PLANT SCIENCE TODAY
ISSN 2348-1900 (online)
Vol x(x): xx–xx
https://doi.org/10.14719/pst.3165

HORIZON
e-Publishing Group
HePG

REVIEWARTICLE

# *Hemionitis calomelanos* (Sw.) Christenh.: From traditional medicinal uses to chemical identification of active principles

**Alfred Maroyi***

Department of Botany, University of Fort Hare, Private Bag X1314, Alice 5700, South Africa

*Email: amaroyi@ufh.ac.za

OPEN ACCESS

**ARTICLE HISTORY**

Received: 05 December 2023
Accepted: 13 March 2024

Available online
Version 1.0 : 20 June 2024

Check for updates

**Additional information**

**Peer review**: Publisher thanks Sectional Editor and the other anonymous reviewers for their contribution to the peer review of this work.

**Reprints & permissions information** is available at https://horizonepublishing.com/journals/index.php/PST/open_access_policy

**Publisher's Note**: Horizon e-Publishing Group remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.

**Indexing**: Plant Science Today, published by Horizon e-Publishing Group, is covered by Scopus, Web of Science, BIOSIS Previews, Clarivate Analytics, NAAS, UGC Care, etc See https://horizonepublishing.com/journals/index.php/PST/indexing_abstracting



**CITE THIS ARTICLE**

Maroyi A. *Hemionitis calomelanos* (Sw.) Christenh.: From traditional medicinal uses to chemical identification of active principles. Plant Science Today (Early Access). https://doi.org/10.14719/pst.3165

## Abstract

*Hemionitis calomelanos* (Sw.) Christenh. is a fern widely used as a traditional medicine throughout its distributional range. This study aims to record, analyze, and provide insights into the historical, scientific, and ethnopharmacological properties of *H. calomelanos*. Multiple searches on existing literature on the medicinal, phytochemical, and pharmacological properties of *H. calomelanos* were conducted in online databases such as Scopus, JSTOR, PubMed, Google Scholar, and Science Direct as well as using pre-electronic literature sources obtained from the university library. This study revealed that the leaves, rhizomes, roots, stems and whole plant parts of *H. calomelanos* are mainly used as ethnoveterinary medicines, lucky and protective charm, and traditional medicine for colds, boils, cough, sores, and diarrhoea. Phytochemical research showed that the species is characterized by flavonoids, steroids, tannins, esters, alcohols, ketones, and alkanes. Ethnopharmacological research revealed that the extracts of the species demonstrated antibacterial and antifungal activities. *H. calomelanos* is an important medicinal plant species in several countries with numerous medicinal applications. Despite its historical and traditional medicinal uses, many questions regarding the species' ethnopharmacological properties and potential therapeutic effects remain to be answered. Therefore, future research should focus on validating the medicinal uses of *H. calomelanos* through elucidation of phytochemical composition, pharmacology, clinical application, toxicology, and safety.

## Keywords

adiantaceae; *Hemionitis calomelanos*; indigenous pharmacopeia; pteridaceae; sinopteridaceae; traditional medicine

## Introduction

*Hemionitis calomelanos* (Sw.) Christenh. is a fern that belongs to the subfamily Cheilanthoideae within the Pteridaceae family. Evidence from recent molecular analysis established that the subfamily Cheilanthoideae composed of genera such as *Cheilanthes* Sw., *Doryopteris* J. Sm., and *Pellaea* Link is polyphyletic (1) and therefore, the entire subfamily has been merged into a single genus *Hemionitis* L. which has nomenclatural priority over the other genera (Fig. 1) (2). The nomenclature of *H. calomelanos* is complicated and proper species name is further hampered by historical references to invalid names and it therefore seems appropriate to include the full synonymy of the species. In literature, synonyms of *H. calomelanos* which are often used include *Allosorus calomelanos* (Sw.) C.Presl, *Notholaena calomelanos* (Sw.) Keyserl., *Pellaea calomelanos* (Sw.) Link, *P. calomelanos* (Sw.) Link var. *swynnertoniana* (Sim) Schelpe, *P. hastata* (Thunb.) Prantl, *P. swynnertoniana* Sim, *Platyloma*

*calomelanos* (Sw.) J.Sm., *Pteris calomelanos* Sw., *Pteridella hastata* (Thunb.) Mett. ex Kuhn, *Pteris codinae* Cadevall & Pau ex Bonap. and *P. hastata* Thunb. (2-4). Similarly, *H. calomelanos* has also been associated with Adiantaceae (5) and Sinopteridaceae (3) families. Leathery hard fern is the English common name used all over the world for *H. calomelanos*.

Medicinal plants such as *H. calomelanos* and other related Pteridophytes are often neglected as a result of inadequate research and pharmaceutical development (6). Pteridophytes have been considered excellent sources of traditional medicines by various indigenous communities since ancient times and remain underexplored in ethnopharmacological aspects when compared with other vascular medicinal plants (7). Pteridophytes are rich in various secondary metabolites such as terpenoids, alkaloids, saponins, tannins, phenolic acids, anthraquinones, lignans, steroids, glycosides, amino acids, fatty acids, and flavonoids which are known to have medicinal properties (8-11). Various extracts and isolated compounds from the Pteridophytes are characterized by diverse biological activities such as antioxidant, antibacterial, anti-inflammatory, antiviral, anticancer, analgesic, antimutagenic, antifungal, immunomodulatory, neuromodulatory, hepatoprotective, antidiabetic and wound healing (12-14). Therefore, in-depth ethnopharmacological studies are needed to adequately record the wealth of cultural, ethnomedicinal, and pharmacological properties of Pteridophytes. Such documentation is particularly important for this ancient evolutionary lineage which could potentially become extinct if used and harvested unsustainably. It is therefore, within this context that the current study was undertaken aimed at recording, analyzing, and providing insights into the historical, scientific, and ethnopharmacological properties of *H. calomelanos*. Such a historical perspective focusing on the medicinal uses, phytochemical properties, and biological activities of *H. calomelanos* is aimed at tapping into the pool of medicinal use records of the species and comparing this historical data with current data and practices. Moreover, about 25-50 percent (5) of the natural health products and their pharmaceutical derivatives are obtained from plants via traditional use records.

