Baccharoides lasiopus: Review of its Medicinal uses, Phytochemistry and Pharmacological Properties

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Abstract: *Baccharoides lasiopus* is a woody shrub widely used as traditional medicine throughout its distributional range in tropical Africa. This study is aimed at providing a critical review of the pharmacological properties, phytochemistry, and medicinal uses of *B. lasiopus*. Documented information on the pharmacological properties, phytochemistry, and medicinal uses of *B. lasiopus* was collected from several online sources, which included Scopus, Google Scholar, PubMed and Science, and pre-electronic sources such as book chapters, books, journal articles and scientific publications obtained from the university library. The articles published between 1971 and 2020 were used in this study. This study showed that the leaves, roots, stems, whole plant parts, root and stem bark of *B. lasiopus* are widely used as galactagogue, purgative and anthelmintic, and traditional medicine for headache, liver diseases, skin diseases, respiratory infections, malaria, augment labour, convulsions, epilepsy, fainting, female reproductive problems, and gastro-intestinal problems. Phytochemical compounds identified from the species include elemanolide type sesquiterpene lactones, alkaloids, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenolics, reducing sugars, saponins, steroids, tannins, terpenoids, and xanthines. Pharmacological research revealed that *B. lasiopus* extracts and compounds isolated from the species have anthelmintic, antibacterial, antifungal, antiviral, antihyperglycemic, antiplasmodial, antimalarial, antiprotozoal, haematological, hepatoprotective, hepatotoxicity, larvicidal, and cytotoxicity activities. Future research on *B. lasiopus* should focus on the possible biochemical mechanisms of action of both the crude extracts and identified phytochemical compounds including toxicological, *in vivo*, and clinical studies to corroborate the traditional medical applications of the species.

Keywords: Asteraceae, Compositae, *Baccharoides lasiopus*, indigenous knowledge, traditional medicine, *Vernonia lasiopus.*

INTRODUCTION

Baccharoides lasiopus (O. Hoffm.) H. Rob. is a woody shrub belonging to the Asteraceae or Compositae family. This species was originally treated under the genus *Vernonia* Schreb. [1], a genus that is now known to be restricted to North America [2]. The genus name *Baccharoides* was first proposed by Moench in 1793 and remained unused until it was resurrected by Robinson in 1990 [2,3]. Synonyms associated with the name *B. lasiopus* include *Vernonia albo-violacea* De Wild., *V. braunii* Muschler, *V. brownii* S. Moore, *V. dumicola* S. Moore, *V. iodocalyx* O. Hoffm., *V. kaessneri* S. Moore, *V. lasiopus* O. Hoffm., *V. massaiensis* S. Moore, *V. mokaensis* Milbr., *V. ringoetti* De Wild., *V. ruwenzoriensis* S. Moore, *V. saltuarii* S. Moore and *V. tuberculata* Hutch. & Burtt. [4]. *Baccharoides lasiopus* is a woody herb or semi-climbing shrub that reaches 4 metres in height [5]. The bark of the species is smooth and greyish brown in colour. The leaves of *B. lasiopus* are densely hairy, ovate to lanceolate in shape with toothed margins. The flower heads of the species are terminal, generally crowded with flowers that are pale mauve to white in colour. The species has been recorded in disturbed areas, bushland, grassland and riverine woodland or forest at an altitude ranging from 1000 m to 2500 m above sea level [5]. The fruit is a tiny dry nutlet achene with white hairs at one end. *Baccharoides lasiopus* has been recorded in Angola, Burundi, the Democratic Republic of Congo (DRC), Ethiopia, Kenya, Mozambique, Rwanda, South Sudan, Sudan, Tanzania, Uganda and Zambia [4,6]. *Baccharoides lasiopus* is considered to be a weed in some regions of Kenya because it can colonize disturbed land and cultivated areas. In Kenya, the leaves of *B. lasiopus* are used in making soap, the species is sometimes grown from seed, wildings and cuttings along field boundaries for use as fodder and for medicine [5]. *Baccharoides lasiopus* is one of the most used traditional medicines in Kenya and the species is traded in informal herbal medicine markets in that country [7]. It is, therefore, within this context that the current study was undertaken, aimed at documenting the pharmacological properties, phytochemistry and medicinal uses of *B. lasiopus.*

