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The role of the *South African Journal of Botany* as a vehicle to promote medicinal plant research– A bibliometric appraisal

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ABSTRACT

South Africa's unique flora and extensive use of African traditional medicines has created a unique research opportunity on medicinal plants for local and international scientists. In this paper, submitted to a special issue of *South African Journal of Botany*(*SAJB*) dedicated to “sub-Saharan Ethnobotany”, we aim to explore the research landscape on medicinal plant research as published in *SAJB*. A bibliometric assessment (1982–2017) showed that medicinal plant research represents 24% of the published volume in *SAJB* and that contributions on this topic are increasing exponentially. Although most papers are broad-based*invitro* screening studies, the range of topics covered is impressive. Antimicrobial (41%) and anti-oxidant (21%) studies dominate the research space with fewer studies focusing on diseases highly relevant to the African continent, *e.g.* malaria (3%) and tuberculosis (2%). Although the *SAJB* has contributed greatly to disseminating knowledge on important species (*e.g. Aspalathus* and *Cyclopia*) several taxa of potential economic relevance remain poorly investigated (*e.g. Adansonia*, *Bulbine* etc.). The citation footprint and authorship networks which have been established attest the pivotal role the *SAJB* has played to build research capacity and create awareness in this important field of research.

1. Introduction

South Africa is globally renowned for its botanical biodiversity, a unique heritage offering abundant opportunities for research and commercial initiatives. Traditional healing is tightly interweaved within this botanical tapestry, a healing modality which is extensively practiced by the diverse cultural groups inhabiting South Africa. The rich indigenous knowledge systems in the country and access to a coveted botanical heritage create unique opportunities for medicinal plant research. It verges on the ironic that this field of research has been neglected for several years and only recently emerged as a topic of high research interest. This trend may also be aligned with consumer preferences and the increased demand for herbal products in preventative health care and general well-being. Globally there has been an upsurge of medicinal plant use which has also ignited local research interest in this discipline.

Internationally, many journals have been established which acutely focus on various facets of medicinal plant research. The *South African Journal of Botany*(*SAJB*) has always covered a wide range of topics as reflected in its aims and scope on the journal website which reads “The *South African Journal of Botany* publishes original papers that deal with the classification, biodiversity, morphology, physiology, molecular biology, ecology, biotechnology, ethnobotany and other botanically related aspects of species that are of importance to southern Africa”. Although medicinal plant research is not specifically mentioned, it would be captured under the broad concept of “ethnobotany”. Ethnobotany by definition is “the scientific study of traditional knowledge and customs of people concerning plants and their medical, religious, and other uses” (Oxford Dictionary of English, 2010). However, many papers published in *SAJB* do not have a strong “ethno” component, as several publications report on the broad screening of plants for a certain bioactivity, which have not been used traditionally for the pharmacological action under investigation.

In this paper, we aimed to summarise the valuable role of the *SAJB* in promoting medicinal plant research through a bibliometrics approach. Bibliometrics (= scientometrics) is described as the use of statistical, mathematical and computational methods to quantitatively analyse corpus academic literature on specific subject areas or research topics (Rostaing, 2003). Bibliometric studies are performed to evaluate research performance and impact through monitoring patterns, trends, relationships and the development of a discipline, researcher or journal. These studies have become an important component in various fields of study including the natural and life sciences. In the past few decades, there has been a renewed interest in the use of natural products. As a consequence, research in the field and particularly in phytomedicine/phytotherapy has grown tremendously with researchers investigating various aspects of phytomedicines. There is, however, a paucity of

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information relating to bibliometric studies on medicinal plant research. These studies are instrumental in exploring the impact of various topics within this research field, identifying topical hotspots, research strengths and weaknesses, information gaps and high performers in the field. The information will assist in informing research priorities, identifying emerging research areas and top researchers for collaborations. Bibliometrics is being applied in many ways to formulate new questions and to offer strategic guidance to further develop a specific journal and/or discipline.

