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Short communication

Ethnobotany and antimicrobial activity of *sieketroos* (*Arctopus* species)

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Abstract

Arctopus echinatus L. and related species are ancient Khoi-San medicinal plants adopted by the early Cape settlers who used them as a "comfort to the sick", hence the Afrikaans vernacular name *sieketroos*. The earliest recorded medicinal use dates back to the days of Thunberg's travels in the eighteenth century when it was used as a remedy for venereal diseases. The rich ethnobotanical history of these interesting and pharmacologically largely ignored South African plants is recorded together with a synopsis of modern day usage. Antimicrobial activities of root extracts of *Arctopus* species on nine pathogens showed strongest activity against *Staphylococcus epidermidis* and moderate to good activity against *Staphylococcus aureus*.

Keywords: Antimicrobial activity; *Arctopus*; Apiaceae; Ethnobotany; Khoi-San; *Sieketroos*

1. Introduction

The genus *Arctopus* L. is a member of the family Apiaceae, and consists of three very distinctive and unusual species, endemic to the Cape Floristic Region of South Africa (Goldblatt and Manning, 2000). Their resinous roots are chemically similar to those of *Alepidea amatymbica* Eckl. and Zeyh. (*ikhathazo*), a well-known Zulu and Sotho medicinal plant, with an equally rich ethnobotanical history (Van Wyk et al., 1997; Van Wyk and Gericke, 2000). The name *Arctopus*, given to this plant by Linnaeus, means 'bear's foot' and aptly describes its broad simple leaves that remain appressed to the ground and are armed with large inflexed spines. These plants were held in great esteem as a "comfort to the sick", hence the Afrikaans vernacular name *sieketroos* (Pappe, 1847, 1857). It is thought to have been adopted from the Khoi-San by the Early Cape Settlers (Pappe, 1847, 1857), however according to Theodore (1972), no original Khoi-San name is known today. In Smith's (1966), *Common names of South African plants*, *Arctopus echinatus* is recorded by the vernacular names *platdoring*, *sieketroos* and *pokkiesdoring*, the latter suggesting a more specific connotation with its use against syphilis (Afr. *pokkies*). It has been mentioned numerously in the literature of the last two centuries and has a rich ethnobotanical history. The name "sieketroos" usually refers specifically to *A. echinatus* (the most common and widely distributed species) but the three species are superficially quite similar and the name may sometimes apply to all three.

The aim of this paper is to provide a summary of all known ethnobotanical information on *Arctopus* species and to investigate possible antimicrobial activity.

2. Material and methods

2.1. Materials studied

Voucher specimens of all six extracts that were tested (listed in Table 1) are given below. The specimens are housed in the University of Johannesburg herbarium (JRAU).

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Table 1
The mean minimum inhibitory concentrations (mg/mL) for methanol:water (80:20) extracts of the roots of *Arctopus* species

Test samples	Voucher specimens	Gram-positive			Gram-negative				Yeasts	
		S. aureus	*S. epidermidis*	*E. coli*	*P. vulgaris*	*E. aerogenes*	*P. aeruginosa*	*K. pneumoniae*	*C. neoformans*	*C. albicans*
A. dregei 1	*Magee & Boatwright 2*	4.0	0.9	4.0	NS	4.0	NS	4.0	2.0	4.0
A. dregei 2	*Magee & Boatwright 31*	4.0	0.1	4.0	NS	4.0	NS	6.0	NS	6.0
A. echinatus 1	*Magee & Boatwright 15*	0.5	0.2	4.0	NS	4.0	NS	4.0	NS	6.0
A. echinatus 2	*Van Wyk 4128a*	0.5	0.05	4.0	NS	4.0	NS	4.0	NS	4.0
A. monacanthus 1	*Van Wyk 4161a*	1.0	0.05	4.0	NS	4.0	NS	4.0	NS	3.0
A. monacanthus 2	*Van Wyk 4141a*	0.3	0.02	4.0	NS	4.0	NS	NS	NS	6.0
Control		0.5×10^{-3} [a]	0.6×10^{-3}[a]	0.04×10^{-3}[a]	0.04×10^{-3}[a]	0.6×10^{-3}[a]	0.1×10^{-3}[a]	2.5×10^{-3}[a]	2.5×10^{-3} [b]	2.5×10^{-3}[b]

NS = not susceptible (either having no activity at the highest concentration tested or activity equivalent to the DMSO control).
Voucher specimens were deposited in the University of Johannesburg Herbarium (JRAU).
[a] Control = ciprofloxacin.
[b] Control = amphotericin B.

