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A review of medicinal uses, phytochemistry and biological activities of *Eriocephalus punctulatus*

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Abstract
Eriocephalus punctulatus is a small shrub widely used as traditional medicine in South Africa. This study is aimed at providing a critical review of the botany, medicinal uses, phytochemistry and biological activities of *E. punctulatus*. Documented information on the botany, medicinal uses, phytochemistry and biological activities of *E. punctulatus* was collected from several online databases which included BMC, Scopus, SciFinder, Google Scholar, Science Direct, Elsevier, Pubmed and Web of Science. Additional information on the botany, medicinal uses, phytochemistry and biological activities of *E. punctulatus* was gathered from pre-electronic sources such as book chapters, books, journal articles and scientific publications obtained from the University library. This study showed that the leaves and oil of *E. punctulatus* are mainly used as aromatherapy, diaphoretic and diuretic and herbal medicine for fever, urinary problems, ringworm and skin problems, heart problems, high blood pressure, diabetes, respiratory problems and gastro-intestinal problems. Ethnopharmacological research revealed that the leaf, root and twig extracts of *E. punctulatus* and essential oils isolated from the species have antibacterial, antifungal, anti-inflammatory, antioxidants and antitermitic activities. *Eriocephalus punctulatus* should be subjected to detailed phytochemical, pharmacological and toxicological evaluations aimed at correlating its medicinal uses with its phytochemistry and pharmacological properties.

Keywords: Asteraceae, Compositae, *Eriocephalus punctulatus*, ethnopharmacology, herbal medicine, indigenous pharmacopeia

INTRODUCTION

Eriocephalus punctulatus DC. is a slender shrub belonging to the Asteraceae or Compositae family, commonly known as the aster, daisy or sunflower family. *Eriocephalus punctulatus* is a commercial source of Cape chamomile oil which is widely used in perfumes and skin care preparations.[1-6] The leaves and stems of *E. punctulatus* are used in the development of commercial natural products sold locally and abroad as tincture, oil, loose and ground sachets and cosmetics.[7] Therefore, *E. punctulatus* is cultivated commercially in the Eastern Cape province in South Africa through vegetative propagation to meet the demand for natural products derived from the species.[2,8,9] The leaves and stems of *E. punctulatus* are also sold in informal herbal medicine markets in the Eastern Cape, Northern Cape and Western Cape provinces in South Africa as sources of traditional medicines.[10] *Eriocephalus punctulatus* is one of the important medicinal plants in South Africa and the species is included in the book "medicinal plants of South Africa", a photographic guide to the most commonly used plant medicines in the country, including their botany, main traditional uses and active ingredients.[5] Research by Van Wyk[11] showed that the leaves and essential oils of *E. punctulatus* have commercial potential as bitter tonics, inhalant and aromatherapy, and herbal medicines for digestive, stomach pain and fever in South Africa. It is within this context that this review was undertaken aimed at reviewing the botany, medicinal uses, phytochemical and biological activities of *E. punctulatus* so as to provide the baseline data required in evaluating the therapeutic potential of the species.

Botanical profile of *Eriocephalus punctulatus*

The genus *Eriocephalus* L. consists of 34 species which are mostly sclerophyllous shrublets, with some species characterized by aromatic oils and small thorns or spines.[3] The genus name *Eriocephalus* is derived from two Greek words "*erion*" meaning "wool" and "*cephale*" meaning "head", and therefore, the genus name mean "woolly head".[12] The species name "*punctulatus*" means "with small dots".[13,14] The English common name of *E. punctulatus* is "Cape chamomile". Synonyms associated with the name *E. punctulatus* include *E. pedicellaris* DC. and *E. pteronoides* Sch. Bip.[15] *Eriocephalus punctulatus* is a slender sclerophyllous, attractively scented, woody shrub which can grow up to 1.5 metre in height.[16-18] The leaves are small, linear, glabrescent, bright green in colour, alternate on flowering shoots or opposite on short-shoots or arranged in clusters along the branches. The inflorescence consist of small white or pale purplish flower heads borne in corymbs. The species has been recorded on rocky and sandstone slopes in the winter rainfall regions of the Northern Cape and Western Cape provinces in South Africa at an altitude ranging from 300 m to 2000 m above sea level.[15,16]

