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

samuel chane teferi (✉ samuelchane19@gmail.com )
Salale University  https://orcid.org/0000-0002-5805-7857

Research Article

Keywords: Ethiopia, Medicinal plants, Phytochemical, Rabies, Traditional medicine

DOI: https://doi.org/10.21203/rs.3.rs-386304/v1

License: ©  This work is licensed under a Creative Commons Attribution 4.0 International License. Read Full License
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 livestock [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 per year globally. It also causes about 3.7 million disability-adjusted life years (DALYs) burden and 8.6 billion USD economic 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 owned dog per five household nationally [1]. The highest number of rabies cases was reported in cold season (June to September) in Ethiopia. This is most probably due to mass gathering and highest reproduction of dogs during the period which increases the contact between rabid and healthy dogs [11].

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

The Ethiopian Health and Nutrition Research Institute, the current Ethiopian Public Health Institute, indicated that human rabies has been reported in Ethiopia in 1903 for the first time. A national surveillance data conducted from 2007 to 2012 showed that 15,178 exposure cases (3.4/100,000), 272 fatal cases with more than 88% of the 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 species in 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 medicine is believed to be very significant 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 and Analysis

Valuable information on medicinal plants, including species and family of the plants, their specific uses, parts used, conditions and modes of preparation, routes of administration, and their regional distribution were thoroughly explored, extracted. All data were entered into Excel spreadsheet. 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%) in SNNP (South Nation and
Nationalities Peoples) region, 5 (10.20%) in Tigray region. (Fig. 1). Alebie et al. [19] and Woldeab et al. [20] indicated a similar result as many studies were conducted in Amhara, Oromia, and SNNP regions. However, Benishangul, Afar, and Somali regions have received less attention so far; hence, studies should be conducted in these regions as the ethnomedicinal knowledge varies even in the same ethnic 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 of rabies were reported (Table 1). Among the families that contributed more medicinal species were the Cucurbitaceae and Euphorbiaceae, represented by 7 species (8.75%) each, Solanaceae by 6 (7.5%) species, and Moraceae and Fabaceae by 4 (5%) species each, and other families contributing 28 (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-rabies medicinal 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)     |
| Asclepiadaceae  | 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 medicinal plants used for rabies treatment in Ethiopia showed that herbs constituted the highest proportion being represented by 18 (22.5%) species, while there were 17 (21.25%) shrub species and 11 (13.75%) trees (Fig. 2). This was in agreement with other reviews [23, 25–29]. This might be due to their easy propagation, availability, and accessibility in the country. Because of their easy accessibility to various microorganisms, insects, and animals, they defended themselves by producing diverse offensive and defensive phytochemicals. These phytochemicals might have diverse biological effects, including therapeutic benefits, when exposed to other life forms. However, harvesting herbaceous plants for medicinal purposes is not sustainable as it threatens the survival of the plants. But herbs might not exist in dry seasons; hence, cultivation of medicinal plants, including medicinal plants gardens and lands are vital to sustain their availability throughout the year [30].
3.3. Plant Parts Used in Rabies Treatment.

Local people of Ethiopia harvest different plant parts for preparation of traditional drugs for rabies treatment. About 42% of medicinal plants were harvested for their roots 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 the plant species. Moreover, studies are indicating that overcollection of root parts for remedy preparation poses a threat to medicinal plants as it was observed in many plant species where the roots are utilized [32, 33]. Therefore, application of proper harvesting strategies and conservation measures is necessary to ensure sustainable utilization of medicinal plant resources [19].

3.4. The Authors Consensus on Medicinal Plants Used to Treat Rabies

Of 80 medicinal plants used to treat rabies, all species were not reported equally. Some medicinal plants were reported by various researchers as there are also a single species reported by a single author. For instance, 21 authors reported the use of *Phytolacca dodecandra* for rabies treatment followed by *Justitia schimperiana* reported by twelve authors, *Cucumis ficifolius* reported by twelve authors, *Euphorbia abyssinica* reported by four authors and *Brucea anti-dysenterica* reported by five authors for rabies treatment in different parts of Ethiopia. A review by Woldeabet 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 frequently reported plant species. This review could be used as baseline information to prioritize phytochemical and pharmacological studies on medicinal plants and to conserve the plants used for rabies treatment.
Table 2
Frequently cited anti-rabies medicinal plants from different parts of Ethiopia.

