



Contents lists available at ScienceDirect

Journal of Traditional and Complementary Medicine

journal homepage: <http://www.elsevier.com/locate/jtcme>

Review article

Bryophytes: Hoard of remedies, an ethno-medicinal review



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ARTICLE INFO

Article history:

Received 29 August 2015

Received in revised form

11 December 2015

Accepted 20 January 2016

Available online 4 April 2016

Keywords:

Anti cancer

Hepatic disorder

Hornworts

Liverworts

Mosses

ABSTRACT

Bryophytes are the second largest group of land plants after angiosperms. There is very less knowledge available about medicinal properties of these plants. Bryophytes are popular remedy among the tribal people of different parts of the world. Tribal people use these plants to cure various ailments in their daily lives. Bryophytes are used to cure hepatic disorders, skin diseases, cardiovascular diseases, used as antipyretic, antimicrobial, wound healing and many more other ailments by different tribal communities of Africa, America, Europe, Poland, Argentina, Australia, New Zealand, Turkey, Japan, Taiwan, Pakistan, China, Nepal and different parts of South, North and Eastern India. Apart from ethno-medicinal uses some bryophytes possess antitumor activities against different cancer cell lines and this property of bryophytes needs to be more focused in the future. Compile information about medicinal properties and anticancer properties of bryophytes is lacking till date. In the present review, the authors tried to compile all the ethno-medicinal and other related information of bryophytes and fill the knowledge lacuna in this particular field. Some published reviews are available but the information is segregated. This manuscript will help people doing research in the bryophytes.

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1. Introduction

The division bryophytes include mosses (Bryopsida or Musci), hornworts (Anthocerotopsida or Anthocerotae) and liverworts (Hepaticopsida or Hepaticae) and represented by 14,000 to 15,000 species around the world. The mosses contains approximately 8000 species, liverworts 6000 species and hornworts 200 species.¹ Some studies stated that these are the second largest group of land plants after angiosperms.² In India, bryophytes represented by total 2504 species comprising 17.27% of world bryophytes. Among these, 642 species of bryophytes are endemic to India, showing 25.64% endemism. In India, mosses represented by 1786 species and 355 genera, liverworts 675 species and 121

genera and hornworts 25 species and 6 genera.^{3,4} A total of 133 threatened species are reported from India and placed under rare category, out of these 78 species are mosses, 53 are liverworts and 2 are hornworts. Furthermore, 14 species from a different groups of bryophytes are recorded under the endangered category of threatened plants in India.⁵

Bryophytes play a remarkable role in maintaining ecosystems because they provide an important buffer system for other plants. As bryophytes do not have seeds or flowers hence they are placed under cryptogams. These plants are less known to most people due to the small size consequently less biomass made these plants neglected for wide use.⁶ They are found everywhere in the world from desert to ice cold polar region except seas. From the ancient times, bryophytes were used in packing, plugging as well as in decoration.

Bryophyte are used as indicator species, erosion control, bioindicators of heavy metals in air pollution, aquatic bioindicators, radioactivity indicators, as material for seed beds, fuel, medicines and food sources, pesticides, nitrogen fixation, moss gardening, treatment of waste, construction, clothing, furnishing, packing, genetic engineering and for soil conditioning and culturing.^{7,8} The

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Peer review under responsibility of The Center for Food and Biomolecules, National Taiwan University.

active constituents of bryophytes are widely used as antibacterial, antifungal, cytotoxic, antitumor and insecticidal^{9,10} also in medicinal and agricultural areas.^{7,11}

The phytochemistry finding of bryophytes exhibit a greater range of biologically active compounds such as carbohydrates, lipid, protein, steroids, polyphenols, terpenoids, organic acids, sugar alcohols, fatty acids, aliphatic compounds, acetogenins, phenylquinones, and aromatic and phenolic substances which show significant bioactivities.^{12,13}

2. Material and methods

In the present review, information about bryophytes and their medicinal properties and biochemical properties was gathered via searching scientific databases including PubMed, Elsevier, Google Scholar, Springer etc. and related books either online or offline.

3. Aim of present review

Information about medicinal properties of bryophytes is segregated and not present in well documented form. In the present review, we have been trying to compile information regarding to medicinal properties and other related pharmacological properties of bryophytes.

