Ethnomedicinal Plants Used for the Treatment of Rabies in Ethiopian Traditional Medical Practices: a review

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Research Article

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Abstract

Background

Rabies is a zoonotic disease affecting a wide range of wild and domestic animals, including livestocks.It is a major public-health problem which presents huge economic and health burdens in most parts of the developing world. The objective of this review was to prepare a compiled checklist of medicinal plants used traditionally for the management of rabies from various ethnobotanical, ethno pharmacological, and related studies in Ethiopia.

Methods

A website-based search strategy was employed. Databases (PubMed, Google Scholar, Research Gate, Medline, Scopus, Web of Science) were searched for published studies. The search items used were“medicinal plants”, “traditional medicines”, and “Ethiopia or Indigenous people.” A descriptive statistical method, percentage and frequency were used to analyze ethno-botanical data on reported medicinal plants and associated indigenous knowledge. The results were presented using charts and tables.

Results

Eighty medicinal plant species which belong to 43 families and 68 genera were found to be used in the treatment of rabies in Ethiopia. Those medicinal plants were distributed in Amhara, Oromia and Southern nation, nationalities and peoples of Ethiopia.Cucurbitaceae and Euphorbiaceae, represented by 7 species (8.75%), Solanaceae represented by 6 (7.5%) species. *Phytolacca dodecandra* and *Justicia schimperiana*were the most used/cited plant species. The habit forms of the plant species were herbs 18 (22.5%), shrubs 17 (21.25%) and while the most commonly used parts of the plant were 42% roots and 15% leaf.

Conclusions

According to the review there are many medicinal plants for the treatment of rabies. It is recommended to perform phytochemical screening for most reported plants.Ethiopia requires an enforceable policy that protects wild medicinal plants and policy incentives for the cultivation of medicinal plants to reduce overexploitation.

1. Introduction

Rabies is the most serious zoonotic disease of virus which is released in the saliva of infected animals that someone might encounter[1, 2].Rabies virus belongs to the order Mononegavirales, family

Rhabdoviridae, and genus lyssavirus. Despite the invention and application of the first rabies vaccine by Louis Pasteur in 1885, human rabies, is still deadly disease globally [3].It affects a wide range of wild and domestic animals, including livestocks [4]. Domestic dogs are the main sources of exposure and primary transmitter of human rabies, especially in African and Asian where there is no or inadequate dog rabies control strategies [5].The animal usually contracts rabies from the bite of an infected animal. The virus may also enter the body if the mucous membranes (the wet part of the eyes, nose, or mouth) or a scratch or break in the skin have contact with saliva containing the rabies virus [1]. Once the rabies virus enters the body, it begins to multiply in the area near the entry site [1, 6].

Rabies is estimated to cause 59,000 human deaths peryear globally. It also causes about 3.7 million disabilityadjusted life years (DALYs) burden and 8.6 billion USDeconomic losses per year in the world [7].Most human deaths due to rabies occur in developing countries of Asia and Africa [8]due to the presence of endemic canine rabies and dogs remain the major animal reservoirs in such areas [9].Of these, Ethiopia is one of the worst affected [7].Canine rabies continued to be a serious problem in Africa, including Ethiopia [10]. Although there are no formal studies, it is estimated that there is one owneddog per five household nationally [1]. The highest number of rabies cases wasreported in cold season (June to September) in Ethiopia. This is most probably due to massgathering and highest reproduction of dogs during the period which increases the contactbetween rabid and health dogs [11].

Rabies is a major public-health problem which presents hugeeconomic and health burdens in most parts of the developing world[12]. The disease is known to cause large number of deaths in humansand animals each year [2]. An estimatedof US $583.5 million (most of which is due to the cost of post exposure prophylysis was annually spent in Africa and Asia due to rabies andthe annual cost of livestock losses due to rabies is estimated to be US$ 12.3 million in these continents [13].An estimated 10 million peopleworldwide receive post-exposure treatment after being exposed toanimals suspected of rabies [12].

The Ethiopian Health and Nutrition ResearchInstitute, the current Ethiopian Public Health Institute, indicated that human rabies has been reported in Ethiopia in1903 for the first time. A national surveillance data conducted from 2007 to 2012 showed that 15,178 exposurecases (3.4/100,000), 272 fatal cases with more than 88% ofthe exposure cases were due to dog bites [14].