| Scientific Name                                      | Part(s) used | Total reports | References                      |
|-----------------------------------------------------|--------------|---------------|---------------------------------|
| Justicia schimperiana (Hochst. Ex Nees) T. Anders  | Root & Leaf  | 12            | [34–45]                         |
| Phytolaccadodecandra L’Herit.                       | Root & Leaf  | 21            | [34, 37–40, 44, 46–60]          |
| Cucumis ficifolius A. Rich                          | Root         | 12            | [37, 38, 43, 44, 47, 50, 56, 57, 61–64] |
| Euphorbia abyssinica J. F. Gmel.                    | Sap & Root   | 4             | [34, 37, 57, 65]                |
| Brucea anti-dysenterica J.F. Mill.                  | Leaf         | 5             | [38–40, 43, 51]                 |
| Stephania abyssinica (Quart.Dill. & A. Rich.) Walp  | Root         | 5             | [34, 38, 41, 51, 55]            |
| Croton macrostachyus Hochst. Ex Del.                | 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 of the traditional medicine was oral application 61 (76.25 %) followed by oral and dermal 4 (5 %). About 11 (13.75) % of the 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 were used for masking off objectionable tastes, smells, and colors of the remedies. They also used as antidotes for the poisonings of the herbs. Dose of herbal 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 for seeds, leaves and fruits; index finger estimation of root size [19]. Generally, recommendation was made to administer the herbal remedies twice or three times per day for one, two or three consecutive days to many months or until recovery. Lack of precision and standardization is widely acknowledged to be an important drawback of traditional healthcare 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 gibora* Hems, *Adhatoda schimperiana*, *Eucleadivinorum* Hiern, *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 on 1 day and 3 days treatment groups with the chloroform extract are significantly associated with the survival time [1]. The bio-guided study of the chemical constituents of the bark and leaves of *Salix subserrata* (Salicaceae) has resulted in the isolation and 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 is also used to treat hypertension, common cold, measles, abdominal pain, and chancroid as well as evil spirits as smoke [78]. Root decoction is also given orally three times a day to treat common cold, headache and fever. Another study by Deressa et al. [1] also revealed chloroform and 80% methanolic root extract of *Silenemacroselen* were found to increase the survival time of mice significantly [1].

**Phytolacca dodecandra**

The Phytochemical screening test carried out on 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 from methanolic extract of *Phytolacca dodecandra* and has been reported to have anticancer effects [80]. A toxicity evaluation study of *Phytolacca dodecandra* extract for its toxicity effectiveness against aquatic macroinvertebrates clearly indicated that the LC50 and LC90 values for berries crude extract of *Phytolacca dodecandra* against Baetidae were 181.94 and 525.78 mg/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 received the aqueous leaf extract of *P. dodecandra* at the dose of 2048 mg/kg displayed a reduced appetite, sleepiness and excessive urination and shivering [79].

**Justicia schimperiana**

Leaf of *Justicia schimperiana* is used for treatment of different diseases like rabies, malaria, syphilis, leprosy, gonorrhea and measles[72]. According to his report methanol extraction of the plant is preferable with concentration of 2000µg/ml, 1000µg/ml or above. Polyphenols, unsaturated sterols and saponin chemical compounds are present in the preparations which are supposed to have anti-microbial and anti-viral properties [72].
| 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] |
| *Dorsteniabamimimiana* Schweinf. (Moraceae) | Phytochemical screening showed the presence of coumarins [83] |
| *Rumexnepalensis*Spreng. (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 simensis*Fresen. (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 so far focused on medicinal plants used by rural communities. The paradigm shift is also needed from ethnobotanical studies to phytochemical and 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 phytochemical and pharmacological studies, ethnobotanical studies should also continue, particularly in areas that have received less attention so far. Ethnobotanical studies in Ethiopia should increase the number of informants to have a representative sample size. This will help to gather sufficient information about medicinal plant species [20]. Another concern in Ethiopian ethnobotanical study is the age and sex of participants. No comparative studies on the knowledge of medicinal plants have been made between young and old generations to reach the conclusion. In addition, a number of female participants were lower compared to male participants (31). Regarding the effectiveness anti-rabies medicinal plants, continuous studies should be done to confirm the local medicinal plant knowledge with a scientific approach.

Medicinal plants are adversely affected by anthropogenic and natural forces. They are mostly obtained from wild habitats, 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 plants commonly used for rabies treatment in Ethiopia. In this review, herb constituted the highest proportion. Roots are harvested to prepare the drug to get relief from the disease. The review also found that medicinal plants such 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.

Acknowledgments

Not applicable.

