Review Article

International Journal of Research in Pharmaceutical Sciences

Published by JK Welfare & Pharmascope Foundation Journal Home Page: www.ijrps.com

Maerua juncea Pax and *M. schinzii* Pax (Capparaceae): A comparative analysis of their ethnobotany and ethnomedicinal uses

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Article History:

Received on: 11 Jul 2020
Revised on: 13 Aug 2020
Accepted on: 14 Aug 2020

Keywords:

Capparaceae, indigenous pharmacopoeia, Maerua juncea, Maerua schinzii, traditional medicine

Abstract

Maerua juncea Pax and *M. schinzii* Pax have a long history of medicinal use in southern Africa. This study aimed to review the ethnomedicinal uses, phytochemistry and pharmacological properties of the two species. Results of this study are based on data derived from several online databases such as Scopus, Google Scholar, PubMed and Science Direct, and pre-electronic sources such as scientific publications, books, dissertations, book chapters and journal articles. The leaves, roots, stems or whole plant parts of *M. juncea* and *M. schinzii* are mainly used as protective charm and tonic, and traditional medicines for fever, heart problems, headache, earache, skin disorders, fatigue and respiratory problems. This study showed that betaines and quaternary ammonium compounds such as 3-hydroxyprolinebetaine, proline betaine and 3-hydroxy-1,1-dimethyl pyrrolidinium had been identified from the aerial parts of *M. juncea*. In contrast, alkaloids, bitter principles, coumarins, flavonoids, saponins and terpenes have been identified from the leaves of *M. schinzii*. The leaf extracts and compounds isolated from the species exhibited antibacterial, antifungal, anti-HIV and cytotoxicity activities. There is a need for extensive phytochemical, pharmacological and toxicological studies of crude extracts of *M. juncea* and *M. schinzii* to establish the safety profiles of different preparations of the two species.

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ISSN: 0975-7538

DOI: https://doi.org/10.26452/ijrps.v11i4.3266

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INTRODUCTION

The genus *Maerua* Forssk is one of the most important sources of herbal medicines among the Capparaceae genera. Species belonging to the family Capparaceae are widely used throughout the world as food sources and traditional medicines (Rivera *et al.*, 2003; Mishra *et al.*, 2007). The Capparaceae family is characterized by several phytochemical compounds such as alkaloids, amino acids, anthocyanins, fatty acids, flavonoids, glycosides, saponins, steroids, sterol and terpenes (Rajesh *et al.*, 2009; Mali, 2010). Members of the Capparaceae family demonstrated anti-diabetic, anti-obesity, cholesterol-lowering, anti-hypertensive, antihepatotoxic, anthelmintic, antimicrobial, analgesic, anti-inflammatory, immunomodulatory, antipyretic, psychopharmacological, antidiarrheal and hepatoprotective activities (Sudhakar *et al.*, 2006; Bawankule *et al.*, 2007). *Maerua juncea* Pax and *M. schinzii* Pax are among the species widely used as herbal medicines in southern Africa (Schmelzer and Gurib-Fakim, 2013). Other *Maerua* species regarded as important medicinal plants in tropical Africa and included in the book "Plant resources of tropical Africa 11(2): medicinal plants 2" include *M. angolensis* DC., *M. bussei* (Gilg & Gilg-Ben.) Wilczek,

M. cafra (DC.) Pax, *M. crassiflora* Forssk., *M. denhardtiorum* Gilg, *M. duchesnei* (De Wild.) F. White, *M. edulis* (Gilg & Gilg-Ben.) DeWolf, *M. endlichii* Gilg & Gilg-Ben., *M. filiformis* Drake, *M. kirkii* (Oliv.) F. White, *M. nuda* Scott-Eliot, *M. oblongifolia* (Forssk.) A. Rich., *M. parviflora* Pax, *M. pseudopetalosa* (Gilg & Gilg-Ben.) DeWolf, *M. subcordata* (Gilg) DeWolf and *M. triphylla* A. Rich (and, 2013; Margaret and Elisabeth, 2013). Apart from used as herbal medicines for similar medicinal conditions, *M. juncea* and *M. schinzii* have been recorded in overlapping geographical areas in southern Africa (Figure 1). It is, therefore, within this context that the current review was undertaken aimed at providing a comparative analysis of the botanical, medicinal, chemical and biological activities of *M. juncea* and *M. schinzii*.

MATERIALS AND METHODS

Results of the current study are based on a literature search on the botanical, medicinal, chemical and biological activities of *M. juncea* and *M. schinzii* using information derived from several internet databases. The databases included Scopus, Google Scholar, PubMed and Science Direct. Other sources of information used included pre-electronic sources such as journal articles, theses, books, book chapters and other scientific articles obtained from the university library.