2. Methodology

The search for relevant publications in *SAJB* was conducted in March 2018, using the Scopus database (Elsevier, The Netherlands). The search string "*South African Journal of Botany*" in the source title was used to retrieve all publications from 1982 to 2017 (inclusive). Scopus coverage for *SAJB* is from 1982 to 1986, 1988 to 1990, and 1993 to 2017. The search yielded 2669 multidisciplinary publications, which were manually screened to include only publications broadly related to medicinal plant research. Defining the inclusion and exclusion criteria was challenging due to the broad nature of medicinal plant research. However, all papers dealing with classical pharmacognosy, botany, chemistry and bioactivity of medicinal plants were selected. The selection was broadened to also include papers that cover reviews, ethnobotanical surveys, propagation and cultivation, ecology and taxonomy of medicinally important taxa. The final data set comprised of 629 publications which were subjected to descriptive bibliometric analysis and mapping.

Firstly in Scopus, the built-in function to "analyse data" was applied to the data set to extract statistics such as publications per year, document type, citation frequency, active authors, institutions and countries. Parallel to this, the data set was saved as a .csv file and exported to VOSviewer (CWTS, The Netherlands) and MS Excel® (Microsoft, USA) for further processing. In VOSviewer, co-occurrence of terms in the keywords and abstracts were used to generate term maps and the bibliographic data were used to explore author networks. Default settings were used to construct network maps and other visualisations (van Eck and Waltman, 2010). In MS Excel®, an in-depth analysis of the research landscape was performed to identify the various subject areas, topics of research interest and types of experimental design.

3. Results and discussion

3.1. An aerial perspective of the research landscape

The Scopus database currently contains 2669 papers published in *SAJB* in the period 1982 to 2017. Through manual selection, 629 papers were extracted which relate to aspects of medicinal plant research which represents 24% of the journal content contained in Scopus. Fig.1 clearly shows the upward trajectory in medicinal plant manuscripts with 96% (603) of the papers published in the past 17 years (2001–2017). Over this period the journal also published five special issues (2002, Ethnobotany; 2010, Plant volatiles; 2011, Economic botany; 2012, Quality control; and 2017, Herbal Teas) dedicated to aspects of medicinal plant research. This visionary initiative clearly had a positive impact on stimulating research and many of the most highly cited medicinal plant research papers were carried in these special issues (Table1).

Over the period 1982–2017, 67% of published papers carried a South African affiliation. In the early years (2002–2012), the authorship of most papers were almost exclusively South African (74–100%). There is a progressive change in this tendency and in the period 2013–2017, 45–60% of the papers were authored/co-authored by South African researchers. This observation is congruent with the general internationalisation observed for *SAJB*. The *SAJB* has played an important role to initiate and foster collaboration networks on the topic of medicinal plant research. The country network map (Fig.2) shows that South African authors have developed linkages with 19 countries based on co-authored papers. The various funding programmes of the National Research Foundation have also stimulated collaboration with many countries benefitting from bilateral research funding initiatives. Few linkages however seem to exist between South Africa and other BRICS countries (Brazil, Russia and China) with only limited collaboration observed between South African and Indian authors. This void in collaboration is surprising as these countries too have well-documented traditional