Availability of data and materials

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

Funding

Not applicable.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not Applicable.
References

[1] A. Deressa, A. Ali, M. Beyene, B. Newayesilassie, E. Ymer, K. Hussein, “The status of rabies in Ethiopia: a retrospective record review,” *Ethiopia Journal health Development*, vol.24, no.2, pp. 127 – 132, 2010.

[2] T. Reta, S. Teshale, A. Deressa, G. Getahun, M.P.O. Baumann, T. Muller, C.M. Freuling, “Evaluation of rapid immunodiagnostic test for rabies diagnosis using clinical brain samples in Ethiopia,” *Journal of Veterinary Science & Medical Diagnosis*, vol.2, no.3, pp.1-3, 2013.

[3] C.M. Hendekli, “Brief review Current therapies in rabies,” *J. Archvirol*, vol.150, pp.1047– 1057, 2005.

[4] C.B. Barecha, F. Girzaw, V. Kandi, M. Pal, “Epidemiology and public health significance of rabies,” *Perspectives in Medical Research*, vol.5, no.1, pp.55–67, 2017.

[5] A.S. Fahrian, A. Mikhailov, B. Abela-Ridder, J. Giacinti, J.Harriesa, “Human rabies transmitted by dogs: current status of global data,” *World Health Organization Weekly epidemiological record 91th report*, vol. 2, pp. 13–20, 2016.

[6] N. Moges, “Rabies in Ethiopia: Review Article,” *Academic Journal of Animal Disease*, vol. 4, no.2, pp. 74-81, 2015.

[7] K. Hampson, L. Coudeville, T. Lembo, *et al*, Estimating the Global Burden of Endemic Canine Rabies,” *PLoS Negl Trop Dis*, vol. 9, no.4, 2015.

[8] D.L. Knobel, S. Cleaveland, P.G. Coleman, *et al,* “Re-evaluating the burden of rabies in Africa and Asia,” *Bull World Health Organ*, vol. 83, no. 5, pp. 360–368, 2005.

[9] W.H. Wunnerand D.J. Briggs, “Rabies in the 21 century,” *PLoS Negl Trop Dis*,vol.4, no.3, 2010.

[10] J.Pritchard and Z. Dagnatchew, “Animal welfare policy and Legislative Gap Analysis,” Addis Ababa, Ethiopia, 2010.

[11] P. Admassu, Y. Mekonnen, “Rabies and its folk drugs remedies in Ethiopia: a review,” *International Journal of Basic and Applied Virology*, vol.3, no.2, pp. 22 – 27, 2014.

[12] A. Ali, F. Mengistu, K. Hussen, G. Getahun, A. Deressa, *et al*,”Overview of Rabies in and around Addis Ababa, in Animals Examined in EHNRI Zoonoses Laboratory Between, 2003 and 2009,” *Ethiopian Veterinary Journal*, vol.14, pp.91-101, 2010.

[13] A.Meresa, S. Degu, A.Tadele, B.Geleta, H. Moges, F. Teka and N.Fekadu, "Medicinal Plants Used for the Management of Rabies in Ethiopia – A Review," *Medicinal Chemistry (Los Angeles)*, vol.7, no.2, 2017.

[14] The Ethiopian Health and Nutrition Research Institute. National workshop on rabies prevention and control in Ethiopia. Adama. Ethiopia, pp.18–9, 2012.
[15] World health organization, “Promoting the role of traditional medicine in health care system. A strategy for the African region,” Harare: World Health organization, 2000.

[16] F. Mesfin, S. Demissew, and T. Teklehaymanot, “An ethnobotanical study of medicinal plants in Wonago woreda, SNNPR, Ethiopia,” Journal of Ethnobiology and Ethnomedicine, vol. 5, no. 1, p. 28, 2009.

[17] D. Abebe, In: M. Zewdu, A. Demissie, editors, “The role of medicinal plants in healthcare coverage of Ethiopia, the possible benefits of integration. 6–21 in conservation and sustainable use of medicinal plants in Ethiopia,” Proceedings of the National Workshop, 28 April–01 May 1998. Addis Ababa: Institute of Biodiversity Conservation and Research, 2001.

[18] A. Dawit and A. Ahadu, “Veterinary practice and medicinal plants. In: Medicinal plants and Enigmatic Health practice of Northern Ethiopia,” ILCA, Addis Ababa, Ethiopia, pp: 419-432, 1993.

[19] G. Alebie, B. Urga, and A. Worku, “Systematic review on traditional medicinal plants used for the treatment of malaria in Ethiopia: trends and perspectives,” Malaria Journal, vol. 16, p. 307, 2017.

