**Bryophyllum pinnatum**: A mini review on Ethnobotany and Phytochemistry

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ABSTRACT: *Bryophyllum pinnatum* is from the family crassulaceae. It is used in folk medicine to treat ailments such as dysentery, hypertension, boil and so on. It contains a wide range of active phytochemical compounds including alkaloids, terpenes, glycosides and flavonoids. It has been known to process some biological activities. This review focus on its biological activities, phytochemistry and its ethnomedicinal uses.

Key words: Bryophyllum, flavonoids, glycosides, phytochemistry.

INTRODUCTION

*Bryophyllum pinnatum* (Supplementary Figure 1) is from the family Crassulaceae (Randall, 2012). Its common names are air plant, Canterbury bells, cathedral bells, curtain plant, floppers, good-luck leaf, green mother of millions, leaf of life, life plant, live leaf, live plant, Mexican love plant, miracle leaf, resurrection plant and sprouting leaf. It originated from Madagascar and Southern Africa (Anonymous, 2007a). It is also widely distributed across the coastal regions of South-eastern Queensland and North-eastern New South Wales. It is also relatively common in the coastal regions of Central and Northern Queensland, present in other parts of New South Wales, and naturalised on several offshore islands (Lord Howe Island, Norfolk Island and the Cocos Islands) (Anonymous, 2006c). It is widely naturalised in other parts of the world including tropical Eastern Africa, Asia (Taiwan, Indonesia and New Guinea), New Zealand, South-eastern USA (Florida), the Caribbean, and the Pacific (the Galapagos Islands, Melanesia, Polynesia and Hawaii).

The family Crassulaceae has distinguishing features as follows: a fleshy upright plant usually growing 60 to 120 cm tall (De Lange et al., 2005). It leaves are relatively broad with scalloped margins and are oppositely arranged. The leaves are also fleshy and are either simple or compound with three or five leaflets. They are oppositely arranged, flattened, and the number of leaflets present varies from one near the base of the stems to three or five higher up the stems. These leaves (5 to 25 cm long and 2 to 12.5 cm wide) are green or yellowish-green in colour, hairless, and are borne on stalks 2 to 10 cm long. The leaflets are oval or narrowly oval in shape with rounded tips, and when more than one leaflet is present the end leaflet is usually significantly larger than the others. Tiny plantlets may occasionally be formed in the scalloped margins of these leaflets. These plantlets are more often produced if the leaves become detached from the stems (De Lange et al., 2005).

It has a bell-shaped, drooping flowers with greenish-yellow to pinkish-red in colour (up to 7 cm long). The flowers are arranged in branched clusters at the tips of the stems (in terminal inflorescences). These flowers are borne in branched clusters at the top of its stems (Hannan-Jones and Playford, 2002). Each flower is borne on a stalk 10 to 25 mm long. They have prominent, inflated, yellowish-green or pale green coloured sepals (25 to 55 mm long) that are partially fused into a tube and streaked with pink or reddish coloured blotches. The yellowish-green to dark red coloured petals (3 to 6 cm long) are also partially fused into a tube that divides into four petal lobes near the tip. Flowers are produced mainly during winter and spring (Everett and Noris, 1990).

The fruit are papery and membranous (about 15 mm long), with four slender compartments. They generally remain enclosed within the old flower parts and contain numerous minute, slender, brownish-coloured seeds (less than 1 mm long) (Green, 1994).
SIMILAR SPECIES

Resurrection plant (Bryophyllum pinnatum) is similar to lavender scallops (Bryophyllum fedtschenkoi) and relatively similar tomother-of-millions (Bryophyllum delagoense), hybrid mother-of-millions (Bryophyllum houghtonii), mother-of-thousands (Bryophyllum daigremontianum) and prolific mother-of-millions (Bryophyllum proliferum). These species can be distinguished by the following differences:

Resurrection plant (Bryophyllum pinnatum) has large, broad, flattened, leaves (5 to 25 cm long and 20 to 125 mm wide) that are often compound. The leaves are usually bright green or light green in colour and it has numerous blunt teeth along their margins (Anonymous, 2006c).

Lavender scallops (Bryophyllum fedtschenkoi) has small, broad, flattened, leaves (12 to 50 mm long and 8 to 25 mm wide) that are always simple. The leaves are usually bluish-green or purplish-green in colour and have numerous reddish-brown coloured blunt teeth along their margins.