RESULTS AND DISCUSSION

Botanical description of *Maerua juncea* and *M. schinzii*

Both *M. juncea* and *M. schinzii* are evergreen shrubs or small trees and often climbing (Palmer and Pitman, 1972). The leaves of *M. juncea* are simple, trifoliate, alternate, grey-green in colour, narrowly elliptic to ovate, rounded at the apex with a bristle tip. The flowers are bisexual, creamy white and borne singly in the upper leaf axils. The fruit of *M. juncea* is ellipsoid with a smooth surface, green in colour when immature and orange when ripe. *Maerua juncea* is divided into two infraspecific taxa, that is, subsp. *juncea* and subsp. *crustata* (Wild) Wild (Wild, 1965). These two species are easily distinguished using fruit characters. The synonyms associated with the name *M. juncea* include *M. Angustifolia* Schinz, *M. flagellaris* (Oliv.) Gilg & Gilg-Ben., *M. flagellaris* (Oliv.) Gilg & Gilg-Ben. subsp. *crustata* Wild, *M. guerichii* Pax, *M. kassakalla* De Wild., *M. maschonica* Gilg, *M. Nervosa* (Hochst.) Oliv. Var. *flagellaris* Oliv. and *M. ramosissima* Gilg. (Wild, 1960). *Maerua juncea* has been recorded in hot and dry woodlands in Botswana, the Democratic Republic of Congo (DRC), Eswatini, Namibia, Malawi, Mozambique, Tanzania, Zambia and Zimbabwe at an altitude ranging from sea level to 1370 m above sea level (Wild, 1960; Palgrave, 2002) (Figure 1). *Maerua schinzii* is a much-branched tree growing to seven metres in height (Palgrave, 2002). The species has a dense, rounded crown recorded in arid bushveld, semi-desert areas, along river banks, watercourses and rocks at bases of mountains in Botswana, Namibia and South Africa (Figure 1). The species has been recorded in stony and sandy soils at an altitude ranging from 290 m to 1500 m above sea level (Wild, 1960). Numerous whitish lenticels characterize the branchlets of M. schinzii. The leaves are elliptic to ovate in shape, leathery and yellow-green, rounded at the apex with a bristle tip, base broadly tapering to rounded. The flowers of *M. schinzii* occur in terminal racemes with many long stamens. The fruit is a long slender pod which is irregularly constricted between the seeds.

Traditional uses of *Maerua juncea* and *M. schinzii*

The fruits of *M. juncea* and *M. schinzii* are eaten as a snack in Namibia and South Africa (Sullivan, 1998). In Namibia and South Africa, the fruits of *M. schinzii* are crushed and mixed with water to make a non-alcoholic beverage or drink. In Botswana, the roots of *M. schinzii* are boiled or roasted while its leaves are eaten raw. In Namibia, the leaves of *M. schinzii* are used as a substitute for soap (Van Den Eynden *et al.*, 1992; Sullivan, 1998). The foliage and pods of *M. juncea* and *M. schinzii* are browsed by livestock and game (Malan and Owen-Smith, 1974; Sullivan, 1998).

The leaves, roots and stems of both *M. juncea* and *M. schinzii* are widely used as traditional medicines in southern Africa. The roots and stems of *M. juncea* are traded as herbal medicines in local informal herbal medicine markets in the Limpopo province in South Africa. Similarly, the roots of *M. juncea* are traded in local informal herbal medicine markets in Maputo, Mozambique for the treatment of bacterial and parasitic diseases. A total of 24 human and livestock diseases and ailments are treated with herbal concoctions prepared by *M. juncea* and *M. schinzii* (Table 1).

The leaves, roots, stems or whole plant parts of both species are used as sources of good luck or protective charm against evil spirits or traditional medicines for body weakness, fatigue and heart problems (Palmer and Pitman, 1972; Semenya and Maroyi, 2018). The leaves, roots, stems or whole plant parts of *M. juncea* and *M. schinzii* are mainly used as protective charm and tonic, and traditional

medicines for fever, heart problems, headache, earache, skin disorders, fatigue and respiratory problems (Figure 2). In South Africa, the roots of *M. juncea* are mixed with the bark of *Cassia abbreviata* Oliv. And bulb of *Drimia elata* Jacq. As traditional medicine for fatigue (Semenya and Maroyi, 2018).