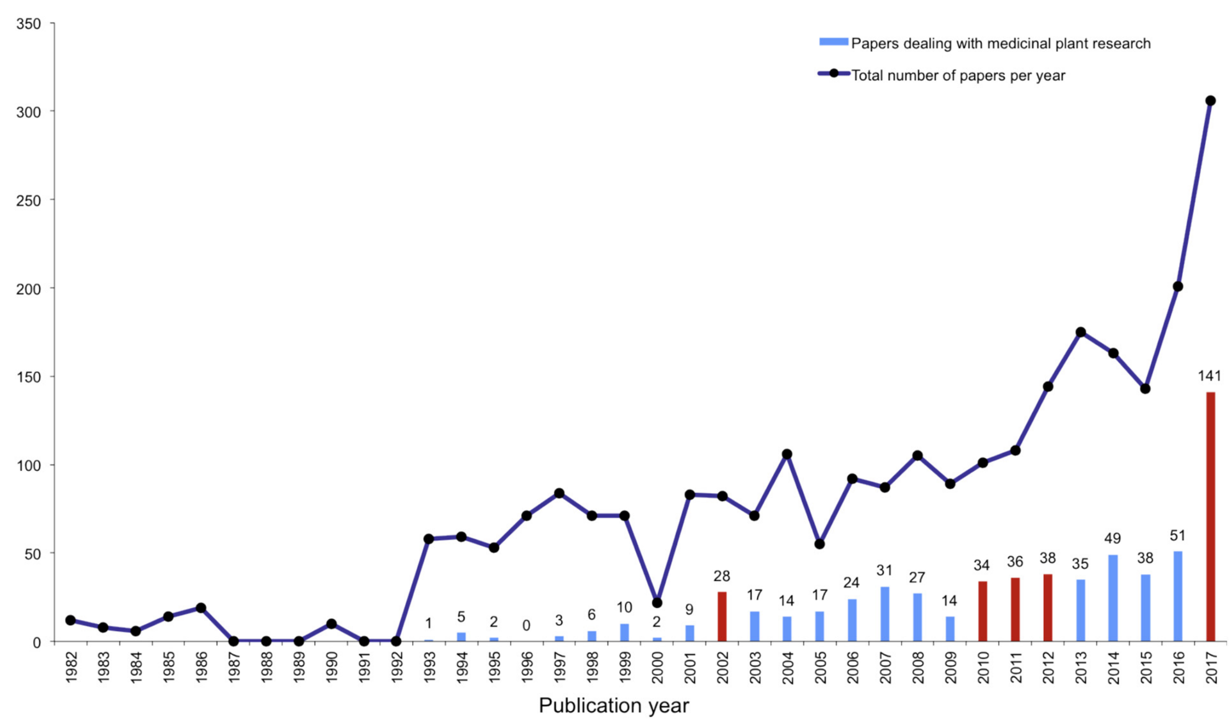

Fig.1. Total number of papers published in *SAJB* per year and the number of papers dealing with medicinal plant research (relevant special issues are indicated by red bars).

Table1
Top 10 cited papers in *South African Journal of Botany* related to medicinal plant research as extracted from the Scopus database ($n = 629$).

Paper details	Citations
Chen W., etal., 2010. Geraniol - a review of a commercially important fragrance material. *South African Journal of Botany* 76, 643–651.[*,@]	112
Mativandlela S.P.N., etal., 2006. Antibacterial, antifungal and antitubercular activity of (the roots of) *Pelargonium reniforme* (CURT) and *Pelargonium sidoides* (DC) (Geraniaceae) root extracts. *South African Journal of Botany* 72, 232–237.[@]	100
Maffei M.E. 2010. Sites of synthesis, biochemistry and functional role of plant volatiles. *South African Journal of Botany* 76, 612–631.[*,@]	97
Kotzé M., etal., 2002. Extraction of antibacterial compounds from *Combretum microphyllum* (Combretaceae). *South African Journal of Botany* 68, 62–67.[*]	95
Masoko P., etal., 2007. The antifungal activity of twenty-four southern African *Combretum* species (Combretaceae). *South African Journal of Botany* 73, 173–183.	83
Joubert E and de Beer D., 2011. Rooibos (*Aspalathus linearis*) beyond the farm gate: From herbal tea to potential phytopharmaceutical. *South African Journal of Botany* 77, 869–886.[*]	78
Joubert E., etal., 2011. Honeybush (*Cyclopia* species): From local cottage industry to global markets - the catalytic and supporting role of research. *South African Journal of Botany* 77, 887–907.[*]	73
Bourgou S., etal., 2010. Bioactivities of black cumin essential oil and its main terpenes from Tunisia. *South African Journal of Botany* 76, 210–216.	65
Luseba D., etal., 2007. Antibacterial, anti-inflammatory and mutagenic effects of some medicinal plants used in South Africa for the treatment of wounds and retained placenta in livestock. *South African Journal of Botany* 73, 378–383.	57
McGaw L.J., etal., 2002. Isolation of β-asarone, an antibacterial and anthelmintic compound, from *Acorus calamus* in South Africa. *South African Journal of Botany* 68, 31–35.[*]	54