Medicinal uses

The different parts of *B. lasiopus* are widely used as galactagogue, purgative and anthelmintic, and traditional medicine for headache, liver diseases, skin

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diseases, respiratory infections, malaria, augment labour, convulsions, epilepsy, fainting, female reproductive problems and gastro-intestinal problems (Table **1**; Figure **1**). Other important medicinal applications of *B. lasiopus* that are supported by at least two literature sources include the use leaves as aphrodisiac in Tanzania [8,9], leaves and roots against colic pain in Uganda [10,11], and leaves, and stems as ethnoveterinary medicine in Kenya [12-14].

Phytochemistry

Koul *et al.* [43] identified two elemanolide type sesquiterpene lactones, epivernodalol, and lasiopulide from the aerial parts of *B. lasiopus*. Similarly, Kimani *et al.* [44,45] identified six elemanolide type sesquiterpene lactones, such as 8-desacylvernolide, vernolepin, vernomenin, vernodalol, vernodalin and 11,13-dihydrovernodalin, from the aerial parts of *B. lasiopus*.

Table 1: Medicinal uses of *Baccharoides lasiopus*

Medicinal use	Parts used	Country	References
Anorexia	Leaves and roots	Uganda	[11]
Anthelmintic	Leaves, roots and stems	DRC, Kenya, Rwanda and Uganda	[4,10-12,15-19]
Aphrodisiac	Leaves	Tanzania	[8,9]
Augment labour and postpartum pains	Leaves and roots	Kenya, Tanzania and Uganda	[4,16,20]
Back pains	Leaves	Kenya	[16]
Body cleanser	Leaves and roots	Uganda	[11]
Colic pain	Leaves and roots	Uganda	[10,11]
Colorectal cancer	Stem bark	Kenya	[21]
Convulsions, epilepsy and fainting	Leaves, stem bark and whole plant	DRC, Tanzania and Uganda	[4,22,23]
Diabetes	Leaves	Kenya	[19]
Female reproductive problems (fertility, menstruation and prevent abortion)	Leaves, roots and stem bark	DRC, Kenya, Tanzania and Uganda	[8,19,22,24,25]
Fever	Leaves and roots	Uganda	[11]
Galactagogue	Leaves and stem bark	DRC and Tanzania	[22,24]
Gastro-intestinal disorders (abdominal pains, constipation, diarrhoea, indigestion and stomachache)	Leaves and roots	Kenya, Rwanda, Tanzania and Uganda	[4,8-11,15,16,18,20,26-32]
Headache	Leaves, roots and stem bark	DRC and Uganda	[20,22]
Heart burn	Leaves and roots	Kenya	[33]
Hemorrhoids	Leaves and stem bark	DRC	[22]
Inflammation	Leaves and roots	Uganda	[11]
Liver diseases	Leaves	Kenya and Rwanda	[18,30,34]
Malaria	Bark, leaves and roots	Kenya and Uganda	[9,11,15,17,19,20,28-30,35-38]
Otitis media	Flowers	Kenya	[39]
Pre-hepatic jaundice	Leaves	Uganda	[23]
Purgative	Leaves and roots	Kenya and Tanzania	[4,9,28]
Respiratory infections (colds, cough and pneumonia)	Bark, leaves and roots	Kenya and Uganda	[10,11,17,20,39,40]
Skin diseases (measles, pimples, scabies and rashes)	Leaves and stem bark	DRC and Kenya	[16,22,41]
Sores	Stem bark	Rwanda	[4]
Splenomegaly	Leaves and roots	Uganda	[11]
Toothache	Leaves and stem bark	DRC	[22]
Typhoid	Roots	Kenya	[42]
Ethnoveterinary medicine (ectoparasites and worms)	Leaves and stems	Kenya	[12-14]