Insufficient supplies of drugs, cost of treatments, side effects of synthetic drugs, and the development of drug resistance have led to the increasing use of plant materials. Medicinal plants have made a significant contribution to the primary healthcare of people around the world.It is estimated that 80% of the African people depend on traditional medicine to meet up their care needs [15].There are about 6,500 to 7,000 speciesin Ethiopia, with approximately 12% of these endemic[16]. Approximately 80% of humans and 90% of the livestock population rely on traditional medicinal plants to cure different ailments in Ethiopia [17].The search for antiviral agents that are selectively virucidal remains a goal. In this regard, the potential of medicinal plants, especially those employed in indigenous medicineis believed to be verysignificant in providing novel antiviral compounds or prototypes [18].Therefore, the aim of the current

review was to prepare a compiled checklist of medicinal plants used traditionally for the management of rabies from various ethnobotanical, ethno pharmacological, and related studies in Ethiopia.

2. Methods

2.1. Search Strategies

A website-based search strategy was employed. Databases (PubMed, Google Scholar, Research Gate, Medline,Scopus, Web of Science) were searched for published studies done on ethnomedicinal plants in Ethiopia. Additional articles were also searched from the reference lists of retrieved articles. No restriction was applied on the year of publication, methodology, or study subjects.The resource materials were collected between January-March, 2021.A literature search was done using specific search terms such as “medicinal plants”, “traditional medicines”, and “Ethiopia or Indigenous people.” After identifying potential literatures, searched if there is a report of medicinal plants used for treatment of rabies in the region where the study was carried out.Moreover, literature search was also done to document the biological and pharmacological activities of the mostly used plant species for treatment of rabies. A total of 49 published papers were reviewed that provided information about the use of medicinal plant species to treat rabies diseases in Ethiopia. The plant names were directly extracted from the literature and validated using the website (http://www.theplantlist.org).

2.2. Selection Criteria

Published ethnobotanical, ethno pharmacological, and ethno medicinal surveys reporting on the use of plants for rabies and conducted at any time in Ethiopia were included in the review. Review article, unpublished data, non-open accessed and abstract-only articles, historical documents, and experimental studies as well as plants of unknown locations and scientific names were excluded from the review. Availability of plants was also checked and confirmed using various volumes (1–8) of the Flora of Ethiopia and Eritrea.

2.3. Data Extraction andAnalysis

Valuable information on medicinal plants, including species and family of the plants, their specific uses, partsused, conditions and modes of preparation, routes of administration, and their regional distribution were thoroughly explored, extracted. All data were entered into Excel spread sheet. A descriptive statistical method, percentage and frequency were used to analyze ethno-botanical data on reported medicinal plants and associated indigenous knowledge. The results were presented using charts and tables.

3. Result And Discussion

Indigenous knowledge requires standard procedures for botanical identification, reliable documentation, and further preservation.The current review included a total of 49 original ethnomedicinal studies. However, no research was conducted specifically on rabies treatment. Of the studies, 19 (38.77%) in Amhara, 14 (28.57%) were carried out in the Oromia region, 10 (20.408%) inSNNP (South Nation and

Nationalities Peoples) region, 5 (10.20%)in Tigray region. (Fig. 1). Alebie *et al*. [19] andWoldeab *et al.* [20] indicated a similar result as many studies were conducted inAmhara, Oromia, and SNNP regions. However, Benishangul, Afar, and Somali regions have received less attention sofar; hence, studies should be conducted in these regions asthe ethnomedicinal knowledge varies even in the sameethnic group.Amhara region is the first this might be due to extensive ethnomedicine practitioners by the Ethiopian Orthodox Church (like “Mergetas” and “Debteras”) [21].Regarding the use of those eighty medicinal plants species, 24 used for human, 16 livestock, 22 both human and livestock treatment respectively and the remaining 18 is not stated.

3.1. Taxonomic Diversity of Medicinal Plants

In this review a total of eighty plant taxa, belonging to 68 genera and 43 families used by Ethiopian people for the treatment ofrabies were reported (Table 1). Among the families that contributedmore medicinal species were the Cucurbitaceae and Euphorbiaceae, represented by7 species (8.75%) each, Solanaceae by 6 (7.5%) species, and Moraceae and Fabaceae by 4 (5%) species each, and other families contributing28 (35%) species are represented by 1 species (Table 1).