Medicinal uses of *Eriocephalus punctulatus*

The leaves and oil of *E. punctulatus* are mainly used as aromatherapy, diaphoretic and diuretic and herbal medicine for fever, urinary problems, ringworm and skin problems, heart problems, high blood pressure, diabetes, respiratory problems and gastro-intestinal problems (Table 1, Figure 1). The leaves of *E. punctulatus* are mixed with those of *Metalasia muricata* (L.) D. Don and used as a fumigant for colds and diarrhoea.[3,19]

Table 1: Medicinal uses of *Eriocephalus punctulatus*

Medicinal use	Parts used	References
Abdominal pains	Leaves	Mugomeri et al.[20]
Aromatherapy	Oil	Njenga[3]; Makunga et al.[7]; Lall and Kishore[21]
Backache	Leaves	Nortje and Van Wyk[22]
Bile problems	Leaves	Nortje and Van Wyk[22]
Colds and diarrhoea	Leaves mixed with those of *Metalasia muricata* (L.) D. Don	Njenga[3]; Moffett[19]
Colic	Leaves	Njenga et al.[23]
Gastro-intestinal problems (constipation, diarrhoea and stomach problems)	Leaves	Mierendorff et al.[2]; Njenga[3]; Mugomeri et al.[20]; Lall and Kishore[21]; Njenga et al.[23]; Jacot Guillarmod[24]; Shale[25]; Fennell et al.[26]; Moteetee and Van Wyk[27]; Philander[28]; Mabaleha et al.[29]
Diabetes	Leaves	Njenga[3]; Moffett[19]; Mugomeri et al.[20]; Moteetee and Van Wyk[27]; Mabaleha et al.[29]; Pitso and Ashafa[30]; Balogun et al.[31]; Mudumbi et al.[32]
Diaphoretic	Leaves	Njenga[3]; Njenga et al.[23]; Balogun et al.[31]; Watt and Breyer-Brandwijk[33]; Thring and Weitz[34]
Diuretic	Leaves	Njenga et al.[23]; Philander[28]; Balogun et al.[31]; Watt and Breyer-Brandwijk[33]; Thring and Weitz[34]
Fever	Leaves	Philander[28]; Hulley and Van Wyk[35]
Heart problems	Leaves	Njenga et al.[23]; Philander[28]; Thring and Weitz[34]; Hulley and Van Wyk[35]
High blood pressure	Leaves	Moffett[19]; Mugomeri et al.[20]; Moteetee and Van Wyk[27]; Mabaleha et al.[29]; Thornton-Barnett[36]
Kidney problems	Leaves	Hulley and Van Wyk[35]
Migraine	Leaves	Philander[28]
Respiratory problems (chest complaints, colds, influenza and tuberculosis)	Leaves	Makunga et al.[7]; Mugomeri et al.[20]; Jacot Guillarmod[24]; Moteetee and Van Wyk[27]; Mabaleha et al.[29]; Kose et al., 2015; Nortje and Van Wyk[22]; Balogun et al.[31]
Ringworm and skin problems	Leaves	Njenga[3]; Njenga et al.[23]; Nortje and Van Wyk[22]
Urinary problems	Leaves	Lall and Kishore[21]; Hulley and Van Wyk[35]

