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Review Article

Medicinal Plants Used as Snake Venom Antidotes in East African Community: Review and Assessment of Scientific Evidences

Timothy Omara[1,2,3*], Caroline Kiwanuka Nakiguli[1,2,4], Rania Awad Naiyl[1,2,5], Florence Atieno Opondo[1,2], Sadia Benard Otieno[1,2], Merab Lilian Ndiege[1,2], Immaculate Mbabazi[1,2], Winfred Nassazi[1,2], Papias Nteziyaremye[1,2,6], Sarah Kagoya[7], Augastine Okwir[7], Edmond Etimu[7]

[1]*Department of Chemistry and Biochemistry, School of Sciences and Aerospace Studies, Moi University, Eldoret, Kenya*
[2]*Africa Centre of Excellence II in Phytochemicals, Textiles and Renewable Energy (ACE II PTRE), Moi University, Eldoret, Kenya*
[3]*Department of Quality Control and Quality Assurance, AgroWays Uganda Limited, Jinja, Uganda*
[4]*Chemistry Department, Faculty of Science, Mbarara University of Science and Technology, Mbarara, Uganda*
[5] *Mohamed Obiad Mubarak Laboratories, University of Gezira, Gezira, Sudan*
[6]*Department of Chemistry, College of Science and Technology, University of Rwanda, Kigali, Rwanda*
[7] *Department of Chemistry, Faculty of Science, Kyambogo University, Kampala, Uganda*

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ABSTRACT

Poisonous snake envenomation is a complex neglected health problem implicated in mortality, disability, psychological morbidity, and socio-economic losses recorded worldwide. An antivenin serum, the only medically recommended treatment for snakebites, has several drawbacks including, hypersensitivity, inability to prevent local tissue damage, are scarce and unaffordable in most snakebite endemic areas. In many rural communities all over the world, plants have been utilized for managing snakebites. This review seeks to identify plants reported as antivenom remedies in the East Africa and the scientific studies thereof which could support their use in the treatment of snake envenomation. A review of scientific articles was undertaken to identify information on traditional knowledge of medicinal plants used to treat snake envenomation in East Africa and their antivenom efficacy. A total of 361 plant species were retrieved to have been reported as traditional therapies for snakebites in East Africa. The review identified distinct cases of doctrine of signatures and zoopharmacognosy in snakes using *Opilia amentacea*, *Hugonia castaneifolia* and *Microglossa pyrifolia* respectively. Evaluations of the antivenom efficacy of 44 species (12.2%) have been done globally, and most species found to be effective in neutralizing the lethal activities of snake venoms. Ethnomedicinal plants play a revered holistic role in East African antisnake venom therapy. *Conyza sumatrensis*, *Hyptis pectinata*, *Justicia betonica*, and *Maesa lanceolata* used to treat specific snakebites merit further studies.

GRAPHICAL ABSTRACT

* Corresponding author: Timothy Omara
✉ E-mail: prof.timo2018@gmail.com, prof.timo2018@mu.ac.ke

Introduction

Envenomation by poisonous snakes is a complex neglected health problem implicated as one of the major causes of mortality, disability, psychological morbidity, and socio-economic losses recorded worldwide [1]. About 2.7 million people are bitten by snakes annually and 81,000-138,000 of these victims die [2]. An additional 400,000 amputations and other severe health consequences such as psychological sequelae, haemorrhage, tetanus, contractures, myonecrosis, scarring, and tissue inflammation accompany the bites [3, 4]. Snake envenomation was added to the list of the neglected tropical diseases by the World Health Organization (WHO) in March 2009 and later removed [5]. With sufficient epidemiological data, the menace was re-included in category A of neglected tropical diseases in June 2017 [6]. In East Africa, there are at least 200 species of snakes reported [7]. Some are harmless or rare; however, the puff adder (*Bitis arietans*), Gabon viper (*Bitis gabonica*), green or Jameson's mamba (*Dendroaspis jamesoni*), black mamba (*Dendroaspis polylepis*), forest cobra (*Naja melanoleuca*) and black-necked spitting cobra (*Naja naja nigricollis*) accounts for most venomous bites in the East African Community [7-10].

Horse-derived antivenin sera is currently the mainstay for neutralization of the systemic actions of snake venoms. However, they are ineffective in the neutralization of local tissue damage which continues even after intravenous administration of the antidote [11]. Worse still, they exert no effect on the reversal of local symptoms, are unavailable, possess administration problems and usually induce adverse reactions such as progeny reaction, anaphylactic shock, and serum sickness [12]. The barriers to effective management of snake envenomation in East African Community ranges from poor road networks, fragmented records and lack of public health education to the absence of antivenoms and poor antivenom preservation facilities in health centres [8, 10, 13-15].

This context has been the force behind the obsessive search for complementary treatments for snakebites [7, 11, 16]. Therefore, the use of plants and other traditional alternatives in rural areas for managing the scourge of snakebites is justifiable. WHO reported that 80% of the emerging world's population subsists on traditional medicine for various ailments. Similarly, the developed countries have also portrayed ascendancy in the use of complementary and alternative medicine, particularly employing herbs [17, 18]. It is not surprising therefore that most allopathic medications have their roots from ancient medicine, and it is argued that novel therapeutic molecules will be developed from African biodiversity in close association with leads furnished by traditional knowledge and experiences [19, 20]. The revered utilization of medicinal plants in rural Africa, and specifically East Africa is linked to cultural and economic reasons. This is why WHO encourages African member states to promote and integrate traditional medical practices in their health systems. In the current study, we reviewed literature on the knowledge and practices of snakebite management in Eastern Africa using medicinal plants. A probe was made into antivenom studies to discern if the use of the identified species in antivenom therapy is justifiable.

Methods

We used the definition of East Africa as the region including Uganda, Kenya, Tanzania, Rwanda, Burundi, and South Sudan. An electronic review of the literature was perfected in two steps: firstly, we searched all the published work (ethnobotanical books, reviews, reports, theses and primary scientific articles) with data on medicinal plants related to the six countries. The search key terms: snakebite, snake envenomation, snake poison, traditional medicine, ethnobotany, alternative medicine, ethnopharmacology, antivenom, antivenin, antiophidic, antitoxin, and snake antidotes were combined with the individual names of the

countries [7, 104]. Secondly, a search targeted to the use of medicinal plants in antivenom therapy was done. We extracted information on the knowledge and practices of treating snakebites using medicinal plants in the region. The review also examined the supportive evidences from global studies for the efficacy of the identified plant species to discern if their use in antivenom therapy is justified. Databases: Scopus, Science Direct, PubMed, Web of Science Core Collection, Scientific Electronic Library Online, Google Scholar and the Google search engine were used to source for scientific information dated until August 2020.

Only full text primary research articles published in peer-reviewed journals, books, theses, dissertations, patents and reports written or translated to English were considered. Missing information in some studies such as local names, plant growth forms, and misspelled botanical names were checked from google search engine and botanical databases: The Plant List, International Plant Names Index, NCBI taxonomy browser and Tropicos. The majority of the plant names were checked manually in the botanical databases at point of entry, while the remainder were already previously checked as part of our previous work on medicinal plants in the region [7, 8, 104, 114, 177]. The collected data were checked for completeness and processed independently by the authors.

Descriptive statistical methods were used to analyze the collected data. Results on ethnobotanical information and associated traditional knowledge were expressed as percentages and frequencies, and subsequently presented as tables and charts. The analyses were done using Microsoft Excel 365 (Microsoft Corporation, USA).

Result and Discussion

In aggregate, we retrieved 79 studies and reports with information on ethnomedicinal plants used for treating snake poisoning in East Africa.

Ethnomedicinal plants used in treating snake poisoning across East African countries

This review retrieved 361 plant species used in treating snake poisoning in different parts of East Africa. The identified species belong to 240 genera spread across 82 botanical families (Table 1). A whole fungus (*Termitomyces mirocarpus*, locally known as *Akatiko akabaala* in Luganda dialect) is also eaten in Uganda for management of snakebites [21]. The common botanical families of the identified plants were Fabaceae (53 species, 14.8%), Asteraceae (25 species, 7.0%), Apocynaceae and Euphorbiaceae (16 species, 4.5%), and Rubiaceae (15 species, 4.2%) (Figure 1). Fabaceae dominates in ethnobotanical surveys owing to the universal prevalence of species from this family as well as the possession of pathways that produce flavonoids, terpenoids, and alkaloids which are key therapeutic secondary metabolites [22].