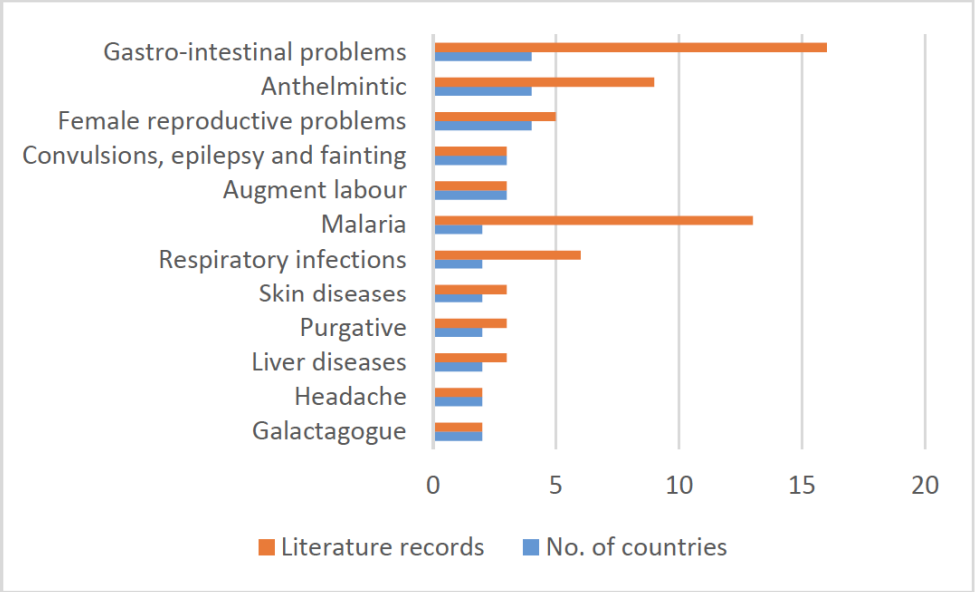

Figure 1: Medicinal applications of *Baccharoides lasiopus* derived from literature records.

Other phytochemical compounds identified from the leaves, roots and stem bark of *B. lasiopus* include alkaloids, anthraquinones, cardiac glycosides, coumarins, flavonoids, phenolics, reducing sugars, saponins, steroids, tannins, terpenoids, and xanthines [8,12,18,31,46-55]. Some of these phytochemical compounds identified from the species may be responsible for the biological activities of the species.

Pharmacological Properties

The following biological activities have been reported from the aerial parts, leaves, roots, stems, root bark, and stem bark of *B. lasiopus* and compounds isolated from the species: anthelmintic, antibacterial, antifungal, antiviral, antihyperglycemic, antiplasmodial and antimalarial, antiprotozoal, haematological, hepatoprotective, hepatotoxicity, larvicidal and cytotoxicity activities.

Anthelmintic Activities

Njonge *et al.* [12] evaluated the anthelmintic activities of aqueous extracts of *B. lasiopus* leaves using the *in vitro* anthelmintic assay against the gastro-intestinal nematode infective larvae of *Haemonchus, Mecistocirrus, Ostertagia, Trichostrogylus, Cooperia, Bunostomum* and *Oesophagostomum* species. The extract exhibited moderate anthelmintic activities [12].