[20] B. Woldeab, R. Regassa, T. Alemu, and M. Megersa, “Medicinal plants used for treatment of diarrhoeal related diseases in Ethiopia,” Evidence-Based Complementary and Alternative Medicine, vol. 2018, Article ID 4630371, 20 pages, 2018.

[21] A. Tilahun, H. Terefe, T. Soromessa, “The contribution of Ethiopian orthodox Tewahido Church in forest management and its best practices to be scaled up in north Shewa zone of Amhara region, Ethiopia,” Agric For Fish, vol. 4, pp. 123–37, 2015.

[22] B. Garedew and B. Bizayehu, “A Review on Ethnobotanical Study of Traditional Medicinal Plants Used for Treatment of Liver Problems in Ethiopia,” European Journal of Medicinal Plants, vol. 26, no. 1, pp. 1-18, 2018.

[23] A. Maroyi, “Traditional use of medicinal plants in southcentral Zimbabwe: review and perspectives,” Journal of Ethnobiology and Ethnomedicine, vol. 9, no. 1, p. 31, 2013.

[24] A. H. M. Rahman, “Ethno-botanical survey of traditional medicine practice for the treatment of cough, diabetes, diarrhea, dysentery and fever of santals at Abdullahpur village under AkkelpurUpazilla of Joypurhat district, Bangladesh,” Biomedicine and Biotechnology, vol. 1, no. 2, pp. 27–30, 2013.

[25] S. T. Esubalew, A. Belete, E. Lulekal, T. Gabriel, E. Engidawork, and K. Asres, “Review of ethnobotanical and ethnopharmacological evidences of some Ethiopian medicinal plants traditionally used for the treatment of cancer,” Ethiopian Journal of Health Development, vol. 31, no. 3, pp. 161–187, 2017.

[26] T. Ngarivhumea, C. I. Klooster, J. T. de Jong, J. H. van der Westhuizen, “Medicinal plants used by traditional healers for the treatment of malaria in the Chipinge District in Zimbabwe,” Journal of Ethnopharmacology, vol. 159, pp. 224–37, 2015.
[27] M. Pani, G. Nahak, R.K. Sahu, “Review on ethnomedicinal plants of Odisha for the treatment of malaria,” \textit{Int J PharmacognPhytochem Res}, vol.7, pp.156–65, 2015.

[28] A. Maroyi and A. Cheikhyoussef, “A comparative study of medicinal plants used in rural areas of Namibia and Zimbabwe,” \textit{Indian J TraditKnowl}, vol.14, pp.401–6, 2015.

[29] I.P. Adachukwu and O.N. Yusuf, “A review of the ethnotherapeutics of medicinal plants used in traditional/alternative medicinal practice in eastern Nigeria,” \textit{Int J Curr Microbiol App Sci}, vol.3, pp.675–83, 2014.

[30] A. Belachew and M. Wubetu, “Medicinal plants utilized for hepatic disorders in Ethiopian traditional medical practices: a review,” \textit{Clinical Phytoscience}, vol. 6, no.52, 2020.

[31] M. Megersa, T. Tolossa, K. Kumela, “The Use of Medicinal Plants for the Treatment of Toothache in Ethiopia,” \textit{Evidence-Based Complementary and Alternative Medicine}, Volume 2019, Article ID 2645174.

[32] T. Flatie, T. Gedif, K. Asres, and T. Gebre-mariam, “Ethnomedicinal survey of Bertha ethnic group Asossa Zone, Benishangul-Gumuz regional state, mid-west Ethiopia,” \textit{Journal of Ethnobiology and Ethnomedicine}, vol. 5, no. 1, p. 14, 2009.

[33] M. Megersa, Z. Asfaw, E. Kelbessa, A. Beyene, and B. Woldeab, “An ethnobotanical study of medicinal plants in Wayu Tuka district, east Welega zone of Oromia regional state, west Ethiopia,” \textit{Journal of Ethnobiology and Ethnomedicine}, vol. 9, no. 1, p. 68, 2013.

[34] G. Chekole, Z. Asfaw, and E. Kelbessa, “Ethnobotanical studyof medicinal plants in the environs of Tara-gedam and Ambaremnant forests of LiboKemkem district, northwestEthiopia,” \textit{Journal of Ethnobiology and Ethnomedicine}, vol. 11, no. 1, p. 4, 2015.

[35] B. Abera, “Medicinal plants used in traditional medicine by Oromo people, Ghimbi district, southwest Ethiopia,” \textit{Journal of Ethnobiology and Ethnomedicine}, vol. 10, no. 1, p. 40, 2014.