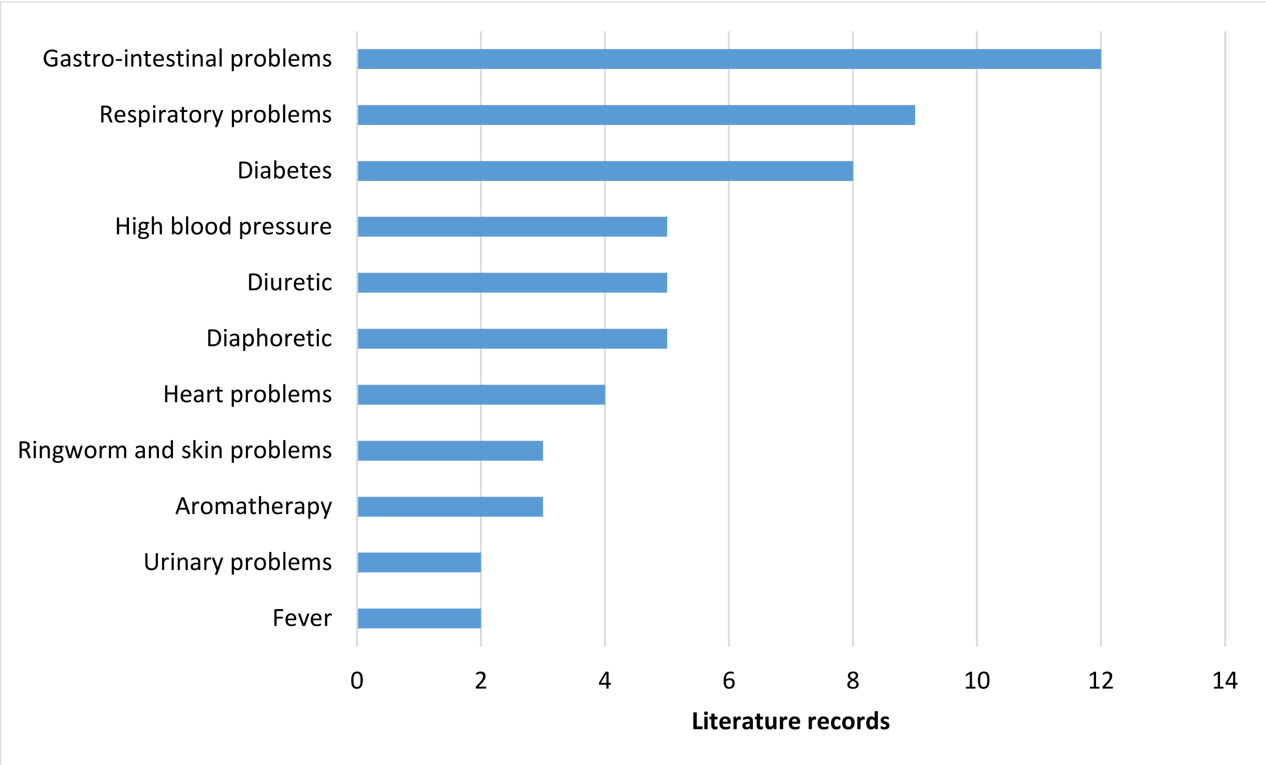

Figure 1. Medicinal applications of *Eriocephalus punctulatus* derived from literature records

Phytochemistry and biological activities of *Eriocephalus punctulatus*

The aerial parts and leaves of *E. punctulatus* contain essential oils which appear to vary with geographical origin of the specimens as shown in Table 2. The major compounds that have been identified from the species include axenol (0.1 – 11.1%), bornyl acetate (0.3 – 18.9%), camphor (0.0 – 15.1%), 1,8-cineole (0.1 – 53.1%), isobutyl isobutanoate (14.3%), 2-methyl butyl 2-methylpropanoate (21.2%), 2-methyl butyl isobutanoate (27.4%), τ-muurolol (0.7 – 13.9%), piperitone (0.0 – 25.6%), pogostol (0.1 – 15.9%) and yomogi alcohol (0.0 – 19.7%).[2,3,37,38] Future research should focus on evaluating the biological activities of the isolated compounds. The following biological activities have been reported from the leaf, root and twig extracts of *E. punctulatus* and essential oils isolated from the species: antibacterial,[3,23,25,39] antifungal,[3,23,39,40] anti-inflammatory,[3,4,25] antioxidants[3,4] and antitermitic[38] activities.

Table 2: Phytochemical compounds identified from aerial parts and leaves of *Eriocephalus punctulatus*