Antibacterial Activities

Kareru *et al.* [56] evaluated the antibacterial activities of aqueous extracts of leaves and stems of *B. lasiopus* against *Bacillus subtilis, Escherichia coli* and *Staphylococcus aureus* using the disc-agar diffusion method with tetracycline (100.0 µg), streptomycin (25.0 µg), sulphamethoxazole (200.0 µg), cotrimoxazole (25.0 µg) and gentamicin (10.0 µg) as positive controls. The extracts exhibited activities against *Escherichia coli* and *Bacillus subtilis* with the zone of inhibition of 6.5 mm and 13.2 mm, respectively, in comparison to the zone of inhibition of 12.0 mm to 24.0 mm exhibited by the positive control [56]. Rachuonyo *et al.* [49] evaluated the antibacterial activities of crude leaf extracts of *B. lasiopus*, and leaves of *B. lasiopus* combined with those of *Aloe secundiflora* Engl., *Bulbine frutescens* (L.) Willd. and *Tagetes minuta* L. against *Shigella flexineri, Salmonella typhi, Escherichia coli, Enterococcus faecalis* and *Staphylococcus aureus* using the disc agar diffusion and micro dilution methods with ciprofloxacin and vancomycin as positive controls. The extract exhibited activities with the zone of inhibition values ranging from 12.0 mm to 18.2 mm and the minimum bactericidal concentration (MBC) values ranging from 5.0 mg/ml to 14.2 mg/ml [49]. Rachuonyo *et al.* [50] evaluated the antibacterial activities of methanol leaf extracts of *B. lasiopus* against *Staphylococcus aureus* using the disc agar diffusion and micro dilution methods with ciprofloxacin (5.0 µg/ml) and vancomycin (3.0 µg/ml) as positive controls. The extract exhibited activities against the pathogen with minimum inhibitory concentration (MIC), the MBC and the zone of inhibition values of 12.2 mg/ml, 14.2 mg/ml and 14.0 mm, respectively [50]. Rachuonyo *et al.* [51] evaluated the antibacterial activities of methanol leaf extracts of *B. lasiopus*

against *Escherichia coli* using the disc agar diffusion and micro dilution methods with ciprofloxacin as a positive control. The extract exhibited activities against the pathogen with the MIC, MBC and zone of inhibition values of 10.0 mg/ml, 11.5 mg/ml and 12.0 mm, respectively [51]. Rachuonyo *et al.* [52] evaluated the antibacterial activities of crude leaf extracts of *B. lasiopus* against *Enterococcus faecalis* using the disc agar diffusion method with ciprofloxacin (5 µg/ml) as a positive control. The extract exhibited activities against the pathogen with the zone of inhibition of 18.0 mm against 21.7 mm exhibited by the control [52]. Rachuonyo *et al.* [53] evaluated the antibacterial activities of methanol leaf extracts of *B. lasiopus* against *Salmonella typhi* using the disc agar diffusion and micro dilution methods with ciprofloxacin as a positive control. The extract exhibited activities against the pathogen with the MIC, MBC and zone of inhibition values of 5.6 mg/ml, 7.5 mg/ml and 13.0 mm, respectively [53]. Mutembei *et al.* [55] evaluated the antibacterial activities of aqueous extracts of *B. lasiopus* leaves against *Pseudomonas aeruginosa, Escherichia coli, Bacillus subtilis* and *Staphylococcus aureus* using the disc agar diffusion method with benzathine penicillin and streptomycin as positive controls. The extract exhibited activities against *Pseudomonas aeruginosa* and *Escherichia coli* with the zone of inhibition of 9.0 mm and 10.5 mm, respectively, while the zone of inhibition exhibited by the controls ranged from 11.5 mm to 52.6 mm [55].