Table 1: Antivenom plants used across East African communities

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
Acanthaceae	*Asystasia gangetica* T. And.	Kichwamangwo (Swahili)	L	Herb	Not reported	Tanzania	[23]
	Asystasia schimperi T. Anders.	Nyante (Lusoga)	Rt	Herb	Chewed	Uganda	[24]
	Barleria grandicalyx Lindau	Cheberenet (Kipsigis)	L	Shrub	Chewed/ pulped and rubbed on the bite	Kenya	[25-27]
	Dyschoriste hildebrandtii	Kwilangaswe (Shambaa)	Rt	Shrub	Decoction drunk/ used for washing bite	Tanzania	[26]
	Ecbolium viride (Forssk.) Alston	Mbuguno (Sukuma)	Rt	Shrub	Chewed. For further treatment, infusion taken/used for washing the wound	Tanzania	[26, 28]
	Justicia betonica	Muzukizi (Luganda),	L (green)	Herb	Infusion drunk for	Uganda,	[26, 29]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	L.	Cheberenet-Neo (Kipsigis), Lumasani (Luhya)			cobra bites. Juice applied on the bite	Kenya	
	Justicia calyculata (Deflers.) T. Anders.	Apiwo, Piu piu (Luo)	AP	Herb	Crushed and rubbed on the bite to facilitate removal of the ''snake's fangs''	Kenya	[30, 31]
	Justicia heterocarpa T. Anderson	Mwidu (Kiluguru)	L	Herb	Not reported	Tanzania	[32]
	Pseuderanthemum hildebrandtii Lindau	Mguruma (Shambaa)	Rt	Shrub	Not reported	Tanzania	[26]
	Thunbergia alata Bojer ex Sims	Nyakatao (Jita, Kerewe)	L	Herb	Fresh powder mixed with water to give paste applied on incisions of affected area	Tanzania	[33]
	Whitfieldia elongate	Ngeula (Nguru)	Rt	Shrub	Chewed	Tanzania	[26]
Amaranthaceae	*Achyranthes aspera* L.	Kagiri (Luganda)	Rt, Sd	Herb	Apply paste on bitten part	Uganda, Tanzania	[21, 34]
	Aerva lanata (L.) Juss. ex Schult.	Luwecha (Sukuma), Paramoya (Shambaa)	Rt	Herb	Not reported	Tanzania	[26]
	Aerva leucura	Mwenza (Bende)	Rt	Herb	Not reported	Tanzania	[26]
	Cyathula uncinulata (Schrad) Schinz	Kulabakak (Karamojong)	Rt	Herb	Apply powder to bite area after making small cuts with a razor blade	Uganda	[35]
	Psilotrichum elliottii Baker	Nyangarakilo (Ngoni)	Rt	Herb	Chewed	Tanzania	[26]
	Pupalia lappacea (Linn.) Juss	Mamata (Shambaa)	Rt	Herb	Infusion drunk thrice a day	Tanzania	[26]
Amaryllidaceae	*Allium cepa* L.	Kitunguu (Kamba), Tungulu (Luo)	L, Rt, Blb	Herb	Pounded and sap applied. Squeeze, mix with ash, put on the affected area	Uganda, Kenya	[21, 24, 30, 35-39]
	Allium sativum L.	Katunguluccumu (Lug)	Blb	Herb	Crush, smear at the bite.	Uganda	[37]
	Ammocharis tinneana	Joda (Luo of Uganda), Apap thwon pap, Rabwond otenga (Luo)	L, Rt	Herb	Decoction drunk. Sap used in preparation of an alexiteric	Uganda, Kenya	[30, 31, 35]
	Crinum kirkii Bak	Atumgulu (Lango)	Blb	Shrub	Not reported	Uganda	[36]
	Haemanthus multiflorus	Soota (Lusoga)	Tuber, Rt	Herb	Decoction taken	Uganda	[24, 40]
Anacardiaceae	*Lannea kirkii* Burtt Davy.	Mtundu (Suaheli)	Rt	Tree	Not reported	Tanzania	[23]
	Lannea schweinfurthii Engl.	Kyuasi, Muasi	L	Tree	Terminal leaves infusion drunk	Kenya	[39]
	Lannea welwitschia (Hiern) Engl.	Mukowa (Luganda)	Bk	Tree	Used with another unspecified tree	Uganda	[26]
	Heeria mucronata Bernh.	Mkalakala (Nyamwezi)	L	Tree	Juice used as antidote	Tanzania	[23]
	Ozoroa insignis Delile	Mutung'wa (Markwet)	B	Tree	Crushed and extract applied on the bite	Kenya	[41]
	Ozoroa mucronata (Bernh. Ex Krausss) R.&A.Fernandes	Livangi (Matengo), Mlago (Nyamwezi, Sukuma)	L	Tree	Juice used as antidote	Tanzania	[26, 28]
	Searsia pyroides	Akakwansokwanso	L, Rt	Shrub	Immediately eat the	Uganda	[21]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	(Burch.) Moffett	(Luganda)			leaves & roots		
Annonaceae	*Annona chrysopylla* Bojer.	Obolo (Luo), Mtopetope, Mfira, Mkonora (Nyamwezi)	Rt, L	Shrub	Decoction drunk	Uganda, Tanzania	[23, 35]
	Annona senegalensis Pers.	Obolo, obolobolo (Luo), Likonyo (Jita)	L, St, Rt, SB	Tree	Crushed and rubbed on bite. Chewed & juice swallowed. Stem and leaf decoction taken. Rt poultice applied topically	Uganda, Kenya, Tanzania	[30, 31, 33-35, 42]
	Popowia fornicata Baill.	Mkalia (Nyamwesi)	Rt, L	Shrub	Powdered and used	Tanzania	[23, 34]
	Uvaria acuminata Oliv.	Msofu (Swahili)	Rt	Shrub	Decoction taken	Tanzania	[26, 28, 43]
	Uvaria scheffleri Diels	Mukukuma (Kamba)	Rt, L	Shrub	Dried in the sun and powder applied	Kenya	[30]
	Ovariodendron anisatum Verdc.	Ndonga (Embu, Kamba)	Rt, WP, L	Shrub	Ashes applied to the bite	Kenya	[44-47]
Apiaceae	*Coriandrum sativum* L.	Giligilani (Swahili), dhaniya (Luganda)	NS	Herb	Infusion with raw eggs and little lemon taken	Uganda	[29]
	Heteromorpha trifoliata Wendl. Eckl. & Zeyh.	Luguguni (Zigua)	L	Tree	Not reported	Tanzania	[26]
	Steganotaenia araliacea Hochest.	Muvuavui, Kivuavui (Kamba), Chokuwo (Pokot), Mogura (Zigua), Olwiro (Acholi), Ilwilwi (Lango)	Rt, L	Shrub	Rt burnt & powder applied topically. Chewed. Leaf infusion used to wash out venom from eyes to avert blindness	Uganda, Kenya, Tanzania	[26, 30, 35, 36, 39, 48]
Apocynaceae	*Acokanthera schimperi* (A.D.C) Schweinf	Kelwo/Ng'wono (Marakwet)	Bk	Tree	powder applied on incisions made on the bitten area to arrest venom movement	Kenya	[49]
	Alstonia boonei De Wild	Mujwa (Lunyoro), Mukoge (Luganda)	Rt, St	Tree	Infusion drunk	Uganda	[26]
	Ancylobothrys petersiana (Klotzsch) Pierre	Kabaneza (Sandawi)	Rt	Shrub	Decoction taken	Tanzania	[26]
	Calotropis procera (Aiton) W.T.Aiton	Boah (Somali), Etithuru (Turkana), Mpamba Mwitu (Swahili)	Rt	Shrub	Not reported	Tanzania	[26, 50]
	Carrisa edulis (Forsk.) Vahl.	Ekamuriei (Ateso)	Rt	Shrub	Not reported	Uganda	[51]
	Carissa spinarum L.	Mukawa (Kamba)	L	Shrub	Not reported	Kenya	[52]
	Catharanthus roseus (L.) G.Don	Olubinu	L	Herb	Infusion drunk	Kenya	[26]
	Ceropegia lugardiae Schltr.	Gonyera (Sukuma)	Fresh Rt	Tree	Chewed & juice swallowed. The rest of chewed stuff is squeezed on the wound	Tanzania	[26, 28, 50]
	Cryptolepis sanguinolenta (Lindl.) Schltr	Kafulu/muganga kiba (Lusoga)	Rt	CL	Chewed, rubbed at the bite	Uganda	[24]
	Diplorhynchus condylocarbon	Mtoga (Rufiji), Msonga (Nyamwezi)	Rt, Bk, AP	Shrub	Used as powder	Tanzania	[26, 28, 34]
	Diplorhynchus mossambicensis Benth.	Mtogo (Seguha), Mbelembele (Nyamwezi)	RB	Shrub	Not reported	Tanzania	[23]
	Dregea abyssinica (Hochst.) K. Schum.	Lamee, Ubombo (Shambaa)	Fresh Rt	Tree	Chewed	Tanzania	[26]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	Landolphia petersiana (Klotzsch) Dyer.	Mbohoya (Nyamwezi), Mpera ya porini (Swahili)	Twigs, Fr	CL	Not reported	Tanzania	[23]
	Secamone parvifolia (Oliv.) Bullock.	Limuaga (Sukuma), Meramera (Nyamwezi)	Rt	Shrub	Decoction taken	Tanzania	[26, 28, 50]
	Strophanthus eminii Asch. ex Pax	Msengululu (Nyamwezi), Msungururu (Sukuma)	Br, Rt, Sd	Liana	Chewed. Pounded Rt soaked in warm water and vapour inhaled while bathing	Tanzania	[26, 28, 50]
	Thevetia peruviana (Pers.) Schumann	Busitani (Lusoga)	Rt	Shrub	Infusion drunk	Uganda	[24]
Aristolochiaceae	*Aristolochia densivenia* Engl.	Lunkulwe (Shambaa, Sukuma)	Rt	Herb	Not reported	Tanzania	[23]
	Aristolochia elegans Mast	Mukumya (Luganda)	Rt	Liana	Infusion drunk, root chewed	Uganda	[24]
	Aristolochia petersiana Klotzsch	Lunkulwe, Unkulwe (Sukuma), Tamba Ya Nyoka (Swahili)	Rt	Herb	Pounded and mixed with salt	Tanzania	[26, 28, 53]
	Aristolochia saccata Wall.	Kasero (Luganda)	Rt	CL	Decoction drunk	Uganda	[21]
	Aristolochia tomentosa Sims.	Kankapu (Ateso)	St	Tree	Infusion drunk	Uganda	[51]
Asparagaceae	*Albuca abyssinica* Jacq.	Amujej (Ateso)	Blb, L	Herb	Decoction drunk/applied topically	Uganda	[35]
	Asparagus flagellais (Kunth.) Baker	Umm Mushbat	Rt	Herb	Decoction	South Sudan	[54]
	Chlorophytum species 1	Emutungulu akwangan (Ateso)	Tuber	Herb	Pound and apply on the snake bitten area	Uganda	[35]
	Chlorophytum species 2	Eryau (Ateso)	Tuber	Herb	Chew fresh roots	Uganda	[35]
	Drimia maritima (L.) Stearn	Baroug/galb albarida	Blb	Herb	Juice rubbed on place of bite	South Sudan	[55]
	Sansevieria dawei Stapf	Yat-twol (Lango)	Rt	Shrub	Pounded root extract given as an emetic	Uganda	[56]
	Sansevieria kirkii Baker	Mukonge (Hehe)	L, Rt	Herb	Leaf sap applied on bite. Rt decoction taken	Tanzania	[26]
	Sansevieria parva N.E.Br.	Twoch bungu (Luo)	L	Herb	Sap applied on the bite wound	Kenya	[30, 31]
	Sansevieria trifasciata Prain	Tworo (Luo), Akagoogwa (Luganda)	L, Rt	Herb	Pound and drink juice. Applied topically. Rt crushed & chewed or chewed directly	Uganda	[35, 56]
Asteraceae	*Aspilia africana* C.D. Adams	Makaayi (Luganda)	L, Rt	Herb	Squeeze and drink the juice 1 glass/day	Uganda	[21, 57]
	Aspilia pluriseta Schweinf.	Muti	L	Herb	Sap squeezed and applied	Kenya	[58]
	Bidens pilosa L.	Nyanyiek mon, Onyiego (Luo), Sere/labika (Luganda)	L, WP	Herb	Crushed & rubbed on fresh cuts as an astringent, bite antidote and antiseptic	Uganda, Kenya	[24, 30, 31]
	Blepharispermum zanguebaricum Oliv. & Hiern	Mkonaka (Sukuma)	Rt	Shrub	Chewed boiled or pounded and soaked in water.	Tanzania	[26]
	Bothriocline longipes (Oliv. & Hiern) N.E.Br	Ekyoganyanja	L	Herb	Make incisions on snake bite and apply	Uganda	[38]
	Conyza canadensis L. Cronq.	Akamwisanga (Kerewe)	WP	Herb	Decoction taken	Tanzania	[33]
	Conyza persicifolia	Not reported	L	Herb	Not reported	Kenya	[26]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	(Benth.) Oliv. & Hiern						
	Conyza sumatrensis (Retz.) E. Walker	Yadh asere, yadh tong (Luo)	L	Herb	Infusion drunk for puff adder bites	Kenya	[30, 31]
	Crassocephalum mannii (Hook.f.) Milne-Redh.	Mgangogango (Kerewe), Ekigango	L (fresh)	Shrub	Decoction (500 ml) drunk	Uganda, Tanzania	[33, 59]
	Echinops amplexicaulis Oliv.	Lukwang (Luo)	Rt	Herb	Infusion drunk once/chewed and applied on site the next day	Uganda	[35, 57]
	Echinops issphaerocephalus L.	Okeya (Luo)	Rt	Herb	Infusion drunk once/chewed and applied on site the next day	Uganda	[35]
	Echinops longifolius A. Rich.	Ofilifil (Karamojong), okeya (Luo)	L	Herb	Burnt into ashes and applied topically once only/rubbed directly on bitten part/mix 1 teaspoon with water	Uganda	[35]
	Erigeron floribundus (Kunth) Sch.Bip.	Ejut dolei (Ateso)	L	Herb	Squeezed juice drunk thrice a day for at least 3 days	Uganda	[35]
	Lactuca inermis Forssk.	Ekile (Ateso)	Rt	Herb	Infusion drunk thrice a day for 3 days	Uganda	[35]
	Microglossa pyrifolia (Lam.) O. Kuntze	Etutum (Ateso), Akafugakadde (Luganda)	Rt	Herb	Decoction drunk for 2 days/Chewed. Poultice used	Uganda	[21, 24, 35]
	Senecio lyratipartitus	Rwinkithia (Meru)	Rt	Tree	Powder applied topically and covered with leaves of *C. molle.* The wound is then bandaged using dry banana sheaths	Kenya	[26]
	Sigesbeckia orientalis L.	Yat twol (Luo)	L	Herb	Squeezed juice drunk/paste applied topically	Uganda	[35]
	Solanecio mannii (Hook.f) C. Jeffrey	Maroo, marowo (Luo), Livokho, Yergekwa (Markwet)	L	Shrub	Crushed/chewed leaves rubbed onto the bite	Kenya	[26, 30, 31, 41]
	Tagetes minuta L.	Muvangi (Kamba)	L	Herb	Infusion applied on the bite	Kenya	[30]
	Tithonia diversifolia (Hemsl.) A. Gray.	Maua madongo, akech (Luo), Mula (Kamba)	L	Shrub	Infusion administered orally	Kenya	[30, 31]
	Vernonia amygdalina Del.	Mtugutu (Zigua)	L	Tree	Chewed	Tanzania	[60]
	Vernonia auriculifera Hiern.	Lisavakhwa	L	Herb	Crushed and applied topically	Kenya	[61]
	Vernonia biafrae Oliv. & Heirn	Ebwolibwol (Ateso)	Rt	Herb	Pound and mix with water and drink as a purgative	Uganda	[35]
	Vernonia cinerea (L) Less	Yat Kwong (Lango), Lukohe (Luganda), Kifuha (Swahili)	WP, L	Herb	Leaves chewed or infusion drunk	Uganda, Kenya	[24, 26, 36]
	Vernonia glabra (Steez) Vatke	Olusia (Luo)	L	Herb	Ashed/ crushed & rubbed on the bite	Kenya	[30, 31]
Balanophoracaeae	*Sarcophyte piriei* Hutch.	Ibatikanthi (Mbeere)	NS	Herb	Not reported	Kenya	[46]
Basellaceae	*Basella alba* L.	Enderema (Luganda)	WP	CL	Crushed & packed on the bite	Uganda	[62]
Bignoniaceae	*Markhamia lutea* (Benth.) K. schum	Lusiola, Shisimbali	L	Tree	Fresh leaf infusion drunk and used for cleaning the bite	Kenya	[26]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
					wounds		
	Markhamia obtusifolia	Mkala (Haya), Mpapa (Zinza), Mpugupugu (Zaramo)	Rt, L	Tree	Root decoction taken	Tanzania	[26, 50, 63, 64]
	Trichodesma zeylanicum (L.) (Burm.f.) R.Br.	Agilo (Lango), Igunguru (Nyamwezi)	Rt, L	Tree	Chewed, or pounded and decoction drunk while some are used for washing the wound. Leaf powder used	Uganda, Kenya, Tanzania	[26, 28, 36, 41, 65]
Burseraceae	*Commiphora africana* (A. Rich.) Endl	Osilalei (Maa), Mutungu (Kamba), Mbambara, Mlororo (Swahili), Mpome (Rufiji)	Bk	Tree	Chewed alone and swallowed or with *Nicotiana tabacum* and applied on bite. Washed bark with salt applied on bite	Kenya, Tanzania	[26, 34, 66]
	Commiphora pilosa Engl.	Mponda (Nyamwesi)	Rt, L	Tree	Not reported	Tanzania	[23]
	Commiphora eminii Engl.	Mũkũngũgũ (Kikuyu)	Bk, St, Rt	Tree	Decoction, root powder used	Kenya, Tanzania	[41, 63, 67]
	Commiphora species	Mumuongo, Muongo (Nyamwezi)	Bk	Tree	Not reported	Tanzania	[23]
	Commiphora zimmermannii	Mbombwe (Shambaa), Mnyakwa (Swahili), Mtulansuwi (Sukuma)	Rt	Tree	Not reported	Tanzania	[26]
Canellaceae	*Warburgia ugandensis* Sprague	Ntale ya ddungu (Luganda), Eusuk (Ateso)	L, Bk	Tree	Fresh leaf or dried bark decoction drunk 1 tea spoonful thrice daily	Uganda	[38]
Capparaceae	*Maerua kirkii* (Oliv.) F.White	Moramana (Nyamwezi)	Rt	Shrub	Decoction taken	Tanzania	[28]
	Maerua triphylla A. Rich.	Chokowa (Pokot), Milamila (Zigua)	Fresh Rt	Tree	Chewed, infusion drunk/used for washing the wound	Tanzania	[26, 68]
	Thylachium africanum Lour.	Nguruka (Sukuma)	Rt	Shrub	Not reported	Tanzania	[26]
Capparidaceae	*Capparis micrantha* A. Rich.	El Mardo	Rt	Shrub	Decoction	South Sudan	[54]
	Capparis tomentosa Lam.	Muzingani (Lusoga)	Rt	Shrub	Infusion drunk	Uganda	[24]
Caricaceae	*Carica papaya* L.	Apapalu (Lango), Paapali essajja (Luganda)	Rt	Tree	Chew, poultice applied to the bite	Uganda	[24, 36, 51]
Celastraceae	*Maytenus senegalensis* (Lam) Exell.	Eterka, Itereka (Lango), Luwenje (Sukuma)	Rt, L	Tree	Leaves crushed and soaked in water are used to prepare an eye-drop	Uganda, Tanzania	[26, 28, 36]
	Gymnosporia species	Mibwasungu (Nyamwesi)	Bk	Tree	Not reported	Tanzania	[23]
Cleomaceae	*Cleome gynandra* L.	Akeo (Lango), Eyobyo (Rutoro)	Fresh L	Herb	Infusion drunk	Uganda	[59]
Colchicaceae	*Gloriosa superba* L.	Lobon bong (Karimojong), Emmereyannamunye (Luganda)	Rt	Herb	Powder sometimes mixed with those of *G. dalenii*. Paste applied on the bite	Uganda	[21, 35]
Combretaceae	*Combretum aculeatum* Vent.	Shukheit	Rt	Shrub	Decoction	South Sudan	[54]
	Combretum apiculatum Sond.	Landala (Sukuma), Musana (Nyamwezi), Leleiya (Markwet)	Rt	Tree	Chewed or may be pounded, soaked in water and the infusion/decoction drunk	Tanzania, Kenya	[26, 28, 41]
	Combretum collinum Fresen	Adugo (Luo), Odugu (Lango, Acholi), Ititu (Kamba)	Rt	Tree	For treatments effected by scarification	Kenya, Uganda	[26, 30, 31, 36, 48]
	Combretum constrictum	Mbambagoma (Shambaa)	Rt	Tree	Chewed roots put on snake bite wounds	Tanzania	[26]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	(Benth.) M.A. Lawson						
	Combretum gueinzii Sond. subsp. splendens Exell.	Mulama, Mlama (Nyamwezi), Mnama (Sukuma)	Rt, L	Tree	Not reported	Tanzania	[23]
	Combretum longispicatum (Engl.) Engl. & Diels	Linsugu (Nyamwezi)	Rt	Tree	Powder used	Tanzania	[28]
	Combretum microlepidotum	Msaua (Sawa)	Rt	Tree	Fresh or dry roots chewed	Tanzania	[26]
	Combretum molle G. Don	Muama, Kiama (Kamba), Loro (Lango), Cheporosto (Pokot), Mukhungula (Luhya)	Bk, Rt, L, RB	Tree	Infusion/decoction drunk 2 glasses twice a day. Leaves are placed on the wound on which has been applied *S. lyratipartitus* Rt powder & banana leaves are used as bandage. A mixture of small chips of Rt and Rt of *M. obtusifolia* and *Vungueria rotundata* is applied to the bite	Uganda, Kenya, Tanzania	[26, 30, 34, 36, 39, 41, 50, 61, 63, 64]
	Combretum padoides Engl. & Diels	Mshinda arume	L	Tree	Crushed leaves are applied on the bite	Kenya	[69]
Commelinaceae	*Aneilema petersii* (Hassk.) C.B.Clarke	Nganga Kulula (Sukuma)	Rt	Herb	Chewed. Decoction drunk and some of it used for washing the wound	Tanzania	[26]
	Murdannia simplex Vahl. Branan	Muhinduka (Rutoro)	Fresh L	Shrub	Squeeze and drink	Uganda	[59]
Connaraceae	*Byrsocarpus orientalis* (Baill.) Baker	Fifi (Sukuma), Mpandaradu, Mungitungo (Ndengereko)	Rt	Shrub	Dried roots are burnt, mixed with powdered charcoal and tobacco, and the infusion drunk	Tanzania	[60]
Convolvulaceae	*Astripomoe amalvacea* (Klotzsch) A. Meeuse	Apom (Ateso)	Rt, St	Herb	Decoction drunk once daily for 2-5 days	Uganda	[35]
	Dichondra repens J.R. Forst. & G. Forst.	Not reported	L	Herb	Rubbed on bite to ''remove snake fangs''	Kenya	[30, 31]
	Hewittia malabarica (L.) Suresh	Musotataluma (Luganda)	Rt, L	CL	Paste applied on the bite	Uganda	[21]
	Hewittia sublobata L. Kuntze	Musota taluma (Luganda)	Rt, tuber	Herb	Smear on head and bitten part	Uganda	[37]
	Ipomoea batatas (L.) Lam.	Icok (Lango), Mboli (Lusoga), Lumonde (Luganda)	Rt, tuber	Herb	Chewed	Uganda	[24]
	Jucquemontia paniculata (Burm. f .) Hall. f.	Mwidilimbwi (Zigua)	Fresh Rt	Herb	Pounded and applied topically	Tanzania	[60]
	Jacquemontia tamnifolia (L.) Griseb.	Kikopwe (Swahili)	Rt, L	CL	Chewed/infusion drunk and used for washing the wound	Tanzania	[26]
	Merremia angustifolia Hall. f.	Miguasungu (Nyamwezi)	L	Herb	Not reported	Tanzania	[23]
Crassulaceae	*Bryophyllum delagoense* (Eckl. & Zeyh.)	Omucaga (Ateso)	L	Herb	Leaf juice/paste taken orally	Uganda	[35]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	Druce						
	Kalanchoe species	Ecucuka (Ateso)	L	Herb	Leaf juice/paste taken orally	Uganda	[35]
Cucurbitaceae	*Coccinia grandis* (L.) Voigt	Bomo twol (Luo)	Rt	Herb	Decoction taken	Uganda	[35]
	Corallocarpus boehmii (Cogn.) C. Jeffrey	Nyencha (Sukuma)	Rt	Herb	Infusion drunk. For quick action, the root tuber is chopped into small pieces and chewed.	Tanzania	[26]
	Curcubita maxima Duschesne	Marenge (Embu, Mbeere, Meru)	NS	Herb	Not reported	Kenya	[46]
Cyperaceae	*Cyperus rotundus* L.	Omugugu	L	Herb	Decoction taken; residue smeared the on affected area	Uganda	[38]
Dilleniaceae	*Tetracera boiviniana* Bail.	Mpalafigi (Swahili), Mpitayo (Zaramo)	Rt, L	Tree	Root powder eaten. Squeezed leaf juice drunk	Tanzania	[60]
Dracaenaceae	*Dracaena steudneri* Engl.	Kajjolyenjovu (Lusoga), Ekigorogoro	L, Bk	Tree	Pound and smear on affected area, decoction drunk	Uganda	[37, 38]
Ebenaceae	*Euclea divinorum* Hiern	Jeptuiya, Uswet (Markwet), Cheptuya (Pokot), Muda, Kasalagala (Lusoga)	Bk, Rt	Tree	Crushed & applied on incisions made on the bite area. Sometimes used with of *Gardenia volkensii* and *Plectranthus barbatus.* Root decoction drunk	Kenya, Uganda	[24, 41, 70-72]
	Diospyros usambarensis F. White	Mkongo (Kamba), Mkuruponya (Giriama)	Fresh Rt	Shrub	Chewed or soaked in water and used orally, and externally for washing the wound	Kenya	[26]
	Royena macrocalyx Gürke	Mdaa (Swahili), Mkuruponya (Giriama)	NS	Shrub	Not reported	Kenya	[53]
Euphorbiaceae	*Acalypha bipartita* Muell. Arg.	Helele (Lusoga)	Rt	Herb	Poultice applied on the bite	Uganda	[24, 73]
	Acalypha fruticosa Forrsk.	Mzahati (Nyamwezi)	L, Rt	Shrub	Not reported	Tanzania	[23, 34]
	Croton macrostachyus Hochst. ex. Delile	Musogasoga (Lusoga)	Rt, tuber	Tree	Poultice smeared on the bite	Uganda	[37]
	Cyathogyne bussei Pax	Kinkundunkunesa (Zigua), Kirihi, Mzidishanguvu (Swahili)	Rt	Tree	Chewed and only the juice swallowed. Warm Rt decoction drunk. This prevent the poison from circulating in the blood	Tanzania	[26]
	Euphorbia candelabrum Trémaux ex Kotschy	Enkuukuulu (Luganda)	Rt	Shrub	Eaten immediately/decoction drunk	Uganda	[21]
	Euphorbia grantii Oliv.	Muthuri (Meru), Ndulwa Nsongo, Mtulasongo (Nyamwezi)	St	Tree	Fresh milky sap applied to wounds/fresh cuts	Tanzania	[26, 28]
	Euphorbia hirta L.	Acakacak (Luo), Kasadasada (Luganda), Mziwaziwa (Swahili)	Bk, Rt	Herb	Decoction drunk or paste applied on the bite	Uganda, Tanzania	[21, 34, 35]
	Euphorbia hypericifolia L.	Loje (Karamojong)	L	Herb	Pounded/squeezed juice applied on bite twice daily for 2 days	Uganda	[35]
	Euphorbia tirucalli L.	Kilajok (Luo), Enkoni (Rutoro), Ngesa	Rt, fresh L	Herb	Drink decoction/sap applied topically.	Uganda, Tanzania	[26, 34, 35, 59,