The finding of the family Euphorbiaceae as the contributor of the higher number of plant species used for rabies treatment than other families agree with a review study conducted on treatment of liver problems in Ethiopia [22]. On the other hand, other researchers reported that Fabaceae is the leading family with the highest number of medicinal plants in various diseases treatment in Ethiopia [19, 20] or elsewhere in the world [23, 24].

Table 1
The taxonomic distribution of anti-rabiesmedicinal plants.

Family (N = 43)	Species N (%)	Genera N (%)
Cucurbitaceae	7 (8.75)	5 (7.35)
Euphorbiaceae	7 (8.75)	5 (7.35)
Solanaceae	6 (7.5)	3 (4.41)
Moraceae	4 (5)	3 (4.41)
Fabaceae	4 (5)	4 (5.88)
Acanthaceae	3 (3.75)	3 (4.41)
Apocynaceae	3 (3.75)	2 (2.94)
Ascclepiadaceae	3 (3.75)	2 (2.94)
Lamiaceae	3 (3.75)	3 (4.41)
Apiaceae	2 (2.5)	2 (2.94)
Asparagaceae	2 (2.5)	1 (1.47)
Asteraceae	2 (2.5)	2 (2.94)
Malvaceae	2 (2.5)	2 (2.94)
Menispermaceae	2 (2.5)	2 (2.94)
Plantaginaceae	2 (2.5)	1 (1.47)
Other Families	28 (35)	28 (41.2)
Total	**80 (100%)**	**68 (100%)**

3.2. Growth Forms of Ant- Rabies Medicinal Plants

The result of the growth form analysis of medicinalplants used for rabies treatment in Ethiopia showed thatherbs constituted the highest proportion being representedby 18 (22.5%) species, while there were 17 (21.25%) shrub speciesand 11 (13.75%) trees (Fig. 2). This was in agreement with otherreviews [23, 25–29]. This might be due to theireasy propagation, availability, and accessibility in thecountry. Because of their easy accessibility to variousmicroorganisms, insects, and animals, they defendedthemselves by producing diverse offensive and defensivephytochemicals. These phytochemicals might havediverse biological effects, including therapeutic benefits,when exposed to other life forms. However, harvestingherbaceous plants for medicinal purposes is not sustainable as it threatens the survival of the plants. But herbsmight not exist in dry seasons; hence, cultivation of medicinal plants, including medicinal plants gardens andlands are vital to sustain their availability throughout theyear[30].

3.3. Plant Parts Used in Rabies Treatment.

Local people ofEthiopia harvest different plant parts for preparation oftraditional drugs for rabies treatment. About 42% of medicinal plants were harvested for theirroots and these were followed by leaves (15%) (Fig. 3). The present study agrees with Moa *et al*. [31].Plant root structures, such as tuber and rhizome, can be rich sources of potent bio-active chemical compounds. The utilization of roots for drug preparation is not a good practice as it threatens the survival of theplant species. Moreover, studies are indicating that overcollection of root parts for remedy preparation poses a threatto medicinal plants as it was observed in many plant specieswhere the roots are utilized [32, 33].Therefore, application ofproper harvesting strategies and conservation measuresis necessary to ensure sustainable utilization of medicinalplant resources[19].

3.4. TheAuthors Consensus on Medicinal Plants Used to TreatRabies

Of 80 medicinal plants used to treat rabies, all species were not reported equally. Somemedicinal plants were reported by various researchers asthere are also a single species reported by a single author. Forinstance, 21 authors reported the use of *Phytolacca dodecandra* for rabies treatment followed by *Justitia schimperiana*reportedby twelve authors, *Cucumis ficifolius* reported by twelve authors,*Euphorbia abyssinica*reported by four authors and*Brucea anti-dysenterica* reported by five authorsfor rabies treatment in differentparts of Ethiopia. A review by Woldeab*et al*. [20] on antidiarrheal plants indicated that *Amaranthus caudatus, Calpurnia aurea, Coffea arabica, Cordia africana, Rumexnepalensis, Verbena officinalis, Verbascumsinaiticum, Vernonia amygdalina*, and*Zehneriascabra*are frequentlyreported plant species. This review could be used as baseline information to prioritize phytochemical andpharmacological studies on medicinal plants and to conservethe plants used for rabies treatment.