[36] S. Zerabruk and G. Yirga, “Traditional knowledge of medicinal plants in Gindeberet district, Western Ethiopia,” \textit{South African Journal of Botany}, vol. 78, pp. 165–169, 2012.

[37] D. Alemneh, “Ethnobotanical Study of Plants Used for Human Ailments in YilmanaDensa and Quarit Districts of West Gojjam Zone, Amhara Region, Ethiopia,” \textit{BioMed Research International}, Volume 2021, Article ID 6615666.

[38] Z. Kassa, Z. Asfaw, and S. Demissew, “Ethnobotanical studyof medicinal plants used by the local people in Tulu Korma and its surrounding areas of Ejere district, western Shewa zone of Oromia regional state, Ethiopia,” \textit{Journal of Medicinal Plants Studies}, vol. 4, no. 2, pp. 24–47, 2016.

[39] T. Awas and S. Demissew, “Ethnobotanical study of medicinal plants in Kafficho people, southwestern Ethiopia,” in Proceedings of the 16th International Conference of Ethiopian Studies, pp. 711–
726, Trondheim, Norway, July 2009.

[40] M.Agize, S.Demissew and Z. Asfaw, “Ethnobotany of Medicinal Plants in Loma and Gena Bosa Districts (Woredas) of Dawro Zone, Southern Ethiopia,” Topclass Journal of Herbal Medicine, vol. 2, no. 9, pp. 194-212, 2013.

[41] A. Kefalew, Z. Asfaw, and E. Kelbessa, “Ethnobotany of medicinal plants in Ada’a district, East Shewa zone of Oromia regional state, Ethiopia,” Journal of Ethnobiology and Ethnomedicine, vol. 11, no. 1, p. 25, 2015.

[42] T. Fufa, M. Melaku, T. Bekele, T. Regassa and N. Kassa, “Ethnobotanical study of ethnoveterinary plants in Kelem Wollega Zone, Oromia Region, Ethiopia,” Journal of Medicinal Plants Research, vol. 11, no. 16, pp. 307-317, 2017.

[43] T. Birhanu, D. Abera and E. Ejeta, “Ethnobotanical Study of Medicinal Plants in Selected Horro Gudurru Woredas, Western Ethiopia,” Journal of Biology, Agriculture and Healthcare, vol. 5, No. 1, p. 25, 2015.

[44] W. Yetechalew, M. Woyessa, and B. Wodajnew, “Survey on ethno-veterinary medicinal plants in Dangla district, awi zone of amhara regional state North West Ethiopia,” Journal of American Science, vol. 14, no. 11, 2018.

[45] S. Suleman and T. Alemu, “A survey on utilization of ethnomedicinal plants in Nekemte town, east Wellega (Oromia), Ethiopia,” Journal of Herbs, Spices & Medicinal Plants, vol. 18, no. 1, pp. 34–57, 2012.

[46] F. Tewelde, M. Mesfin and S. Tsewene, “Ethnobotanical Survey of Traditional Medicinal Practices in Laelay Adi-yabo District, Northern Ethiopia,” International Journal of Ophthalmology & Visual Science, vol. 2, No. 4, pp. 80-87, 2017.

[47] G. Chekole, “Ethnobotanical study of medicinal plants used against human ailments in Gubalafto district, northern Ethiopia,” Journal of Ethnobiology and Ethnomedicine, vol. 13, no. 1, p. 55, 2017.

[48] H. Atnafu, T. Awas, S. Alemu and S. Wube, “Ethnobotanical study of medicinal plants in Selale mountain ridges, North Shoa, Ethiopia,” Biodiversity International Journal, vol. 2, no. 6, pp. 567–577, 2018.

[49] M. Giday, Z. Asfaw, and Z. Woldu, “Medicinal plants of the Meinit ethnic group of Ethiopia: an ethnobotanical study,” Journal of Ethnopharmacology, vol. 124, no. 3, pp. 513–524, 2009.

[50] T. Mekuanent, A. Zebene, and Z. Solomon, “Ethnobotanical study of medicinal plants in Chilga district, northwestern Ethiopia,” Journal of Natural Remedies, vol. 15, no. 2, pp. 88–112, 2015.

[51] E. d’Avigdor, H. Wohlmutt, Z. Asfaw and T. Awas, “The current status of knowledge of herbal medicine and medicinal plants in Fiche, Ethiopia,” Journal of Ethnobiology and Ethnomedicine, vol. 10, no. 38, 2014.
[52] M. Giday, Z. Asfaw, Z. Woldu, and T. Teklehaymanot, “Medicinal plant knowledge of the bench ethnic group of Ethiopia: an ethnobotanical investigation,” *Journal of Ethnobiology and Ethnomedicine*, vol. 5, no. 1, p. 34, 2009.