Mother-of-millions (Bryophyllum delagoense) has relatively small cylindrical leaves (usually less than 10 cm long and only 2 to 6 mm wide) that are always simple. The leaves are greyish in colour with some darker patches and have a few teeth at their tips (Anonymous, 2006a).

Hybrid mother-of-millions (Bryophyllum houghtonii) has relatively small boat-shaped or folded leaves (4 to 8 cm long and 8 to 20 mm wide) that are always simple. The leaves are greyish or greyish-green in colour with some darker patches and have numerous teeth along their margins (Anonymous, 2006b).

Mother-of-thousands (Bryophyllum daigremontianum) has relatively large boat-shaped or folded leaves (often more than 10 cm long and 25 mm wide) that are always simple. The leaves are greyish-green in colour with some darker patches and have numerous teeth along their margins (Anonymous, 2007b).

Prolific mother-of-millions (Bryophyllum proliferum) has relatively large compound leaves with 7 to 11 leaflets (7.5 to 15 cm long and about 3.5 cm wide). The greenish-coloured leaflets are somewhat elongated in shape, flattened, and have numerous blunt teeth along their margins (Anonymous, 2006a).

Cotyledon (Cotyledon orbiculata) is also relatively similar to mother of millions (Bryophyllumdelagoense). However, this species can be distinguished by its much broader, green or greyish, leaves that usually have a reddish-coloured margin (Auld and Medd, 1996).

PHYTOCHEMISTRY AND BIOLOGICAL ACTIVITIES OF SOME COMPOUNDS FROM BRYOPHYLLUM SPECIES

B. pinnatum is rich in alkaloids, triterpenes, glycosides, flavonoids, cardenolides, steroids, bufadienolides and lipids (Marriage and Wilson, 1971). The leaves contain a group of chemicals called bufadienolides which are very active. Bufadienolides like bryotoxin A, B, C which are very similar in structure and activity to two other cardiac glycosides, digoxin and digitoxin (Kamboj and Saluja, 2005). Syringic acid, caffeic acid (Guain and Gupta, 1972), 4-hydroxy-3-methoxy-cinnamic acid, 4-hydroxybenzoic acid, p-hydroxycinnamic acid, paracoumaric acid, ferulic acid, phasophenolpyruvate and protocatechuic acid are isolated from aerial parts of plant.

The leaves contain astragalin, 3,8-dimethoxy-4, 5, 7 trihydroxyflavone, friedelin, epigallocatechin-3-o-syringate, luteolin, rutin (Costa et al., 1995), kaempferol, quercetin, quercetin-3-L-rhamnosido-L-arabinofuranoside, quercetin-3-O-diarabinoside, kaempferol-3-glucoside, kaempferol-3-O-α-L-arabinopyranoside (1→2) α-L-rhamno pyranoside (Da Silva et al., 1995), quercetin-3-O-α-L-arabino pyranosyl (1→2) α-L-rhamno pyranoside (Mehta and Bhat, 1995) and 4’, 5-dihydroxy-3’, 8-dimethoxy flavone-7-O-β-D-glucopyranoside (Akinpelu, 2000).


Tatsimo et al. (2012) reported Ethylacetate extract of the
whole plant of *Bryophyllum pinnatum* to possess antioxidant and antimicrobial activity. It was subjected to column chromatography to yield seven kaempferol derivatives: kaempferitin (435.10 mg), kaempferol3-O-α-L-(2-acetyl) rhamnopyranoside-7-0-α-L-rhamnopyranoside (10.10 mg), kaempferol3-O-α-L-(3-acetyl) rhamnopyranoside-7-0-α-L-rhamnopyranoside (38.40 mg), kaempferol 3-O-α-L-4(acyetyl) rhamnopyranoside-7-0-α-L-rhamnopyranoside (25.10 mg), kaempferol 3-O-α-D-glucopyranoside-7-0-α-L-rhamnopyranoside (40.90 mg), afzelin (34.60 mg) and α-rhamnosorobin (5.0 mg). These compounds except afzelin were isolated for the first time in this species.