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
		(Shambaa)			Roasted leaves squeezed & juice drunk		63]
	Jatropha curcas L.	Omararot (Lango), Ekiroowa (Luganda), Mucariki (Embu)	Fr, fresh L	Shrub	Leaf latex applied topically	Uganda, Kenya	[24, 46]
	Jatropha nogalensis	Jilba Dig (Somali)	Fresh Rt	Shrub	Chewed & juice taken/applied topically	Kenya	[26]
	Ricinus communis L.	Ekisogasoga (Rutoro), Mukakale (Lusoga), Libono	SB, Rt, L	Tree	Mix bark with black salt and chew. Infusion drunk. Root/leaf decoction taken/applied topically	Uganda, Kenya	[24, 59, 61]
	Securinega virosa (Willd) Baill.	Ilakara (Lango), Mkwamba (Shambaa & Swahili)	Rt, Fr	Tree	Chewed	Uganda, Kenya, Tanzania	[26, 36]
	Suregada zanzibarensis	Mkangala (Sukuma)	L, Rt	Shrub	Roots chewed or its juice is drunk twice a day	Tanzania	[26, 28, 74]
	Tragia brevipes Pax	Kimelei ne mining (Markweta)	Rt	Shrub	Crushed and applied on incisions on the bitten area	Kenya	[70, 72]
	Tragia furialis Bojer	Kiwari (Swahili), Pupu (Zigua)	WP, Rt	Tree	WP decoction drunk, Rt powder applied topically	Tanzania	[75]
Fabaceae	*Abrus precatorius* L.	Motipitipi (Swahili), Mwanga-La-Nyuki (Digo)	Rt, L	CL	Chewed	Kenya, Tanzania	[23, 26]
	Acacia brevispica Harms	Kiptare (Marakwet)	Rt	Tree	Decoction taken	Kenya	[26]
	Acacia oerfota (Forssk.) Schweinf	Laoat	Fresh Rt	Shrub	Crushed & rubbed on the bite; decoction taken	South Sudan	[55, 76]
	Acacia polyacantha Willd.	Migogwe (Padhola)	Rt	Tree	Chewed/infusion drunk/put on the bite	Uganda	[26, 34]
	Acacia seyal Del. var. *fistula* (Schweinf.) Oliv.	Mufuhanduzi/Muwela manyo (Lusoga)	Rt	Tree	Not reported	Uganda	[24]
	Acacia species	Mukongoito (Lusoga)	Rt	Tree	Infusion drunk	Uganda	[24]
	Afzelia quanzensis	Mkongo (Swahili)	Fresh Rt	Tree	Chewed or infusion drunk	Tanzania	[26, 63]
	Albizia coriaria (Welw. ex) Oliver	Etek (Lango), Musita (Luganda, Lusoga)	Rt	Tree	Infusion drunk	Uganda	[24]
	Albizia harveyi E.Fourn.	Mfirigisi	L	Tree	Not reported	Tanzania	[74]
	Cajanus cajan (L.) Millsp	Ekolimbo/empindi (Luganda), Njugu (Embu)	Rt, L	Shrub	Squeeze and drink the juice	Uganda, Kenya	[21, 46]
	Canavalia ensiformis L. D.C	Yat twol (Luo), Kijanjalo (Luganda), Ekihimba	Sd, L	Herb	Split & attach a clean piece on the affected area. Chew Sd. Leaf infusion drunk	Uganda	[35, 38, 40]
	Cassia abbreviata Oliv.	Mahemba, Mhumba (Zigua)	Rt	Tree	Decoction taken	Tanzania	[43]
	Cassia occidentalis L.	Omwitanjoka (Rutoro)	Fresh L	Shrub	Decoction drunk; 500 ml thrice a day	Uganda	[59]
	Cassia sieberana D.C.	Umm Kasho	Rt	Tree	Decoction taken	South Sudan	[54]
	Cassia singueana Del.	Mvumba	L	Shrub	Juice taken	Tanzania	[64]
	Crotalaria laburnifolia	Muongozo (Shambaa)	L	Herb	Pounded and applied to the afflicted area	Tanzania	[26]
	Crotalaria	Sukuru Matwi	Fresh Rt	Herb	Chewed. Infusion is	Tanzania	[26]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	quartiniana A. Rich.	(Sukuma)			taken/topically used		
	Dalbergia melanoxylon Guill. et Perr.	Gembe (Sukuma), Mpingo (Swahili, Zigua)	SB	Tree	Decoction drunk	Tanzania	[77]
	Delonix elata Gamble.	Mvutambula (Nyamwesi)	L	Tree	Not reported	Tanzania	[23]
	Dichrostachys cinerea L.	Impangala (Nyika), Mgegere (Hehe), Mundua (Kamba), Mulagembe (Shambaa), Msingino(Boni)	Bk, Rt, L, Fr	Tree	Rt or L chewed & paste applied on the bite to remove poison. Rt decoction drunk. Incisions are made at the site of bite and poultice from pods applied on snakebites	Tanzania, Kenya	[26, 53, 63, 77, 78]
	Dichrostachys glomerata Chiov.	Mwingano (Chagga), Mtundulu (Nyamwezi), Mkeragembe	L	Tree	Not reported	Tanzania	[23]
	Entada leptostachya Harms	Mwaitha (Kamba)	St, Rt, MP, exudate	Tree	Stem crushed, sap squeezed out and applied on the bite. Root infusion taken	Kenya	[30, 39, 79, 80]
	Erythrina abyssinica ex D.C.	Omutembe (Kuria), Muhuti (Kikuyu), Ejirikiti (Luganda)	Bk, Rt	Tree	Sap is used as an antidote. Paste applied on the bite/decoction taken	Kenya, Uganda	[21, 26, 48, 81]
	Erythrina excelsa Baker	Roko, yuoma (Luo-Kenya), Omubajjangabo (Luganda)	Bk	Tree	Sap is used as an antidote, squeeze and take juice or apply paste on the bite	Kenya, Uganda	[21, 30, 31]
	Erythrophloeum guineense Don.	Muhai (Songea), Mkola (Nyamwezi), Muafi (Suaheli)	L	Tree	Not reported	Tanzania	[23]
	Glycine max (L.) Merr.	Soya (Luo)	Sd	Herb	Chewed	Uganda	[21, 35]
	Indigofera arrecta Host. A. Rich.	Eragwii (Ateso), Awee (Lango), Kyeyo ekisaiza (Lusoga), Umusororo	Rt, WP	Shrub	Enchantments using roots. Decoction drunk or powder/poultice applied topically. Plant powder applied topically.	Uganda, Tanzania	[24, 35, 37, 38, 82]
	Indigofera capitata Forsk.	Yat twol (Luo), Awee dyang, Ocukulak (Lango)	Rt, L, shoot	Herb	Pound and drink juice and apply topically	Uganda	[35, 36]
	Indigofera circinella Baker f.	Odolo (Luo)	L	Herb	Poultice chewed and pasted on the bite	Kenya	[30, 31]
	Indigofera garckeana Vatk	Mukitimbo (Lusoga)	Rt	Shrub	Chewed or infusion drunk	Uganda	[24, 83]
	Lonchocarpus bussei Harms	Enahl (Boni)	Bk	Tree	Used to make a tourniquet that is applied below the snake bite	Kenya	[26]
	Lonchocarpus capassa	Mkunguga (Luguru)	WP	Tree	Not reported	Tanzania	[34]
	Lonchocarpus laxiflorus Guill. & Perr	Eputon (Ateso)	Rt	Tree	Chewed to induce vomiting	Uganda	[35]
	Millettia usaramensis Taub.	Mfutambula (Sukuma)	Rt	Shrub	Not reported	Tanzania	[26]
	Ormocarpum trachycarpum	Ederut (Ateso)	Rt	Shrub	Infusion drunk	Uganda	[51]
	Phaseolus lunatus L.	Kayindiyindi (Luganda)	WP	Herb	Decoction drunk/ paste applied on bite	Uganda	[21]
	Phaseolus radiatus L.	Choroko (Swahili)	Sd	Herb	Powder with honey & rubbed on incisions	Tanzania	[33]
	Piliostigma	Ogali (Luo)	L, Bk	Tree	Decoction	Uganda	[35]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	malabaricum (Roxb.) Benth						
	Piliostigma reticulatum (DC.) Hochst.	Abu Khameira	SB	Tree	Decoction taken/powder pasted on the bite	South Sudan	[76]
	Piliostigma thonningii (Schumach.) Milne-Redh.	Ogali (Acholi), Mchikichiki (Swahili), Murema (Kikuyu)	L (dry)	Tree	Ash spread over wound sustained from snake bite in order to facilitate healing	Uganda, Kenya	[26]
	Pseudarthria hookeri Wight & Arn.	Luganila (Lusoga)	Rt	Shrub	Infusion drunk	Uganda	[24, 84]
	Pterolobium stellatum (Forssk.) Brenan	Kibai (Meru), Kormande (Tugen), Osirimatindo (Luo)	Rt	Shrub	Chewed and juice swallowed	Kenya	[26]
	Rhynchosia minima (L.) DC.	Adan alfar/shgrdabib	Rt	Herb	Fresh crushed Rt rubbed on the bite	South Sudan	[55]
	Rhynchosia sublobata (Schumach. & Thonn.) Meikle	Fundo-Fundo, Pimbili, Ufundofundo (Shambaa, Kapupu (Giriama)	St, Rt, Bk	Herb	Stem chewed as an emetic. Roots and bark used as antidotes	Tanzania	[26]
	Senna alata (L.) Roxb.	Ekifura (Luganda)	L	Tree	Paste applied on the bite	Uganda	[21]
	Senna hirsuta (L.) H.S.Irwin & Barneby	Elekumare (Ateso)	Rt	Tree	Mix the powder with cold water and drink 3 times daily for at least 3 days	Uganda	[35]
	Senna occidentalis (L.) Link	Kasagalyansasi (Lusoga)	Rt	Herb	Chewed	Uganda	[24]
	Senna septemtrionalis	Not reported	Fl, L	Shrub	Crushed and packed into or onto the bite	Uganda	[62]
	Senna siamea (Lam.) Irwin et Barnaby	Ndege owinu, oyieko (Luo), Kasia (Lusoga)	Rt	Tree	Used with *Zanthoxylum chalybeum* Engl. roots. Infusion drunk	Kenya, Uganda	[24, 30]
	Senna singueana (Del.) Lock	Musumbila bafele, Mukengenta, Mukengeka	Rt, St	Tree	Infusion or decoction drunk. Powder applied topically. Stem ash swallowed	Uganda, Kenya	[24, 39]
	Tamarindus indica L.	Chwaa (Luo)	Sd, L	Tree	Chewed/applied topically	Uganda, Tanzania	[34, 35]
	Tephrosia purpurea	Ludumio (Sukuma)	L	Shrub	Not reported	Tanzania	[26, 28]
	Vigna unguiculata (L.) Walp	Kunde (Suaheli)	Rt	Herb	Not reported	Tanzania	[23]
Iridaceae	*Gladiolus dalenii* Van Geel	Lodokole (Karamojong)	Bk	Herb	Powder applied once on incisions/decoction drunk	Uganda	[35]
Lamiaceae	*Clerodendrum myricoides* R. Br.	Umukuzanyana	Bk	Shrub	Not reported	Tanzania	[82]
	Clerodendrum scheffleri	Mkuga (Sukuma)	Rt	Shrub	Not reported	Tanzania	[26]
	Fuerstia africana T.C.E. Fr.	Abunga-useke, aremo (Luo)	L	Herb	Crushed and filtered infusion drunk	Kenya	[30, 31, 85]
	Hoslundia opposita Vahl	Etutu/Tutu (Ateso), Itutu (Kumam), Nfodo (Lusoga), Munjinua, Mswele (Nyamwezi)	Rt, L	Shrub	Decoction drunk/rubbed on the bite. Poultice applied/ warm water decoction drunk twice daily for 3 days	Uganda, Tanzania	[24, 34, 35]
	Hyptis pectinata (L.) Poit	Not specified	L	Herb	Infusion with *Corchurus trilocularis* L. is dropped/ sprinkled into the eye	Kenya	[30]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
					to neutralize venom ejected into it by black-necked spitting cobra. After, the victim is scarified on the hind torso		
	Leonotis mollissima Guerke.	Irenge (Chagga), Muhasi (Sukuma)	L	Herb	Not reported	Tanzania	[23]
	Ocimum americanum L.	Pupu (Chagga), Kinuka (Suaheli), Msumbampungu (Sukuma)	L	Herb	Not reported	Tanzania	[23]
	Ocimum basilicum L.	Omujaaja (Luganda)	WP	Herb	Decoction drunk	Uganda	[21]
	Plectranthus barbatus Andrews	Kan'gurwet (Markweta), Ebiriri omutano (Ateso)	WP, L, St, Rt	Herb	Leaves mixed with those of *G. volkensii* and *E. divinorum.* Powder mixture is applied on incisions made around bite. Infusion drunk for leaves and other parts	Kenya, Uganda	[51, 72, 86]
	Premna chrysoclada (Bojer) Gürke	Mvuma (Digo), Muwumo (Swahili)	Rt	Tree	Not reported	Kenya	[26]
	Vitex amboniensis Guerke.	Mtalali (Suaheli)	WP	Tree	Not reported	Tanzania	[23]
	Vitex stricken Vakte	Msundwi, Mtarali (Sukuma)	Rt, L	Tree	Rt infusion drunk twice a day; leaf decoction applied as a hot fermentation to reduce inflammation	Tanzania	[26]
Lauraceae	*Cassytha filiformis* L.	Hauna shina (Zaramo), Mlangamia (Nyamwezi)	WP	CL	Not reported	Tanzania	[23, 34]
Liliaceae	*Anthericum cameroneii* Bak	Yat twol ororo (Lango)	Rt	Shrub	Not reported	Uganda	[36]
Linaceae	*Hugonia castaneifolia* Engl.	Not reported	WP	CL	Not reported	Kenya	[87]
Loganiaceae	*Strychnos henningsii* Gilg	Muteta (Kamba)	Rt	Shrub	Chewed while fresh	Kenya	[26]
	Strychnos innocua Del.	Akwalaakwala (Lango), Bungundu (Bende), Lumbora (Madi), Mhundu (Sukuma)	Fresh Rt	Shrub	Not reported	Uganda, Tanzania , Kenya	[26, 28, 36, 88]
	Strychnos pungens Solered.	Mkole (Swahili)	NS	Tree	Not reported	Tanzania	[23]
	Strychnos spinosa Lam.	Mtonga (Swahili), Muhonga, Mukonga, Murasapungu (Digo)	Rt	Tree	Chewed or decoction drunk	Kenya, Tanzania	[23, 26]
	Strychnos volkensii Gilg.	Moage, Muage (Nyamwezi)	Rt	Tree	Not reported	Tanzania	[23]
Loranthaceae	*Erianthemum dregei* (Eckl. & Zeyh.) Tiegh	Not reported	Bk	Shrub	Pounded bark applied on snake bite wounds	Kenya	[41]
	Loranthus dregei Eckl. & Zeyh.	Nyulukesi (Sukuma)	Bk	CL	Chewed. Decoction is drunk/used for washing wound	Tanzania	[26]
Lythraceae	*Punica granatum* L.	Enkomamawanga (Luganda)	WP	Tree	Paste applied on the bite	Uganda	[21]
Malvaceae	*Corchurus trilocularis* L.	Apoth (Luo)	L	Herb	Infusion with *H. pectinata* used as eyedrops to neutralize venom ejected into human eyes	Kenya	[30, 31]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	Grewia bicolor Juss.	Esiteti (Massai), Mulawa (Kamba), Mkone (Swahili)	Rt	Shrub	Cold infusion drunk	Kenya, Tanzania	[26, 48, 66, 89]
	Grewia damine Gaertn.	Enkomakoma (Luganda), Ositeti	Bk, Rt, St, Fr, Br, WP	Shrub	Whole plant is eaten	Uganda, Kenya	[21, 90]
	Grewia fallax K. Schum.	Powo (Luo), Ilawa (Kamba), Kamagere (Sukuma)	L, Bk, Rt	Shrub	Used in cooking envenomed carcass to prevent secondary poisoning. Crushed L used to wipe the bite. Rt chewed/ decoction taken	Kenya, Tanzania	[26, 30, 31, 48]
	Grewia similis K.Schum.	Not reported	Bk	Tree	Pounded and applied on bite wound	Kenya	[41]
	Grewia truncata Mast.	Msensemazi (Sukuma)	L, Rt	Shrub	Chewed/decoction taken	Tanzania	[26]
	Hibiscus micranthus L.	Muambe (Swahili), Muharasha-mbuzi (Zigua), Mburi (Sukuma)	Rt, WP, L	Shrub	Rt decoction taken. Fresh WP/L infusion applied to incisions on the bite	Tanzania	[23, 78]
	Hibiscus sabdariffa L.	Karkadeh	Fl (calyx)	Herb	Decoction taken	South Sudan	[91]
	Sida alba L.	Minyundimi (Sukuma), Omucundeezi	L	Shrub	Decoction drunk or smear/tie the residue on bite. Chewed and the juice swallowed	Uganda, Tanzania	[26, 28, 38]
	Sida rhombifolia L.	Rushuhya (Haya), Ufagio (Swahili)	Rt	Shrub	Not reported	Tanzania	[34]
	Sida veronicifolia Lam.	Eihoza	L	Shrub	Powder mixed with vaseline smeared on bite/ three spoons of decoction taken	Uganda	[38]
	Triumfetta rhomboidea Jacq.	Muinda nguue(Kamba), Kulibha (Kerewe)	Rt, L	Herb	Infusion drunk/applied on bite. Leaf powder tied to bite; decoction taken once	Kenya, Tanzania	[30, 33, 39]
	Urena lobata L.	Bikadantama (Lusoga)	L	Herb	Not reported	Uganda	[24]
Melastomataceae	*Tristemma mauritianum* J.F. Gmel.	Alwedo, Alea (Lango)	Rt	Tree	Not reported	Uganda	[36]
Meliaceae	*Azadirachta indica* A. Juss.	Omuttankuyege (Luganda)	Fr	Tree	Decoction taken, paste applied on the bite	Uganda, South Sudan	[21, 35]
	Ekebergia capensis Sparrm	Akwirakwir (Lango)	Rt, L	Tree	Decoction taken	Uganda	[92]
	Pseudocedrela kotschyi (Schweinf.) Harms	Ekaka (Ateso)	Rt	Shrub	Powder applied topically/decoction drunk	Uganda	[35]
	Toona ciliata M. Roem.	Yat bwoc (Luo)	Rt	Tree	Infusion drunk once	Uganda	[35]
	Trichilia ematica Vahl	Akwirakwir (Lango)	Rt, L	Tree	Rt infusion with *M. foetida* Rt drunk. Leaves rubbed on cuts	Uganda	[56, 57]
Menispermaceae	*Cissampelos mucronata* A. Rich.	Kavamagombe (Lusoga), Omanobya (Lango), Kishiki Cha Buga (Swahili), Olandra (Luo)	Rt, RB, L, Fr (cover)	Tree	Pound leaves and tie on affected part. RB is chewed, and juice swallowed	Uganda, Kenya, Tanzania	[26, 36, 37, 75]
	Cissampelos pareira L.	Moeru (Rufiji), Msimbasi (Sukuma), Malutiatito (Pokot)	L, Rt	Liana	Leaves powdered and mixed with water then taken or simply chewed. Powdered roots used	Tanzania, Kenya	[26, 41, 75]
	Cissampelos truncata	Nyakasihio (Rufiji), Shikio Ya Paka (Swahili)	Rt	Liana	Chewed. Chewed Rt placed on the snakebite wound	Tanzania	[26]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	Tinospora bakis (A. Rich.) Miers	Bun balash/irgalhagar	Rt	CL	Maceration (infusion)	South Sudan	[55]
Monimiaceae	*Xymalos monospora* Baill.	Mkaliakusimu (Nyamwezi)	RB	Tree	Not reported	Tanzania	[23]
Moraceae	*Cardiogyne africana* Bureau	Mrambangoma (Shambaa)	Rt, L	Tree	Chewed	Tanzania	[26, 34, 77]
	Ficus exasperata Vahl	Oluwawu (Luganda)	Rt, Bk	Tree	Decoction taken	Uganda	[21]
	Ficus natalensis Hochst.	Mugaire (Lusoga), Munangara (Ikizu)	Rt	Tree	Infusion drunk	Uganda, Tanzania	[23, 24, 34, 83]
	Ficus sycomorus L.	Antsi	L	Tree	Not reported	Tanzania	[63]
Moringaceae	*Moringa oleifera* Lam.	Molinga (Luganda)	Rt/Bk	Tree	Decoction taken	Uganda	[21, 35]
Musaceae	*Ensete edule* (J. F. Gmel.) Horan	Kitembe (Luo)	St	Herb	Fresh stem sap is wiped onto the bite	Kenya	[30, 31]
	Musa balbisiana Colla	Embidde (Luganda)	Sap	Tree	Juice made with other plants and taken	Uganda	[21]
	Musa × *paradisiaca* L.	Kayinja (Luganda)	Bk	Tree	Juice made with other plants and taken	Uganda	[21]
	Musa species	Amemo (Luo)	Rt	Liana	Decoction taken	Uganda	[35]
Myricaceae	*Morella kandtiana* (Engl.) Verdic & Polhill	Ekikimbo (Luganda)	Rt	Herb	Decoction taken, paste applied on the bite	Uganda	[21, 37]
Myrtaceae	*Eucalyptus viminalis* Labill	Kalatuc (Luo)	Rt, L	Tree	Decoction taken	Uganda	[35]
	Eucalyptus species	Kalatuc (Luo)	L	Tree	Decoction taken	Uganda	[35]
Ochnaceae	*Brackenridgea zanguebarica* Oliv.	Kiogo Kueka, Moka (Nyamwezi)	L, Br, Bk	Tree	Powdered and applied topically	Tanzania	[23, 26, 34, 77]
Olacaceae	*Ximenia cafra* Sond.	Lisheka (Jita)	Rt	Tree	Decoction drunk & to wash victim's cloth	Tanzania	[33]
Oleaceae	*Jasminum eminii* Gilg	Mkumba (Sukuma)	Rt	Herb	Chewed as soon as one is bitten	Tanzania	[26]
	Jasminum fluminense Vell.	Mtanyeze (Sukuma), Kolion (Pokot)	L, Rt	CL	Pounded, squeezed in cotton cloth & juice taken twice. Root powder rubbed on bite	Tanzania, Kenya	[26, 33, 34, 41]
	Jasminum mauritianum Bojer ex D.C.	Mandale (Sukuma), Muafu (Nyamwezi)	RB	Herb	Not reported	Tanzania	[23]
	Jasminum schimperi Vatke	Ederut (Ateso)	Rt	Herb	Powder with that of *C. cyphopetalum* applied topically/ decoction drunk	Uganda	[35]
Opiliaceae	*Opilia amentacea* Roxb.	*Mutonga* (Kamba)	Rt	CL	Burnt into charcoal, crushed, mixed with crushed snake teeth and applied to bite. Decoction taken	Uganda, Kenya	[30, 35, 39]
Oxalidaceae	*Oxalis corniculata* L.	Kajjampuni (Luganda), Otunyunyanbuzi	L, WP	Herb	Dried, pounded into powder and smeared on the bite	Uganda	[21, 38]
Passifloraceae	*Adenia cissampeloides* (Hook.) Harms	Lugelogelo (Lusoga)	Rt	Liana	Chewed	Uganda	[24]
	Adenia gummifera (Harv.) Harms	Gale (Luguru), Mugore, Munua Nyoka (Digo)	Rt	CL	Chewed	Tanzania	[26]
	Adenia keramanthus	Kasikimara (Sukuma)	L, Rt	Herb	Not reported	Tanzania	[26, 28]
	Tryphostemma longifolium Hams	Ndimansoka (Sukuma)	Rt	Herb	Chewed and swallowed	Tanzania	[26]
Pedaliaceae	*Sesamum calycinum*	Abal/Emelerait (Ateso), Kilode (Luo)	Rt	Herb	Crush in water and drink/rub juice on the	Uganda	[35]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
					bitten part		
Phyllanthaceae	*Antidesma venosum* E.Mey. ex. Tul.	Chikura (Digo), Mnyamara (Vidunda), Musaga (Swahili)	Rt, Bk	Tree	Chewed. It is a very bitter	Kenya, Tanzania	[26, 89]
	Flueggea virosa (Roxb. ex Willd.) Royle	Olukandwa (Luganda)	Rt	Shrub	Chewed/eaten	Uganda	[21]
	Phyllanthus maderaspatensis	Mkasiri (Mwera)	Rt	Herb	Not reported	Tanzania	[26]
	Phyllanthus ovalifolius Forssk	Elakas (Ateso)	Rt	Shrub	Infusion drunk thrice daily for 3 days/apply topically	Uganda	[35]
	Phyllanthus reticulatus Poir.	Mkwamba-mazi (Swahili, Zaramo)	L	Shrub	Infusion taken	Tanzania	[75]
Phytolacaceae	*Phytolacca dodecandra* L. Hiern	Kupsogotit	L, Fr	Shrub	Burnt, chewed	Kenya	[71]
Poaceae	*Brachiuria reptans* (L.) Gardner	Lukoka (Pare)	WP	Herb	Burnt and ashes applied topically	Tanzania	[75]
	Cynodon dactylon (L.) Pers	Akacwamba	L	Herb	Tie above the affected area	Uganda	[38]
	Cynodon species	Omucwamba	WP	Herb	Tied or pound and smear on the bite	Uganda	[38]
	Imperata cylindrica (L.) P. Beauv	Obiya (Ateso/Luo), Essenke (Luganda), Omushojwa	St, L, Rt	Herb	Decoction drunk 250 ml daily for stem. tied above the affected area. Chewed	Uganda	[21, 24, 35, 37, 38]
	Pennisetum purpureum Schumach	Ekibingo, Urubingo	L, WP	Herb	Decoction drunk, smear the residue on affected area. Plant powder with other herbs is applied on the bite	Uganda, Tanzania	[38, 82]
	Sporobolus pyramidalis P. Beauv.	Alioc (Lango), Nakaselye (Lusoga), Chinswi, Kurumuzya (Kerewe)	Rt, L	Herb	Decoction taken 3 times a day	Uganda, Tanzania	[24, 33, 35]
Polygalaceae	*Polygala wadibomica* Chodat	Kiguru (Sukuma)	Rt	Herb	Chewed and swallowed	Tanzania	[26, 28]
	Securidaca longipedunculata Fresen	Omukondwa (Lusoga), Awee ilila (Lango), Eliloi (Ateso), Mbaso Nengonengo (Sukuma)	L, RB	Shrub	Infusion drunk	Uganda, Kenya, Tanzania	[23, 24, 36, 51, 83, 93]
Portulacaceae	*Portulaca oleracea* L.	Mkoga (Rufiji), Loirabirab (Dorobo)	Rt	Shrub	Chewed, or decoction applied on to wounds	Tanzania	[26]
	Portulaca quadrifida	Bwanda (Luganda)	WP	Herb	Juice added to other plants and drunk	Uganda	[21]
Primulaceae	*Maesa lanceolata* Forssk.	Katera (Luo), Ribotio (Markwet), Mushebeshebe (Luhya)	Rt	Tree	Decoction administered as a follow up for puff adder bites	Kenya	[30, 31, 41]
Pteridaceae	*Pellaea viridis* (Forssk.) Prantl	Not reported	L	Herb	Pulped and rubbed on the bite	Kenya	[30, 31]
Ranunculaceae	*Thalictrum rhynchocarpum* Dillon ex. A. Rich	Ubugomboro (Kinyarwanda)	L	Herb	Juice taken	Rwanda	[94]
Rhamnaceae	*Rhamnus prinoides* L.'Herit	Kinyil (Samburu)	Rt	Shrub	Decoction in soup is taken	Kenya	[95]
	Ziziphus mucronata Willd.	Ilegero (Sukuma), Lang'o (Luo), Nonoiywa (Markwet)	Rt	Shrub	Infusion drunk. Powder used	Kenya, Tanzania	[26, 28, 41, 66]
Rosaceae	*Rubus pinnatus*	Enkenene (Luganda),	L	Liana	Chewed/roasted,	Uganda	[21, 38]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	Willd.	Enkyerere			ground with rock salt and 250 ml drunk thrice daily or powder is smeared on the bite		
	Rubus rigidus Sm	Kawule (Luganda)	L	Shrub	Crush and tie on affected area	Uganda	[37]
Rubiaceae	*Agathisanthemum bojeri* Klotzsch	Chivuma Nyuki, Kivuma Nyuki (Digo), Mvumanyuki (Swahili)	L	Shrub	Chewed	Kenya	[26]
	Catunaregam nilotica (Stapf) Tirvengadum	Mdasha (Zigua), Mwachanguku (Sukuma)	SB	Shrub	Infusion drunk	Tanzania	[96]
	Chassalia buchwaldii K. Schum.	Not reported	Rt	Tree	Not reported	Kenya	[26]
	Gardenia jovis-tonantis (Welw.) Hiern	Geninyet (Maasai)	Rt	Shrub	Infusion taken which leads to heavy vomiting	Kenya	[26]
	Gardenia ternifolia Schumach. & Thonn.	Ekoroi (Ateso), Odwong (Luo), Lukoole, Kawuna (Lusoga)	Rt	Tree	Cold water infusion drunk thrice a day for at least 3 days/applied topically	Uganda	[24, 35]
	Gardenia volkensii K. Schum.	Mogilio (Markweta)	L	Tree	Mixed with those of *P. barbatus* and *E. divinorum.* Powder is applied on incisions	Kenya	[72]
	Hymenodictyon parvifolium Oliv.	Mluhindi (Pare)	L, Rt	Shrub	Crushed and infusion drunk	Kenya, Tanzania	[26, 97]
	Oldenlandia Bojeri Hiern.	Mkuku pingua (Nyamwezi)	L	Herb	Not reported	Tanzania	[23]
	Oldenlandia herbacea (L.) Roxb.	Kayitanseva (Lusoga), Lambula (Lukiga)	Rt	Herb	Not reported	Uganda	[26]
	Pavetta species	Kipolopolo (Hehe)	L	Tree	Decoction taken to induce vomiting	Tanzania	[26]
	Psychotria eminiana (Kuntze) E.M.A. Petit	Mhalah (Sukuma)	Rt	Tree	Chewed when fresh and juice swallowed. Infusion taken and also applied on the bite	Tanzania	[26]
	Tricalysia ovalifolia Hiern	Mpandua Nguku (Sukuma)	Rt	Tree	Chewed when fresh and juice swallowed. Infusion taken and also applied on the bite	Tanzania	[26]
	Vangueria rotundata Robyns	Not reported	Rt	Shrub	Powder mixture with roots of *Markhamia obtusifolia* and *C. mole* applied topically	Tanzania	[64]
	Vangueria tomentosa Hochst.	Mvilu (Shambaa)	Rt	Shrub	Chewed	Tanzania	[26]
	Xeromphis nilotica (Stapf) Keay	Mtutuma (Zaramo), Papa (Makua)	Rt	Shrub	Not reported	Tanzania	[26]
	Xeromphis obovata (Hochst.) Keay.	Mbasho (Zigua)	Rt	Shrub	Not reported	Tanzania	[26]
Rutaceae	*Citrus limon* L. Burm. F	Mliamo	L	Tree	Not reported	Tanzania	[74]
	Citrus sinensis (L.) Osbeck	Enniimu (Luganda), Amacunga (Lango), Mucungwa (Lusoga)	Fr (& fr peel), Rt	Tree	Squeeze out juice and drink. Roots chewed or infusion drunk	Uganda	[21, 24, 35]
	Clausena anisata (Willd.) Hook.f.	Omutanu	L	Shrub	Boil with rock salt and drink 250 ml or dry, grind and smear powder on bite	Uganda	[38]