## Methodology

The literature review of the historical or traditional medicinal uses, phytochemical properties, and biological activities of *H. calomelanos* within its geographical range was conducted using online databases such as Scopus, JSTOR, PubMed, Google Scholar, and Science Direct. In addition to this, pre-electronic literature sources were used which included books, book chapters, journal articles, dissertations, theses, and other scientific articles obtained from the University of Fort Hare library. The keywords which included scientific and common plant names such as "*H. calomelanos", "Pellaea calomelanos", "Pteris calomelanos",* "leathery hard-fern", "biological activities", "pharmacological properties", "ethnobotany", "taxonomy", "nomenclature", "ecology", "chemistry", "biochemistry", "medicinal uses", "phytochemistry", "toxicology", and "traditional uses of *H. calomelanos, Pellaea calomelanos* or *Pteris calomelanos"* were used to search for relevant articles as shown in the flow diagram (Fig. 2).

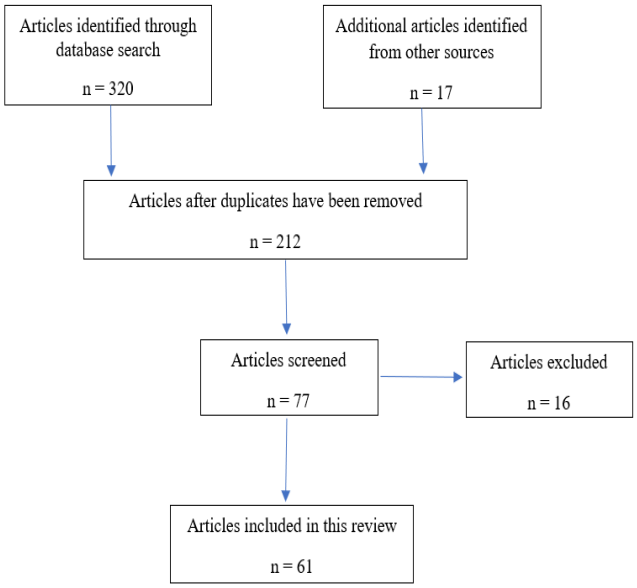


**Fig. 2:** Flow diagram showing identification and screening of articles used in this review

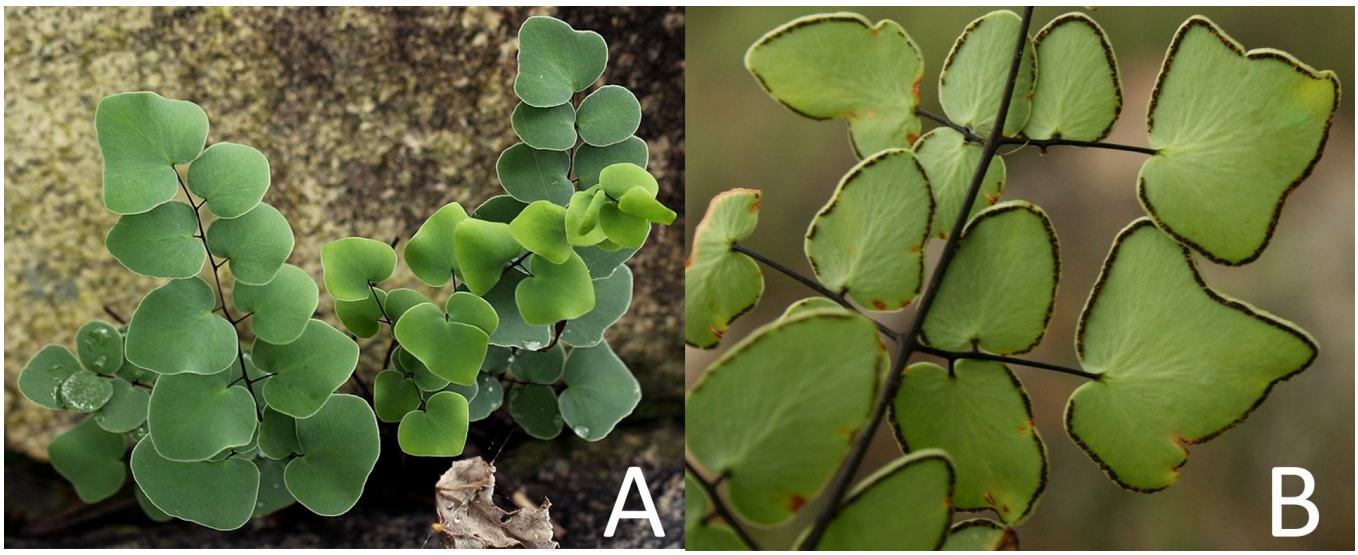


**Fig. 1:** *H. calomelanos*. A: entire plant growing on rock crevices (photo: B Wursten) and B: sori (Photo: P Ballings)

## Results

### Morphological description and taxonomy of the species

The genus *Hemionitis* comprises over 400 species (2, 15, 16). The genus name "*Hemionitis*" is derived from the Greek word "*hemionos*", meaning "mule" about the general belief in the early years that plants were sterile (17). The species name "*calomelanos*" is derived from the Greek words "*calos*" which means "beautiful" and "*melanos*" which means "black" about the shiny black stipe and rachis of the species which forms a striking contrast to the grey-green pinnules (3). *H. calomelanos* is a hard-textured, grey-blue to blue-green fern growing to about 40 cm in height (4). This fern has an underground rootstock of about 6 mm in diameter covered with small brown scales (5). The leaves are tufted on a short rhizome with an almost black leaf stalk. The leaf blade is narrowly triangular in outline with rounded to triangular pinnules (Fig. 1). The leaf blade has two spreading basal lobes and a blunt apex bearing sporangia in a line along the margin below (Fig. 1B). *H. calomelanos* has been recorded in rock crevices and at the foot of boulders, occasionally on vegetation islands on bare rock, in the shade, and in the sun at an altitude ranging from 100 m to 2100 m above sea level (3). *H. calomelanos* has been recorded in Angola, Botswana, Burundi, China, Comoros, the Democratic Republic of Congo (DRC), Eswatini, Ethiopia, Kenya, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Nepal, Pakistan, Rwanda, Réunion, Somalia, South Africa, South Sudan, Spain, Sudan, Tanzania, Uganda, West Himalaya and Zimbabwe (Fig. 3). *H. calomelanos* is categorized as Critically Endangered in Spain (18, 19), threatened by general habitat degradation due to wildfires, changes in land use, and competition with weedy plants. Further research is needed to assess the causes of the threats the species is currently facing, and measures should be taken to protect these subpopulations in Spain, as they represent an isolated outlying population of the species (18, 19).