[*] Papers appearing in a special issue.
[@] Papers ranking under the top 10 cited papers for SAJB ($n = 2669$).

healing systems and many have developed a firm research base on the topic over years. It needs to be noted that not all countries shown on the country network map (Fig.2) co-publish with South African authors. Brazilian authors, *e.g.* have published 17 papers in *SAJB* (2012–2017) mostly on Brazilian plants. The perception exists, based on the name of the journal that *SAJB* would focus on plants indigenous to South Africa. The journal however has become attractive to international researchers publishing research findings on plants indigenous to their specific region (*e.g.*Tunisia, China, India). South African laboratories have remained attractive to international researchers facilitating skills and knowledge transfer between institutions.

The co-author network map (Fig.3) shows geographical (and institutional) clustering patterns where pockets of research excellence have been established over several years. The academic lineages which have been established over several years have left a firm footprint on local medicinal plant research. Several well-established researchers have trained students who remained in the academic environment who in turn continued to train the next generation of academics. It is clear from Fig.3 that the topic of medicinal plant research has built research capacity at various institutions and that these local collaborations have been maintained and even extended to form international linkages.

Table2 lists the most productive institutions that have published papers on aspects of medicinal plants in *SAJB*. The University of KwaZulu-Natal (UKZN) has clearly been at the very epicentre of this field and has dominated the research arena by contributing 33% of all published papers considered in this bibliometric assessment. The UKZN finds itself located in a “sweet-spot” as the province is home to the Zulu, an ethnic group that extensively uses traditional medicines. Over the past years, the UKZN has invested strongly in medicinal plant research and several departments (*e.g.* Botany, Chemistry and recently Pharmacy and Pharmacology) have developed a multidisciplinary research interest in medicinal plant research spanning phytochemistry, bioactivity screening, propagation/cultivation *etc.* The institution has acted as an incubator to train a strong cohort of postgraduate students who have continued their professional careers locally and abroad while maintaining research linkages with their former *alma mater*.

After the UKZN, four Gauteng-based institutions (University of Pretoria, University of the Witwatersrand, Tshwane University of Technology and University of Johannesburg) have collectively contributed to 43% of the total published literature. These institutions have very distinct, yet complementary expertise relating to medicinal plant research. The research group at the University of Pretoria has focused on infectious diseases and added valuable phytochemistry and metabolomics components to their studies allowing them to research topics to a greater level of depth. The National Research Foundation has recently appointed an NRF/DST Chair “Plant Health Products from Indigenous Knowledge Systems” at the institution which will focus on bioprospecting of South African plants for the medicinal and cosmetic industries. Since the days of Watt and Breyer-Brandwijk (1962) who produced the benchmark publication “The Medicinal and Poisonous Plants of Southern and Eastern Africa”, the University of the Witwatersrand has always had a research interest in medicinal plants. Currently, the institution has strong research expertise in antimicrobial assays, synergy research, ethnobotany and conservation. As a new emerging