Antifungal Activities

Vlietinck *et al.* [57] evaluated the antifungal activities of crude extracts of *B. lasiopus* leaves and stems against *Microsporum canis* and *Trichophyton mentagrophytes* using the agar diffusion method with nystatin (1000 µg/ml) as a positive control. The extracts exhibited moderate activities against the tested pathogens [57]. Rachuonyo *et al.* [48] evaluated the antifungal activities of crude leaf extracts of *B. lasiopus* against *Candida albicans* using the agar diffusion and micro dilution methods with fluconazole (15.0 µg/ml) as a positive control. The extract exhibited activities against the fungus with the MIC, minimum fungicidal concentration (MFC) and zone of inhibition values of 4.0 mg/ml, 5.5 mg/ml and 20.0 mm, respectively [48]. Rachuonyo *et al.* [49] evaluated the antifungal activities of crude leaf extracts of *B. lasiopus*, and the leaves of *B. lasiopus* combined with those of *Aloe secundiflora, Bulbine frutescens* and *Tagetes minuta* against *Candida albicans* using the agar diffusion and micro dilution methods with fluconazole (15.0 µg/ml) as a positive control. The extract exhibited activities against the fungus with the zone of inhibition ranging from 13.0 mm to 20.0 mm and the MFC value of 5.5 mg/ml [49].

Antiviral Activities

Vlietinck *et al.* [57] evaluated the antiviral activities of crude extracts of *B. lasiopus* leaves and stems against herpes simplex, poliomyelitis, measles, coxsackie and Semliki forest using the 50.0% end point titration technique. The extracts exhibited moderate activities against the tested pathogens [57].

Antihyperglycemic Activities

Kimani *et al.* [54] evaluated antihyperglycemic activities of aqueous leaf extract of *B. lasiopus* in alloxan-induced diabetic male albino mice with insulin and glibenclamide treated mice for intraperitoneal and oral routes respectively as positive controls. The extract at 25.0, 48.4, 93.5, 180.9 and 350.0 mg/kg body weight demonstrated antihyperglycemic activities in a dose independent manner [54].

Antiplasmodial and Antimalarial Activities

Muregi *et al.* [58] evaluated the antiplasmodial activities of water, hexane, chloroform, ethyl acetate and methanol extracts of *B. lasiopus* leaves against chloroquine sensitive and resistant *Plasmodium falciparum* using the semi-automated micro-dilution technique that measures the ability of the extracts to inhibit the incorporation of (G-^{3}H) hypoxanthine into the malaria parasite. The chloroform, ethyl acetate and methanol extracts exhibited the best activities with half maximal inhibitory concentration (IC_{50}) values ranging from 1.0 µg/ml to 3.6 µg/ml. Combination of chloroform, ethyl acetate and methanol extracts with chloroquine against the multi-drug resistant *Plasmodium falciparum* isolate revealed some synergistic effects [58]. Irungu *et al.* [59] evaluated the antiplasmodial activities of aqueous, dichloromethane and methanol extracts of the root bark of *B. lasiopus* against two strains of *Plasmodium falciparum* (K1 chloroquine resistant and NF54 chloroquine sensitive) using the [G-^{3}H] hypoxanthine incorporation assay with chloroquine as a positive control. The dichloromethane extract exhibited the highest activities with the IC_{50} values of 4.7 µg/ml and 4.9 µg/ml against K1 and NF54, respectively [59]. Muthaura *et al.* [60] evaluated the antiplasmodial activities of methanol extracts of *B. lasiopus* leaves against the chloroquine sensitive (D6) and resistant (W2) *Plasmodium falciparum* using the semi-automated micro-dilution technique that measures the

ability of the extracts to inhibit the incorporation of (G-^{3}H) hypoxanthine into the malaria parasite. The extract exhibited weak activities with the IC_{50} values of 44.3 µg/ml and 52.4 µg/ml against D6 and W2, respectively [60]. Njenga *et al.* [61] evaluated the antiplasmodial activities of crude and dichloromethane: chloroform extracts of *B. lasiopus* aerial parts and roots against the chloroquine sensitive (D6) and resistant (W2) *Plasmodium falciparum* using the semi-automated micro-dilution technique that measures the ability of the extracts to inhibit the incorporation of (G-^{3}H) hypoxanthine into the malaria parasite. The extracts exhibited weak activities with the IC_{50} values ranging from 11.2 µg/ml to 68.8 µg/ml [61]. Kimani *et al.* [44] evaluated the antiplasmodial activities of n-hexane, dichloromethane, ethyl acetate, n-butanol, methanol and water extracts of aerial parts of *B. lasiopus* using the [G-^{3}H] hypoxanthine incorporation assay against the chloroquine and pyrimethamine sensitive and resistant strains of *Plasmodium falciparum* with chloroquine as a positive control. The organic extracts exhibited the best activities with the IC_{50} values ranging from 1.1 µg/mL to 27.0 µg/mL in comparison to the IC_{50} value of 0.002 µg/mL exhibited by the control [44].