### Medicinal uses of the species

*H. calomelanos* is an important source of traditional medicines in several countries throughout its distributional range. In both historical, modern, official, and non-official traditional pharmacopeia, the preparations of *H. calomelanos* as traditional medicine are well-defined and extensively studied. Despite this rich historical and traditional medicinal applications and therapeutic effects, recent studies categorized *H. calomelanos* as neglected and often underutilized as traditional medicine (5, 6). In South Africa, the leaves and stems of *H. calomelanos* are traditionally used to make herbal tea used against colds and chest ailments (5, 20-22). The early settlers and colonists around the Cape region in South Africa used *H. calomelanos* for similar medicinal applications as *Adiantum capillus-veneris* L. (maiden-hair fern), a traditional European remedy used as a mild diuretic and traditional medicine against asthma, coughs, and kidney problems (5). Therefore, the practice of making *H. calomelanos* herbal tea decoctions was probably introduced by the early settlers and colonists, and the practice was adopted by the local communities. Such popularity as a source of traditional medicines led to the inclusion of the species in the monograph Medicinal Plants of South Africa (5), Sesotho: plant and animal names and plants used by the Basotho (23), and Medicinal and magical plants of southern Africa: an annotated checklist (24). Similarly, the different plant parts of *H. calomelanos* are sold as sources of traditional medicines in informal herbal medicine markets in South Africa (25) and Zimbabwe (26). In literature, it is clear that wild harvesting of *H. calomelanos* is of economic importance for local communities and cultivation of the species plays a limited role in the livelihoods of local communities (6).

The smoke or herbal concoctions prepared from the leaves, rhizomes, roots, stems, and whole plant parts of *H. calomelanos* are used to treat and manage 30 human and animal diseases and ailments (Table 1). The

**Fig. 3** Distribution of *H. calomelanos* in the world (https://www.gbif.org/occurrence/map?has_coordinate=true&has_geospatial_issue=false&taxon_key=7335563)

major diseases and ailments treated by *H. calomelanos* extracts include colds recorded in three countries based on 14 literature records (Fig. 4), followed by lucky and protective charm (three countries and seven literature records), boils (two countries and 18 literature records), cough (two countries and eight literature records), ethnoveterinary medicine (two countries and six literature records), sores (two countries and three literature records) and diarrhoea (two countries and two literature records). Other medicinal applications of *H. calomelanos* supported by at least five literature records include the use of the leaves, rhizomes, roots, stems, and whole plant parts as traditional medicines against abscesses, asthma, chest colds, chest pains, convulsions, headaches, head colds, and intestinal parasites or worms (Table 1). In Zimbabwe, the whole plant parts of *H. calomelanos* are mixed with the roots of *Peltophorum africanum* Sond. (family Fabaceae) and taken orally as a remedy for abdominal pains (27). The Kgatla people of Lesotho and South Africa as well as the Kwena people of southern Africa, that is, Botswana, Eswatini, Lesotho, South Africa, and Zimbabwe traditionally used milk decoctions of the rhizome of *H. calomelanos* to calm frightened children at night (27). Other species related to *H. calomelanos* widely used as sources of traditional medicines include *H. atropurpurea* (L.) Christenh. (28-30), *H. longipilosa* (Bonap.) Christenh. (6, 31), *H. nivea* (Poir.) Christenh. (32, 33), *H. ternifolia* (Cav.) Christenh. (34, 35), *H. tomentosa* Raddi (7, 36), *H. viridis* (Forssk.) Christenh. (37-40) and *H. yikka* Christenh. (6, 41). This data on other *Hemionitis* species characterized by medicinal properties is useful for comparative analyses on ethnomedicinal uses of *Hemionitis* species.

## Phytochemical compounds of *H. calomelanos*

The phytochemical compounds identified from the leaves of *H. calomelanos* (Table 2) include flavonoids, steroids, tannins, esters, alcohols, ketones, and alkanes (52). These findings corroborate previous research which showed that Pteridophytes contain flavonoids, steroids, tannins, esters, alcohols, ketones, and alkanes (8-11). Some of these phytochemical compounds may be responsible for the biological activities exhibited by the species. There is very little information on the phytochemistry of *H. calomelanos* but Pteridophytes are characterized by triterpenoids of the hopane type, such as adiantone and related compounds as well as a wide range of flavonoids (5, 78).

## Biological activities of *H. calomelanos*

The leaf extracts of *H. calomelanos* demonstrated antibacterial and antifungal activities. Braithwaite et al. (45) evaluated the antibacterial activities of methanol and acetone extracts of *H. calomelanos* leaves and smoke fraction against *Staphylococcus aureus* (ATCC 25923), *Bacillus cereus* (ATCC 11778) and *Klebsiella pneumoniae* (ATCC 9633) using the microtiter plate technique with ciprofloxacin as a positive control. The extracts exhibited activities with minimum inhibitory concentration (MIC) values ranging from 0.53 mg/ml to >16.0 mg/ml (45). Mabona (48) and Mabona et al. (50) evaluated the antibacterial activities of aqueous and dichloromethane: methanol (1:1) extracts of *H. calomelanos* leaves and rhizomes against *Brevibacillus agri, Propionibacterium acnes, Pseudomonas aeruginosa*, *Staphylococcus aureus* and *Staphylococcus epidermidis* using the microtiter plate assay with ciprofloxacin as a positive control. The extracts exhibited activities with MIC values ranging from 0.02 mg/ml to >16.00 mg/ml (48, 50). Dumisa et al. (79) evaluated the antibacterial activities of a 1:1 mixture of dichloromethane and methanol extracts of *H. calomelanos* leaves against *Staphylococcus aureus* and *Pseudomonas aeruginosa* using the microdilution assay with ciprofloxacin as a positive control. The extracts exhibited activities with MIC values ranging from 2000.0 µg/ml to >8000.0 µg/ml (78). Mahlangu and Serepa-Dlamini (54) evaluated the antibacterial activities of methanol, ethyl acetate, and supernatant extracts of *H. calomelanos* leaves against the Gram-negative bacteria *Escherichia coli* (ATCC 25922), *Pseudomonas aeruginosa* (ATCC 27853) and *Klebsiella pneumoniae* (ATCC 13182) and Gram-positive *Staphylococcus aureus* (NCTC 6571) and *Bacillus cereus* (ATCC 10876) using the disk diffusion method with streptomycin used as a positive control and dimethylsulfoxide (DMSO) as a negative control. The methanol extract exhibited activities against the tested