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
	Fagaropsis angolensis (Engl.) Dale	Omumara (Rutoro)	B	Tree	Decoction taken	Uganda	[98]
	Teclea sansibarensis Engl.	Msjepasjepa (Suaheli).	RB	Shrub	Not reported	Tanzania	[23]
	Toddalia asiatica (L.) Lam	Mururue, Mwikunya (Kikuyu), Ajua (Luo), Mkuro, Chui (Digo), Mdakakomba (Swahili)	RB, Rt, SB	Liana	Infusion taken. Rt juice rubbed onto incisions around the wrists and ankles and taken for snakebite-induced paralysis	Uganda, Kenya	[26, 99]
	Zanthoxylum chalybeum Engl.	Oloisuki (Massai), Eusuk (Ateso), Songoiywa (Markwet)	Rt, St, L	Tree	Rt used with *Senna siamea* Rt. Decoction drunk thrice daily for at least 3 days/applied topically	Kenya, Uganda	[26, 30, 35, 41]
	Zanthoxylum gilletii (De.Wild) Waterman	Sagawatiet (Nandi)	Bk, Rt	Tree	Decoction	Kenya	[27]
Salvadoraceae	*Azima tetracantha* Lam.	Mdanga Ndewe (Swahili), Mwelewele (Nyamwezi)	Rt, L	Shrub	Pounded, rubbed onto the wound. Infusion drunk	Kenya, Tanzania	[23, 26]
Sapindaceae	*Cardiospermum corundum* L.	Tigomi (Samburu), Loitegomi (Dorobo)	Rt	Shrub	Decoction taken. Boiled and mixed with sheep fat and applied to the bite wound	Kenya, Tanzania	[26, 95]
	Paullinia pinnata L.	Mgogote (Sukuma)	L, Rt	Tree	Roots used as a styptic	Tanzania	[26, 28]
	Zanha golungensis Hiern	Ekiya Lo'emun (Ateso)	Rt, St	Tree	Pound, mix with water and drink twice	Uganda	[35]
Sapotaceae	*Manilkara sulcata* (Engl.) Dubard	Mbirizi (Sukuma)	Rt, Fr	Shrub	Fruit extracts taken	Kenya, Tanzania	[26, 53]
Simaroubaceae	*Harrisonia abyssinica* Oliv.	Akere (Lango), Ekeroi (Ateso), Lushaike (Lusoga), Mkoromando (Swahili), Mkussu (Sukuma)	L, Rt	Shrub	Leaf decoction (or with roots)/infusion is taken	Uganda, Kenya, Tanzania	[23, 24, 26, 36, 51]
Solanaceae	*Capsicum annuum* L.	Kamulari (Luo), Emulalu (Ateso)	Fr, L	Herb	Chewed/powdered, mixed with cold water and drunk 3 times a day for at least 3 days/applied topically	Uganda	[35]
	Datura metel L.	Mnanaha (Swahili)	Rt	Shrub	Chewed and the juice swallowed	Tanzania	[26, 28]
	Datura stramonium L.	Yat twol (Lang)	Rt, L, Fr	Shrub	Not reported	Uganda	[36]
	Nicotiana tabacum L.	Taaba (Lango, Luganda, Lusoga), Echimani (Rutoro)	L, R	Herb	Squeeze and tie on the affected area. Eat to vomit the venom	Uganda	[24, 37, 38, 98]
	Physalis minima L.	Akatuutu	L	Herb	Powder smeared on the bite	Uganda	[38]
	Solanum aculeastrum Dunal	Entengo (Luganda), Acokocok lango (Lango)	Fr, Rt, L	Shrub	Eaten immediately	Uganda	[21, 36, 99]
	Solanum aculeatissimum Jacq.	Not reported	Rt, Fr	Shrub	Infusion drunk	Uganda	[57]
	Solanum giganteum Jacq.	Ocok (Luo)	Rt, L	Shrub	Decoction drunk. Powder applied topically. Dry leaf steam inhaled	Uganda	[35]
	Solanum incanum L.	Ocokocok (Lango), Ntonka (Lusoga), Akatengotengo (Luganda), Mutongu	L, St, Fr, Rt, WP	Shrub	Young leaves chewed/rubbed hard/ applied to bite. St/Fr powder applied. Fr sap	Uganda, Kenya, Tanzania	[21, 23, 24, 26, 30, 35, 36, 46,