Muregi *et al.* [62] evaluated *in vivo* antimalarial activities of leaf, root and stem bark extracts of *B. lasiopus* in mice against a chloroquine-tolerant *Plasmodium berghei* NK65, either alone or in combination with chloroquine. The extracts showed activities with parasitemia suppressions ranging from 14.8% to 59.3% when the extract was used alone, and 56.1% to 63.6% when the extract was used in combination with chloroquine. The extracts gave a 60.0% mouse survival when used alone, and 20.0% to 60.0% when the extract was used in combination with chloroquine. In combination with chloroquine, the extracts showed better chemo-suppression as well as longer mouse survival suggesting synergistic interactions of the extract and chloroquine [62].

Antiprotozoal Activities

Kimani *et al.* [44] evaluated the antiprotozoal activities of n-hexane, dichloromethane, ethyl acetate, n-butanol, methanol and water extracts of aerial parts of *B. lasiopus* against *Trypanosoma brucei rhodesiense, Trypanosoma cruzi* and *Leishmania donovani,* using Almar Blue and resazurin assay, with melarsoprol, benznidazole and miltefosine as positive controls. The organic extracts exhibited the best activities with IC_{50} values ranging from 0.2 µg/mL to 65.8 µg/mL in comparison to the IC_{50} values of 0.003 µg/mL to 0.4 µg/mL exhibited by the control. Kimani *et al.* [44] also evaluated the *in vitro* antitrypanosomal activities of the compounds 8-desacylvernolide, vernolepin, vernomenin, vernodalol and mixture of vernodalin and 11,13-dihydrovernodalin (2:1) isolated from the aerial parts of *B. lasiopus* against *Trypanosoma brucei rhodesiense* using Almar Blue and resazurin assay with melarsoprol as a positive control. The compounds exhibited activities with the IC_{50} values ranging from 0.05 µM to 0.8 µM [44]. Kimani *et al.* [45] evaluated the *in vitro* antitrypanosomal activities of the compounds 8-desacylvernolide, vernolepin, vernomenin, vernodalol and mixture of vernodalin and 11,13-dihydrovernodalin (2:1) isolated from the aerial parts of *B. lasiopus* against *Trypanosoma brucei rhodesiense* using Almar Blue and resazurin assay with melarsoprol as a positive control. The compounds exhibited activities with the IC_{50} values ranging from 0.07 µM to 9.8 µM [45].

Haematological Activities

Njagi *et al.* [46] evaluated the hematological activities of methanol extracts of *B. lasiopus* in normal male Swiss albino mice at a concentration of 50 mg/kg and 100 mg/kg administered orally once per two days for 14 days. The extract induced changes in erythrocytes, total and differential white blood cell counts, platelets, induced immunostimulatory activities and thrombopoietin stimulation [46].

Hepatoprotective Activities

Mukazayire *et al.* [18] evaluated the hepatoprotective activities of the aqueous extract of *B. lasiopus* leaves tested on CCl_4-treated guinea pigs by the method of barbiturate-induced sleep modification. The extract allowed animals to recover barbiturate sleep duration in proportions of 34.1% [18].