Preliminary phytochemical investigation of different parts of plant extracts of *B. pinnatum* showed the presence of alkaloids, phenols, flavonoids, saponins, tannins, carotenoids, glycosides (Jain et al., 2010; Umbezese and Falana, 2013; Okwu and Josiah, 2006; Liu et al., 1989), sitosterol, anthocyanins (Nielsen et al., 2005), malic acid, quinines, tocopherol (Pal-Bhadra et al., 1999), lectins (Liu et al., 1989), coumarins (Pal-Bhadra et al., 1999) and bufadienolides (Kuo et al., 2008). It also showed the presence of amino acids (Orisakeye et al., 2015).

Quercitin, a flavonoid is responsible for the antileishmanial activity of *B. pinnatum*. The quercetin aglycone-type, as well as a rhamnosyl unit linked at C-3, also has antileishmanial activity (Muzitano et al., 2006). Da Silva et al. (1995) investigated the antileishmanial properties of three flavonoids (quercitin, quercetin and afzelin) of leaf extract in mice against *L. amazonensis* amastigotes and found oral route was more effective than other intravenous or topical routes. It possessed antioxidant activity (Orisakeye et al., 2015).

Yadav, 2003 reported that the juice of leaves was found more effective than ethanolic extract as evidenced by *in vivo* and *in vitro* histopathological studies for hepatoprotective activity of plant and justifies the use of juice of plant leaves in folk medicine for jaundice. The methanolic fraction possesses a potent central nervous system (CNS) depressant action. Yemitan and Salahdeen (2005) investigated saline leaf extract of the plant and found dose-dependent CNS depressant effects (pentobarbitone induced sleep), exploratory activity (Hole-board method, Evasion), muscle relaxant test (Chimney, Traction, Climbing, Inclined Screen tests), anticonvulsant tests (strychnine induced convulsion, picrotoxin-induced convulsion) in the plant. Thus, the herb possesses remarkable central depressant, skeletal muscle and minor anticonvulsant actions with an acute toxicity higher than 500 mg/kg and 2000 mg/kg when given intraperitoneally and orally respectively (Radford et al., 1986; Yemitan and Salahdeen, 2005).

*Bryophyllum pinnatum* has potent antihistamine and anti-allergic activity (Donatus and Fred, 2011). The methanol extract of the leaves has also been reported to have histamine receptor (H1) antagonism in the ileum, peripheral vasculature and bronchial muscle and protect against chemically induced anaphylactic reactions and death by selectively blocking histamine receptors in the lungs (Haslalka et al., 2007) Quercetin-3-O-α-L-arabinopyranosyl (1−2)-O-α-L-rhamnopyranosyl showed anti allergic activity in rats (Kamboj and Saluja, 2005). Obaseiki-Ebor (1985) investigated that organic solvent extracts of leaves had inhibitory activity induced by ethyl methanesulfonate acting on *S. typhimurium* and were also active against reversions induced by 4-nitro-o-phenylenediamine and 2-aminofluorene. The alkaloidal/water soluble and acid fraction had no appreciable anti-mutagenic activity (Obaseiki-Ebor, 1985).

Flavonoids, the potent water-soluble antioxidants and free radical scavengers, which prevent oxidative cell damage of *B. pinnatum* have strong anticancer activity (Pal and Nagchaudhari, 1991; Salah et al., 1995; Del-Rio et al., 1997; Okwu and Okwu, 2004.) Okwu and Okwu (2004) further added that antioxidants such as flavonoids from these plants provide anti-inflammatory activity. Pal and NagChaudri (1992) revealed that a methanolic fraction of leaves was found to possess significant antiulcer activity.

Ofoaksi et al. (2005) reported that *B. pinnatum* is effective in the treatment of typhoid fever and other bacterial infections, particularly those caused by *S. aureus, E. coli, B. subtilis, P. aeruginosa, K. aerogenes, K. pneumoniae and S. typhi*. In his study of antibacterial activities of the infusion and methanolic extracts against *S. aureus, E. coli, Bacillus, P. aeroginosa, K. pneumonia* and *S. typhi* using the agar diffusion method; also against *S. aureus, E. coli, S. typhi, Klebsiella spp and P. aeruginosa* using a modification of checkerboard method, were found to possess antibacterial activities. These findings supported its use in treating the placenta and navel of newborn baby, which not only heals fast but also prevents the formation of infections (Liu et al., 1989; Okwu and Okwu, 2004; Ofoaksi et al., 2005).