Plant family	Botanical name	Local name (s)	Part (s)	Habit	Mode of preparation /administration	Country	Authors
		(Kikuyu, Mbeere) Mutongu (Kamba), Ntula (Sukuma)			directly applied. Decoction/infusion taken. WP powder applied to bite		48, 66, 82]
	Solanum micranthum Schltdl	Sigowet	Rt, Fr	Shrub	Burnt or boiled and infusion taken	Kenya	[71]
Thymelaeaceae	*Synaptolepis kirkii* Oliv	Mjirambiri (Digo)	Rt	Shrub	Chewed. Induces vomiting	Kenya	[26]
Velloziaceae	*Xerophyta spekei* Baker	Kianduri	WP	Shrub	Ashes applied to the bite	Kenya	[44]
Verbenaceae	*Lantana camara* L.	Owinybilo (Lango), Kanpanga (Ateso)	Rt, L	Shrub	Decoction taken (250 ml for roots)	Uganda	[51, 57]
Violaceae	*Rinorea elliptica* (Oliv.) Kuntze	Mkerenge (Sukuma), Mshunduri (Swahili)	Rt	Shrub	Chewed and the juice swallowed	Kenya, Tanzania	[26, 28, 53]
Vitaceae	*Cissus hildebrandtii* Gilg.	Msango (Shambaa)	L	CL	Juice used	Tanzania	[23]
	Cissus quadrangularis L.	Sala sala	WP	CL	Not reported	South Sudan	[54]
	Cyphostemma adenocaule	Anuno (Luo)	Rt	Herb	Decoction taken	Uganda	[35]
	Cyphostemma cyphopetalum	Anona (Kumam)	Rt	Herb	Squeezed juice taken	Uganda	[35]
Zingiberaceae	*Aframomum mildbraedii* Loes.	Acaet/Asawot (Ateso), Oceyo (Kumam), Ocayo (Luo)	Rt	Herb	Juice drunk/infusion with *C. cyphopetalum* is drunk/applied topically	Uganda	[35]
	Aframomum sanguineum (K.Schum.) K.Schum	Menyua (Meru), Mtangawizi (Digo), Oseyo (Padhola)	Rt	Herb	Decoction taken	Uganda, Kenya	[26]
Zygophyllaceae	*Balanites aegyptiaca* (L.) Delile	Ng'oswo	NS	Tree	Not reported	Kenya	[81]

Parts used. AP: Aerial parts, Blb: Bulb, Br: branches, Bk: bark, L: leaves, Fl: flowers, Fr: Fruit, MP: Multiple parts, SB: Stem bark, Sd: Seeds, St: stem, RB: Root bark, Rt: roots, WP: Whole plant, NS: Not specified. *Growth habit.* CL: climber

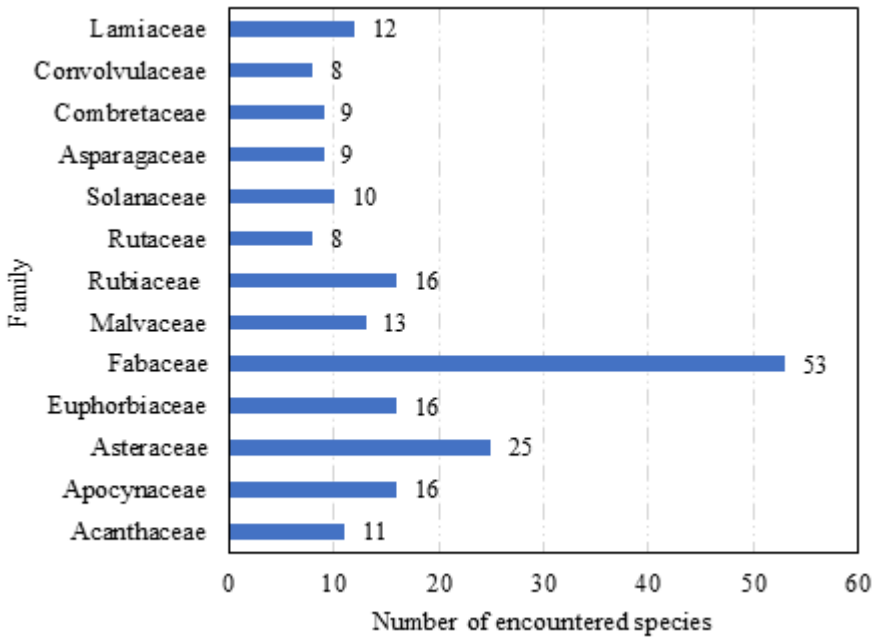

Figure 1: Major botanical families from which antivenom remedies are obtained in East Africa

The genera with the highest recorded number of antivenom plant species in East Africa are *Combretum* (9 species), *Senna* (6 species), *Acacia*, *Commiphora*, *Euphorbia*, *Grewia*, *Solanum*, *Strychnos* and *Vernonia* (5 species each), *Aristolochia, Cassia*, *Indigofera*, *Jasminum* and *Sansevieria* (4 species each). The most used species were *Solanum incanum* L. (11 times), *Combretum molle* G. Don (10 times), *Allium cepa* L. (8 times), *Annona senegalensis* Pers., *Securidaca longipedunculata* Fres., *Steganotaenia araliacea* Hochest. (6 times), *Combretum collinum* Fresen, *Dichrostachys cinerea* L., *Euclea divinorum* Hiern, *Euphorbia tirucalli* L., *Indigofera arrecta* Host. A. Rich., *Imperata cylindrica* (L.) P. Beauv, *Harrisonia abyssinica* Oliv., *Trichodesma zeylanicum* (L.) (Burm.f.) R.Br. (5 times), *Brackenridgea zanguebarica* Oliv., *Cissampelos mucronata* A. Rich., *Entada leptostachya* Harms, *Ficus natalensis* Hochst., *Grewia bicolor* Juss., *Grewia fallax* K. Schum., *Jasminum fluminense* Vell., *Nicotiana tabacum* L., *Ovariodendron anisatum* Verdc., *Solanecio mannii* (Hook.f) C. Jeffrey, *Strychnos innocua* Del., *Zanthoxylum chalybeum* Engl. and *Ziziphus mucronata* Willd. (4 times each).