Phytochemical	Value	Reference
Adamantane 1,3-dimethyl (T) (%)	0.1 – 1.3	Sandasi et al[37]
Amorpha-4-en-7-ol (%)	0.0 – 2.6	Sandasi et al[37]
cis-Arbusculone (%)	<0.05	Mierendorff et al[2]
trans-Arbusculone (%)	<0.05	Mierendorff et al[2]
allo-Aromadendrene (%)	0.4	Mierendorff et al[2]
Aromadendrene (%)	0.1 – 0.4	Sandasi et al[37]
Artedouglasia oxide isomer (%)	0.0 – 2.7	Sandasi et al[37]
Artedouglasia oxide A (%)	2.2	Mierendorff et al[2]
Artedouglasia oxide B (%)	1.3	Mierendorff et al[2]
Artedouglasia oxide C (%)	1.7	Mierendorff et al[2]
Artedouglasia oxide D (%)	0.7	Mierendorff et al[2]
Artemisia alcohol (%)	0.3 – 3.9	Njenga[3];
Artemisia ketone (%)	0.0 – 1.2	Sandasi et al[37]
Axenol (%)	0.1 – 11.1	Sandasi et al[37]
Bicyclogermacrene (%)	0.0 – 0.5	Mierendorff et al[2]; Sandasi et al[37]
Bicyclosesquiphellandrene (%)	0.0 – 0.9	Sandasi et al[37]
Borneol (%)	0.0 - 5.8	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]; Seo et al.[38]
Bornyl acetate (%)	0.3 – 18.9	Mierendorff et al[2]; Njenga[3]
Butyl-3-methyl-2-butenoate (%)	0.1 – 0.2	Sandasi et al[37]
Butyl angelate (%)	0.0 – 3.6	Mierendorff et al[2]; Sandasi et al[37]
Butyl tiglate (%)	0.1	Mierendorff et al[2]
α-Cadinol (%)	0.1 – 7.0	Sandasi et al[37]
δ-Cadinol (%)	0.1 – 0.9	Sandasi et al[37]
α-Calacorene (%)	0.0 – 0.4	Mierendorff et al[2]; Sandasi et al[37]
trans-Calamanene (%)	0.1 – 0.9	Sandasi et al[37]
Camphene (%)	0.0 – 2.3	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]; Seo et al.[38]
Camphor (%)	0.0 – 15.1	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]; Seo et al.[38]
Carvacrol (%)	<0.05	Mierendorff et al[2]
cis-Carveol (%)	0.0 – 0.4	Sandasi et al[37]
Carvone (%)	0.0 – 0.3	Sandasi et al[37]
cis-Carvyl acetate (%)	0.0 – 0.7	Sandasi et al[37]
Caryophylla-3(15),7(14)-dien-6-ol (%)	0.9	Mierendorff et al[2]
Caryophyllene oxide (%)	0.8 – 8.2	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]
β-Caryophyllene (%)	0.5 – 6.9	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]
Chamazulene (%)	0.2	Mierendorff et al[2]
1,8-Cineole (%)	0.1 – 53.1	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]
β-Copaen-4-α-ol (%)	0.5	Mierendorff et al[2]
α-Copaene (%)	0.0 – 1.4	Mierendorff et al[2]; Sandasi et al[37]
β-Copaene (%)	<0.05	Mierendorff et al[2]
α-Cubebene (%)	0.0 – 0.8	Sandasi et al[37]
Cubebol (%)	0.0 – 3.9	Sandasi et al[37]
Cumambrin-A	-	Davies-Coleman et al.[41]
p-Cymene (%)	0.1 – 3.8	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]; Seo et al.[38]
(E,E)-2,4-Decadienal (%)	<0.05	Mierendorff et al[2]
n-Decane (%)	0.1 – 0.8	Sandasi et al[37]
4-Dehydroviridiflorol (%)	0.1 – 0.8	Sandasi et al[37]
Dehydroxylinalool oxide A (%)	0.5	Mierendorff et al[2]
(E,Z)-1,2-Diethylidenecyclopentane (%)	<0.05	Mierendorff et al[2]
4,8-Dimethyl-1,3,7-nonatriene (%)	0.0 – 0.3	Sandasi et al[37]
(E)-2,6-Dimethylocta-1,5,7-trien-3-ol (%)	0.0 – 2.1	Sandasi et al[37]
Diosphenol (%)	<0.05	Mierendorff et al[2]
β-Elemene (%)	0.1 – 0.7	Mierendorff et al[2]; Sandasi et al[37]
Ethyl 3-methyl-2-butenoate (%)	<0.05	Mierendorff et al[2]