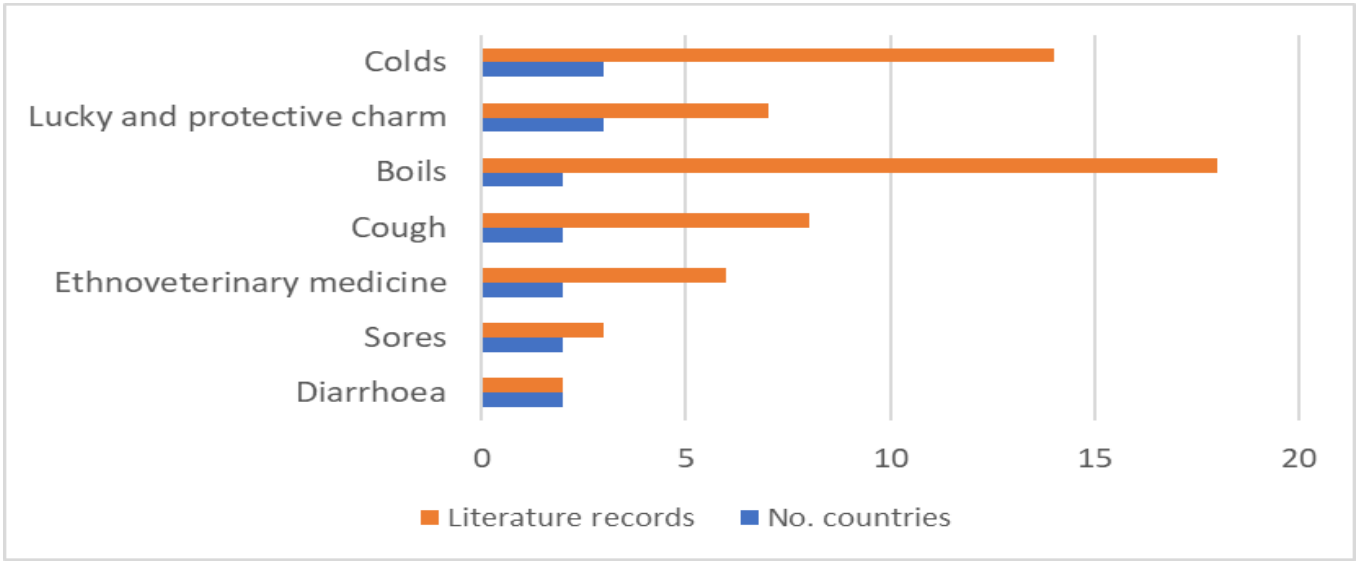


**Fig. 4** Main diseases and ailments treated and managed by *H. calomelanos*

**Table 1** Medicinal uses of *H. calomelanos*

| Medicinal application | Parts used and application | Country | Reference(s) |
|---|---|---|---|
| Abdominal pains | The whole plant mixed with roots of *Peltophorum africanum* Sond. (family Fabaceae) and taken orally | Zimbabwe | (6, 27) |
| Abscesses | Leaf, rhizome, and root decoction applied topically | South Africa | (5, 6, 23, 41-53) |
| Asthma | Smoke of foliage, leaves, and rhizomes inhaled | South Africa | (5, 6, 23, 41, 42, 44-47, 51-56) |
| Boils | Leaf, rhizome, and root decoction applied topically | Eswatini and South Africa | (5, 6, 23, 41-53, 57, 58) |
| Bronchitis | The smoke of foliage, leaves, and rhizomes inhaled | South Africa | (59) |
| Chest colds | Leaf decoction is taken orally | South Africa | (5, 20, 44, 45, 47, 51-56) |
| Chest pains | Leaf and stem decoction taken orally | South Africa | (5, 20, 44, 47, 51) |
| Colds | Foliage, leaf, rhizome, and stem decoction taken orally | Lesotho, Pakistan, and South Africa | (5, 6, 23, 44, 46, 47, 51, 60-66) |
| Convulsions | Whole plant smoke inhaled | Zimbabwe | (6, 27, 67-71) |
| Cough | Leaf decoction is taken orally | Pakistan and South Africa | (6, 41, 42, 51, 52, 56, 62, 64) |
| Depressed fontanelle | Ointment of whole plant applied topically | Zimbabwe | (6, 27) |
| Diarrhea | Leaf decoction is taken orally | Lesotho and South Africa | (6, 72) |
| Dizziness | Leaf decoction is taken orally | Eswatini | (73, 74) |
| Fainting spells | Leaf decoction is taken orally | Eswatini | (73, 74) |
| Headaches | Leaf decoction is taken orally | South Africa | (6, 41, 42, 47, 51, 53-55, 70, 75) |
| Head colds | Leaf decoction is taken orally | South Africa | (6, 41, 42, 44, 45, 47, 51-54, 56) |
| Herbal medicine uses not specified | Not specified | Kenya | (6, 31) |
| Internal sores | Rhizome and root decoction taken orally | South Africa | (6, 41, 47) |
| Insomnia | Not specified | South Africa | (52, 53) |
| Intestinal parasites or worms | Rhizome decoction is taken orally | South Africa | (5, 6, 23, 43, 44, 46, 47, 52, 53) |
| Mouth and nasal ulcers | Rhizome decoction applied topically | South Africa | (6, 41, 47, 54) |
| Placental expulsion | Rhizome decoction is taken orally | Lesotho | (6, 61) |
| Lucky and protective charm | Rhizomes and whole plants used | Lesotho, South Africa and Zimbabwe | (5, 23, 27, 60, 61, 63, 65) |
| Prevent abortion | Powder of whole plant decoction taken orally or smoke directed into the vagina | Zimbabwe | (6, 27) |
| Skin problems | Leaf decoction applied topically | South Africa | (51-53) |
| Sores | Rhizomes and root decoction applied topically | Eswatini and South Africa | (51, 57, 58) |
| Sore throat | Rhizomes and root decoction taken orally | South Africa | (51) |
| Tuberculosis | Root decoction is taken orally | South Africa | (6, 59, 76, 77) |
| Uterine pains | Whole plant decoction is taken orally | Malawi | (6, 27, 55) |
| **Ethnoveterinary medicine** | | | |
| Placental expulsion in cows | Rhizomes used | Lesotho and South Africa | (5, 23, 60, 61, 63, 65) |