Table 2
Frequently cited anti-rabiesmedicinal plants from different parts of Ethiopia.

Scientific Name [Family]	Part(s) used	Total reports	References
Justicia schimperiana (Hochst. Ex Nees) T. Anders [Acanthaceae]	Root & Leaf	12	[34–45]
Phytolaccadodecandra L'Herit. [Phytolaccaceae]	Root & Leaf	21	[34, 37–40, 44, 46–60]
Cucumis ficifolius A. Rich [Cucurbitaceae]	Root	12	[37, 38, 43, 44, 47, 50, 56, 57, 61–64]
Euphorbia abyssinica J. F. Gmel. [Euphorbiaceae]	Sap & Root	4	[34, 37, 57, 65]
Brucea anti-dysenterica J.F. Mill. [Simaroubaceae]	Leaf	5	[38–40, 43, 51]
Stephania abyssinica (Quart.Dill. & A. Rich.) Walp [Menispermaceae]	Root	5	[34, 38, 41, 51, 55]
Croton macrostachyus Hochst. Ex Del. [Euphorbiaceae]	Root & stem bark	4	[33, 50, 54, 66]

3.5. Route of Administration

From the various formulations and application procedures reported, the most preferred administration route ofthe traditional medicine was oral application 61 (76.25 %) followed by oraland dermal 4 (5 %). About 11 (13.75) % ofthe cases, the route of administration has not been specified (Fig. 4). This was similar to other studies [67, 23]. This is the simplest, convenient, and inexpensive route that might make the common route for the administration of herbs.Water was the common solvent used for the preparation and administration of herbal remedies. Because its highest solvent properties and captures heat. The other additives used were honey, milk, butter, *Eragrostis teff* flour, local alcoholic drinks. These additives wereused for masking off objectionable tastes, smells, andcolors of the remedies. They also used as antidotes forthe poisonings of the herbs.Dose ofherbal preparations was usually estimated using different locally available materials/means, including plastic/glass/steel cups (could be coffee-cup, teacup, water-cup)or gourd utensils, number of drops for liquid materials;teaspoons for powders; counting the number of units forseeds, leaves and fruits; index finger estimation of rootsize[19]. Generally, recommendation was made to administerthe herbal remedies twice or three times per day for one,two or three consecutive days to many months or untilrecovery. Lack of precision and standardization is widelyacknowledged to be an important drawback of traditionalhealthcare systems [68, 69].

3.6. Phytochemical and Pharmacological Studies

Due to the increasing resistance of pathogens to conventional antimicrobial drugs, plant compounds are of interest as antiseptics and alternative antimicrobial substances [70]. To fully understand the pharmacological properties of medicinal plants, it is important to study phytochemistry of such plants [71]. Studies indicated that phytochemical insights into several plants that were similarly used in different countries have led to the isolation of novel structures for the manufacture of new drugs [72] (Table 3).

A phytochemical study by Geyid*et al*. [72] has highlighted medicinal plants used to treat human diseases in Ethiopia. The plants studied which showed inhibitory effect on rabies were*Clausena anisate, Stephania abyssinica, Lobelia rhynchopetalum, Lobelia giboraHemsl, Adhatoda schimperiana, EucleadivinorumHiern, Osyris quadripartite Decn, Warburgiaugandensis Sprague, Cordia africana Lam, Myricasalcifolia*.The authors indicated that the species possess one or more of compounds among alkaloids, polyphenols, tannins, unsaturated sterol, saponins, and glycosides.There is also other phytochemical research, for instance, the major phytochemicals isolated from *D. stramonium* are tropane alkaloids, atropine, and scopolamine [73]. Different alkaloids from seeds of *D. stramonium* were reported by Li *et al*. [74]. Sixty-four tropane alkaloids have been isolated from *D. stramonium* [71]. In addition, the phytochemical analysis of the plant revealed that *D. stramonium* contained saponins, tannins, and glycosides [75, 76].