[53] S. Tamene, “Ethnobotanical study of indigenous knowledge on medicinal plant uses and threatening factors around the Malga District, Southern Ethiopia,” *International Journal of Biodiversity and Conservation*, vol. 12, no. 3, pp. 215-226, 2020.

[54] M. Giday, T. Teklehaymanot, A. Animut, and Y. Mekonnen, “Medicinal plants of the Shinasha, agewawi and Amharapeoples in northwest Ethiopia,” *Journal of Ethnopharmacology*, vol. 110, no. 3, pp. 516–525, 2007.

[55] M. Giday, Z. Asfaw, and Z. Woldu, “Ethnomedicinal study of plants used by Sheko ethnic group of Ethiopia,” *Journal of Ethnopharmacology*, vol. 132, no. 1, pp. 75–85, 2010.

[56] M. Meragiaw, Z. Asfaw, and M. Argaw, “E status of ethnobotanical knowledge of medicinal plants and the impacts of resettlement in Delanta, northwestern Wello, northern Ethiopia,” *Evidence-Based Complementary and Alternative Medicine*, vol. 2016, Article ID 5060247, 24 pages, 2016.

[57] T. Teklehaymanot and M. Giday, “Ethnobotanical study of medicinal plants used by people in Zegie Peninsula, northwestern Ethiopia,” *Journal of Ethnobiology and Ethnomedicine*, vol. 3, no. 1, p. 12, 2007.

[58] Z. Getnet, S. Chandrodyam, and G. Masresha, “Studies on traditional medicinal plants in Ambagiorgis area of Wogera District, Amhara Regional State, Ethiopia,” *Int. J. Pure App. Biosci*, vol. 4, no. 2, pp. 38-45, 2016.

[59] Y. Simegniew, S. Leshe, Y. Abebe, N. Minuye, “Ethnobotanical Study of Medicinal Plants used to treat Human Diseases in EnarjEnawga District, East Gojjam Zone, Amhara Region, Ethiopia,” *SM J Med Plant Stud*, vol. 1, no. 1, pp. 1006, 2017.

[60] S. Araya, B. Abera, and M. Giday, “Study of plants traditionally used in public and animal health management in Semarti Samre District, Southern Tigray, Ethiopia,” *Journal of Ethnobiology and Ethnomedicine*, vol. 11, no. 1, p. 22, 2015.

[61] T. Teklehaymanot, “Ethnobotanical study of knowledge and medicinal plants use by the people in Dek Island in Ethiopia,” *Journal of Ethnopharmacology*, vol. 124, pp. 69–78, 2009.

[62] E. Lulekal, E. Kelbessa, T. Bekele, and H. Yineger, “An ethnobotanical study of medicinal plants in Mana Angetu District, Southeastern Ethiopia,” *Journal of Ethnobiology and Ethnomedicine*, vol. 4, no. 1, p. 10, 2008.

[63] A. Fassil and G. Gashaw, “An ethnobotanical study of medicinal plants in chiro district, West Hararghe, Ethiopia,” *African Journal of Plant Science*, vol. 13, no. 11, pp. 309-323, 2019.
[64] Seble W. Yohannis, Zemed Asfaw and Ensermu Kelbessa. Ethnobotanical study of medicinal plants used by local people in Menz Gera Midir District, North Shewa Zone, Amhara Regional State, Ethiopia,” *Journal of Medicinal Plants Research*, Vol. 12(21), pp. 296-314, 2018.

[65] N. Amsalu, Y. Bezie, M. Fentahun, A. Alemayehu, and G. Amsalu, “Use and conservation of medicinal plants by indigenous people of Gozamin Wereda, East Gojjam Zone of Amhara region, Ethiopia: an ethnobotanical approach,” *Evidence-Based Complementary and Alternative Medicine*, vol. 2018, Article ID 2973513, 23 pages, 2018.

[66] Y. Limenih, S. Umer and M. Wolde-Mariam, “Ethnobotanical study on traditional medicinal plants in Dega Dmot woreda, Amhara region, North Ethiopia,” *International Journal of Research in Pharmacy and Chemistry*, vol. 5, no. 2, pp. 258-273, 2015.

[67] M. J. Mukazayirea, V. Minanib, C. K. Ruffob, E. Bizuruc, C. Stévignya, P. Dueza, “Traditional phytotherapy remedies used in southern Rwanda for the treatment of liver diseases,” *J Ethnopharmacol*, vol. 138, pp. 415–31, 2011.