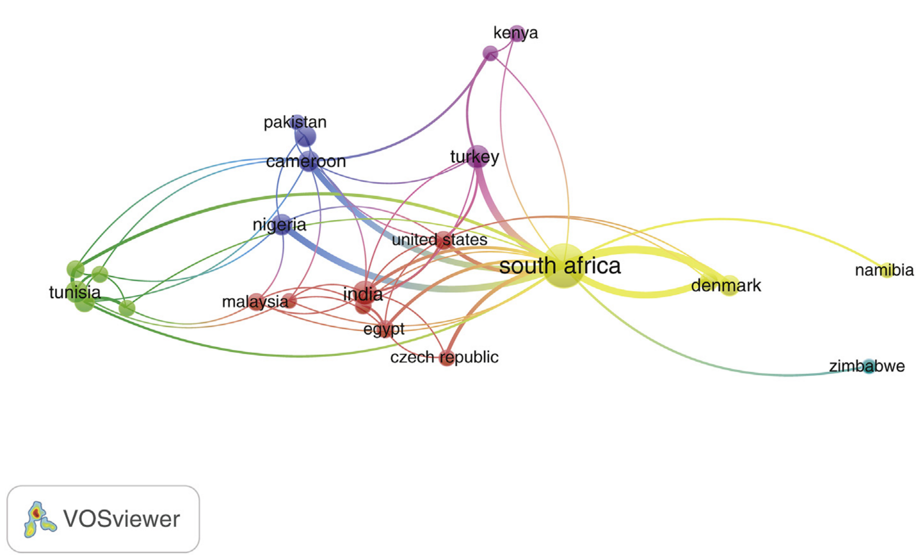

Fig.2. Country network map based on country of affiliation.