A. dregei 1: Rondeberg near Malmesbury, *Magee and Boatwright 2* (JRAU), collected 05.09.2004; *A. dregei* 2: Malmesbury, *Magee and Boatwright 31* (JRAU), collected 06.12.2004; *A. echinatus* 1: Hermanus, *Magee and Boatwright 15* (JRAU), collected 27.11.2004; *A. echinatus* 2: Nieuwoudtville, *Van Wyk 4128a* (JRAU), collected 10.09.2004; *A. monacanthus* 1: Gifberg, *Van Wyk 4161a* (JRAU), collected 26.10.2004; *A. monacanthus* 2: Citrusdal, Elandskloof pass, *Van Wyk 4141a* (JRAU), collected 23.10.2004.

2.2. Extract preparation

Finely chopped and air-dried root material for all three species of *Arctopus* (two samples of 10 g for each species) were extracted with 250 ml methanol:water (80:20). They were sonicated for 10 min in an ultrasound bath and left to extract for 24 h The extracts were subsequently filtered and concentrated to dryness. The three species are *A. echinatus* L., *A. monacanthus* Carmichael ex. Sond. and *A. dregei* Sond. Authorities for names are not repeated elsewhere.

2.3. Microorganisms

Reference bacterial and yeast strains were selected for investigation based on the traditional use of the plant. *Staphylococcus aureus* ATCC 12600 and *Staphylococcus epidermidis* ATCC 2223 were included on the basis of their pathogenesis to primarily infect the skin. *Escherichia coli* ATCC 25922, *Proteus vulgaris* ATCC 33420, *Enterobacter aerogenes* ATCC 13048, *Pseudomonas aeruginosa* ATCC 9027 and *Candida albicans* ATCC 10231 are the causative organisms associated with bladder infections. *Klebsiella pneumoniae* ATCC 13883 and *Cryptococcus neoformans* ATCC 90112 were investigated for their potential respiratory pathogenesis.

2.4. Minimum inhibitory assay

The microplate bioassay minimum inhibitory concentrations (MIC) were determined using the microplate method (Carson et al., 1995; Eloff, 1998; NCCLS, 2003). All bacterial cultures were subcultured from stock agar plates and grown in Tryptone Soya broth overnight. The yeasts were incubated for a further 24 h. Microtitre plates were aseptically prepared by the addition of 100 µl distilled, sterile water into each well. The *Arctopus* extracts (100 µl) prepared in Dimethyl Sulfoxide (DMSO) at starting stock concentrations of 64 mg/mL were subsequently transferred into the first rows of a microtitre plate and serial dilutions performed. Microbial cultures were diluted in fresh Tryptone Soya broth to a 0.5 McFarland standard (approximate inoculum size of 1×10^6 CFU/mL) and 100 µl was added to all wells (NCCLS, 2003; Andrews, 2004). Positive controls at starting stock concentrations of 0.01 µg/mL i.e. ciprofloxacin for bacterial test organisms or amphotericin B for the yeast strains were included in each assay to confirm antimicrobial susceptibility. The use of DMSO as a solvent was necessary for the miscibility of the extracts. To account for the inhibitory effect of the solvent, a negative control was included for all pathogens. This was achieved by preparing the control DMSO sample in the same way as the plant sample, however with sterile water in place of test plant material. Any activities equivalent to or greater than that found for the DMSO control were omitted from the data (Table 1) and considered not susceptible (NS). Optimal (37 °C for 24 h for bacteria and 48 h for yeasts) incubation conditions followed. A 0.2-mg/ml *p*-iodonitrotetrazolium violet solution was transferred into all inoculated wells (40 µl) and examined to determine a colour change in relation to concentration of microbial growth after 6 h for bacteria and 24 h for the yeasts. Tests were performed either in duplicate or in triplicate where resulting MIC values did not show congruency after the second replicate.