Phytochemical	Value	Reference
Eugenol (%)	<0.05	Mierendorff et al[2]
β-Eudesmol (%)	0.8 – 6.3	Njenga[3]
α-Funebrene (%)	0.4	Mierendorff et al[2]
Geraniol (%)	<0.05	Mierendorff et al[2]
Geranyl acetate (%)	0.5	Mierendorff et al[2]
2-Heptyl acetate (%)	0.1	Mierendorff et al[2]
Hexyl 2-methylpropanoate (%)	<0.05	Mierendorff et al[2]
α-Humulene (%)	0.0 – 0.6	Mierendorff et al[2]; Sandasi et al[37]
Isobutyl isobutanoate (%)	14.3	Seo et al.[38]
Isobutyl isovalerate (%)	1.1	Seo et al.[38]
Isodavanone (%)	0.2	Mierendorff et al[2]
8-isobutyloxycumambrin-B	-	Davies-Coleman et al.[41]
Isoamyl isovalerate (%)	0.0 – 3.3	Sandasi et al[37]
α-Isocomene (%)	0.1	Mierendorff et al[2]
Isopinocamphonone (%)	0.3 – 4.3	Sandasi et al[37]
Juniper Camphor (%)	0.1 – 9.3	Sandasi et al[37]
Laciniata furanone E (%)	0.3	Mierendorff et al[2]
Laciniata furanone F (%)	0.4	Mierendorff et al[2]
Laciniata furanone G (%)	0.2	Mierendorff et al[2]
Laciniata furanone H (%)	0.5	Mierendorff et al[2]
Lavandulol (%)	0.0 – 0.8	Sandasi et al[37]
Limonene (%)	0.0 – 0.7	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
Linalool (%)	0.2 – 1.5	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
Linalyl acetate (%)	2.9 – 4.4	Mierendorff et al[2]; Seo et al.[38]
Longicyclene (%)	0.3	Mierendorff et al[2]
Longifolene (%)	0.2	Mierendorff et al[2]
α-Longipinene (%)	0.2	Mierendorff et al[2]
Lyratyl acetate (%)	0.4	Mierendorff et al[2]
Menthone (%)	0.1	Mierendorff et al[2]
cis-p-Menth-2-en-1-ol (%)	0.0 – 0.4	Mierendorff et al[2]; Sandasi et al[37]
trans-p-Menth-2-en-1-ol (%)	0.1 – 0.3	Sandasi et al[37]
2-Methyl-1-butanol (%)	0.4	Mierendorff et al[2]
3-Methyl-2-butyl acetate (%)	<0.05	Mierendorff et al[2]
7-Methyl-2-octyl acetate (%)	4.5	Mierendorff et al[2]
7-Methyl-2-octanol (%)	0.7	Mierendorff et al[2]
2-Methyl butanol (%)	0.0 – 0.8	Sandasi et al[37]
3-Methyl butyl acetate (%)	<0.05	Mierendorff et al[2]
2-Methyl butyl acetate (%)	0.1	Mierendorff et al[2]
3-Methyl butyl angelate (%)	0.0 – 0.9	Sandasi et al[37]
2-Methyl butyl benzoate (%)	0.1	Mierendorff et al[2]
2-Methyl butyl butyrate (%)	0.0 – 0.7	Sandasi et al[37]
2-Methyl propyl acetate (%)	<0.05	Mierendorff et al[2]
2-Methyl propyl propanoate (%)	<0.05	Mierendorff et al[2]
2-Methyl propyl 2-methylpropanoate (%)	5.3	Mierendorff et al[2]
2-Methyl propyl methacrylate (%)	0.0 – 1.1	Mierendorff et al[2]; Sandasi et al[37]
3-Methyl butyl propanoate (%)	<0.05	Mierendorff et al[2]
2-Methyl butyl propanoate (%)	0.2	Mierendorff et al[2]
2-Methyl butyl 2-methylbutanoate (%)	5.5 - 5.6	Mierendorff et al[2]; Seo et al.[38]
3-Methyl butyl 2-methylbutanoate (%)	1.1 – 1.3	Mierendorff et al[2]; Seo et al.[38]
2-Methyl butyl 3-methylbutanoate (%)	1.1	Mierendorff et al[2]
2-Methyl butyl 2-methylpropanoate (%)	21.2	Mierendorff et al[2]
3-Methyl butyl 2-methylpropanoate (%)	2.6	Mierendorff et al[2]
2-Methyl butyl methacrylate (%)	0.2	Mierendorff et al[2]
3-Methyl butyl methacrylate (%)	<0.05	Mierendorff et al[2]
2-Methyl butyl butanoate (%)	0.1	Mierendorff et al[2]
2-Methyl butyl angelate (%)	3.5	Mierendorff et al[2]
3-Methyl butyl angelate (%)	0.3	Mierendorff et al[2]
2-Methyl butyl isobutanoate (%)	27.4	Seo et al.[38]
3-Methyl butyl isobutanoate (%)	3.0	Seo et al.[38]
2-Methyl butyl isovalerate (%)	1.0	Seo et al.[38]
2-Methyl butyl phenylacetate (%)	0.7	Mierendorff et al[2]
3-Methyl butyl phenylacetate (%)	0.3	Mierendorff et al[2]
2-Methyl propyl angelate (%)	1.6	Mierendorff et al[2]
2-Methyl propyl 2-methylbutanoate (%)	1.4	Mierendorff et al[2]
2-Methyl propyl 3-methylbutanoate (%)	1.2	Mierendorff et al[2]
Methyl butyl metacrylate (T) (%)	0.0 – 2.1	Sandasi et al[37]