Salix subserrata

Chloroform crude extract on1 day and 3 days treatment groups with the chloroform extract aresignificantly associated with the survival time [1].The bio-guided study of the chemical constituents of the barkand leaves of Salix subserrata (Salicaceae) has resulted in the isolationand characterization of eight compounds[77].

Silenemacroselen; Beside it is used for rabies treatment, in Ethiopia,the aqueous infusion of the stem and bark of this medicinal plant isalso used to treat hypertension, common cold, measles, abdominal pain,and chancroid as well as evil spirits as smoke [78]. Root decoction isalso given orally three times a day to treat common cold, headache andfever.Another study by Deressa *et al*. [1] also revealed chloroform and 80% methanolic root extractsof *Silenemacroselen* were found to increase the survival time of micesignificantly [1].

Phytolacca dodecandra

The Phytochemical screening test carried outon the aqueous indicated the presence of alkaloids, tannins, phenols,steroids, triterpenoids, free amino acids and reducing sugars [79].Oleanolic acid (OA) is one of bioactive compounds isolated fromethanolic extract of *Phytolacca dodecandra* and has been reported to haveanticancer effects [80].A toxicity evaluation study of *Phytolacca dodecandra*extract for its toxicity effectiveness against aquatic macroinvertebratesclearly indicated that the LC50 and LC90 values for berries crude extractof *Phytolacca dodecandra* against Baetidae were 181.94 and 525.78mg/l and lethal

doses (LC50 and LC90) required for Hydropsychidae were 1060.69 and 4120.4 mg/l respectively[81].An acute toxicity study revealed that female rats that receivedthe aqueous leaf extract of *P. dodecandra* at the dose of 2048 mg/kgdisplayed a reduced appetite, sleepiness and excessive urination andshivering [79].

Justicia schimperiana

Leaf of *Justicia schimperiana* is used fortreatment of different diseases like rabies, malaria, syphilis, leprosy, gonorrhea and measles[72]. According to his report methanol extraction of the plant is preferable withconcentration of 2000µg/ml, 1000µg/ml or above. Polyphenols, unsaturated sterols and saponinchemical compounds are present in the preparations which are supposed to have anti-microbialand anti-viral properties [72].

Table 3
Phytochemical and Pharmacological Studies of Some anti-rabies plant species.

Botanical name (family)	Biological activity/ Chemical constituents
Justicia schimperiana (Hochst. ex Nees) T. Anderson (Acanthaceae)	In vitro cytotoxicity [82]; in vitro antioxidant activity on DPPH assay [83]; in vivo suppression of parasitaemia on Plasmodium berghei-infected mice in the 4-day suppressive test [84]; and in vivo hepatoprotective activity in mice intoxicated with CCL4 [85]
Acokanthera schimperi (A.DC.) Schweinf. (Apocynaceae)	In vitro cytotoxicity [86]; in vitro antiviral activity against coxsackie B3, influenza A, and herpes simplex type1 virus [87]; in vitro antimicrobial activity against Staphylococcus aureus, Pseudomonas aeruginosa, Trichophyton mentagrophytes [88]; and in vivo parasitaemia suppression in Plasmodium berghei-infected mice [89]
Carissa spinarum L. (Apocynaceae)	In vitro antioxidant activity on DPPH assay and in antiproliferative activity [90]
Croton macrostachyus Hochst. ex Delile (Euphorbiaceae)	Ethanol extract showed in vitro antioxidant activity on DPPH assay [90]
Calpurnia aurea (Aiton) Benth. (Fabaceae)	alkaloids, tannins, flavonoids, and saponins [85] Methanol extract showed in vitro antimicrobial activity against Staphylococcus aureus, Escherichia coli, and Pseudomonas aeruginosa [88]; methanol and dichloromethane crude extracts showed in vitro cytotoxicity on human leukaemia cells [86]
Bersama abyssinica Fresen. (Melianthaceae)	Flavonol glycosides isoquercetrin, hyperoside, quercetin-3-O-arabinopyranoside, kaempferol-3- O-arabinopyranoside, xanthone glycoside, mangiferin [91] Ethanol water extracts showed in vitro antioxidant activity on DPPH assay and antiproliferative activity on human liver carcinoma cell line and normal human fetal lung cells [90]; methanol extract showed in vitro antioxidant activity on DPPH assay [91]
Dorsteniabarnimiana Schweinf. (Moraceae)	Phytochemical screening showed the presence of coumarins [83]
RumexnepalensisSpreng. (Polygonaceae)	Ethanol water extracts showed in vitro antiproliferative activity on human liver carcinoma cell line and on normal human fetal lung cells and antioxidant activity on DPPH assay [90], and methanol and dichloromethane crude extracts showed in vitro cytotoxicity on human leukaemia cells [86]
Clematis simensisFresen. (Ranunculaceae)	Triterpenoids, saponins, alkaloids, polyphenols, and unsaturated sterols [72] In vivo anti-inflammatory and antinociceptive activities [92]
Clausenaanisata (Willd.) Hook.f. ex Benth. (Rutaceae)	Methanol and dichloromethane crude extracts showed in vitro cytotoxicity on human leukaemia cells [86]

