol extract. The aqueous extract showed very significant activity at a concentration of 100 mg ml^{-1} compared with albendazole (15 mg ml^{-1}); the respective times of paralysis and death were 1.63 ± 0.36 and 6.77 ± 0.11 in aqueous extract, 2.91 ± 0.10 and 8.86 ± 0.66 in ethanol extract, 3.19 ± 0.56 and 6.44 ± 0.83 in methanol extract and 32.00 ± 0.87 and 38.87 ± 0.65 in albendazole. At the concentration of 100 mg ml^{-1}, the ethanol, methanol, and aqueous extracts of *Monodora myristica* showed significant activities when compared to albendazole (15 mg ml^{-1}), the respective times of paralysis and death were 1.98 ± 0.67 and 7.23 ± 0.19 in aqueous extract, 2.30 ± 0.28 and 0.30 ± 0.34 in ethanol extract, and 4.06 ± 0.60 and 6.30 ± 0.88 in methanol extract (Ekeanyanwu and Etienajirhevwe, 2012). The seed of *Aframomum danielli*, which contain diterpenes as acids and aldehydes, affect larval development following the incubation of *H. contortus* larvae in the extract. The calculated LC_{50} values of ethanolic, hexane and aqueous extracts of *A. danielli* were 0.33, 0.39, and 0.36 mg ml^{-1}, respectively (Ajayi *et al.*, 2008).

Ademola *et al.* (2007a) reported the anthelmintic activity of *N. latifolia* in sheep infected with *Haemonchus* spp., *Trichostrongylus* spp., *Strongyloides* spp., and *Trichuris* spp. The presence of *N. latifolia* extracts in the cultures reduced the survival of larvae, and the LC_{50} of aqueous and ethanolic extracts were 0.704 and 0.650 mg ml^{-1}, respectively, *in vitro*. While *in vivo* these extracts showed activity at 500 mg kg^{-1} against *Haemonchus* spp., *Trichostrongylus* spp. and *Strongyloides* spp., at 250 mg kg^{-1} against *Trichuris* spp., and were ineffective against *Oesophagostomum* spp. This is comparable to the anthelmintic activity of *N. latifolia* reported previously by Asuzu and Njoku (1996) against *T. colubriformis* larvae. Similarly, the anthelmintic efficacy of *N. latifolia* stem bark aqueous extract in sheep with natural acute or subacute parasitic gastroenteritis, due to mixed intestinal nematode infection, provided 93.8% reduction when treated with 1600 mg kg^{-1} of the extract, which was comparable to 94.1% reduction afforded by 5 mg kg^{-1} of albendazole. *Cassia alata* leaf is also credited for the treatment of intestinal parasites in human beings (Adjanahoun *et al.*, 1991). Hence, Ademola and Eloff (2011c) investigated the ovicidal and larvicidal activity of *C. alata* leaf acetone extract against *H. contortus*, and reported a measure of activity. The LC_{50} values of 0.562, 0.243, 0.490, 0.119, and 0.314 mg ml^{-1} were reported for the acetone extract, chloroform, hexane, 35% water in methanol, and butanol fractions, respectively, when tested against nematode eggs. While the LC_{50} values of 0.191, 0.505, 1.444, 0.040, and 0.306 mg ml^{-1} were reported for acetone extract, chloroform, hexane, 35% water in methanol fractions and butanol, respectively, *in vitro*. Similarly, *Cassia occidentalis* was found to be effective against *H. contortus* eggs and larvae at LC_{50} values of 4.23 and 0.11 mg ml^{-1} against *H. contortus* eggs and larvae, respectively. In addition, *Guiera senegalensis* was reported to be active against *H. contortus* eggs and larvae with LC_{50} values of 88.24 and 0.0012 mg ml^{-1}, respectively (Suleiman *et al.*, 2014). *Cassia* spp. from India were also reported to possess anthelmintic properties. Kundu *et al.* (2014) reported loss of motility by *Heterakis gallinarum* at (5.71 ± 0.10), (6.60 ± 0.86), and (13.95 ± 0.43) h with *C. angustifolia, C. alata*, and *C. occidentalis*, respectively, at a concentration of 40 mg ml^{-1}.