4. Medicinal properties

4.1. Ethno-medicinal properties

An ancient method of determining the medicinal properties of plants is the concept of Paracelsus “doctrine of signatures” which deals with resemblance of plant body parts to shape and structure of organ in the human or animal body for which it is remedial. As per above philosophy, liverworts (e.g. *Marchantia polymorpha*) used to cure hepatic disorders.¹⁴ Similarly, *Polytrichum commune* bears hairy calyptra and called hair cup moss. The expressed oil from this moss was used by the women’s of ancient time on their hair.⁸ Bryophytes adequately used in traditional Chinese medicinal system. Different ethnic groups of different parts of the world used these tiny plants to cure various ailments in their daily lives. The people of Gaddi tribes of Himachal Pradesh, India used *Plagiochasma appendiculatum* for treating skin diseases.¹⁵ The thalloid *Targionia hypophylla* used by Irular tribe of the Attappady valleys of Kerala state to cure skin diseases due to resembles of thallus of this liverwort to the rough surface of the diseased part. Due to long-stemmed and hair-like thallus of *Frullania ericoides* this liverwort is applied for hair-related afflictions by tribal people of South India.¹⁶ More information about ethno-medicinal uses of bryophytes is summarized in Table 1.

4.2. Anticancer properties

A number of naturally derived compounds act as an important source of several useful anti-cancer agents. *Polytrichum commune* used in Traditional Chinese Medicine (TCM) for curing diseases such as fever, hemostatic and traumatic injury to pneumonia, uterine prolapse and lymphocytic leukemia.³⁴ Apart from this, the pharmacological exploration of acid and alcohol extract of *Polytrichum juniperum* exhibited inhibitory property against Sarcoma 37 implanted in CAF1 mice.³⁵ The compound ohioensin A isolated from *Polytrichum ohioense* shows cytotoxicity against 9PS murine leukemia and MCF-7 human breast tumor cells. Benzophenanthrenones and cinnamoyl bibenzyls derivatives isolated from ethanolic extract of *Polytrichum pallidisetum* can significantly impede the growth of RPMI-7951 melanoma and U-251 glioblastoma

multiforme.³⁶ Bryophytes have great potential for anti-leukemia activity. Marchantin A from *Marchantia palacea*, *M. polymorpha*, and *M. tosana*, riccardin from *Riccardia multifida*, and perrottetin E from *Radula perrottetii* show cytotoxicity against the leukemic KB cells.³⁷ The active constituent Diplophyllin, an ent-eudesmanolide isolated from liverworts *Diplophyllum ablicans* and *D. taxifolium* having α -methylene lactone unit showed significant anticancer activity against human epidermoid carcinoma.³⁸ The Sesquiterpenoids costunolide and tulipinolide isolated from *Frullania monocera*, *Marchantia polymorpha*, *Porella japonica*, *Wiesnerella denudate*, *Conocephalum supradecompositum* and *Plagiochila semidecurrans* showed the anticancer activity against human carcinoma of the nasopharynx. The compound extracted from *Plagiochilla fasciculatae* seemed to inhibit P388 cells (leukemia).³⁹ It has been also suggested that mosses also retard the growth of cancer cell in culture.¹ The mechanism of how bryophytes inhibit growth of different cancer cell lines and exhibit anticancer activity yet to be studied.

5. Other miscellaneous uses

The synthetic compound like pesticides, fungicides, rodenticides and insecticides are used commercially by the people that might have adverse effects on the environment and human health related issues. Apart from this, the concerted use of insecticides leads to increased resistance in insects.^{40,41} Therefore, environment friendly and low toxicity new natural products are needed to provide alternatives to hazardous chemical that may otherwise alter the soil health and chemistry.

The use of bryophytes with insecticidal activity has gained importance over the past few years. Fatty acids derived from *Hypnum cupressiforme*, *Dicranum scoparium*, *Polytrichastrum formosum*, *Homalothecium lutescens* and liverwort *Conocephalum conicum*, used as insecticides against *Sitophilus granaries*. Likewise, the solution of moss powder of *Calymperes afzelii*, *Thuidium gratum*, *Bryum coronatum* and *Barbula lambarenensis* used against maize stem borers.^{42,43} Several reports also confirmed the importance and activities of plants extract worked against insects⁴⁴ fumigant⁴⁵ contact⁴⁶ repellent⁴⁷ and antifeedant effects on stored product pests.⁴⁸