**Table 2** Phytochemical composition of *H. calomelanos* leaves (52)

| Chemical components | Value (%) |
|---|---|
| Flavonoids | - |
| Steroids | - |
| Tannins | - |
| Caffeoylquinic acid | - |
| Caffeoyl-hexoside | - |
| p-Coumaroylquinic acid | - |
| Quercetin-O-hexose-O-rhamnoside | - |
| Benzoic acid, 4-ethoxy-, ethyl ester | 0.79 |
| Hexadecanoic acid, methyl ester | 0.83 |
| L-Proline, N-pivaloyl-, heptadecyl ester | 1.74 |
| Methyl stearate | 0.47 |
| N-Ethylpyrrolidine-2,2-dicarboxylic acid, dimethyl ester | 0.60 |
| Propanoic acid, 2-methyl-, 2-ethyl-3-hydroxyethyl ester | 0.33 |
| Succinic acid, but-3-yn-2-yl 2-methoxy-5-methyl phenyl ester | 0.49 |
| Phthalic acid, 2-chloropropyl hexyl ester | 0.53 |
| Phthalic acid, 3,3-dimethyl but-2-yl tetradecyl ester | 0.18 |
| Phenol, 2,5-bis(1,1-dimethyl ethyl) | 0.46 |
| Phytol | 1.5 |
| Ethanol, 2-(2-butoxy ethoxy) | 1.7 |
| 1H-Isoindole-1,3(2H)-dione, 2-(2-hydroxyethyl) | 0.16 |
| 2H-imidazole-2-thione, 1,3-dihydro-4-(2-methyl propyl) | 0.47 |
| Ergotaman-3',6',18-trione, 9,10-dihydro-12'-hydroxy-2'-methyl-5'-(phenylmethyl)-,(5'à,10à) | 6.23 |
| Cycloheptasiloxane, tetradecamethyl | 2.2 |
| Cyclohexasiloxane, dodecamethyl | 0.48 |
| Cyclooctasiloxane, hexadecamethyl | 1.5 |
| Dodecanamide | 0.29 |
| Cyclo-(l-leucyl-l-phenylalanyl) | 0.40 |
| 2-Methylmercaptoaniline | 0.03 |
| 3-Methyl-4-phenyl-1H-pyrrole | 0.43 |
| Pyrrolo[1,2-a]pyrazine-1,4-dione, hexahydro-3-(2-methyl propyl) | 4.19 |
| 5,10-Diethoxy-2,3,7,8-tetrahydro-1H,6H-dipyrrolo[1,2-a:1',2'-d]pyrazine | 9.08 |
| Tetradecanamide | 0.75 |

pathogens with the diameter of each zone of inhibition ranging from 3.0 mm to 8.0 mm which was lower than the 10.0 mm to 15.0 mm exhibited by the positive control (54). The documented antibacterial activities appear to account for the therapeutic effects of *H. calomelanos*.

Braithwaite et al. (45) evaluated the antifungal activities of methanol and acetone extracts of *H. calomelanos* leaves and a smoke fraction against *Cryptococcus neoformans* (ATCC 90112) using the microtiter plate technique with amphotericin B as a positive control. The extracts exhibited activities with MIC values ranging from 0.53 mg/ml to >32.0 mg/ml (45). Mabona (48) and Mabona et al. (50) evaluated the antifungal activities of aqueous and dichloromethane: methanol (1:1) extracts of *H. calomelanos* leaves and rhizomes against *Candida albicans, Microsporum canis,* and *Trichophyton mentagrophytes* using the microtiter assay with amphotericin B as a positive control. The extracts exhibited activities with MIC values ranging from 0.5 mg/ml to >16.0 mg/ml (48, 50). Dumisa et al. (79) evaluated the antifungal activities of a 1:1 mixture of dichloromethane and methanol extracts of *H. calomelanos* leaves against *Candida albicans* using the microdilution assay with amphotericin B as a positive control. The extracts exhibited activities with MIC values ranging from 1000.0 µg/ml to >8000.0 µg/ml (78). These antibacterial and antifungal activities of *H. calomelanos* seem to account for the therapeutic effects of the species in humans suffering from microbial infections such as abscesses, asthma, boils, bronchitis, chest pains, colds, cough, diarrhoea, skin problems, sores, sore throat, and tuberculosis. Van Wyk et al. (5) argued that there is no clear link between the chemistry of *H. calomelanos* leaves and its reported therapeutic value but triterpenoids could be responsible for the ethnopharmacological effects. Research by Braithwaite et al. (45) showed that smoke of aromatic plants sometimes has higher antimicrobial activities than the essential oil or solvent extracts, and therefore, smoke inhalation may be a very effective therapy for respiratory infections such as asthma, bronchitis, chest pains, colds, cough, sore throat, and tuberculosis, see Table 1. The leaves of *H. calomelanos* are characterized by bacterial endophytes which demonstrate antimicrobial activities (52-54). Previous research showed that endophytes are capable of producing secondary metabolites with pharmaceutical properties meant to protect their plant host from harmful pathogens (80-83). Therefore, there is a need to understand the interactions between *H. calomelanos* and the symbiotic endophytes.

## Conclusion

*H. calomelanos* is a well-established medicinal Pteridophyte. A large body of ethnomedicinal data exists and to some extent, preliminary phytochemical composition and biological activities have been established. However, the ethnopharmacological evaluations conducted so far are not sufficient to reach a final judgment on the therapeutic potential of *H. calomelanos* in both humans and animals. In addition to this, there are no *in vivo* nor clinical studies that have been conducted. Therefore, detailed studies focusing on pharmacological and phytochemical evaluations including toxicological, *in vitro*, *in vivo,* and clinical studies to corroborate the traditional medical applications of the species are recommended.

## Acknowledgements

This study was funded by the University of Fort Hare, South Africa.