Out of the plants identified, no plant was reported from Burundi, while Rwanda, South Sudan, Tanzania, Kenya and Uganda had 1, 12, 154, 94, and 162 species reported, respectively. A comparison of plant usage demonstrated that South Sudan and Uganda shared 1 species (*Azadirachta indica* A. Juss.), Uganda and Kenya shared 21 species, Uganda and Tanzania shared 13 species, while Tanzania and Kenya shared 18 species. A total of 10 plant species were recorded to be shared by Uganda, Kenya and Tanzania. The disparity in plant usage across the countries could be due to the choice of medicinal plants utilized by traditional medicine practitioners is based on complex mechanisms [100]. Plant scent and appearance (such as possession of aerial roots reminiscent of a snake) may influence the choice of a plant used in snakebite therapy [35, 101, 102]. In addition, the differences in plant usage are more likely due to the climatic and soil variations that is known to account for variations in species distribution and phytochemical composition of the same plant species in different geographical locations [103]. This disparity could also be due to variations in the knowledge and experiences of antivenom therapy resulting from differences in the social and cultural backgrounds in the East African community [104]. Uganda had the highest number of plant species reported because it had more ethnobotanical reports, two of which reported exclusively on ethnomedicinal plants used in treating snakebites [21, 35] as compared to Tanzania and Kenya which had one study each reporting on antivenom plants only [30, 33].

Habit, used part (s), mode of preparation and use of antivenom plants in East Africa

The herbal remedies are primarily from roots (47.4%) and leaves (27.7%) (Figure 2) of herbs (117 species, 33%), trees (114 species, 32%) and shrubs (102 species, 29%) (Figure 3). In contrast, generative parts such as fruits, seeds, buds, bulbs and flowers which are known for accumulating phytochemicals are not often used and this is in congruence with reports from other countries [105, 106]. The regular use of roots and leaves in antivenom preparations is a characteristic feature of traditional antisnake venom therapy [34, 105, 107]. The frequent use of roots could also be related to the fact that snakebites' effects are internal to the body, is hidden, and so are the roots of plants below the ground. This gives a correlation to the doctrine of signature concept i.e. herbs with shape or colour resemblances to body parts could be used to manage ailments of those body parts [108]. Indeed we identified that this pharmacognostical tenet, first postulated by Paracelsus (1490-1541) [109], existing in East African antisnake venom therapy. *Hugonia castaneifolia* Engl. (a climber) with snake-like crawling characteristics was reiterated as a revered source of herbal remedy for treatment and protection against snakebites in Kenya [87]. In Uganda, Okot *et al*. [35] reported of a herbalist using *Opilia amentacea Roxb*. for treating snakebites because of the scale-like and dotted

appearance of its bark, and its creeping habit. In addition, the same authors identified a case of zoopharmacognosy in snakes using *Microglossa pyrifolia* (Lam.) O. Kuntze [35]. Zoopharmacognosy has been previously reported in chimpanzees in Uganda [110] and led to the identification of important medicinal plants as well as isolation of therapeutic pure compounds [111]. Though the doctrine of signatures has often received scientific criticisms/scepticisms [112, 113], the cases of doctrine of signatures and zoopharmacognosy could be further explored in the identified plants.

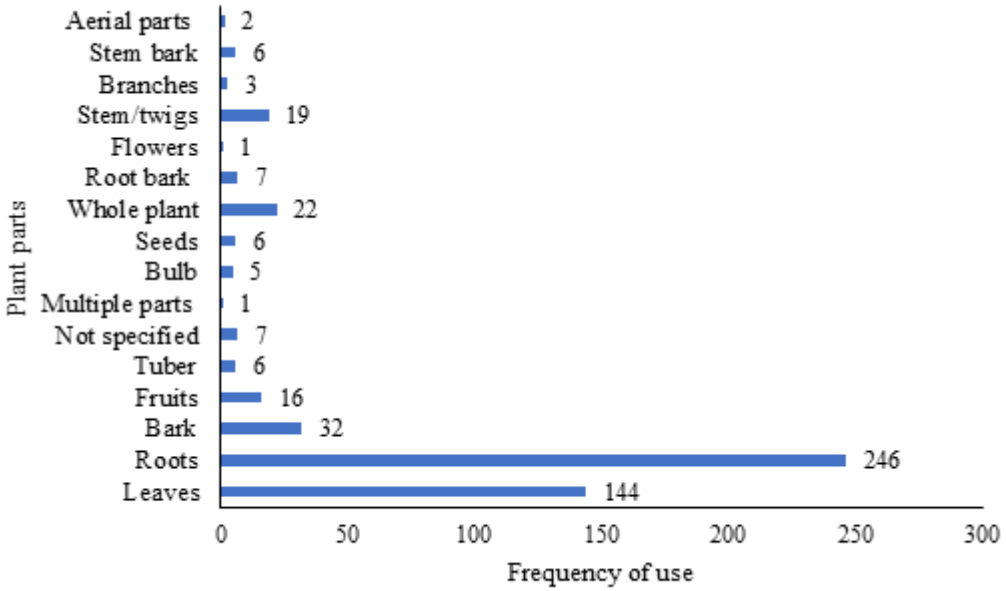

Figure 2: Frequency of the reported plant parts used for preparation of antivenom remedies in East Africa

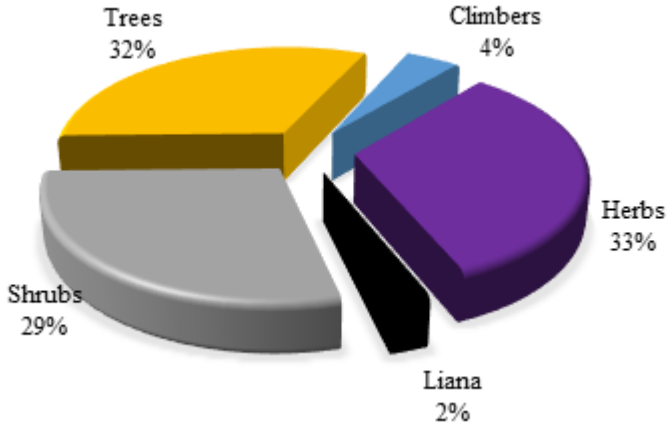

Figure 3: Growth habit of antivenom plants used across East African communities as per reports of ethnobotanical surveys

Indigenous herbal antisnake venom remedies in East Africa are prepared as poultices (30%), decoctions (21%), infusions (20%) or steam (0.4%), though sometimes the collected plant materials are used directly (16%) (Figure 4). Decoctions, infusions, squeezed juices, saps or latexes may be taken orally (47%), applied topically to the bites (34%), eaten/chewed directly, after crushing, drying or pounding (19%). Remedies for topical application as poultices, ointments, and liniments are frequently percutaneous, by rubbing or bandaging which are occasionally complimented by massage. For example, *Combretum molle* leaves are placed on the wound on which has been applied *Senecio lyratipartitus* root powder and banana leaves are

used as bandage. Conversely, antivenom remedies are not usually administered through the nasal route; only *Solanum giganteum* (dry leaves) and *Strophanthus eminii* (root powder) were reported to be administered by inhalation of their steam (0.5%).

Some treatments, however, involve use of spiritual, magical or scientifically unexplainable remedies. *Indigofera arrecta* roots for instance is used with enchantments in the treatment of snakebites in Uganda [38]. For *Toddalia asiatica*, after taking juice from its roots, the victim must also bite the part that was bitten by the snake [26]. Though uncommon, sometimes plant materials and non-plant materials are mixed in the treatment procedures. A citation was made of the inclusion of recipes such as "head of a snake", a thorn and blood from a slaughtered black chicken during the preparation of a potential remedy used for management and protection against snakebites [87]. Snake "teeth" was also reported to be crushed and mixed with powder of burnt *Opilia amentacea* roots and applied topically to snakebite wounds [30].

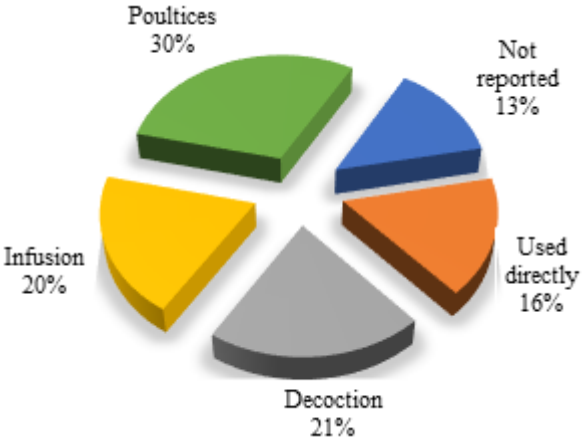

Figure 4: Methods used for preparation of herbal remedies used in treating snake poisons in East African community as per reports of ethnobotanical surveys

Some plants such as *Drimia maritima* (L.) Stearn (bulb) and *Sigesbeckia orientalis* L. (leaves) had their routes of administration indicated in the use reports to hint that internally mediated antivenom effects would be unlikely when such plant remedies are taken orally. Other reported species (13%) did not have details on how they are used in treating snakebites. Furthermore, we noted that some species used for treating snake poisons were also utilized as snake baits or for dissuading snakes. Other species are specifically used for these, rather than being used as antivenom remedies (Table 2). A distinguished example is *Sansevieria intermedia* (leaf sap) employed as a bait for killing snakes in Kenya [70]. Against this background, we emphasize the relevance of capturing fine details of medicinal plants such that knowledge of a traditional use can be more specific (e.g. to alleviate snakebite pains and/or panics or improve the survival of envenomed victims). In some use reports, the administration modes were simply generalized as utilized against/for snakebites. Collection of specific and detailed ethnobotanical data could also aid in the choice of the most appropriate pharmacological tests to use in validating the claimed use of these plants in snakebite treatment.

Table 2: Plants used in East Africa for repelling/killing snakes

Family	Botanical name	Habit	Part used	Mode of use to kill/dissuade snakes	References
Amaryllidaceae	*Allium cepa* L.	Herb	Bulb	Decoction made and sprinkled around the house. Snakes are dissuaded by the citrus smell	[40]

	Allium sativum L.	Herb	Bulb	Decoction made and sprinkled around the house.	[40]
Annonaceae	*Annona chrysopylla* Bojer.	Shrub	Stems, leaves	Not reported	[35]
	Annona senegalensis Pers.	Tree	Stem bark	Not reported	[35]
Apocynaceae	*Carissa spinarum* L.	Shrub	Leaves	Used as a repellent	[52]
Asparagaceae	*Albuca abyssinica* Jacq.	Herb	Whole plant	Planted as a snake repellent	[35]
Asparagaceae	*Sansevieria intermedia* N.E. Brown	Herb	Leaves	Sap used as bait to kill snakes	[70]
Asteraceae	*Tagetes minuta* L.	Herb	Leaves	Its bitter smell causes discomfort and disorientation to snakes when they slither over them	[40]
Euphorbiaceae	*Ricinus communis* L.	Herb	Leaves, whole plant	Its strong smell causes discomfort and disorientation to snakes	[40]
Fabaceae	*Acacia macrothyrsa* Harms	Tree	Roots	Put near the house	[26]
Poaceae	*Cymbopogon citratus* (DC.) Stapf	Herb	Leaves	Decoction sprinkled around the house. Snakes are dissuaded by the citrus smell	[40]
Solanaceae	*Nicotiana tabacum* L.	Shrub	Leaves	Grown in house vicinity or leaves burnt	[40]

Adverse Side Effects and Antidotes of Antivenom Remedies

Most reports encountered on antivenom plants used in East Africa did not mention the side effects of herbal preparations from them when used in treating snake poisons. Nevertheless, herbal preparations from some plants (*Cissampelos truncata*, *Lannea schweinfurthii*, *Lonchocarpus laxiflorus*, *Gardenia jovis-tonantis* and *Synaptolepis kirkii*) were reported to induce violent vomiting [26, 35, 39]. This could be due to the improper posology, toxic phytochemicals or metabolic byproducts of the herbal remedies [114]. Indeed, most of the plants identified as used for treating snake poisons are purgatives or emetics. For example, the *ching'ei* tree (*Euclea divinorum*), *Antidesma venosum*, *Cissampelos truncata*, *Lannea schweinfurthii*, *Senna singueana* and *Toddalia asiatica* are some of the powerful purgatives known in East Africa [26, 39, 89, 95]. It should be emphasized that plant toxicity is important in initiating purgation and emesis which are regarded as the key treatment regimen for removal of snake poisons in East Africa [26, 39].

In some circumstances, antivenom remedies are prepared with other plants or with addition of non-plant materials. For example, *Rhamnus prinoides* root decoction is prepared with soup and taken [95]. This could act as an antidote for the side effects of this plant. Another plausible explanation could be that some side effects of the herbal remedies might be masked through the use of more than one plant (or plant parts). However, East African herbalists are known to use more one plant or plant part as a strategy of keeping secret their actual herbal recipes [115].

Antisnake Venom Activities of Antiophidic Plants Reported in East Africa

To rationalize the antivenin activities of the 361 species identified, data from use reports were inadequate. We assessed scientific evidences in literature to hypothesize and discuss the potential scientific basis for the use of the identified plant species in antivenom therapy. Pharmacological effects of the identified species associated with specific activity against snake venoms were discussed. Most of the reported species (317, 87.8%) we retrieved have no published reports that robustly provide a scientific explanation for their use in treatment of snake poisoning. Only 44 species (12.2%) have been investigated for their inhibitory action against haemolytic, neurotoxic, creatine kinase isoenzyme, 5' nucleotidase, phospholipase A2

(PLA2), lipoxygenase, hyaluronidase, acetyl cholinesterase and phosphodiesterase enzymes from snake venoms (Table 3).