Mosses like *Bryum*, *Hypnum* and *Fissidens* growing in association with thallophytes in shallow waters of lakes, streams and spring contain huge amount of lime and act as rock builders. The insoluble calcium carbonate precipitates along with mosses and their symbionts aids in soil conservation. Developed countries like Sweden, West Germany, Finland, Poland, Ireland and Soviet Union uses hepaticae and musci as a source of fuel for generating natural gas, hydrogen, ethylene, methanol, etc. Among the mosses, peat mosses are the best sources of fuel for generation of heat, methane and have rapid regeneration, low sulfur content and their heating value is greater than that of wood.⁷ Bryophytes lack a leaf cuticle hence they are able to gain and loss water more quickly. Unlike higher plants, these plants have the ability to absorb minute quantities of available moisture from fog, mist and dew that other plants cannot utilize. The other uses of bryophytes like-liverworts and mosses as good indicators of environmental conditions, growth regulator (auxins, gibberellins, cytokinins and ethylene) and mosses as stuffing material.²⁴

6. Negative impact of bryophytes

Few species of *Frullania* such as *F. dilatata* Dum., *F. tamarisci* Dum. *F. tamarisci* spp. *nisquallensis*, *Chiloscyphus polyanthos* and *Schistochila appendiculata* have been described as causative of potent allergic contact dermatitis because of containing a number of sesquiterpene lactones with an α -methylene γ -lactone

Table 1
Ethano-medicinal properties of bryophytes.