Phytochemical	Value	Reference
L-2-0-methylchiroinositol	-	Davies-Coleman et al.[41]
Modhephene (%)	<0.05	Mierendorff et al[2]
α-Muurolene (%)	0.0 – 0.4	Mierendorff et al[2]; Sandasi et al[37]
γ-Muurolene (%)	0.0 – 0.4	Sandasi et al[37]
τ-Muurolol (%)	0.7 – 13.9	Njenga[3]; Sandasi et al[37]
β-Myrcene (%)	0.1	Mierendorff et al[2]
Myrtenal (%)	0.1 – 0.5	Sandasi et al[37]
Myrtenol (%)	0.0 – 1.4	Sandasi et al[37]
Myrtenyl acetate (%)	<0.05	Mierendorff et al[2]
Nerol (%)	0.1	Mierendorff et al[2]
Neryl acetate (%)	0.6	Mierendorff et al[2]
2-Nonanone (%)	0.0 – 5.2	Mierendorff et al[2]; Sandasi et al[37]
2-Nonyl acetate (%)	0.6	Mierendorff et al[2]
(E)-β-Ocimene (%)	<0.05	Mierendorff et al[2]
2-Octyl acetate (%)	0.4	Mierendorff et al[2]
β-Oplopenone (%)	0.0 – 1.3	Sandasi et al[37]
Palustrol (%)	0.1 – 3.2	Sandasi et al[37]
Pentyl angelate (%)	1.3	Mierendorff et al[2]
Pentyl tiglate (%)	0.2	Mierendorff et al[2]
Pentyl-3-methyl butenoate (%)	0.0 – 5.6	Sandasi et al[37]
α-Phellandrene (%)	0.0 – 0.9	Sandasi et al[37]
β-Phellandrene (%)	0.2	Seo et al., 2014
2-Phenylethyl 2-methylpropanoate (%)	0.5	Mierendorff et al[2]
α-Pinene (%)	0.0 – 3.9	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]; Seo et al.[38]
β-Pinene (%)	0.0 – 3.2	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
Pinocamphone (%)	3.8 – 5.8	Njenga[3]
Pinocarveol (%)	0.1 – 2.3	Sandasi et al[37]
trans-Pinocarveol (%)	0.1	Mierendorff et al[2]
Pinocarvone (%)	0.1 – 3.7	Sandasi et al[37]
Piperitone (%)	0.0 – 25.6	Njenga[3]; Sandasi et al[37]
cis-Piperitol (%)	0.0 – 0.2	Sandasi et al[37]
Pogostol (%)	0.1 – 15.9	Sandasi et al[37]
Prezizaene (%)	0.0 – 0.3	Sandasi et al[37]
Propyl 2-methylpropanoate (%)	<0.05	Mierendorff et al[2]
Pulegone (%)	0.1	Mierendorff et al[2]
Sabinene (%)	0.0 – 0.6	Mierendorff et al[2]; Sandasi et al[37]
Sabinene hydrate (%)	0.2	Seo et al.[38]
cis-Sabinene hydrate (%)	0.0 – 0.8	Mierendorff et al[2]; Sandasi et al[37]
trans-Sabinene hydrate (%)	0.0 – 1.5	Mierendorff et al[2]; Sandasi et al[37]
trans-Sabinene hydrate acetate (%)	<0.05	Mierendorff et al[2]
Santolina alcohol (%)	7.3	Njenga[3]
Santolinatriene (%)	0.0 – 3.1	Sandasi et al[37]
α-Selinene (%)	0.1	Mierendorff et al[2]
Spathulenol (%)	0.0 – 7.8	Mierendorff et al[2]; Njenga[3]; Sandasi et al[37]
Terpinen-4-ol (%)	0.0 – 6.6	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
α-Terpinene (%)	0.1 – 0.6	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
γ-Terpinene (%)	0.0 – 1.3	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
α-Terpineol (%)	0.0 – 2.9	Mierendorff et al[2]; Sandasi et al[37]; Seo et al.[38]
δ-Terpineol (%)	0.0 – 0.6	Sandasi et al[37]
4-Terpineol (%)	1.5 – 5.6	Njenga[3]
Terpinolene (%)	0.2 – 0.3	Mierendorff et al[2]; Seo et al.[38]
α-Terpinyl acetate (%)	<0.05	Mierendorff et al[2]
α-Thujene (%)	<0.05	Mierendorff et al[2]
Thymol (%)	<0.05	Mierendorff et al[2]
Tricyclene (%)	<0.05	Mierendorff et al[2]
2,2,3-Trimethyl-3-cyclopentene-1-acetaldehyde (%)	<0.05	Mierendorff et al[2]
Verbenene (%)	<0.05	Mierendorff et al[2]
Verbenone (%)	0.0 – 0.3	Sandasi et al[37]
Viridiflorol (%)	0.0 – 0.9	Mierendorff et al[2]; Sandasi et al[37]
Yomogi alcohol (%)	0.0 – 19.7	Njenga[3]; Sandasi et al[37]