[68] E. A. Sofowora, “Medicinal plants and traditional medicine in Africa,” New York: Wiley; 1982.

[69] D. Abebe, “Traditional medicine in Ethiopia: the attempts being made to promote it for effective and better utilization,” *SINET Ethiop J Sci*, vol. 96, pp. 1–69, 1986.

[70] M. Ayyanar and S. Ignacimuthu, “Ethnobotanical survey of medicinal plants commonly used by Kanitribals in Tirunelveli hills of western Ghats, India,” *Journal of Ethnopharmacology*, vol. 134, no. 3, pp. 851–864, 2011.

[71] U. Mabona and S. F. Van Vuuren, “Southern African medicinal plants used to treat skin diseases,” *South African Journal of Botany*, vol. 87, pp. 175–193, 2013.

[72] A. Geyid, D. Abebe, A. Debella et al., “Screening of some medicinal plants of Ethiopia for their antimicrobial properties and chemical profiles,” *Journal of Ethnopharmacology*, vol. 97, no. 3, pp. 421–427, 2005.

[73] S. Jakabová, L. Vincze, A. Farkas, F. Kil’ar, B. Boros, and A. Felinger, “Determination of tropane alkaloids atropine and scopolamine by liquid chromatography–mass spectrometry in plant organs of Datura species,” *Journal of Chromatography*, vol. 1232, pp. 295–301, 2012.

[74] J. Li, B. Lin, G. Wang, H. Gao, and M. Qin, “Chemical constituents of Datura stramonium seeds,” *Zhongguo Zhong Yao Za Zhi*, vol. 37, no. 3, pp. 319–322, 2012.

[75] M. H. Shagal, U. U. Modibbo, and A. B. Liman, “Pharmacological justification for the ethnomedical use of Datura stramonium stem-bark in treatment of diseases caused by some pathogenic bacteria,” *Journal of International Research of Pharmacy and Pharmacology*, vol. 2, no. 1, pp. 16–19, 2012.
[76] P. Soni, A. A. Siddiqui, J. Dwivedi, and V. Soni, “Pharmacological properties of Datura stramonium L. as a potential medicinal tree: an overview,” Asian Pacific Journal of Tropical Biomedicine, vol. 2, no. 12, pp. 1002–1008, 2012.

[77] H. Hussain, A. Badawy, A. Elshazly, A. Elsayed, K. Krohn, et al., “Chemical constituents and antimicrobial activity of Salix subserrata,” Records of Natural Products, vol. 5, no. 133, 2011.

[78] H. Kloos, T. VMenberu, A. Tadele, T. Chanie, Y. Debebe, et al., “Traditional medicines sold by vendors in Merkato, Addis Ababa: Aspects of their utilization, trade, and changes between 1973 and 2014,” The Ethiopian Journal of Health Development, vol. 28, 2016.

[79] P. Admasu, A. Deressa, A. Mengistu, G. Gebrewold, T. Feyera, “In vivo Antirabies Activity Evaluation of Hydroethanolic Extract of Roots and Leaves of Phytolacca dodecandra,” Global veterinaria, vol. 12, pp. 12-18, 2014.

[80] S. Ghosh, K. Bishayee, A.R. Khuda-Bukhsh, “Oleanolic acid isolated from ethanolic extract of Phytolacca decandra induces apoptosis in A375 skin melanoma cells: drug-DNA interaction and signaling cascade,” Journal of integrative medicine, vol. 12, pp. 102-114, 2014.

[81] K. Karunamoorthi, D. Bishaw, T. Mulat, “Laboratory evaluation of Ethiopian local plant Phytolacca dodecandra extract for its toxicity effectiveness against aquatic macroinvertebrates,” Eur Rev Med Pharmacol Sci, vol. 12, pp. 381-386, 2008.

[82] B. Desta, “Ethiopian traditional herbal drugs—part III: antifertility activity of 70 medicinal plants,” Journal of Ethnopharmacology, vol. 44, no. 3, pp. 199–209, 1994.

[83] R. A. Mothana, R. Gruenert, P. Bednarski, and U. Lindequist, “Evaluation of the in vitro anticancer, antimicrobial and antioxidant activities of some Yemeni plants used in folk medicine,” Die Pharmazie—An International Journal of Pharmaceutical Sciences, vol. 64, no. 4, pp. 260–268, 2009.