Botanical name	Family	Uses	References
Liverworts			
<i>Riccardia</i> Gray. sp.	Aneuraceae	Used for anti-leukemic activity	17,18
<i>Plagiochasma appendiculatum</i> Lehm. & Lindenb.	Aytoniaceae	Used in skin diseases (the fine paste of the thoroughly washed thalli is applied externally on affected area)	17,19
<i>Reboulia hemisphaerica</i> (L.) Radd	Aytoniaceae	Used for blotches, hemostasis, external wounds, and bruises	9
<i>Conocephalum conicum</i> (L.) Underw.	Conocephalaceae	Used as antimicrobial, antifungal, antipyretic, antidotal activity; used to treat cuts, swollen tissue, scalds, burns, fractures, poisonous snake bites, and gallstones	17,20
<i>Herbertus</i> Gray. sp.	Herbertaceae	Used as antiseptics, antidiarrheal agents, expectorants and astringents	17,18
<i>Frullania tamarisci</i> (L.) Dumort.	Jubulaceae	Used for antiseptic activity	9
<i>Frullania ericoides</i> (Nees ex Mart.) Mont.	Jubulaceae	Used to get rid from head lice (<i>Pediculus humanus</i>) and nourishment of hair	16
<i>Marchantia polymorpha</i> L.	Marchantiaceae	The thallus Paste applied externally on inflammation, used as diuretics, for liver ailments, insect bites, used to cure cuts, fractures, poisonous snake bites,	18,19,21
<i>Marchantia convoluta</i> Gao et K.C. Zhang	Marchantiaceae	Used for treatment of hepatitis, fever and gastric intolerance	22
<i>Marchantia palmata</i> Nees	Marchantiaceae	Fleshy leaf paste is directly applied during acute inflammation caused by the touch of fire and hot	23
<i>Marchantia paleacea</i> Bertol.	Marchantiaceae	Used in skin tumefaction, hepatitis and as antipyretic	24
<i>Dumortiera hirsuta</i> (Sw.) Nees	Marchantiaceae	Used as source for antibiotics	18
<i>Pallavicinia</i> Gray. sp.	Pallaviciniaceae	Used as antimicrobial agent	18
<i>Plagiochila</i> (Dum.) Dum. sp.	Plagiochilaceae	Used for anti-leukemic activity/anti-microbial activity and used as perfumes or as perfume components	17,9
<i>Plagiochila beddomei</i> Steph.	Plagiochilaceae	Used for wound healing	25
<i>Riccia</i> L. sp.	Ricciaceae	The thallus is washed and ground to paste and mixed with jiggery and given to the children affected by the ringworms.	19
<i>Targionia hypophylla</i> L.	Targioniaceae	Used with leaves of (<i>Actinopteris radiata</i>) ground in to a paste and mixed with two tablespoons of coconut oil and smeared over the body of the children affected by scabies, itches and other skin diseases	16
Mosses			
<i>Cratoneuron filicinum</i> (Hedw.) Spruce	Amblystegiaceae	Used to treat heart disease	9,11
<i>Leptodictyum riparium</i> (Hedw.) Warnst.	Amblystegiaceae	Used as antipyretic and in uropathy	11
<i>Philonotis fontana</i> (Hedw.) Brid.	Bartramiaceae	Used to relieve pain of burn and heal burns, adenopharyngitis, antipyretic	9,11,26
<i>Philonotis</i> Bridel sp.	Bartramiaceae	Used to heal burns, for adenopharyngitis, as antipyretic and antidote	9
<i>Plagiopus oederi</i> (Brid.) Limpr.	Bartramiaceae	Used as sedative, epilepsy	11
<i>Bryum argenteum</i> Hedw.	Bryaceae	Used as antidote, antipyretic, antifungal	9
<i>Rhodobryum giganteum</i> (Schwagr.) Paris	Bryaceae	Used to treat cardiovascular problem and nervous prostration, to cure angina, anti-hypoxia, diuretic, antipyretic, and antihypertensive	9,11,27
<i>Rhodobryum roseum</i> (Hedw.) Limpr.	Bryaceae	Used to treat nervous prostration and cardiovascular diseases sedative	9,11,28
<i>Leucobryum bowringii</i> Mitt.	Dicranaceae	During body pain, paste of leaf tips mixed in a cup of <i>Phoenix sylvestris</i>	25
<i>Oreas martiana</i> (Hoppe and Hornsch.) Brid.	Dicranaceae	Used for anodyne (pain), hemostasis, external wounds, epilepsy, menorrhagia, and neurasthenia (nervosism, nervous exhaustion)	9
<i>Ditrichum pallidum</i> (Hedw.) Hampe	Ditrichaceae	Used for convulsions, particularly in infants	9,11
<i>Entodon flavescens</i> (Hook.) A. Jaeger	Entodontaceae	Used during earache, leaf juice is used as ear drops, during cold, leaf juice is administered daily twice	25
<i>Fissidens nobilis</i> Griff.= (<i>Fissidens japonicus</i> Dozy and Molk.)	Fissidentaceae	Used for growth of hairs and diuretic activity	11,18
<i>Funaria hygrometrica</i> Hedw.	Funariaceae	Used for hemostasis, pulmonary tuberculosis, bruises, skin infection	11
<i>Fontinalis antipyretica</i> Hedw.	Fontinalaceae	Used in chest fever	29
<i>Taxiphyllum taxirameum</i> (Mitt.) M. Fleisch.	Hypnaceae	Used for external wounds, hemostasis	9,11
<i>Aerobryum lanosum</i> (Mitt.) Mitt.	Meteoriaceae	Used during burns, decoction of whole plant boiled in goat urine is applied externally	25
<i>Mnium cuspidatum</i> Hedw.	Mniaceae	Used for hemostasis, nose bleeding	9,11
<i>Mnium</i> Hedw. sp.	Mniaceae	Poultice to reduce pain of burns, bruises and wounds	18
<i>Plagiomnium</i> T. Kop. sp.	Mniaceae	Used for infections and swellings	18
<i>Octoblepharum albidum</i> Hedw.	Octoblepharaceae	Used as febrifuge and anodyne	30
<i>Dawsonia superba</i> Grev.	Polytrichaceae	Used as diuretics, hair growth stimulation and for treating cold	18
<i>Polytrichum commune</i> Hedw.	Polytrichaceae	Used for hemostasis, wound healer, antipyretic, antidotal activity, dissolve kidney and gall bladder stones, to speed up labor process during child birth	11,19,20,31,32
<i>Polytrichum juniperinum</i> Hedw.	Polytrichaceae	Used to treat prostate, urinary difficulties and skin ailments	8,31
<i>Pogonatum macrophyllum</i> Dozy & Molk.	Polytrichaceae	Used to reduce inflammation and fever, also used as detergent diuretic, laxative and hemostatic agent	17,18
<i>Barbula unguiculata</i> Hedw.	Pottiaceae	Used to treat fever and body aches	18
<i>Barbula indica</i> (Hook.) Spreng.	Pottiaceae	Used during menstrual pain and intermittent fever	25
<i>Hyophila attenuata</i> Broth.	Pottiaceae	Used during cold, cough and neck pain, leaf decoction is administered with a pinch of pepper powder daily	25
<i>Weisia viridula</i> (L.) Hedw.	Pottiaceae	Used to treat cold and fever	9,11
<i>Sphagnum sericeum</i> Mull. Hal.	Sphagnaceae	Used to dressing wounds, with anti-microbial properties for skin ailments (insects bites, scabies, acne), haemorrhoids and to treat eye diseases	18
<i>Sphagnum teres</i> (Schimp.) Angstrom	Sphagnaceae	Used to treat eye diseases	8,20
<i>Haplocladium microphyllum</i> (Hedw.) Broth. = (<i>Haplocladium capillatum</i> (Mitt.) Broth.)	Thuidiaceae	Used to treat cystitis, bronchitis, tonsillitis pneumonia and fever	11,20
Hornworts			
<i>Ceratophyllum demersum</i> L.	Ceratophyllaceae	Used as purgative, astringent, constipating and antipyretic	33