Antigen-antibody interaction is the suggested mechanism of action of venom antidotes. Venom inactivation occurs through precipitation, chelation, denaturing of toxic proteins, adjuvant action, venom enzyme inhibition, antioxidant action or a combination of these mechanisms [7]. *Combretum molle* had ten reports for both topical and internal use of its roots, leaves and root bark. Its aqueous and ethanolic leaf (folium) extracts had 28-113% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with median inhibitory concentration (IC_{50}) of 0.07 ± 0.02 mg/ml for aqueous extracts in anti-hyaluronidase activity inhibition of *N. nigricollis* venom [116]. Other commonly used plants in East Africa such as *Allium cepa*, *Annona senegalensis*, *Securidaca longipedunculata* and *Euphorbia tirucalli* have reports of antivenom activity which justifies their use in antisnake venom therapy (Table 3).

Table 3: Antivenom activities, toxicity and active phytochemicals of some plants used for snakebite treatment in East Africa

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
Acalypha fruticosa Forrsk.	Leaves	Ethanol	Extracts inhibited Indian saw-scaled viper (*Echis carinatus*) venom-induced changes in haematological parameters for rats envenomed with 60 µL/mL of venom. Inhibitory activity (90%) against 5'Nucleotidase, phospholipase A2 (PLA2), hyaluronidase, acetyl cholinesterase and phosphodiesterase enzymes of *E. carinatus* venom tested at 1.25 mL with 50-400 µg of extract	Flavonoids, carbohydrates, cardiac glycosides, proteins, xanthoprotein, phenols, fatty acids, phlobatannins and emodins	[117, 118]
Achyranthes aspera L.	Stem	Water	Extracts significantly inhibited *Bitis arietans* venom PLA2 in an uncompetitive manner and stimulated protease activity i.e. the Michealis Mentens and maximum velocity of *B. arietans* venom protease were significantly increased.	Flavonoids, tannins, steroids, saponins, terpenoids	[119-122]
	Leaves	Water, ethanol	Effectively neutralized Russeli's viper venom induced lethality with a median lethal dose (LD_{50}) of 11 µg/µL, with effective dose (ED_{50}) of 0.3 mg and 1.5 mg for aqueous and ethanolic extracts. PLA2 activity was neutralized at a dose of 0.05 mg and 0.06 mg for aqueous and ethanolic extracts, respectively. Neutralized venom-induced haemolysis in the range of 50-100 µg/µL		
	Leaves, stem	Methanol	A glycoside from it did not counteract the effects of *C. adamanteus* venom even at higher doses (2.4 mg/kg bw)		
	Roots	Methanol	No anti-haemorrhagic/anti-coagulant/anti-PLA2 activities against *Daboia russelli*, *Echis carinatus, Ophiophagus hannah* and *Naja kaouthia* venoms		
Aerva lanata	Leaves	Acetone	Anti-PLA2 and anti-coagulant activities at 10 µL and 30 µL against *Naja naja* venom. The extract was able to inhibit four times the minimum coagulation dose with coagulation time of 238.0 ± 0.7 s	Triacontane, octacosane, heptacosane, tetratetracontane, docosane, heneicosane, 1.2-benzenedicarboxylic acid, Bis(2-methylpropyl) ester, heptadecane.9-hexyl-, Corynan-17-ol,18,19-didehydro-10-methoxy-, acetate (ester)	[123]

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
Allium cepa L.	Bulb	Methanol	Cardioprotective activity (14.8 ± 1.65 units/L) on creatine kinase isoenzyme levels to neutralize snake envenomation in experimental rabbits. Concentrations (< 160 µg/mL) stabilized human red blood corpuscles membrane (antihemolytic) against *N. naja karachiensis* venom, though elevated concentrations were cytotoxic. Provided 50% protection from *N. naja karachiensis* PLA_2 in terms of an increase in pH of an egg yolk suspension. Neutralized the anticoagulant effect induced by weak PLA_2 enzymes in *N. naja karachiensis* venom (76% inhibition, coagulation time of 106±0.57 s). Quercetin is a potent inhibitor of lipoxygenase	Quercetin (**1**), sulfurous volatile oils, oleanolic acid (**2**), protocatechuric acid (**3**)	[124-128]
Allium sativum L.	Bulb	Methanol	Hepatoprotective activity (49.00 ± 5.01 and 82.50 ± 18.55 units/L of aspartate aminotransferase and alanine aminotransferase against 52.50 ± 3.51 and 69.50 ± 18.55 units/L for standard antiserum) assessed in rabbits. Provided 50% protection from *N. naja karachiensis* PLA2 in terms of an increase in pH of an egg yolk suspension. Neutralized the anticoagulant effect induced by weak PLA2 enzymes in *N. naja karachiensis* venom (40% inhibition, coagulation time of 115±1.52 s).	Quercetin **(1)**, scordinines A, B allicin, thiosulfinates, 2 mercapto-L-cysteines, anthocyanins, alliinase, polysaccharides, sativin I, sativin II, glycosides of kaempferol	[124, 126, 127]
Annona senegalensis Pers.	Leaves, roots	Methanol	Extracts inhibited *Echis ocellatus* (Viper) venom activities. Root extract reduced hyperthermia and directly detoxified snake venom by 16–33% in rats against cobra (*N. nigricotlis nigricotlis*) venom. Extracts had IC_{50} of 2.84± 3.90 mg/ml for hyaluronidase activity inhibition of *B. arietans* venom. Extract had LC_{50} of 232.7 µg/ml in brine shrimp test.	Not reported	[116, 129, 130]
Asystasia gangetica L.	Leaves	Methanol	A concentration of 1000 mg/kg provided 80% protection against *N. melanoleuca* venom (PLA_2)	Flavonoids, saponins and tannins	[107]
Azima tetracantha Lam.	Leaves	Ethyl acetate	Extracts had significant inhibitory effect on phosphomonoesterase, phosphodiesterase, PLA2 and acetylcholinesterase enzymes from *Bungarus caeruleus* and *Vipera russelli* venoms in a dose dependent manner with concentrations ranging from 43.98 –340.1 µg/mL. Inhibited 5' nucleotidase, phosphodiesterase and hyaluronidase activities of *B. caeruleus* venom completely at 100, 100 and 500 µg/mL with IC_{50} of 55.9, 43.98 and 210.8 µg/mL, respectively. Inhibited acetylcholinesterase enzyme activity of *B. caeruleus* venom by 80% at 400 µg/mL with IC_{50} of µg/mL	Flavonoids, phytosterols, proteins	[131-133]
Azadirachta indica	Leaves	Methanol	Inhibited cobra venom (*Naja naja* and *Naja kaouthia*) and *Daboia russelli* venom PLA2 enzymes in a dose-dependent manner. Inhibited catalytic and other activities of cobra and Russell's viper venoms. Unidentified compound (AIPLAI) inhibited purified *N. kaouthia* PLA2 enzymes in a non-competitive manner	Purified unidentified non-terpenoidal *A. indica* PLA2 inhibitor (AIPLAI)	[134-136]

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
		Methanol, water	Extracts prolonged either the survival time(s) of mice, when injected immediately after the administration of *Naja arabica* and *B. arietans* venoms with LD_{50} of 0.180, 1.25 and 0.40 mg/kg, or the clotting time of citrated blood plasma with each venom.		
		Hexane, ethyl acetate	Pooled hexane fraction 3 (PHF3) and ethyl acetate fraction 1B (PEF1B) from the hexane and ethyl acetate fractions, respectively protected envenomed albino rats from death at a dose of 20 mg/kg body weight (bw) against 0.8 mg/kg bw of *N. nigricollis* venom. Fractions at 1 mg/ml of the venom inhibited 86.6% and 89.8% PLA2 activity		
Balanites aegyptiaca (L.) Del.	Stem bark	Acetone, methanol	Extracts afforded 100% protection against *E. carinatus* venom (with lethal dose of 0.194 mg/ml) administered intramuscularly to Wistar rats at 75 and 100 mg/ml	Saponins, tannins, terpenes, volatile oils, phytosterols, glycosides, flavonoids, proteins, carbohydrates, steroids	[137, 138]
	Leafy branches, fruits	Water	Seed oil displayed significant inhibitory action against the lethal toxic and inflammatory effects of *V. russellii* venom (LD_{50} of venom = 0.30 mg/kg). The ED_{50} of the oil in both oil and venom pre-treated mice were 0.2 ml each, with Therapeutic Index of 1.75.		
Bidens pilosa L.	Leaves	Water	Weakly antagonized the *Dendroaspis jamesoni* venom and did not potentiate antivenom lpser Afrique (SAV)	Not reported	[139]
Calotropis procera	Exudate, flowers	Methanol	Afforded 44% and 76% inhibition of *N. naja karachiensis* venom PLA2 enzyme activity, respectively	Resins, tannins, calotropin, sterol, uscharin, calotropagenin, calotoxin, and calactin	[124]
Capparis tomentosa Lam.	Radix	Water, ethanol	Afforded 37-114% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.13 mg/ml for ethanolic extracts in anti-PLA2 activity of *B. arietans* venom	Not reported	[116]
Carica papaya L.	Cortex	Water, ethanol	Caused -2 to 15% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms	Not reported	[116]
Carissa spinarum L.	Leaves	Methanol	Activities of acetylcholinesterase, PLA_2, hyaluronidase, phosphomonoesterase, phosphodiesterase, 5- nucleotidase from *B. caeruleus* and *V. russelli* venoms were inhibited by 100 µg/ml of the extract	Steroids, flavonoids, tannins, saponins, alkaloids, ursolic acid (**4**)	[140]
Cassia occidentalis L.	Leaves, roots	Ethanol	Stimulated angiogenesis, inhibited epidermal hyperplasia, acted positively on wound healing progress and minimized local effects caused by *Bothrops moojeni* venom	Not reported	[141]
Cissampelos mucronata	Herba	Water, ethanol	Had 2-120% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.15±0.02 mg/ml for aqueous extracts in anti-PLA2 activity of *N. nigricollis* venom	Not reported	[116]
Cissampelos pareira L.	Aerial parts (leaves, flowers, tender stems), roots	Water, ethanol	Ethanolic leaf extract (70%) was effective against anxiety-like behaviours. No anti-PLA2 activity for ethanolic root extract. Aerial parts neutralized proteolytic activity of *Bothrops diporus* venom. No inhibitory activity observed for aqueous leaf extracts against haemorrhagic and proteolytic activities from *Bothrops asper* venom. Ethanolic root extracts	Quercetin-3-O-sophoroside (**5**), naringenin 7-O-β-D-glucoside (**6**), eriodictyol-7-O-β-D-glucoside, galangin-7-glucoside **(7)** and baicalein-7-O-glucoside (oroxin A) **(8)**	[142-145]

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
			(200, 400 mg/kg) exhibited significant anti-inflammatory activity		
Citrus limon L. Burm. F	Root, ripe fruits	Methanol	Neutralized the coagulant effect induced by weak PLA2 enzymes in *N. naja karachiensis* venom (64% inhibition, coagulation time of 109±1.00 s). *In vitro* inhibitory activity reported against the lethal effect of *Lachesis muta* venom with ED_{50} of 710 µg of extract per mouse.	d-x-pinene camphene, d-limonene, linalool **(9)**, ichangin 4-β-glucopyranoside, nomilinic acid, 4-β-glucopyranoside	[127]
Combretum molle	Folium	Water, ethanol	28-113% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.07 ±0.02 mg/ml for aqueous extracts in anti-hyaluronidase activity inhibition of *N. nigricollis* venom.	Not reported	[116]
Commiphora africana (A. Rich.) Engl.	Stem bark	Methanol	Crude extract 200, 300 and 400 mg/kg incubated each with LD99 (9.70 mg/kg) of the venom) protected treated mice from lethality of *N. nigricollis* venom while n-butane fraction at 200, 400 and 600 mg/kg offered 20%, 60% and 80% survival, respectively. Ethyl acetate, saponin-rich and flavonoid-rich fractions inhibited PLA2 activity of *N. nigricollis* venom with IC_{50} values of 21.36, 26.47 and 17.52 µg/mL, respectively	Not reported	[146, 147]
Cynodon dactylon	Roots	Water	Exhibited remarkable antihemolytic potential (84.3% to 90.6%) against crude *N. naja* venom at 200 to 1,500 µg/ml	7αHCyclopenta[a]cyclopropa[f]cycloundecene2,4,7,7a,10,11hexol,1,1α,2,3,4,4α,5,6,7,10,11,11α-dodecahydro1,1,3,6,9pentamethyl,2,4,7,10,11pentaacetate (**a**), α-D-Glucopyranoside,O-α-D-glucopyranosyl-(1.fwdarw.3)-α-D-fructofuranosy (**b**), 9-Octadecenoicacid(2-phenyl1,3dioxolan4yl)methylester **(c)**, 9,10-Secocholesta-5,7,10(19)-triene-1,3-diol,25-[(trimethylsilyl)oxy]-,(3α,5Z,7E) **(d)**,Octasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13,15,15hexadecamethyl **(e)**, 9-Oximino2,7diethoxyfluorene **(f)**, Hexadecanoicacid,1-(hydroxymethyl)-1,2-ethanediylester **(g)**, Hexasiloxane,1,1,3,3,5,5,7,7,9,9,11,11-dodecamethyl **(h)**, Heptasiloxane,1,1,3,3,5,5,7,7,9,9,11,11,13,13-tetradecamethyl **(i)**, Estra-1,3,5(10)-trien-17α-ol **(j)**	[148]
Dichrostachys cinerea L.	Folium	Water, ethanol	Provided -1% to 19% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.09±0.02 mg/ml and, 0.26±0.04	Not reported	[116]

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
			mg/ml and 0.08±0.02 mg/ml for ethanolic, aqueous and ethanolic extracts in anti-PLA2 and anti-hyaluronidase activities of *B. arietans* and *N. nigricollis* venoms, respectively		
Echinops amplexicaulis Oliv.	Roots	Not specified	A novel crystalline caffeic acid from roots has antivenom agents for hemolytic snake venoms	A novel crystalline caffeic acid	[149]
Euphorbia hirta L.	Whole plant	Methanol	LD_{50} not specified against *N. naja* venom. Reduced PLA2 activity at 200 µM it by up to 96%.	Quercetin-3-O-rhamnoside **(10),** terpenoids, alkaloids, steroids, tannins, flavonoids, phenolics	[150, 151]
	Leaves	Ethanol	LD_{50} of extract is > 5000 mg/kg. Extracts (250 mg/kg bw) decreased clotting and bleeding times (from 1.40 ± 0.30 s to 1.20 ± 0.10 s and 1.90 ± 0.43 s to 0.90 ± 0.33 s) in mice envenomed with *N. nigricollis* venom (LD_{50} = 1,414.21 µg/ml). Extract with that of *Portulaca oleracea* reduced clotting and bleeding times to 1.10 ± 0.10 s and 0.50 ± 0.23 s. Extract at 250 mg/kg bw afforded 100% survival of mice with 5- and 10-minute delay after venom administration		
Gloriosa superba L.	Tuber	Methanol	Protective activity against the lethal action of rattlesnake (*C. adamanteus*) venom administered to mice experimentally envenomed with 2.5–15 µg/kg bw of venom	Esters	[121]
Tephrosia purpurea	Roots	Methanol	Flavonoids fraction showed a moderate neutralizing effect of *C. adamanteus* venom	Flavonoids	[121]
Indigofera capitata Forsk.	Whole plant	Methanol, ethanol, water	Extracts reduced bleeding and clotting times in *N. nigricollis* envenomed rats. Ethanol and aqueous extracts were more effective at 300 mg/kg with lowest clotting time of 174.00 ± 3.67 s and 1000 mg/kg with lowest bleeding time of 228.00 ± 3.00 s. Oedema forming activity was inhibited by ethanol and aqueous extracts, effective at higher doses of 300 mg/kg (ethanol extract) and 1000 mg/kg (aqueous extract) with lowest oedema forming activity of 108.80 ± 1.90 and 102.00 ± 1.90% mm, respectively	Flavonoids, phenolics, steroids, triterpenes, anthraquinones, alkaloids	[152, 153]
		Petroleum ether, ethanol, water	Extracts had LD_{50} values of 774.6, 1131.4 and 3807.8 mg/kg, respectively. Dose-dependent oedema forming activity reported against *N. nigricollis* envenomed rats. Highest reduction in oedema forming activity of the extract were at 300 mg/kg (ethanol) and 1000 mg/kg (aqueous) with lowest edema forming activity of 108.00 ±1.90 and 102.00 ± 1.90 %mm, respectively		
Jatropha carcus L.	Leaves (latex), seeds	Methanol, water, ethanol	Methanolic extract inhibited haemolytic activity of PLA2 from *N. naja* venom. Aqueous and ethanolic extracts had -10 to 21% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms, respectively	Terpenoids, alkaloids, phenolics, flavonoids, saponins	[116, 154]
Maesa lanceolata Forssk.	Cortex	Water, ethanol	Provided 6-144% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.11±0.01 mg/ml and 0.10±0.01 mg/ml for ethanolic extracts in anti-PLA2 and anti-hyaluronidase activities of *B. arietans* and *N. nigricollis* venoms, respectively	Not reported	[116]