[84] J. Abdela, E. Engidawork, and W. Shibeshi, “In vivo antimalarial activity of solvent fractions of the leaves of justiciar schimperiana hochst. ExNees against Plasmodium bergheiin Mice,” Ethiopian Pharmaceutical Journal, vol. 30, no. 2, pp. 95–108, 2014.

[85] S. Umer, K. Asres, and C. Veeresham, “Hepatoprotective activities of two Ethiopian medicinal plants,” Pharmaceutical Biology, vol. 48, no. 4, pp. 461–468, 2010.

[86] E. Nibret and M. Wink, “Trypanocidal and cytotoxic effectsof 30 Ethiopian medicinal plants,” Zeitschrift fur Natur–forschung C, vol. 66, no. 11-12, pp. 0541–0546, 2011.

[87] T. Gebre-Mariam, R. Neubert, P. Schmidt, P. Wutzler, and M. Schmidtke, “Antiviral activities of some Ethiopian medicinal plants used for the treatment of dermatological disorders,” Journal of Ethnopharmacology, vol. 104, no. 1-2, pp. 182–187, 2006.
[88] H. Tadeg, E. Mohammed, K. Asres, and T. Gebre-Mariam, “Antimicrobial activities of some selected traditional Ethiopian medicinal plants used in the treatment of skin disorders,” *Journal of Ethnopharmacology*, vol. 100, no. 1-2, pp. 168–175, 2005.

[89] T. Mohammed, B. Erko, and M. Giday, “Evaluation of antimalarial activity of leaves of Acokanthera schimperi and *Croton macrostachyus* against Plasmodium berghei in Swissalbino mice,” *BMC Complementary and Alternative Medicine*, vol. 14, no. 1, p. 314, 2014.

[90] J. Tauchen, I. Doskocil, C. Caffi et al., “In vitro antioxidant and anti-proliferative activity of Ethiopian medicinal plant extracts,” *Industrial Crops and Products*, vol. 74, pp. 671–679, 2015.

[91] K. Asres, F. Sporer, and M. Wink, “Patterns of pyrrolizidine alkaloids in 12 Ethiopian *Crotalaria* species,” *Biochemical Systematics and Ecology*, vol. 32, no. 10, pp. 915–930, 2004.

[92] A. Tadele, K. Asres, D. Melaku, and W. Mekonnen, “In vivo anti-inflammatory and antinociceptive activities of the leaf extracts of *Clematis simensis* Fresen,” *Ethiopian Pharmaceutical Journal*, vol. 27, pp. 33–41, 2010.

[93] M. Abebaw, B. Mishra, and D. A. Gelayee, “Evaluation of anti-ulcer activity of the leaf extract of,” *Journal of Experimental Pharmacology*, vol. 9, pp. 1–11, 2017.

[94] W. Rached, R. C. Calhelha, A. Fernandes et al., “Phytochemical characterization and bioactive properties of *Osyris quadripartita* Salzm. ex Decne. leaves from Algeria,” *RSC Advances*, vol. 6, no. 76, pp. 72768–72776, 2016.

[95] A. Amuamuta, Z. Mekonnen, and E. Gebeyehu, “Traditional therapeutic uses and phytochemical screening of some selected indigenous medicinal plants from Northwest Ethiopia,” *African Journal of Pharmacology and Aeperapeutics*, vol. 4, no. 3, 2015.

[96] A. Kefe, M. Giday, H. Mamo, and B. Erko, “Antimalarial properties of crude extracts of seeds of *Brucea antidysenterica* and leaves of Ocimum lamifolium,” *BMC Complementary and Alternative Medicine*, vol. 16, no. 1, p. 118, 2016.

[97] A.L. Dold and M.L. Cocks, “The trade in medicinal plants in the Eastern Cape Province, South Africa,” *SAfr J Sci*, vol. 98, no. 589, 2002.

[98] N.S. Abdel-Azim, K.A. Shams, A.A. Shahat, M.M. EL-Missiry, S.I. Ismail, F.M. Hammouda, “Egyptian herbal drug industry: challenges and future prospects,” *Res J Med Plants*, vol. 5, pp. 136–44, 2011.

[99] C. Njume and N. I. Goduka, “Treatment of diarrhoea in rural African communities: An overview of measures to maximize the medicinal potentials of indigenous plants,” *International Journal of Environmental Research and Public Health*, vol. 9, no. 11, pp. 3911–3933, 2012.
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 treatment of rabies in Ethiopia.
**Figure 3**

Plant parts used for the treatment of rabies in Ethiopia.

**Figure 4**

Routes of rabies traditional medicine remedy administration