functionality. These above mentioned species of *Frullania* also possess medicinal significance and growing epiphytically on the bark of trees, and hence have been recognized in areas of Canada, the United States, Finland and France as the cause of occupational contact dermatitis in forest workers, woodcutters and olive pickers.^{49–51} The allergens (+)-frullanolide and (–)-frullanolide are isolated from *F. dilatata* and *F. tamarisci* subsp. *Tamarisci*, respectively cause very intense allergic contact dermatitis. The allergens of the *Schistochila appendiculata* are long-chain alkylphenols, 3-undecyl, 6-undecyl, 3-tridecyl, 3-pentadecyl, and 3-heptadecyl phenols, long-chain alkyl salicylic acids, 6-tridecyl, 6-pentadecyl salicylates, and their potassium salts, potassium 6-undecyl, 6-tridecyl, 6-pentadecyl salicylates and 6-undecyl catechol, also the cause of contact dermatitis problem.⁵² *Marchantia polymorpha* and *Metzgeria furcata* also possess the allergenic contact dermatitis activity but their allergens still have not been isolated yet.^{37,53}

7. Conclusion

The data mentioned in Table 1 containing 50 medicinal bryophytes which are very popular remedy among tribal people of different part of world. These tiny creatures are widely used by different tribal communities in Africa, America, Europe, Poland, Argentina, Australia, New Zealand, Turkey, Japan, Taiwan, Pakistan, China, Nepal and different parts of the South, North and East India. On the basis of Table 1, it is concluded that major bryophytes used in hepatic disorders are liverworts apart from this; some species of moss are used in hepatic disorders. Some of the bryophytes species that are used in hepatic disorder are *Frullania tamarisci*, *Reboulia hemisphaerica*, *Conocephalum conicum*, *Marchantia polymorpha* and mosses *Sphagnum* spp., *Weissia controversa*, *Funaria hygrometrica*, *Bryum argenteum*, *Rhodobryum roseum*, *Climacium dendroides* and *Polytrichum commune*. The peat moss species *Sphagnum teres* is very popular to treat various eye diseases in China. The moss *Rhodobryum giganteum* and *R. roseum* are widely used within China for cardiovascular disease and nervous prostrations. *Polytrichum commune* is used as an antipyretic, diuretic and hemostatic and *Haplocaldium microphyllum* is applied for tonsillitis, bronchitis, timpanitis and cystitis. Despite the ethno-medicinal property *Sphagnum* spp. are used in surgical dressing because of better and faster absorption.

The plant derived natural products occupy an important place in the area of cancer chemotherapy because of minimal side effects. In this context *Polytrichum commune* play very significant role especially for the therapy of lymphocytic leukemia, Furthermore, it has been found that *P. ohioense* and *P. pallidisetum* also show cytotoxicity against the 9PS murine leukemia and several other tumor cell lines. *Marchantia palacea*, *M. polymorpha*, and *M. tosona*, *Riccardia multifida*, *Radula perrottetii* all show cytotoxicity against the leukemic KB cell.

8. Future prospective

Currently, scientific research on medicinal use of bryophytes is being carried out in most pharmaceutical laboratories, research institutes and universities. The current research is going on the active ingredients of medicinal bryophytes are used in curing diseases such as hepatic disorders, skin diseases, cardiovascular diseases, and many more other ailments. Another area of research is directed towards the discovery of new kinds of drugs from the medicinal bryophytes which have not been explored so far. The drugs obtained from the traditional medicine, like Ayurveda, Unani and Siddha system need to be further evaluated and validated more scientifically. The Council of Scientific and Industrial Research (CSIR), New Delhi, is involved in the validation of about 350

formulations of traditional medicines for different pharmacological activities.⁵⁴ This new trend of evaluation and validation of traditional practices with modern knowledge provides significant opportunities for newer drug discoveries and would be an effective strategy for the improvement of human health care.

Disclosure/Conflict of interest statement

None of the authors of this paper has a financial or personal relationship with other people or organizations that could inappropriately influence or bias the content of the paper. It is to specifically state that “No Competing interests are at stake and there is No Conflict of Interest” with other people or organizations that could inappropriately influence or bias the content of the paper. The manuscript has not been published previously by any of the authors and/or is not under consideration for publication in another journal at the time of submission.

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