Antibacterial activities

Shale[25] evaluated the antibacterial activities of hexane, methanol and water leaf and root extracts of *E. punctulatus* against *Micrococcus luteus, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermis, Escherichia coli, Psuedomonas aeruginosa* and *Klebsiella pneumoniae* using disc diffusion and microplate bioassays with neomycin as a positive control. Only hexane and methanol leaf extracts exhibited activities against *Bacillus subtilis* and *Staphylococcus aureus* with zone of inhibition ranging from 0.4 mm to 0.8 mm.[25] Njenga[3] evaluated antibacterial activities of acetone leaf extracts of *E. panculatus* and essential oil isolated from the species against *Bacillus cereus, Yersinia enterocolitica, Bacillus subtilis, Salmonella typhimurium, Enterococcus faecalis, Salmonella enteriditis, Escherichia coli, Staphylococcus aureus, Proteus vulgaris, Klebsiella pneumoniae, Pseudomonas aeruginosa, Staphylococcus epidermidis* and *Serratia odorifera* using disc diffusion assay and micro-titre plate dilution method with ciprofloxacin (0.01 mg/ml) as a positive control. The essential oil exhibited activities against most of the pathogens with the exception of *Salmonella enteriditis* and *Proteus vulgaris* with the zone of inhibition ranging from <1.0 mm to 3.0 mm. The acetone extract exhibited activities against *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus* and *Pseudomonas aeruginosa* with the zone of inhibition ranging from <1.0 mm to 3.0 mm. The minimum inhibitory concentration (MIC) values of essential oil against *Bacillus cereus, Escherichia coli* and *Staphylococcus aureus* ranged from 0.8 mg/ml to 16.0 mg/ml.[3] Njenga et al.[23] evaluated the antibacterial activities of the essential oil isolated from *E. punctulatus* against *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Staphylococcus epidermidis, Klebsiella pneumoniae, Escherichia coli, Pseudomonas aeruginosa, Yersinia enterocolitica, Salmonella typhimurium, Salmonella enteriditis, Proteus vulgaris, Serratia odorifera* and *Enterococcus faecalis* using the disc diffusion assay with neomycin (30 µg) as a positive control. The essential oil exhibited activities against *Bacillus cereus, Bacillus subtilis, Staphylococcus aureus, Klebsiella pneumoniae* and *Escherichia coli* with zone of inhibition ranging from <1.0 mm to 5.5 mm which was comparable to 2.0 mm to 8.0 mm exhibited by the positive control. The MIC values against *Bacillus cereus, Staphylococcus aureus* and *Escherichia coli* ranged between 0.8 mg/ml to 16.0 mg/ml.[23] Samie et al.[39] evaluated antibacterial activities of essential oil isolated from *E. punctulatus* against *Acinetobacter calcoaceticus, Bacilus cereus, Escherichia coli, Klebsiella pneumoniae, Staphylococcus aureus, Staphylococcus epidermidis, Pseudomonas aeruginosa, Micrococcus kristinae, Salmonella typhi, Proteus vulgaris, Serratia marsecens* and *Streptococcus faecalis* using the microdilution method. The essential oil exhibited weak activities against all tested pathogens with both MIC and minimum bactericidal concentration (MBC) values ranging from 7.5 mg/ml to >7.5 mg/ml.[39]