Botanical name (family)	Biological activity/ Chemical constituents
OsyrisquadripartitaSalzm. ex Decne. (Santalaceae)	Alkaloids, phenols, terpenoids, tannins, saponins, and flavonoids [93] Methanol extracts showed in vitro antimicrobial activity against Escherichia coli, Pseudomonas aeruginosa; in vitro inhibition of NO production and cytotoxicity against MCF-7 and NCI-H460 cell lines [94]
Brucea antidysenterica *J.F.Mill.* (Simaroubaceae)	Flavonoids, amino acids, and vitamin C [95] In vitro antiplasmodial activity against Plasmodium berghei infection [96]

4. Prospects And Viewpoints

Many people in Ethiopia are still dependent on medicinal plants, at least for the treatment of basic human ailments.Reviews on ethnomedicinal uses are vital and starting points for the selection and identification of commonly used medicinal plants. In addition, these reviews are vital for the documentation and preservation of indigenous ethnomedicinal practices.Export of promising indigenous medicinal plant resources offers substantial contribution to the economy and growth of African countries. For instance, export of traditional medicines contributed an estimated R2.9 billion to South Africa's economy [97]. Likewise, Egypt's 2008 exports of selected medicinal plants amounted to 77,850,312 kg with a reported value of US $174,227,384 [98].

Almost all ethnobotanical studies in Ethiopia have sofar focused on medicinal plants used by rural communities.The paradigm shift isalso needed from ethnobotanical studies to phytochemicaland pharmacological studies. As a contribution to the ongoing search for alternatives, available, safe, and effective treatment to conventional drugs used to treat rabies, it is necessary to advocate scientific research on anti-rabies plants. Plant species which are being frequently utilized by different groups of people either in Ethiopia or in the world could be evidence for the activity of plant species on rabies treatment.Along with phytochemicaland pharmacological studies, ethnobotanical studies shouldalso continue, particularly in areas that have received lessattention so far.ethnobotanical studies inEthiopia should increase the number of informants to havea representative sample size. This will help to gather sufficientinformation about medicinal plant species[20]. Another concern in Ethiopian ethnobotanical study is the age and sex of participants.Nocomparative studies on the knowledge of medicinal plantshave been made between young and old generations to reachthe conclusion. In addition, a number of female participantswere lower compared to male participants (31).Regarding the effectiveness anti-rabies medicinal plants, continuous studies should be done to confirm thelocal medicinal plant knowledge with a scientific approach.

Medicinal plants are adversely affected by anthropogenic and natural forces. They are mostly obtained from wild habitants, which are currently threatened by deforestation, overgrazing, drought, commercialization, diseases, pests, agricultural expansion, firing, charcoal, population overgrowth, urbanization, construction, pollution, and climate change.In searching of new drugs from medicinal plants overexploitation and the Nagoya protocol (2010) should not be overlooked. Overexploitation of

medicinal plants especially those found in a restricted geographic location might lead to extinction [20]. Ethiopia requires an enforceable policy that protects wild medicinal plants and policy incentives for the cultivation of medicinal plants to reduce overexploitation. Therefore, pharmaceutical companies and research institutions along with local communities should be encouraged to cultivate these medicinal plants to ensure the continuous supply of plant materials [99].