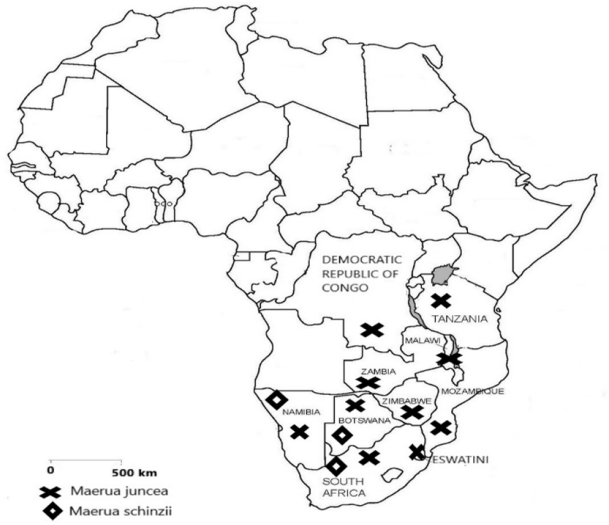

Figure 1: Geographicaldistribution of *Maerua juncea* and *M. schinzii*

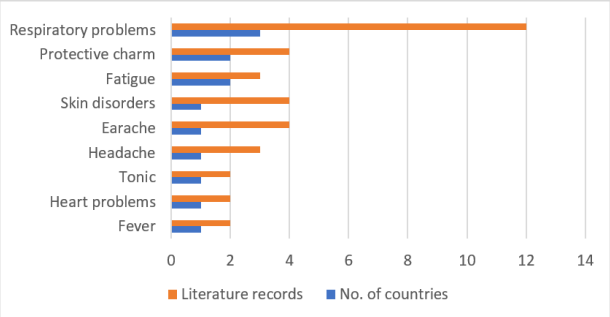

Figure 2: Medicinal applications of *Maerua juncea* and *M. schinzii* derived from literature records

Phytochemical and biological activities of *Maerua juncea* and *M. schinzii*

There is very little information available concerning the phytochemistry and pharmacological properties of the crude extracts or compounds isolated from the two species. However, McLean *et al.* (1996) identified the betaines and quaternary ammonium compounds such as 3-hydroxyprolinebetaine, proline betaine and 3-hydroxy-1,1-dimethyl pyrrolidinium from dried aerial and branches of M. juncea. Loontjens (2013) argued that quaternary ammonium compounds are potent biocides widely used in medical applications, cosmetics, disinfectants, surfactants and solvents. Similarly, Hamalwa (2018) identified alkaloids, bitter principles, coumarins, flavonoids, saponins and terpenes from the leaves of *M. schinzii*. Some of these chemical compounds may be responsible for the pharmacological properties of the species. Several studies showed that alkaloids isolated from plants exhibited anticholinesterase, antioxidant, anxiolytic, anti-inflammatory and antidepressant properties (Chaves *et al.*, 2016).

Similarly, the compound coumarin is known for its biological activities such as anti-inflammatory, anticoagulant, antibacterial, antifungal, antiviral, anticancer, anti-hypertensive, antitubercular, anticonvulsant, antiadipogenic, antihyperglycemic, antioxidant and neuroprotective properties (Venugopala *et al.*, 2013). Many flavonoids and terpenes have anti-inflammatory, anticancer, antioxidant and antiparasitic activities (Sülsen *et al.*, 2017). Saponin compound is known to have anticancer, antiphlogistic, antiallergic, immunomodulating, antihepatotoxic, antiviral, hypoglycemic, antifungal and molluscicidal activities (Lacaille-Dubois and Wagner, 1996).

Mujovo (2009) evaluated the antibacterial activities of acetone extracts of *M. juncea* leaves against *Bacillus cereus, Bacillus pumilis, Bacillus subtilis, Staphylococcus aureus, Enterococcus faecalis, Enterobacter cloacae, Escherichia coli, Klebsiella pneumonia, Pseudomonas aeruginosa* and *Serratia marcescens* using the agar dilution method with streptomycin sulfate as a positive control. The extract exhibited activities against *Bacillus cereus, Bacillus pumilis, Bacillus subtilis, Staphylococcus aureus*, and *Enterococcus faecalis* with minimum inhibitory concentration (MIC) value of 1.0 mg/ml. Similarly, Hamalwa (2018) evaluated the antibacterial activities of a semi-purified compound of *M. schinzii* leaves against *Escherichia coli, Staphylococcus aureus* and *Klebsiella pnemoniae* using the agar disc diffusion and microdilution methods with ampicillin (25.0 μg) as the positive control. The semi-purified compound exhibited activities against *Klebsiella pnemoniae* with the zone of inhibition and MIC values of 9.0 mm and 2.0 mg/ml, respectively.