Hepatotoxicity Activities

Mukazayire *et al.* [18] evaluated the hepatotoxicity activities of dried methanol extracts of *B. lasiopus* leaves tested *in vitro* on rat precision cut liver slices for protection against acetaminophen-induced hepatotoxicity with N-acetyl cysteine as a reference hepatoprotective agent. The extract was found to be hepatotoxic by itself showing a reduction in ATP levels by 88.3%, and was unable to prevent acetaminophen toxicity [18].

Larvicidal Activities

Tarwish *et al.* [31] evaluated the larvicidal activities of hexane, chloroform, ethyl acetate, acetone,

methanol and water extracts of *B. lasiopus* leaves and roots against the third instar larvae of malaria vector *Anopheles gambiae*. All the extracts, with the exception of water extracts, exhibited activities with the ethyl acetate extract of the roots exhibiting the median lethal concentration (LC_{50}) value of 205.9 ppm [31].

Cytotoxicity Activities

Koul *et al.* [43] evaluated the cytotoxicity activities of the compounds epivernodalol and lasiopulide isolated from the aerial parts of *B. lasiopus* against the human cancer cell lines HCT-15, HT-29, SiHa and T47-D using the sulforhodamine B assay with 5-fluorouracil and adriamycin as positive controls. The compounds exhibited activities with the IC_{50} values ranging from 6.5 µM to 109.8 µM [43]. Njenga *et al.* [61] evaluated cytotoxicity activities of crude and dichloromethane: chloroform extracts of *B. lasiopus* aerial parts and roots on Vero 199 cells at starting concentrations of 100.0 µg/ml using (3-(4,5-dimethylthiazolyl-2)-2,5-diphenyltetrazolium bromide) MTT colorimetric assay. The extracts exhibited weak activities with the median cytotoxic concentration (CC_{50}) values ranging from 19.2 µg/ml to >100.0 µg/ml [61]. Kimani *et al.* [44] evaluated the cytotoxicity activities of dichloromethane and ethyl acetate extracts of the aerial parts of *B. lasiopus* against the rat skeletal myoblast L6 cells with podophyllotoxin as a reference drug. The dichloromethane and ethyl acetate extracts exhibited activities with the IC_{50} values of 0.8 µg/mL and 4.8 µg/mL, respectively, which were higher than the IC_{50} value of 0.007 µg/mL exhibited by the control. Kimani *et al.* [44] also evaluated the cytotoxicity activities of the compounds 8-desacylvernolide, vernolepin, vernomenin, vernodalol and mixture of vernodalin and 11,13-dihydrovernodalin (2:1) isolated from the aerial parts of *B. lasiopus* against the rat skeletal myoblast L6 cells with podophyllotoxin as a reference drug. The compounds exhibited activities with IC_{50} values ranging from 0.5 µM to 10.7 µM [44]. Kimani *et al.* [45] evaluated the cytotoxicity activities of the compounds 8-desacylvernolide, vernolepin, vernomenin, vernodalol and mixture of vernodalin and 11,13-dihydrovernodalin (2:1) isolated from the aerial parts of *B. lasiopus* against the rat skeletal myoblast L6 cells with podophyllotoxin as a reference drug. The compounds exhibited activities with the IC_{50} values ranging from 0.5 µM to 34.6 µM [45].

CONCLUSION

Different parts of *B. lasiopus* are used traditionally as galactagogue, purgative and anthelmintic, and traditional medicine for headache, liver diseases, skin diseases, respiratory infections, malaria, augment labour, convulsions, epilepsy, fainting, female reproductive problems, and gastro-intestinal problems. This study revealed nthelmintic, antibacterial, antifungal, antiviral, antihyperglycemic, antiplasmodial, antimalarial, antiprotozoal, haematological, hepatoprotective, hepatotoxicity, larvicidal, and cytotoxicity activities of crude extracts and compounds isolated from the species. Therefore, future research should focus on pharmacokinetics, mechanism of action and structure activity relationship studies of isolated pure compounds, toxicological studies, *in vivo* and clinical studies.

CONFLICT OF INTEREST

No conflict of interest is associated with this work.

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