## Author's contributions

I conceived the study and wrote the manuscript

## Compliance with ethical standards

**Conflict of interest: :** The author declares that there is no conflict of interest.

**Ethical issues:** Ethical standards were maintained in writing this article.

## References

1. Eiserhardt WL, Rohwer JG, Russell SJ, Yesilyurt JC, Schneider H. Evidence for radiations of cheilanthoid ferns in the greater Cape floristic region. Taxon 2011;60:1269– 1283. https://doi.org/10.1002/tax.605004
2. Christenhusz MMJ, Fay MF, Byng JW. The global flora: A practical flora to vascular plant species of the world: Special edition: GLOVAP nomenclature part 1. Plant Gateway, Bradford. 2018
3. Crouch NR, Klopper RR, Burrows JE, Burrows SM. Ferns of Southern Africa: A comprehensive guide. Struik Nature, Cape Town. 2011
4. Hyde MA, Wursten BT, Ballings P, Palgrave CM. Flora of Zimbabwe: Species information: *Pellaea calomelanos var. calomelanos.* 2023. Available from: https://www.zimbabweflora.co.zw/speciesdata/species.php?species_id=100910, accessed on 2 September 2023
5. Van Wyk BE, Van Oudtshoorn B, Gericke, N. Medicinal plants of southern Africa. Briza Publications, Pretoria. 2013
6. Maroyi A. Utilization of pteridophytes as herbal medicines in sub -Saharan Africa. In: Neffati M, Najjaa H, Mathé A, editors., Medicinal and aromatic plants of the world: Africa volume 3. Springer, Dordrecht. 2017; pp. 383-408. https://doi.org/10.1007/978-94-024-1120-1_16
7. Sureshkumar J, Silambarasan R, Bharati KA, Krupa J, Amalraj S, Ayyanar M. A review on ethnomedicinally important pteridophytes of India. J Ethnopharmacol 2018;219:269–287. https://doi.org/10.1016/j.jep.2018.03.024
8. Li Z-F, Huang H, Zhang H-Y, Zhang J-C. Review on the extraction of flavonoids from fern. J Sanming Univ 2008;25(2):200–203
9. Santos_MHG,_Kelecom_A,_Paiva_SR,_Moraes_MG,_Rocha_L. Phytochemical_studies_in_Pteridophytes_grown_in_Brazil:_A review._Am_J_Plant_Sci Biotechnol 2010;4(1):113–125.
10. Chettri S, Manviannan S, Muddursu VR. Nutrient and elemental composition of wild edible ferns of the Himalaya. Am Fern J. 2018;108:95–106. https://doi.org/10.1640/0002-8444-108.3.95
11. Marimuthu J, Janakiraman N, Saleride JC, Sivaraman A, Shivananthini B, Paulraj K. 2022. Phytochemistry of Indian pteridophytes: A review. In: Marimuthu J, Fernández H, Kumar A, Thangaiah S, editors., Ferns: Biotechnology, propagation,

medicinal uses, and environmental regulation, Springer, Singapore. 2022; pp. 433-480. https://doi.org/10.1007/978-981-16-6170-9_19

12. Wu MJ, Weng CY, Wang L, Lian TW. Immunomodulatory mechanism of the aqueous extract of sword brake fern (*Pteris ensiformis* Burm.). J. Ethnopharmacol 2005;98:73–81. https://doi.org/10.1016/j.jep.2004.12.031

13. Nonato FR, Nonato TA, Barros A.M., Lucchese, C.E., Oliveira, R.R.S., Soares, M.B., Villarreal, C.F., 2009. Anti-inflammatory and antinociceptive activities of *Blechnum occidentale* L. extract. J. Ethnopharmacol. 125, 102–107. https://doi.org/10.1016/j.jep.2009.06.005

14. Marimuthu J, Janakiraman N, Saleride JC, Sivaraman A, Shivananthini B, Paulraj K.. Biopotency of Pteridophytes: A review. In: Marimuthu J, Fernández H, Kumar A, Thangaiah S, editors., Ferns: Biotechnology, propagation, medicinal uses, and environmental regulation. Springer, Singapore. 2022; pp. 481-520. https://doi.org/10.1007/978-981-16-6170-9_20

15. Hirai RY, Cruz R, Prado J. A new species of *Hemionitis* (Pteridaceae) from central Brazil. Willdenowia 2018;48:371–380. https://doi.org/10.3372/wi.48.48305

16. Schuettpelz E, Rouhan G, Pryer KM, Rothfels CJ, Prado J, Sundue MA, Windham MD, Moran RC, Smith AR. Are there too many fern genera? Taxon 2018;67:473–480. https://doi.org/10.12705/673.1

17. Hyam R, Pankhurst RJ. Plants and their names: A concise dictionary. Oxford University Press, Oxford. 1995

18. Christenhusz M, Elias BR, Dyer R, Ivanenko Y, Rouhan G, Rumsey F, Väre H. 2017. Leathery hard-fern: *Pellaea calomelanos* (Europe assessment). The IUCN Red List of Threatened species: e.T78680201A85448386. 2017. Available from: https://www.iucnredlist.org/species/78680201/85448386, accessed on 4 September 2023.

19. Criado GM, Väre H, Nieto A, Elias BR, Dyer R, Ivanenko Y, Ivanova D, Lansdown R, Molina JA, Rouhan G, Rumsey F, Troia A, Vrba J, Christenhusz MJM. European Red List of Lycopods and Ferns. IUCN, Brussels. 2017. http://dx.doi.org/10.2305/IUCN.CH.2017.ERL.1.en

20. Forbes VS. Carl Peter Thunberg travels at the Cape of Good Hope 1772-1775. Van Riebeeck Society, Cape Town. 1986

21. Von Koenen E. Medicinal, poisonous and edible plants in Namibia. Klaus Hess Publishers, Windhoek. 2001

22. Welcome AK, Van Wyk B-E. An inventory and analysis of the food plants of southern Africa. S Afr J Bot 2019;122:136–179. https://doi.org/10.1016/j.sajb.2018.11.003

23. Moffett RO. Sesotho plant and animal names and plants used by the Basotho. Sun Press, Stellenbosch. 2010

24. Arnold TH, Prentice CA, Hawkes LC, Snyman EE, Tomalin M, Crouch NR, Pottas-Bircher C. Medicinal and magical plants of southern Africa: An annotated checklist. Strelitzia 13. National Botanical Institute, Pretoria. 2002

25. Williams VK, Balkwill K, Witkowski ETF. 2001. A lexicon of plants traded in the Witwatersrand *umuthi* shops, South Africa. Bothalia 2001;31(1):71-98. https://doi.org/10.4102/abc.v31i1.508

26. Cunningham AB. African medicinal plants: Setting priorities at the interface between conservation and primary health care. People and Plants working paper 1. UNESCO, Paris. 1993