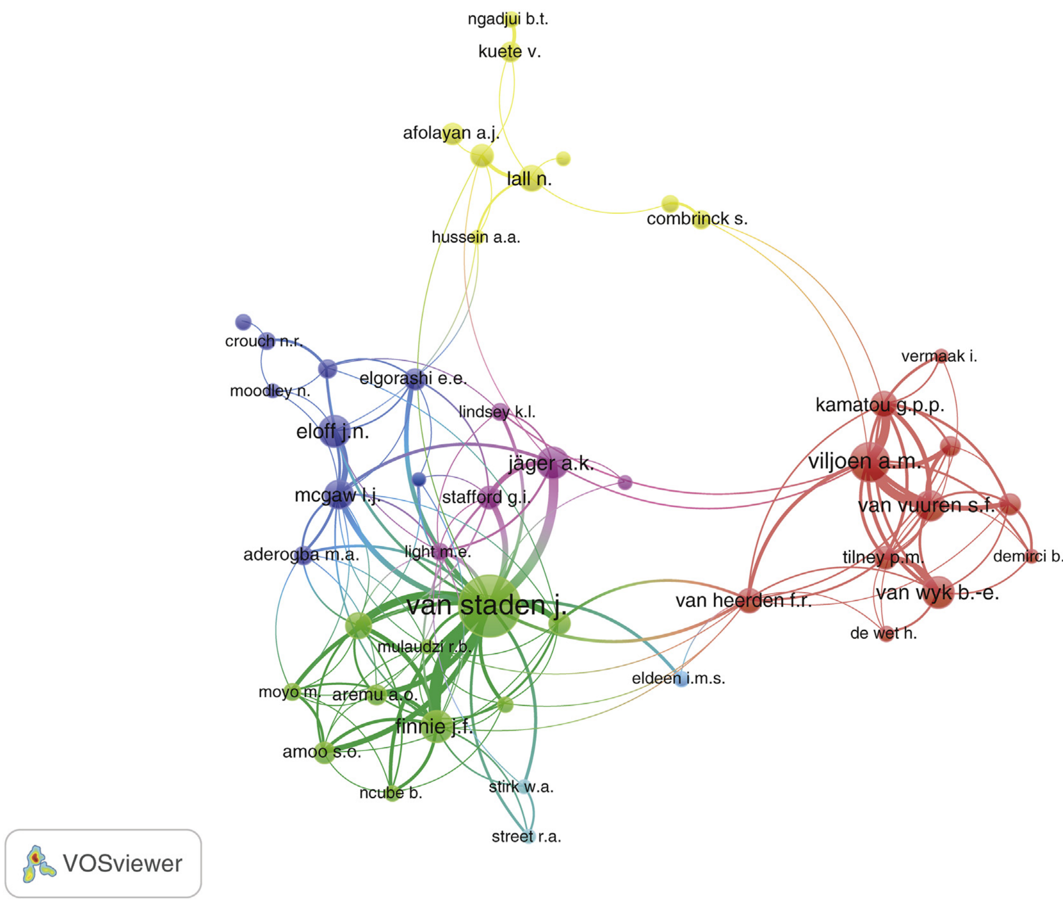

Fig.3. Co-author network map showing linkages and collaboration between various individuals (and institutions).

Table2
The relative percentage contribution of institutions who have published ≥10 papers in *SAJB* and the area of expertise.

Institution	Contribution	Area of expertise
University of KwaZulu-Natal (SA)	33%	*In vitro* screening (*e.g.* inflammation, antibacterial, anti-oxidant), propagation
University of Pretoria (SA)	13%	*In vitro* screening, phytochemistry, metabolomics
University of the Witwatersrand (SA)	13%	Antimicrobial, synergy, antimalarial, ethnobotany, conservation
Tshwane University of Technology (SA)	10%	Phytochemistry, analytical methods, quality control, metabolomics
University of Johannesburg (SA)	7%	Plant taxonomy, ethnobotany, economic botany
Agricultural Research Council (SA)	6%	Herbal teas, analytical methods, phytochemistry, quality control
University of Stellenbosch (SA)	5%	Herbal teas, micropropagation
South African National Biodiversity Institute (SA)	3%	Taxonomy, Ethnobotany
University of Dschang (Cameroon)	2%	*In vitro* screening (*e.g.* antimicrobial, anti-oxidant)
Anadolu University (Turkey)	2%	Essential oil research
University of Fort Hare (SA)	2%	Ethnobotany, *invitro* and *invivo* pharmacology
The Council for Scientific and Industrial Research (SA)	2%	Phytochemistry (analytical aspects)
University of Limpopo (SA)	2%	Ethnobotany, diabetes

institution, the Tshwane University of Technology has targeted medicinal plant research as a strategic focal point for research development. The NRF/DST Chair (Phytomedicine) at TUT currently focuses on aspects of quality, safety and efficacy of herbal drugs. The University of Johannesburg has a valuable focus on plant taxonomy, especially related to ethnomedicinally important plant taxa. The importance of plant taxonomy should not be underestimated as accurate botanical identification is crucially important (and a pre-requisite) in any plant-based study. The group in the Department of Botany and Plant Biotechnology is probably best known for the series of valuable books, which have been authored by the current NRF/DST Chair focusing on Indigenous Plant Use.

At this juncture, it needs to be emphasised that this bibliometric assessment is narrowly focused on the *South African Journal of Botany* as a vehicle to preserve and disseminate knowledge on medicinal plant research. Several institutions however have been active in medicinal plant research but have elected to not publish in *SAJB*. Here, the University of Fort Hare is positively flagged as a major contributor in the field but the institution has only published 11 papers in the *SAJB*. Globally, medicinal plant research is traditionally carried out in pharmacy and pharmacology departments. Considering the affiliations reflected in Table2, the bulk of medicinal plant research in South Africa is conducted in botany departments. It is regrettable that few pharmacy schools are active in this field and it remains perplexing that pharmacognosy has been pruned out of the undergraduate curriculum in most pharmacy schools, especially in view of the widespread use of traditional medicines in South Africa.