3. Ethnobotanical review

3.1. Historical overview

The roots of *A. echinatus* (and to a lesser extent *A. monacanthus* and *A. dregei*) have been used historically against many conditions caused by microbial infections. The famous Swedish botanist and explorer Carl Thunberg mentioned

Arctopus in a letter, dated 28 May 1772, a month after arriving in the Cape of Good Hope. He remarked on the virtue of a decoction of *Arctopus* in the treatment of gonorrhoea (Smith, 1966): "*Radix Arctopi, quae redinam albam stillat, optimum erct mundificans, si decoquatur, etiam in gonnorrhoea*". Thunberg in his diary (Forbes, 1986) mentions *A. echinatus* ("*Ziekte-troost*") as a terrible nuisance to the bare-footed slaves who where often wounded by its sharp spines. The plant seems to have been of great interest to him, as can be seen by the comprehensive description found in Flora Capensis (Thunberg, 1823).

In a report dated 17 February 1827, the assistant surgeon to the Forces, Dr James Barry, fervently discusses the medicinal virtues of what he calls "*Sieketroost*" (or "*Plat Doorn*") and the diseases it is effectively used against (Theodore, 1972). He states that the roots contain large amounts of "gum resin and tannins" as well as a small quantity of essential oil, "extracted narcotic matter", a bitter aromatic acrid principle and "*Feculae Saccharine* matter", as well as an alkaloid he calls arctopine. He makes reference to the various applications of decoctions, tinctures and pills: "In Syphilis, it has been esteemed by the Natives of South Africa a specific, as also in Gonorrhoea. It is much to be depended upon as a remedy in Lepra, Elephantiasis, and some of the obstinate Cutaneous Diseases incident to this climate." He also mentions the use of the decoction as a tonic, as well as a wash and dressing for ulcers and blotches.

Pappe (1847, 1857) describes *A. echinatus* as having demulcent and diuretic properties comparable to that of the *Sarsaparilla*. He reports that the decoction is generally "prescribed in lues, lepra or cutaneous chronic eruptions of all kinds". The presence of an alkaloid, which becomes crystalline when combined with acids, is again mentioned and referred to as the "*Arctopium sulphuricum*". Pappe describes the crystals as astringent in taste and causing coagulation of saliva within the mouth.

Dykman (1891), in her South African recipe book, recommends a decoction of *siekentroost* or *platdoorn* for use against what she calls (in early Afrikaans) "*Fuilsiikte*, *Sifilis*, *of Fenussiikte*" (i.e. syphilis). She implies a preference to the use of material from plants in flower but does not identify the species.

In *Die Sieketrooster* (Kling, 1923), *sieketroos* or *platdoorn* (no species mentioned) is listed numerously under the following indications: "*Lupus*" (lupus), "*Siefilis*" (syphilis), "*Blaaskwale*, *Graweel*, *Katar en Uitgestrekte Klierswelling*" (bladder ailments, gravel, bladder catarrh and glandular swellings) and "*Watersug*" (water retention). The use of the decoction as a blood purifier is also mentioned.

Watt and Breyer-Brandwijk (1962) in their book of medicinal and poisonous plants of southern and eastern Africa, summarised the information about *A. echinatus* given by the above-mentioned authors and also its use as a gonorrhoea remedy as recorded by two other authors (Dragendorff (1898) and Wicht (1918) in Watt and Breyer-Brandwijk (1962)). The chemical composition of the root is recorded as yielding sucrose, a resin and a glucoside. They also make reference to the chemical findings of Meyer and Rindl (1932), who reported a brown essential oil, yielding a "90–100 °C fraction" as well as a "180–190 °C fraction". Unspecified pharmacological tests carried out by Meyer and Rindl (1932), in which small amounts of the resin were administered orally as well as subcutaneously to cats, produced no observable effects. Later Watt (1967) in Lloydia lists *A. echinatus* as being administered, together with potassium nitrate, for epilepsy. He states that in this form it may cause drowsiness.

Interestingly, according to Barry (Theodore, 1972), a large quantity of dry root material was sent to Europe, where it was found to be ineffective. This is confirmed in the Botanical Register (Anonymous, 1823), where an illustration can be found of the plant cultivated in the collection at the Royal Botanic Gardens Kew and the following statement: "We understand its medicinal reputation turned out perfectly ungrounded".