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
Moringa oleifera Lam	Leaves	Water, methanol	LD_{50} of *N. nigricollis* and *B. arietans* venoms in albino rats were 1.0 and 1.5 mg/kg, respectively. The extracts ameliorated *B. arietans* venom-induced hypernatremia and hypercalcemia. Haemorrhagic, haemolytic and coagulating activities of the venoms were inhibited in a dose dependent manner by the extracts. Extracts effectively neutralized *Russelli viper* venom-induced lethality (LD_{50} = 10.9 µg) at 10 µg/mice and 300 µg/mice (ED_{50}), respectively. Both extracts neutralized venom-induced haemolysis (50-100 µg). Inhibitory concentrations against PLA2 activity exhibited by aqueous and methanolic extracts were 0.06 mg and 0.07 mg, respectively. In procoagulant activity inhibition studies, the effective doses in neutralizing effect of Saw scaled viper venom was 1 µg for both extracts.	Saponins, alkaloids, tannins and flavonoids	[155-157]
Musa paradisiaca L.	Exudate/juice	Used directly	Exudate had no antivenom activity singly but mixing it with the venom (1:1) showed 100% inhibition of PLA2 activity of *Bothrops jararacussu* and *Crotalus durissus terrificus* venoms, as well as neutralized significantly the haemorrhagic activity induced by *B. jararacussu* venom	Polyphenols and tannins	[158]
Paullinia pinnata L.	Root bark	Water	LD_{50} of venom and extract were 1.5 and 1,200 mg/kg respectively. Extract at 400 mg/kg presented a weak antivenom activity against Carpet viper (*E. carinatus- ocellatus*) venom. Effective dose (ED_{50}) was estimated as 300 mg/kg (i.p) and > 400 mg/kg (p.o) in treated mice	Carbohydrates, saponins, steroids and tannins	[159]
Portulaca oleracea L.	Leaves	Ethanol Water	LD_{50} of extract was > 5000 mg/kg. Extracts (250 mg/kg bw) decreased clotting and bleeding times (from 2.20 ± 0.10 s to 1.40 ± 0.29 s and 1.90 ± 0.43s to 0.80 ± 0.18 s) in mice envenomed with *N. nigricollis* venom (LD_{50} = 1,414.21 µg/ml). Extract with that of *Euphorbia hirta* reduced clotting and bleeding times to 1.10 ± 0.10 s and 0.50 ± 0.23 s. Extract at 250 mg/kg bw afforded 100% and 80% survival of mice with 5- and 10-minute delay after venom administration. Anti-PLA2 activity showed that 1ml of 500 µg/ml of extract neutralized the toxic effects of 1ml of 200 µg/ml of *N. nigricollis* venom.	Not reported	[160, 161]
Pupalia lappacea Juss	Herba	Water, ethanol	Provided 28-113% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.10±0.07 mg/ml for aqueous extracts in anti-hyaluronidase activity inhibition of *N. nigricollis* venom.	Not reported	[116]
Ricinus communis L.	Roots	Methanol	No anti-haemorrhagic/anti-coagulant/anti-PLA2 activities against *D. russelli*, *E. carinatus, O. hannah* and *N. kaouthia* venoms	Not reported	[122]
Securidaca longipedunculata Fresen	Root bark, leaves, roots	Water	Root bark extract neutralized *N. nigricollis* Hallowel venom at 300 mg/kg bw with 100% survival. Leaf extract had lower antivenom activity with 33.33% mortality at 300 mg/ml. Combined root bark and leaf extracts afforded	Not reported	[162, 163]

Plant	Part used	Solvent	Antivenom activity and toxicity of extracts	Reported chemical constituents	Author(s)
			66.67% survival at 300 mg/ml and 33.33% mortality at 200 mg/ml. Root bark and leaves were not toxic at 200 and 300 mg/ml bw, respectively. Root extracts produced a significant dose-dependent alteration in the serum enzymes (alanine aminotransferase, aspartate aminotransferase, alkaline phosphatase, creatinine kinase, lactate dehydrogenase, and amylase) and urea.		
Securinega virosa (Roxb.) Baill.	Leaves	Hexane, ethyl acetate, methanol	Hexane extract provided protection against lethal dose of *N. nigricollis* venom (significant at 20 mg/kg). Afforded -29% to 127% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.17±0.01 mg/ml and 0.13±0.00 mg/ml for ethanolic extracts in anti-PLA2 and anti-hyaluronidase activities of *B. arietans* and *N. nigricollis* venoms, respectively.	Not reported	[116, 164]
Strychnos innocua Delile	Folium	Water, ethanol	Afforded 28-113% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.10±0.07 mg/ml for aqueous extracts in anti-hyaluronidase activity inhibition of *N. nigricollis* venom	Not reported	[116]
Strychnos spinosa Lam.	Radix	Water, ethanol	Exhibited -1 to 29% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms	Not reported	[116]
Tamarindus indica L.	Seeds	Ethanol, water	Extract inhibited PLA2, protease, hyaluronidase, L-amino acid oxidase and 5'-nucleotidase enzyme activities of *V. russelli* venom in a dose-dependent manner	Not reported	[165, 166]
Xeromphis nilotica (Stapf) Keay	Stem bark	Water	Extract had LD_{50} of 1000 mg/kg. LD_{50} of *N. haje*, *N. katiensis*, *N. nigricollis*, *E. ocellatus* and *B. arietans* venoms in Wistar rats were 0.22, 0.55, 0.87, 1.24 and 1.80 mg/kg, respectively. Extracts afforded 100% and 85.7% protection against *N. nigricollis*, *N. haje*, *N. katiensis, E. ocellatus* and *B. arietans* venom, respectively	Carbohydrates, glycosides, steroids/triterpenes, cardiac glycosides, saponins, glycosides and alkaloids	[167]
Zanthoxylum chalybeum Engl.	Roots	Water	Silver nanoparticles synthesized using the extracts inhibited digestion of albumin by *B. arietans* venom with 100% inhibition of proteolytic activity achieved with 3.28 mg/L of silver nanoparticles	Not reported	[12]
Ziziphus mucronata Wild	Radix	Water, ethanol	Afforded 82-137% inhibition of hyaluronidase, PLA2 and proteolytic activities of *N. nigricollis* and *B. arietans* venoms with IC_{50} of 0.30±0.02 mg/ml for ethanol extracts in anti-hyaluronidase activity of *N. nigricollis* venom	Not reported	[116]

i.p: intraperitoneally, p.o: per os (by mouth)

The most used plant (*Solanum incanum*) had no report of antivenom activity. Another member of this family (*Nicotiana tabacum*) had two use reports of its leaves and roots for both topical application and internal use. *N. tabacum* is a recreational herb whose effects was established to be due to the presence of the alkaloid: 3-(1-methyl-2-pyrrolindyl) pyridine (nicotine) [168].

The alkaloid is known to regulate cholinergic neurotransmission by interacting with nicotinic acetylcholine receptors (nAChRs) and was previously reported to possess neuroprotective potential [169]. Venoms such as α-cobrotoxin reported in cobras (*Naja* species) are neurotoxic because they inhibit nAChRs [170]. It is against this background that oral administration of *N. tabacum* in treating snake poisons may have a rationale because nicotine has anti-nAChR effects that could explain its ability to neutralize anti-cholinergic effects of snake venoms.

In addition, the antisnake venom activity of some of the plants identified could be mediated through their antioxidant, anti-allergic, analgesic, anti-inflammatory, anti-pyretic, anti-anxiety and anti-anaphylactic activities [171]. For example, via antioxidation, plant secondary metabolites antagonize oxidative damage by PLA2 through selective binding to the enzyme active sites or modifying the conserved residues required for PLA2 catalytic activities [172].

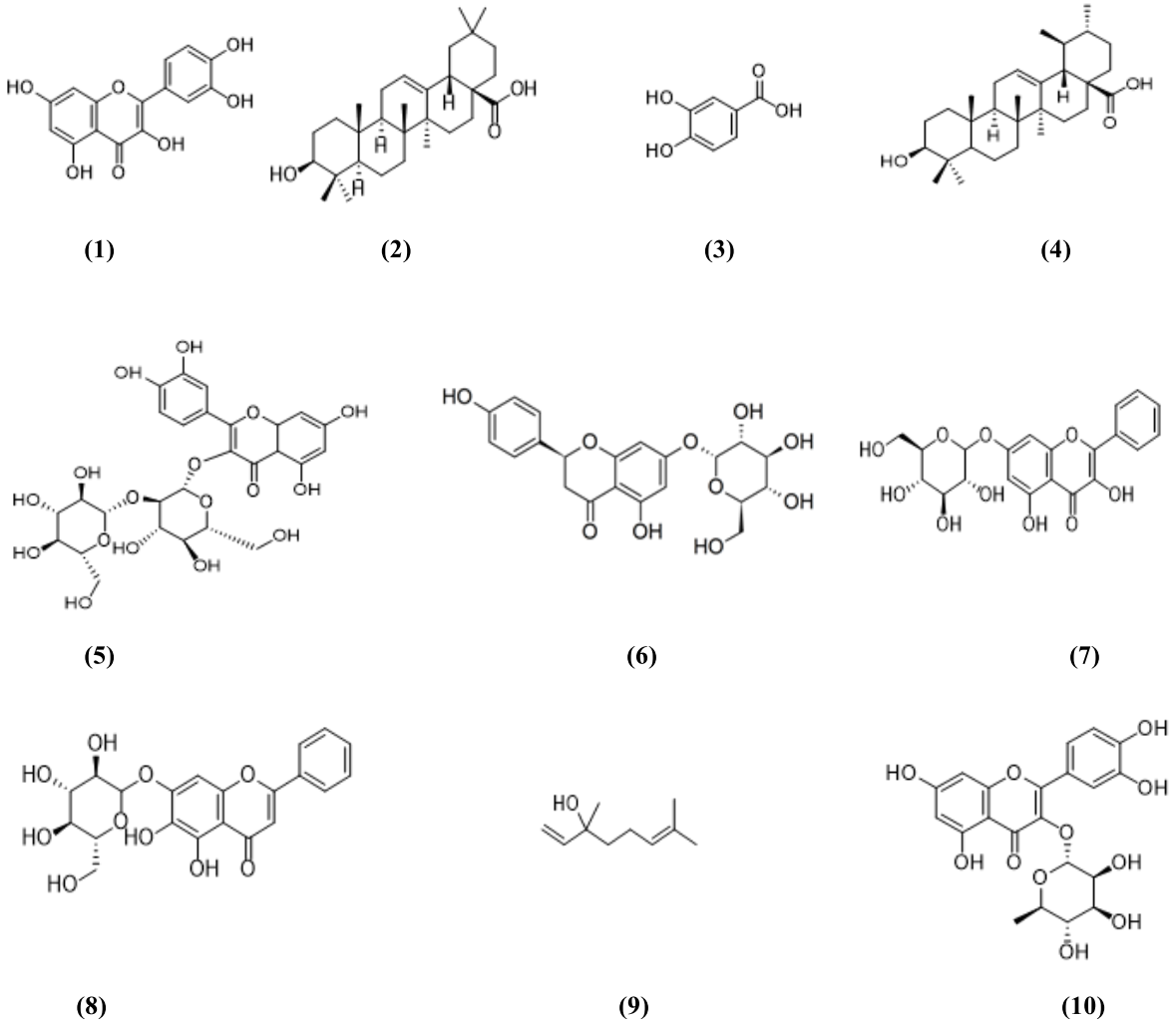

Figure 5: Some of the molecules characterized from extracts of antisnake venom plants reported in East Africa. The numbers **1-10** refers to the molecules mentioned in **Table 3**

The secondary metabolites responsible for plant antivenom activities have been identified to be majorly flavonoids, terpenoids, alkaloids, steroids, tannins and phenolics. Of these, flavonoid compounds such as quercitrin, quercetin (**1**), quercetin-3-O-rhamnoside (**9**) (Figure 5) have been reported to possess significant inhibitory activity against PLA2

enzymes from snake venoms [173-175] with 42% and 96% inhibition at 200 µM, respectively [150, 176]. Higher PLA2 inhibitory activities of quercetin glycosides has been ascribed to the presence of the sugar moiety [150, 175]. Quercetin glycosides interact with Gly30, Gly32, His48 and Asp49 residues in the substrate binding site of PLA2, affording inhibition of its activities [175]. Further, molecular docking studies has reported that these inhibitory activities are due to the formation of hydrogen bonds, polar interactions and hydrophobic interactions, which suggested that other flavonoids with analogous structures to that of quercetin and quercetin-3-O-rhamnoside could be potential PLA2 inhibitors [176].

It is important to note that antivenom efficacy of plant extracts is contingent on the extraction solvent employed. Methanol and ethanol have been the solvents of choice in most studies, probably due to their ability to dissolve both polar and organic phytochemicals [7]. Though some studies used water as the solvent of extraction, organic extracts tended to exhibit higher antivenom activities than the aqueous extracts. A recent study [12] highlighted that silver nanoparticles from aqueous root extracts of *Zanthoxylum chalybeum* completely inhibited the proteolytic activities of *B. arietans* venom at 3.28 mg/L of silver nanoparticles. This provides an insight into a theme that could be further explored as nanoparticles have increasingly become of interest in the management of various diseases.

Conclusion

In this work, we retrieved 361 plant species reported as traditional therapies for snakebites in East Africa. The study also identified distinct cases of doctrine of signatures and zoopharmacognosy in snakes using *Opilia amentacea*, *Hugonia castaneifolia* and *Microglossa pyrifolia* which could be further explored. Only 44 species (12.2%) of the 361 identified species have been evaluated globally for their antivenom activity, with most species found to be effective in reversing the lethal actions of snake venoms. Future studies are required to assess the efficacy of the claimed unstudied species and their active phytoconstituents. Emphasis should be put on the conservation and cultivation of antivenom plants with high use frequency.

Abbreviations

C. adamanteus: *Crotalus adamanteus*, IC_{50}: Half maximal concentration; LD_{50}: Median lethal dose, LD_{99}: Minimum lethal dose, *N. naja: Naja naja*, PLA2: phospholipase A2, *V. russelli*: *Viper russelli.*

Competing interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Conflict of Interest

We have no conflicts of interest to disclose.

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