Machaba and Mahlo (2017) and Machaba *et al.* (2018) evaluated the antifungal activities of acetone, methanol, ethanol, hexane, dichloromethane, ethyl acetate and water extracts of *M. juncea* leaves against *Candida albicans, Aspergillus fumigatus* and *Cryptococcus neoformans* using microdilution assay. The extract exhibited activities against tested pathogens with MIC values ranging from 0.02 mg/ml to 1.0 mg/ml. Similarly, Hamalwa (2018) evaluated the antifungal activities of a semi-purified compound of *M. schinzii* leaves against *Candida albi-*

Table 1: Medicinal applications of *Maerua juncea* and *M. schinzii*

Medicinal use	Parts used	Country	Reference
Maerua juncea			
Aphonia	A root infusion is taken orally	South Africa	Semenya and Maroyi (2019a)
Diarrhoea	Stem infusion is taken orally	Namibia	Sullivan (1998)
Emetic	A root decoction is taken orally	Namibia	El-Kamali (2013)
Fatigue	A root infusion is taken orally	South Africa	Semenya and Maroyi (2018)
Fatigue	Roots mixed with the bark of Cassia abbreviata Oliv. And bulb of Drimia elata Jacq.	South Africa	Semenya and Maroyi (2018)
Heart problems	Stem decoction is taken orally	Namibia	Sullivan (1998)
Protective charm (evil spirits and good luck)	Leaves, roots and whole plant	Namibia and South Africa	Malan and Owen-Smith (1974); Sullivan (1998)
Purgative	Stem decoction is taken orally	Namibia	El-Kamali (2013)
Respiratory problems (asthma, flu and tuberculosis	Leaf, root and stem infusion and decoction are taken orally	Mozambique, Namibia and South Africa	Luo *et al.* (2011); Semenya and Maroyi (2019b)
Ulcers	Stem infusion is taken orally s	Namibia	El-Kamali (2013)
Ethnoveterinary medicine	Stem infusion is taken orally	Namibia	Sullivan (1998)
Maerua schinzii			
Abdominal pains	Roots infusion taken orally	Namibia	Sullivan (1998)
Bladder problems	The root decoction is taken orally	Namibia	Sullivan (1998)
Body weakness	Leaf infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992); Sullivan (1998)
Cough	Leaf infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992); Sullivan (1998)
Diuretic	A root infusion is taken orally s	Namibia	Sullivan (1998)
Earache	Root decoction applied topically El-Kamali, 2013	Namibia	Van Den Eynden *et al.* (1992); El-Kamali (2013)
Eye problems	Leaf decoction applied topically	Namibia	Sullivan (1998)
Fever	Root infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992); Sullivan (1998)
Headache	Leaf infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992)
Heart problems	Root infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992); El-Kamali (2013)
Protective charm (evil spirits)	Whole plant	Namibia	Palmer and Pitman (1972)
Skin disorders (acne and boils)	Leaf and root infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992); El-Kamali (2013)
Sores	Leaf decoction applied topically	Namibia	Sullivan (1998)
Tonic	Root infusion and decoction are taken orally	Namibia	Van Den Eynden *et al.* (1992); El-Kamali (2013)

cans using the agar disc diffusion and microdilution methods with ampicillin (25.0 μg) as the positive control. The semi-purified compound exhibited activities with the zone of inhibition and MIC values of 12.0 mm and 4.0 mg/ml, respectively.

Mujovo (2009) evaluated the anti-HIV activities of ethanol extracts of *M. juncea* leaves by assessing their ability to inhibit the enzymes α-glucosidase and β-glucuronidase and reverse transcriptase with doxorubicin as a positive control. The extract showed inhibitory activities against α-glucosidase and β-glucuronidase at a concentration of 200.0 μg/ml with percentage inhibition of 69.3% and 90.4%, respectively . Similarly, Hamalwa (2018) evaluated the anti-HIV activities of the semi-purified compound of *M. schinzii* leaves against HIV-1 protease and reverse transcriptase with doxorubicin as a positive control. The semi-purified compound inhibited less than 50.0% at the highest concentration tested of 100.0 μg/mL for HIV-1 reverse transcriptase, which is an indication of low inhibitory activity in comparison to activities exhibited by the positive control.

Machaba *et al.* (2018) evaluated the cytotoxicity activities of acetone, methanol, ethanol, hexane, dichloromethane, ethyl acetate and water extracts of *M. juncea* leaves against Vero monkey kidney cells using the MTT (3-(4,5-dimethylthiazol)-2,5-diphenyl tetrazolium bromide). All plant extracts were not toxic against the cells with median lethal concentration (LC_{50}) values ranging from 0.1 mg/ml and >1.0 mg/ml.

CONCLUSION

The present review summarizes the botanical, medicinal, chemical and biological activities of *Maerua juncea* and *M. schinzii*. Based on the presented information, these two species are closely related and deemed as potent traditional medicines for treating and managing fever, heart problems, headache, earache, skin disorders, fatigue and respiratory problems. *Maerua juncea* and *M. schinzii* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating their medicinal uses with their phytochemistry and pharmacological properties.

ACKNOWLEDGEMENT

I am grateful to the reviewers who kindly commented on my manuscript.

Funding Support

The authors declare that they have no funding support for this study.

Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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