3.2. Modern anecdotes

The use of *A. echinatus* still continues in the Cape. Van Wyk and Gericke (2000) recorded many novel anecdotes through communication with Dawid Bester, Mrs Bester, Phillip Kubukhele and Willem Steenkamp. From these sources they mention the topical use of the decoction to relieve inflammatory skin disorders, sores and ulcers and the resin as a remedy for ringworm. They state that the raw root is chewed for tuberculosis and a cough productive of purulent sputum as well as for numerous bladder ailments such as urinary caculi, cystitis, and lymphadenopathy. The traditional oral use of the decoction for syphilis, gonorrhoea, epilepsy and as a blood purifier is summarised. The biological activity is ascribed, by Van Wyk et al. (1997), to the presence of kaurenoic acids similar to those found in *A. amatymbica* (an important Zulu and Sotho medicinal plant used for colds and chest complaints). There are numerous reports on the antimicrobial, anti-parasitic and anti-inflammatory activity of kaurane diterpenoids, including kauren-19-oic acid (Ghisalberti, 1997).

In a recent study (Stafford et al., 2005) it was found that ethanol extracts of *A. echinatus* exhibited $GABA_A$-benzodiazepine receptor activity. This provides, for the first time, evidence to support the traditional use of *A. echinatus* as an anti-convulsant in epilepsy and possible sedative effects. However no published information could be found on the potential antimicrobial activity of *Arctopus* species.

4. Results

All three species of *Arctopus* possessed some antimicrobial activity against at least five of the nine pathogens tested (Table 1). Only *A. dregei* sample 1 exhibited antimicrobial activity against *Cryptococcus neoformans* and only *A. monacanthus* sample 2 was inactive against *Klebsiella pneumoniae*. Highest susceptibilities were found against the two Gram-positive organisms (*Staphylococcus aureus* and *Staphylococcus epidermidis*), observed for most of the test samples. The Gram-negative bacteria (*Escherichia coli*, *Enterobacter aerogenes* and *K. pneumoniae*) and the yeasts (*Candida albicans* and *C. neoformans*) were less susceptible than the Gram-positive bacteria. The MIC values obtained for *Proteus vulgaris*, *Pseudomonas*

aeruginosa, *K. pneumoniae* (one sample), and *C. neoformans* (five samples) were equal to or greater than the DMSO control and should be considered as having no activity. There were no obvious differences in antimicrobial activity between the three species of *Arctopus* with only minor variations for *K. pneumoniae* (4.0–6.0 mg/mL) and *C. albicans* (3.0–6.0 mg/mL). However, some variation was evident for *S. aureus*, with the greatest difference noted for *A. monacanthus* sample 2, where the MIC value was 0.3 mg/mL compared to *A. dregei* (both samples) having a MIC value of 4.0 mg/mL. This variation was also noted for *S. epidermidis*, between *A. monacanthus* sample 2 (MIC 0.02 mg/mL) and *A. dregei* sample 1 (MIC 0.9 mg/mL).

5. Discussion and conclusions

Arctopus is an important South African medicinal plant with a long history of recorded use. Its strong activity against the skin pathogen *Staphylococcus epidermidis* is not surprising as *A. echinatus* is often traditionally used against numerous skin ailments. This opportunistic pathogen resides on the skin as part of the normal biological flora, but in times of stress or reduced immunity can cause a number of infections. It is also one of the most common blood borne pathogens isolated from the blood-stream of ICU patients (Donowitz et al., 1982; Bannister et al., 2000). There appears to be no consistent differences in the antimicrobial activities between the three species and between samples within the same species. *Arctopus monacanthus* sample 2, for example, appears to be more active against both *Staphylococcus* species tested but less active against *Candida albicans* than *A. monacanthus* sample 1. Generalisations seem premature, as chemical variation in the genus has not yet been studied and only a limited number of samples were used in this exploratory study.

While some of the traditional uses can be attributed to the antimicrobial, anti-parasitic and anti-inflammatory activity of the kaurane diterpenoids, there remains a need for further pharmacological investigations to further explore the scientific basis of the wealth of indigenous knowledge available on the uses of this interesting medicinal plant.

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