Pure isolated alkaloids and their synthetic derivatives are used as basic medicinal agents for their analgesic, antispasmodic and bactericidal effects (Okwu and Okwu, 2004). Obaseiki-Ebor (1985) investigated the *in vitro* antibacterial activity of leaf juice. The extract at 5% v/v was found to possess antibacterial activity to a wide spectrum of gram-positive and gram-negative bacteria such as *B. subtilis, S. aureus, S. pyogenes, S. faecalis, E. coli, Proteus spp, Klebsiella spp, Shigella spp, Salmonella spp, S. marcescens, and P. aeruginosa* including the clinical isolates of these organisms possessing multiple antibiotic resistance (Obaseiki-Ebor, 1985). Akinpelu in a study found that 60% methanolic leaf extract inhibits the growth of five out of eight bacteria used, at a concentration of 25 mg/ml. *B. subtilis, E. coli, P. vulgaris, S. dysentriae, S. aureus* were found to be inhibited, while *K. pneumoniae, P. aeruginosa* and *C. albicans* were found to resist the action of the extract (Akinpelu, 2000).

Ojewole (2005) evaluated the anti-nociceptive effect of the herb's aqueous leaf extract by the 'hot-plate' and
ECONOMIC IMPORTANCE OF \textit{BRYOPHYLLUM PINNATUM}

In traditional medicine, the Creoles use the lightly roasted leaves for cancer and inflammations, and a leaf infusion for fevers. The Palikur mix the leaf juice with coconut oil or iroba oil and then rub it on the forehead for migraines and headaches (Da Silva et al., 1995). The Siona indigenous peoples heat the leaves and apply them topically to boils and skin ulcers. It is also used in the treatment of kidney stone and gastric ulcer (Quazi Majaz et al., 2011). Along the Rio Pastaza in Ecuador, natives use a leaf infusion for broken bones and internal bruises (Kamboj and Saluja, 2005). The whole plant is used in treating wounds, boil, rash, insect bites, bruises and stop bleeding (Akinpelu, 2000). In Peru, indigenous tribes mix the leaf with aguardiente (sugar cane rum) and apply the mixture to the temples for headaches; they soak the leaves and stems overnight in cold water and then drink it for heartburn, urethritis and fevers and for all sorts of respiratory conditions (Gardner et al., 2007).

In Maharashtra, its leaves are used to treat dysentery and cough (Quazi Majaz, 2011). The root infusion is also used in epilepsy. Other tribes in the Amazon squeeze the juice from fresh leaves and mix it with mother's milk for earaches. In Mexico and Nicaragua its leaves are also used to promote menstruation, treat eye infection and assist in childbirth (Hannan-Jones and Playford, 2002). In Nigeria and other West African countries, its fleshy leaves are frequently used as herbal remedy for an array of human disorders including: hypertension, Diabetes mellitus, bruises, wounds, boils abscesses, insect bites, arthritis, rheumatism, joint pains, headaches and body pains.

In Arunachal padesh, leaf extract is taken in empty stomach to treat urinary bladder stone and fever in children (Quazi Majaz, 2011). The plant is a good source of vitamins (Okwu and Okwu, 2004). The leaf is among the medicinal plants listed for use by the Yao people of Yunnan province in China, to treat rheumatoid arthritis, tummy bug, numbness of limb, bruises, burn, ulcer (Okwu and Okwu, 2004). The plant itself is a refrigerant, depurative and emollient (Quazi Majaz, 2011). It is an introduced ornamental plant that is now growing as seed around plantation crops (Quazi Majaz, 2011). In South Eastern Nigeria, this herb is used to facilitate the dropping of the placenta of a newly born baby (Okwu and Okwu, 2004). The plant leaf is mildly exposed to heat and the juice extracted and applied to the baby's placenta on daily basis (Okwu and Okwu, 2004).

CONCLUSION

\textit{Bryophyllum pinnatum} has been extensively investigated on its phytochemical compounds, this means the plant could be used to cure various ailments, biological activities and its economic importance. There is a greater need to explore more of its pharmacological activities for researcher and to isolate more compounds to treat and manage some diseases in our societies.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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Kalanchoe pinnata and pharmacological profile.


Appendix

(A) *Bryophyllum pinnatum* leaves; (B) *Bryophyllum pinnatum* plant.

Some compounds previously isolated from *Bryophyllum pinnatum.*