27. Gelfand M, Mavi S, Drummond RB, Ndemera B. The traditional medical practitioner in Zimbabwe: His principles of practice and pharmacopoeia. Mambo Press, Gweru. 1985

28. Romero JB. The botanical lore of the California Indians. Vantage Press, New York. 1954

29. Jacobs ML. Index of plants of North Carolina with reputed medicinal uses. Chapel Hill, North Carolina. 1958

30. May LW. The economic uses and associated folklore of Ferns and Fern allies. Bot Rev 1978;44(4):491-528. https://doi.org/10.1007/bf02860848

31. Timberlake J. Vernacular names and uses of plants in northern Kenya. J East Afr Nat Hist 1994;83:31–69. https://doi.org/10.2982/0012-8317(1994)83[31:vnauop]2.0.CO;2

32. Arenas P, Azorero RM. Plants of common use in Paraguayan folk medicine for regulating fertility. Econ Bot 1977;31(3):298-301. https://doi.org/10.1007/BF02866879.

33. Haag G, Marín GH, Brignoles P, Del Valle ME, Magarinos SMC, Debenedetti SL. Antimicrobial activity of Latin American medicinal plant extracts. J Sci 2014;4(2):128-131.

34. Bussmann RW, Sharon D. Traditional medicinal plant use in Northern Peru: Tracking two thousand years of healing culture. J Ethnobiol Ethnomed 2006;2:47. https://doi.org/10.1186/1746-4269-2-47

35. Bussmann RW, Sharon D, Perez AF, Díaz D, Ford T, Rasheed T, Silva R. Antibacterial activity of Northern-Peruvian medicinal plants: A low cost laboratory approach to assess biological activity. Arnaldoa 2008;15:127–148.

36. Ambasta SP. The useful plants of India. CSIR Publications and Information Directorate, New Delhi. 1986

37. Chifundera K. Contribution to the inventory of medicinal plants from the Bushi area, South Kivu province, Democratic Republic of Congo. Fitoterapia 2001;72:351–368. https://doi.org/10.1016/S0367-326X(00)00294-X

38. Owuor BO, Kisangau DP. Kenyan medicinal plants used as antivenin: a comparison of plant usage. J Ethnobiol Ethnomed 2006;2(1):7. https://doi.org/10.1186/1746-4269-2-7

39. Rakotondrafara A, Rakotondrajaona R, Rakotoarisoa M, Ratsimbason M, Rasamison VE, Rakotonandrasana SR. Ethnobotany of medicinal plants used by the Zafimaniry clan in Madagascar. J Phytopharm 2018;7(6):483–494. https://doi.org/10.31254/phyto.2018.7606

40. Omale JM, Mutai P, Njogu P, Mukungu N, Mwangi J, Odongo E. Ethnobotanical survey of medicinal plants used in Emuhaya Subcounty, Vihiga county in western Kenya. Appl Medical Res 2020;7(1):6–25. https://doi.org/10.5455/ajpbp.20190707020750

41. Hutchings A, Scott AH, Lewis G, Cunningham B. Zulu medicinal plants: An inventory. University of Natal Press, Pietermaritzburg. 1996

42. Watt JM, Breyer-Brandwijk MG. The medicinal and poisonous plants of southern and eastern Africa. E and S Livingstone, London. 1962

43. Pujol J. Nature Africa: The herbalist handbook. Jean Pujol Natural Healers' Foundation, Durban. 1990

44. Braithwaite MC. 2007. A laboratory model for studying inhalation therapy in traditional healing rites. MSc Dissertation, University of the Witwatersrand, Johannesburg. 2007

45. Braithwaite M, Van Vuuren SF, Viljoen AM. Validation of smoke inhalation therapy to treat microbial infections. J Ethnopharmacol 2008;119;501–506. https://doi.org/10.1016/j.jep.2008.07.050

46. Philander LA. An ethnobotany of Western Cape Rasta bush medicine. J Ethnopharmacol 2011;138:578– 594. https://doi.org/10.1016/j.jep.2011.10.004

47. Kondlo M. *Pellaea calomelanos*. 2012. Available from: https://pza.sanbi.org/pellaea-calomelanos, accessed on 19 September 2023

48. Mabona U. Antimicrobial activity of southern African medicinal plants with dermatological relevance. [MSc Dissertation], University of the Witwatersrand, Johannesburg. 2013

49. Mabona U, Van Vuuren SF. Southern African medicinal plants used to treat skin diseases. S Afr J Bot 2013;87:175–193. https://doi.org/10.1016/j.sajb.2013.04.002

50. Mabona U, Viljoen A, Shikanga E, Marston A, Van Vuuren SF. Antimicrobial activity of southern African medicinal plants with dermatological relevance: From an ethnobotanical screening approach, to combination studies and the isolation of a bioactive compound. J Ethnopharmacol 2013;148:45–55. https://doi.org/10.1016/j.jep.2013.03.056

51. Roberts M, Roberts S. Indigenous healing plants. Briza Publications, Pretoria. 2017

52. Mahlangu SG. The antimicrobial activity of secondary metabolites produced by bacterial endophytes isolated from *Pellaea calomelanos.* [MSc Dissertation], University of Johannesburg, Johannesburg. 2019

53. Tshishonga K. The genomic profiles of endophytic bacteria isolated from *Pellaea calomelanos.* [MSc Dissertation], University of Johannesburg, Johannesburg. 2020

54. Mahlangu SG, Serepa-Dlamini MH. The first report of bacterial endophytes from the leaves of *Pellaea calomelanos* in South Africa. S Afr J Sci 2018;114:9-10. https://doi.org/10.17159/sajs.2018/4235.