5. Conclusion

The present study records 80 reported medicinal plantscommonly used for rabies treatment in Ethiopia. In in this review, herb constituted the highest proportion.Roots are harvested to prepare the drug to get relief from thedisease. The review also found that medicinal plantssuch as *Justitia schimperiana, Cucumis ficifolius, Euphorbia abyssinica* and *Brucea anti-dysenterica* were reported by more than four researches indifferent parts of Ethiopia.Therefore, further experimental studies are recommended to assure their safety, efficacy, phytochemistry, and quality. Documentation and preservation of ethnobotanical indigenous knowledge,which contributes to drug development, before they are lost due to environmental and anthropogenic factors, are also strengthened.

Declarations

Competing Interests

The author declares that there are no conflicts of interest.

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Availability of data and materials

The datasets used and/or analyzed during the current study are available from the author on reasonable request.

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Consent for publication

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Figures

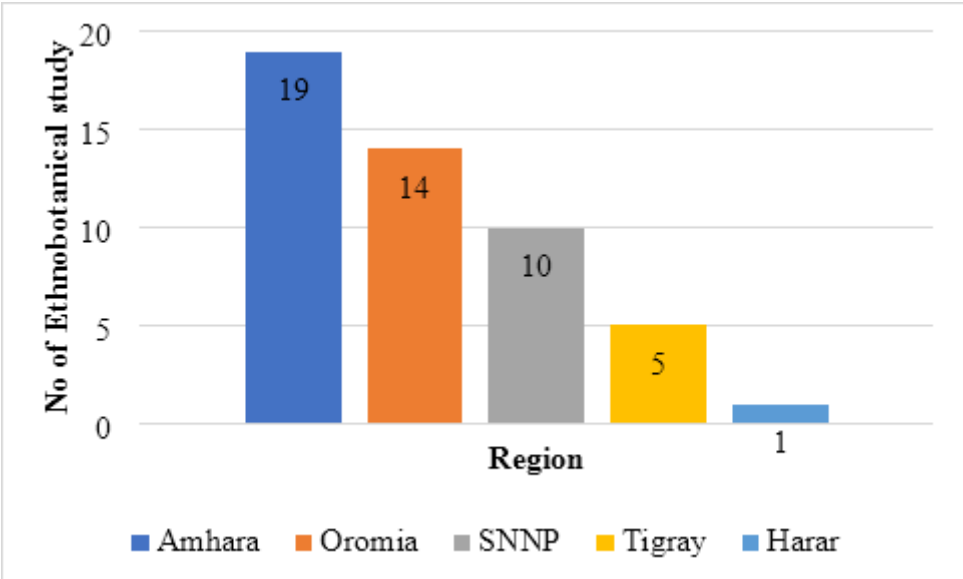

Figure 1

Number of ethnobotanical studies in Ethiopia that reported the use of medicinal plants for rabies treatment.

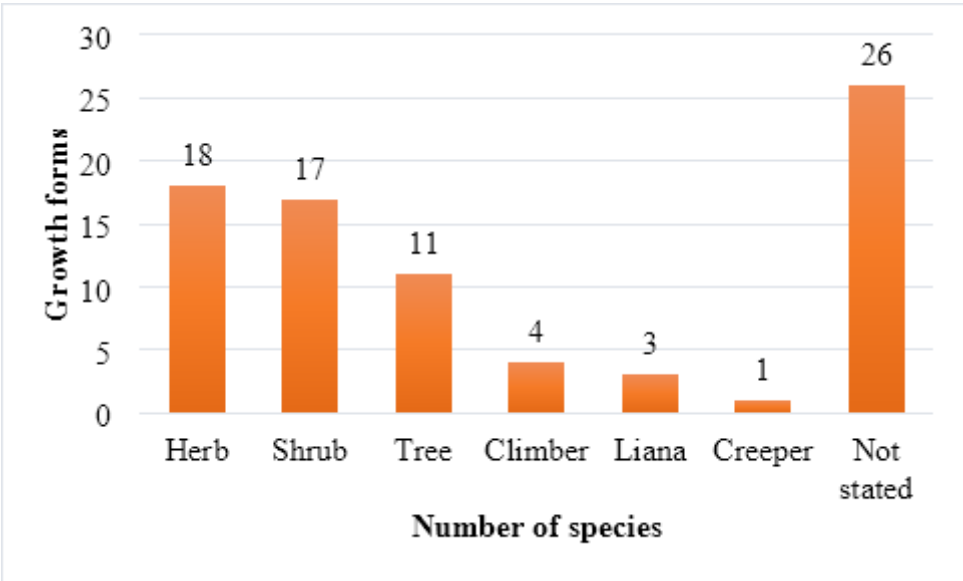

Figure 2

Growth forms of medicinal plants used in the treatmentof rabies in Ethiopia.