Antifungal activities

Njenga[3] evaluated antifungal activities of acetone leaf extracts of *E. punctulatus* and essential oil isolated from the species against *Cryptococcus neoformans* and *Candida albicans* using disc diffusion assay and micro-titre plate dilution method with amphotericin B (0.01 mg/ml) as a positive control. The essential oil exhibited activities against both species with the zone of inhibition ranging from <1.0 mm to 3.0 mm. The acetone extract exhibited activities against *Cryptococcus neoformans* with the zone of inhibition of 3.0 mm. The MIC values of essential oil against *Cryptococcus neoformans* and *Candida albicans* was 0.8 mg/ml and 8.0 mg/ml, respectively.[3] Njenga et al.[23] evaluated the antifungal activities of the essential oil isolated from *E. punctulatus* against *Cryptococcus neoformans, Candida albicans* and *Alternaria alternata* using the disc diffusion assay with nystatin (100 IU) as a positive control. The essential oil exhibited activities against *Cryptococcus neoformans* and *Candida albicans* with zone of inhibition ranging from <1.0 mm to 9.0 mm which was comparable to 7.0 mm to 11.0 mm exhibited by the positive control. The MIC values against *Cryptococcus neoformans* and *Candida albicans* ranged from 0.8 mg/ml to 8.0 mg/ml.[23] Samie and Nefefe[40] evaluated antifungal activities of essential oil isolated from *E. punctulatus* against *Fusarium verticillioides, Fusarium nygamai, Fusarium oxysporum, Fusarium proliferatum* and *Fusarium graminearum* using the agar diffusion and microdilution methods with nystatin as a positive control. The essential oil exhibited activities against tested pathogens with MIC and minimum fungicidal concentration (MFC) values ranging from 0.2 mg/ml to 7.5 mg/ml.[40] Samie et al.[39] evaluated antifungal activities of essential oil isolated from *E. punctulatus* against *Candida albicans, Candida glabrata, Candida krusei, Candida parapsilosis, Candida tropicalis* and *Cryptococcus neoformans* using the microdilution method. The essential oil exhibited weak activities against all tested pathogens with MIC and MFC values ranging from 7.5 mg/ml to >7.5 mg/ml.[39]

Anti-inflammatory activities

Shale[25] evaluated the anti-inflammatory activities of hexane, methanol and water leaf extracts of *E. punctulatus* using the cyclooxygenase-1 (COX-1) bioassay with indomethancin as a positive control. The hexane and methanol extracts exhibited anti-inflammatory activities of 89.0% and 81.0%, respectively.[25] Njenga[3] evaluated anti-inflammatory activities of essential oil isolated from the leaves of *E. punctulatus* using the 5-lipoxygenase enzyme (5-LOX) assay with nordihydroguaiaretic acid (NDGA) as a reference drug. The essential oil exhibited activities with half maximal inhibitory concentration (IC_{50}) values ranging from 63.0 µg/ml to 63.8 µg/ml against IC_{50} of 5.0 µg/ml exhibited by the positive control.[3] Njenga and Viljoen[4] evaluated anti-inflammatory activities of essential oil isolated from the leaves of *E. punctulatus* using the 5-LOX enzyme assay with NDGA as a positive control. The essential oil exhibited activities with IC_{50} values ranging from 63.0 µg/ml to 98.9 µg/ml against 5.0 µg/ml exhibited by the positive control.[4]

Antioxidants activities

Njenga[3] evaluated antioxidant activities of acetone leaf extracts of *E. punctulatus* and essential oil isolated from the species using 2,2,diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay with vitamin C as the positive control. The essential oil did not show any activity but the acetone extract exhibited IC_{50} values ranging from 21.5 µg/ml to 79.6 µg/ml.[3] Similarly, Njenga and Viljoen[4] evaluated antioxidants activities of acetone leaf extracts of *E. punctulatus* and the essential oil isolated from the species using the DPPH free radical scavenging assay with vitamin C as a positive control. The essential oil did not show any activities but the leaf extract exhibited activities with IC_{50} values ranging from 21.5 µg/ml to 79.6 µg/ml against 2.9 µg/ml exhibited by the positive control.[4]

Antitermitic activity

Seo et al.[38] evaluated the antitermitic activities through the fumigant toxicity of the essential oil isolated from the leaves of *E. punctulatus* against the Japanese termite *Reticulitermes speratus* Kolbe. The adult worker termites were considered dead if their appendages did not move when prodded and cumulative mortalities were determined after two and seven days after the treatment. The termite mortalities varied according to dose and exposure times, exhibiting 100% fumigant toxicity two days after treatment at 10 mg/L and 44.0% two days after treatment at 2.5 mg/L.[38]

CONCLUSION

The diverse medicinal uses of *E. punctulatus* and the preliminary phytochemical and pharmacological evaluations carried out so far indicate its potential as traditional medicine. The documented preliminary diverse pharmacological activities are directly or indirectly involved in a range of physiological processes which offers protection against growth of undesirable microbes and free radicals. Although contemporary ethnopharmacological research involving *E. punctulatus* is promising, it is too preliminary and sometimes too general to be used to explain and support some of the medicinal uses of the species. There is need for evaluation of the clinical significance of the anti-inflammatory, antioxidant properties, cytotoxicity and toxicity using *in vivo* models.

Conflict of interest

The author declares that there is no conflict of interest regarding the publication of this paper.

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