55. Van Wyk B-E, Gericke N. People's plants: A guide to useful plants of Southern Africa. Briza Publications, Pretoria. 2018

56. Tshishonga K, Serepa-Dlamini MH. Draft genome sequence of *Pseudarthrobacter phenanthrenivorans* strain MHSD1, a bacterial endophyte isolated from the medicinal plant *Pellaea calomelanos*. Evol Bioinformatics 2020;16:117693432091325. https://doi.org/10.1177/1176934320913257

57. Roux JP. Swaziland ferns and fern allies. Southern African Botanical Diversity Network Report No. 19. National Botanical Institute, Pretoria. 2003

58. Long C. Swaziland's flora: siSwati names and uses. Swaziland National Trust Commission. 2005. Available from: http://www.sntc.org.sz/index.asp, accessed 19 November 2016

59. Mogale MMP, Raimondo DC, Van Wyk B-E. The ethnobotany of central Sekhukhuneland, South Africa. S Afr J Bot 2019;122:90–119. https://doi.org/10.1016/j.sajb.2019.01.001

60. Jacot Guillarmod A. Flora of Lesotho. Cramer, Lehre. 1971

61. Moteetee A, Van Wyk B-E. 2011. The medical ethnobotany of Lesotho: A review. Bothalia 2011;41:209–228. https://doi.org/10.4102/abc.v41i1.52

62. Gul A, Alam J, Ahmad H, Irfan M. An updated checklist of pteridophytes of district Mansehra, Khyber Pukhtunkhwa-Pakistan. Int J Biosci 2016;9(5):116-133. http://dx.doi.org/10.12692/ijb/9.5.116-133

63. Moteetee A. A review of plants used for magic by Basotho people in comparison with other cultural groups in southern Africa. Indian J Trad Knowl 2017;16:229–234.

64. Ozturk M, Altay V, Latiff A, Salman T, Choudhary I. A comparative analysis of the medicinal Pteridophytes in Turkey, Pakistan, and Malaysia. In: Ozturk M, Hakeem KR, editors., Plant and human health volume 1, Springer International Publishing AG, Cham. 2018; pp. 349-390. https://doi.org/10.1007/978-3-319-93997-1_9

65. Moteetee A, Moffett RO, Seleteng-Kose L. A review of the ethnobotany of the Basotho of Lesotho and the Free State province of South Africa (South Sotho). S Afr J Bot 2019;122:21–56. https://doi.org/10.1016/j.sajb.2017.12.012

66. Cock IE, Van Vuuren SF. The traditional use of southern African medicinal plants in the treatment of viral respiratory diseases: A review of the ethnobotany and scientific evaluations. J Ethnopharmacol 2020;262:113194. https://doi.org/10.1016/j.jep.2020.113194

67. Sobiecki JF. A preliminary inventory of plants used for psychoactive purposes in southern African healing traditions. Transact Royal Soc S Afr 2002;57(1):1-24. https://doi.org/10.1080/00359190209520523

68. Stafford GI, Pedersen ME, Van Staden J, Jäger AK. Review on plants with CNS effects used in traditional South African medicine against mental diseases. J Ethnopharmacol 2008;119:513–537. https://doi.org/10.1016/j.jep.2008.08.010

69. Gomes NGM, Campos MG, Órfão JMC, Ribeiro CAF. Plants with neurobiological activity as potential targets for drug discovery. Progress Neuro-Psychopharmacol Biol Psychiatry 2009;33:1372–1389. https://doi.org/10.1016/j.pnpbp.2009.07.033

70. Kinsou LDC, Assogba MF, Zinsou CMD, Goudjo AIM, Sezan A, Gbénou JD. Review of literature and phytochemistry screening of medicinal plants used in traditional treatment of brain diseases in Africa. Int J Phytopharm 2019;9(6):e5285. https://doi.org/10.7439/ijpp.v9i6.5285

71. Masondo NA, Stafford GI, Aremu AO, Makunga NP. Acetylcholinesterase inhibitors from southern African plants: An overview of ethnobotanical, pharmacological potential and phytochemical research including and beyond Alzheimer's disease treatment. S Afr J Bot 2019;120:39–64. https://doi.org/10.1016/j.sajb.2018.09.011

72. Zepp RA. Lesotho ferns. Morija Printing Works, Morija. 1982.

73. Amusan OOG, Dlamini P, Msonthi JD, Makhubu LP, Dlamini BB. Some medicinal plants used in traditional medicine in Swaziland. UNISWA J Agric Sci Tech 2000;4:20–26. https://doi.org/10.4314/uniswa-rjast.v4i1.4686

74. Amusan OOG. Herbal medicine in Swaziland: An overview. In: Juliani HR, Simon JE, Ho C-T, Editors., African natural plant products: New discoveries and challenges in chemistry and quality. American Chemical Society, Washington DC. 2009; pp. 31-49. https://doi.org/10.1021/bk-2009-1021.ch003

75. Neuwinger HD. African ethnobotany: Poisons and drugs: Chemistry, pharmacology, toxicology. Chapman and Hall, Weinheim. 1996

76. Semenya SS, Maroyi A. Medicinal plants used for the treatment of tuberculosis by Bapedi traditional healers in three districts of the Limpopo province, South Africa. Afr J Trad Compl Alt Med 2013;10(2):316-323. http://dx.doi.org/10.4314/ajtcam.v10i2.17

77. Sagbo IJ, Hussein AA. Are plants used as a combating strategy against tuberculosis in the Mpumalanga province, South Africa? Appl Sci 2023;13:5008. https://doi.org/10.3390/app13085008

78. Markham KR. Distribution of flavonoids in the lower plants and its evolutionary significance. In: Harborne JB, editor., The flavonoids: Advances in research since 1980. Springer, Boston, MA. 1988; pp. 427-468. https://doi.org/10.1007/978-1-4899-2913-6_12

79. Dumisa M, Aiyegoro OA, Van Vuuren S. Medicinal plant: Dye combinations: Impact on antimicrobial potency and toxicity. S Afr J Bot 2020;135:188-200. https://doi.org/10.1016/j.sajb.2020.09.002

80. Hardoim PR, Van Overbeek LS, Berg G, Pirttilä AM, Company S, Campisano A, Döring M, Sessitsch A. The hidden world within plants: ecological and evolutionary considerations for defining functioning of microbial endophytes. Microbiol Mol Biol Rev 2015;79:293-320. https://doi.org/10.1128/mmbr.00050-14.

81. Strobel GA. Endophytes as sources of bioactive products. Microbes Infect 2003;5:535-544. https://doi.org/10.1016/S1286-4579(03)00073-X

82. Subbulakshmi GK, Thalavaipandian A, Bagyalakshmi RV, Rajendran A. Bioactive endophytic fungal isolates of *Biota orientalis* (L) Endl., *Pinus excelsa* Wall. and *Thuja occidentalis* L. Int J Adv Life Sci 2012;4:9-15

83. Alvin A, Miller KI, Neilan BA. Exploring the potential of endophytes from medicinal plants as sources of antimycobacterial compounds. Microbiol Res 2014;169:483-495. https://doi.org/10.1016/j.micres.2013.12.009