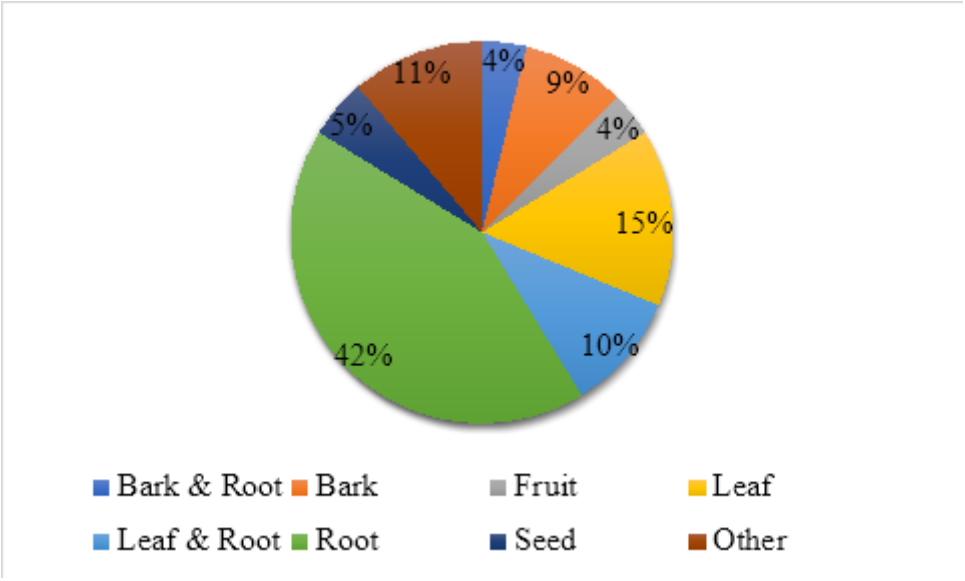

Figure 3

Plant parts used for the treatment of rabies inEthiopia.

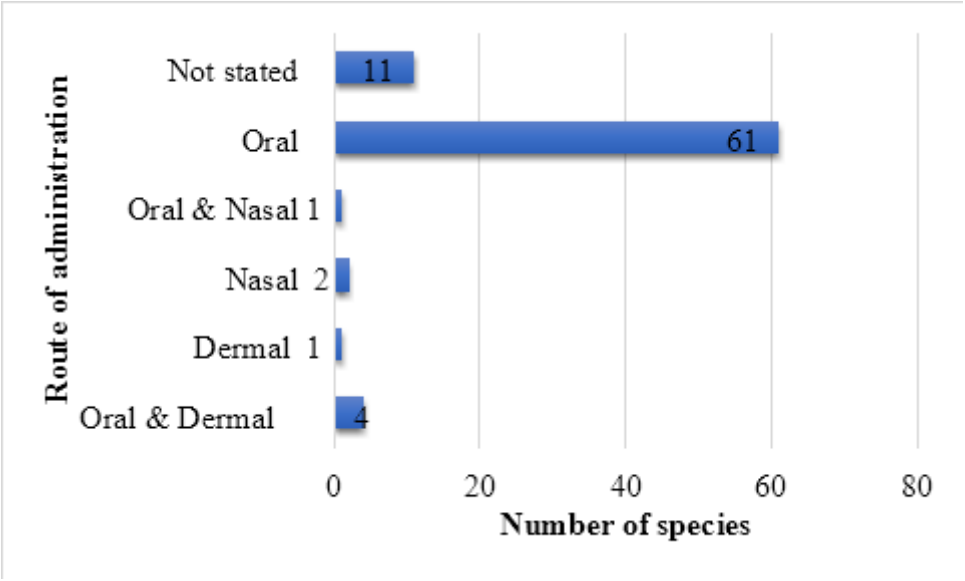

Figure 4

Routes of rabies traditional medicine remedy administration