Strongyles of sheep and goats reported to be susceptible to *Acanthus montanus* and egg hatch assay results revealed a 91.75% reduction in egg hatchability at concentration of 25 mg ml^{-1}. The extract inhibited 100% of the eggs from hatching at 200 mg ml^{-1} (Adamu *et al.*, 2010). The presence of *Spigelia anthelmia* extracts in larval cultures decreased the survival of L_3 larvae. The *in vitro* anthelmintic activity of aqueous extract of *S. anthelmia* showed an LC_{50} value of 0.714 mg ml^{-1}, which differs significantly from the LC_{50} of the ethanolic extract (0.628 mg ml^{-1}), while *in vivo* revealed a significant decrease of *Strongyloides* spp. at 500 mg kg^{-1}, *Oesophagostomum* spp. and *Trichuris* spp. at 250 mg kg^{-1}, and *Haemonchus* spp. and *Trichostrongylus* spp. at 125 mg kg^{-1} (Ademola *et al.*, 2007b). Similarly, extracts of *S. anthelmia* from Brazil obtained with hexane, chloroform, ethyl acetate or methanol, and tested on *H. contortus* eggs and larvae via egg hatch and larval development tests, demonstrated anthelmintic activity. At 50.0 mg ml^{-1}, the ethyl acetate extract prevented 100% of the eggs from hatching and 81.2% of the larvae were inhibited from developing. In a similar way, the methanolic extract prevented 97.4% of the eggs from hatching and 84.4% of larvae from developing (Assis *et al.*, 2003). The acetone, ethanol, hydro-alcohol, and distilled water extracts of *Heliotropium indicum, Senna fistula*, and *S. anthelmia* showed dose-dependent anthelmintic activities at various concentrations (0.25, 0.50, and 1.0 mg ml^{-1}) when tested against nematodes larvae from sheep. The anthelmintic activities of aqueous extracts of *H. indicum* and *S. fistula* were better than *S. anthelmia* with mortality rates of 80, 90, and 100%; 90, 95, and 100%; and 70, 85, and 90%, respectively (Sobiyi and Tom Ashafa, 2015). Both the aqueous and ethanolic extracts of *S. mombin* leaves demonstrated anthelmintic efficacy *in vivo* and inhibitory effects on larval development and survival of *H. contortus*. The presence of *S. mombin* in *in vitro* cultures of larvae decreased the survival of L_3 larvae. The LC_{50} of the aqueous extracts of *S. mombin* was 0.907 mg ml^{-1}, while that of the ethanolic extract was 0.456 mg ml^{-1}. Sheep drenched with 500 mg kg^{-1} of the extract showed mean fecal egg reductions of 15, 27.5, 65, 65, 100% against *Haemonchus* spp., *Trichostrongylus* spp., *Oesophagostomum* spp., *Strongyloides* spp. and *Trichuris* spp., respectively (Ademola *et al.*, 2005b). Similarly, the chloroform and 80% methanol extracts of *S. mombin* leaves from Malaysia also showed LC_{50} values of 1.279 and 0.158 mg ml^{-1} respectively, while the LC_{50} of the *S. mombin* fruits extracts were 0.416 and 2.200 mg ml^{-1}, respectively, when tested on trichostrongylid nematodes from goats and sheep (Wahab and Hiew, 2014). The acetone extract of *Combretum molle* affected the hatchability of *H. contortus* eggs and survival of larvae in a concentration-dependent manner. The LC_{50} values of 0.866, 0.333, 0.833, 0.065, and 0.747 mg ml^{-1} were reported for acetone extract, *n*-butanol, hexane, 35% water in methanol, and chloroform fractions, respectively, for the egg hatch. While LC_{50} values of 0.604, 0.362, 1.077, 0.131, and 0.318 mg ml^{-1} were reported for the acetone extract, butanol, hexane, chloroform, and 35% water in methanol fractions, respectively, for the larval development test (Ademola and Eloff, 2010). The oil of *Anacardium occidentale* was reported to be active against *Ascaridia galli* in chicken (Varghese *et al.*, 1971). The presence of *A. occidentale* acetone crude extract in *H. contortus* cultures was also found to decrease the hatchability of eggs and survival of L_3 larvae in a concentration-dependent pattern. The acetone extract had LC_{50} values of 0.311 and 1.72 mg ml for egg hatch and larval viability test, respectively (Ademola and Eloff, 2011d). In an *in vitro* egg hatch assay, the aqueous extracts of the leaf and stem bark of *Azadirachta indica* inhibited egg hatching by 51 and 50%, respectively (Nwosu *et al.*, 2006).

Similar attention has not been paid to screening plants for anthelmintic activity against Platyhelminthes. Chopped pieces of dried stem and root of *Acalypha wilkesiana* Mull. Arg. were steeped in alcohol and used for stomach ache and as worm expellant in man in the Delta region of Nigeria (Iwu, 1993). Onocha and Olusanya (2010) reported that the extracts exhibited an *in vitro* anthelmintic activity against *Fasciola gigantica* (Trematoda), *Taenia solium* (Cestoda), and *Pheritima pasthuma* (Oligochaeta). Notably, *T. solium* and *P. pasthuma* were found to be more sensitive to the extract compared with piperazine citrate. *Bridelia ferruginae* (Benth)-Euphorbiaceae is also one of the most popular medicinal plants used in Northern and Southwestern Nigeria and other African countries for gastrointestinal infections (Ayensu, 1978; Iwu, 1986; Addae-Mensah and Munenge, 1989). The stem bark extract of *B. ferruginae* and its fractions showed concentration-dependent anthelmintic potencies against *F. gigantica, T. solium*, and *P. posthuma* (Lasisi and Kareem, 2011).

Conclusion

Quite a number of plants naturally available in Nigeria possess narrow or broad spectrum anthelmintic activities. Certainly this is true in other parts of the world as well, where gastrointestinal parasitism is an important problem in livestock production, and where commercial drugs may not be readily available. The phytochemical analyses of these plants and experimental anthelmintic tests, along with the knowledge of parasite control strategies, may offer new opportunities for effective and cheaper control strategies of parasitic diseases. Little has been done to test pharmacological activity of most medicinal plant species to validate efficacy, yet demands for natural products and interest in discovery of new drugs from plants is on the rise globally. Validation of medicinal plants in non-laboratory animals is still in its infancy in Nigeria due to poor research funding, and needs to be greatly expanded. The above records demonstrate the richness of diversity of bioactive plants available in Nigeria, as a potentially fertile ground for evolving pharmacological research.

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