3.2. Analysing the research content

The term map (Fig.4) provides an overview of the research landscape based on content and topics published. The map reveals five

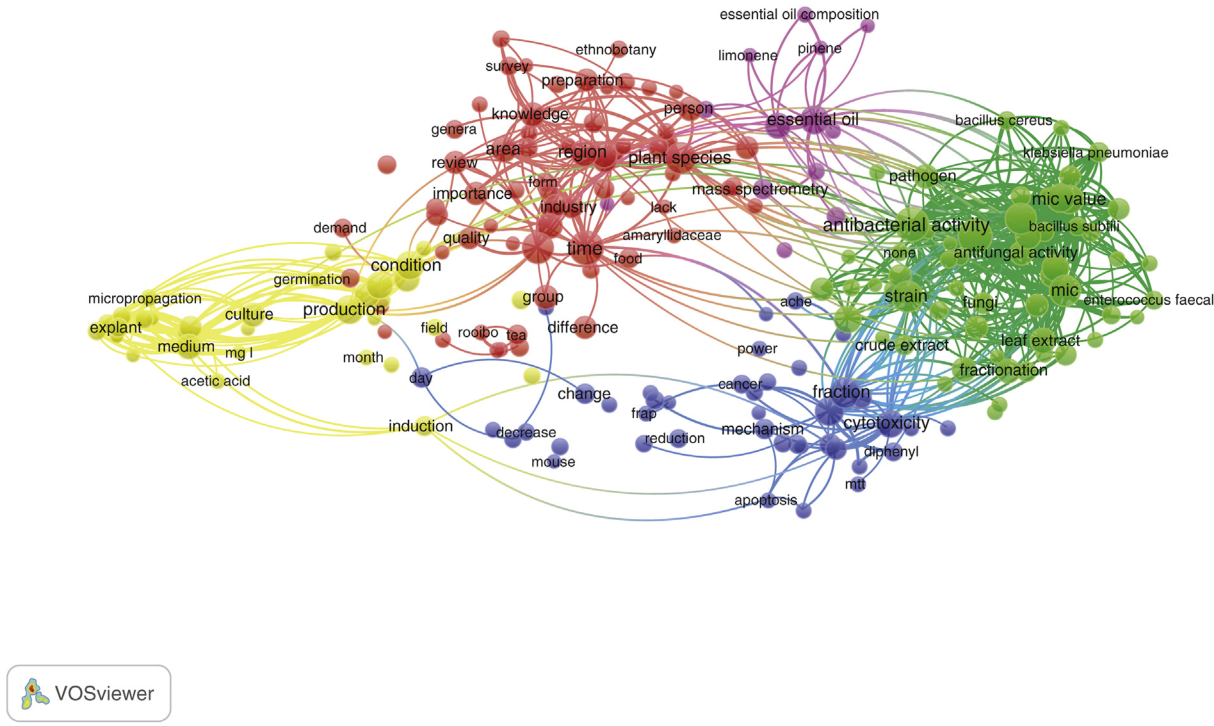

Fig.4. Term map based on co-occurrence of text in both the title and abstract fields using 629 publications.

major clusters. The most dominant cluster in green represents the plethora of papers covering antimicrobial assays and Fig.5 shows that of the 629 publications considered in this paper, ≥40% were devoted to plant-based antimicrobial studies. Several plants are traditionally used to treat all kinds of infections which provides the rationale for studies in evidence-based traditional medicines. The urgent need to find new antimicrobials to combat the upsurge in resistance has provided further impetus and relevance for broad plant-based antimicrobial studies. Furthermore, these assays are relatively easy to perform which has also contributed to the volume of research performed in the area. It needs to be noted that no matter how well such studies are motivated, there has been no new class of antimicrobials developed from a botanical resource. From this, one can deduce either that there are no highly active antimicrobial substances in plants or that the research approach, which is mostly focused on the biocidal properties of extracts may not be the best approach. Botanicals may act *via* other modes of action such as impeding cell-to-cell communication through the process of quorum sensing or may exert anti-adhesion properties, *e.g. Vaccinium macrocarpon* Aiton (Peron etal., 2017). These activities will obviously be missed using the most

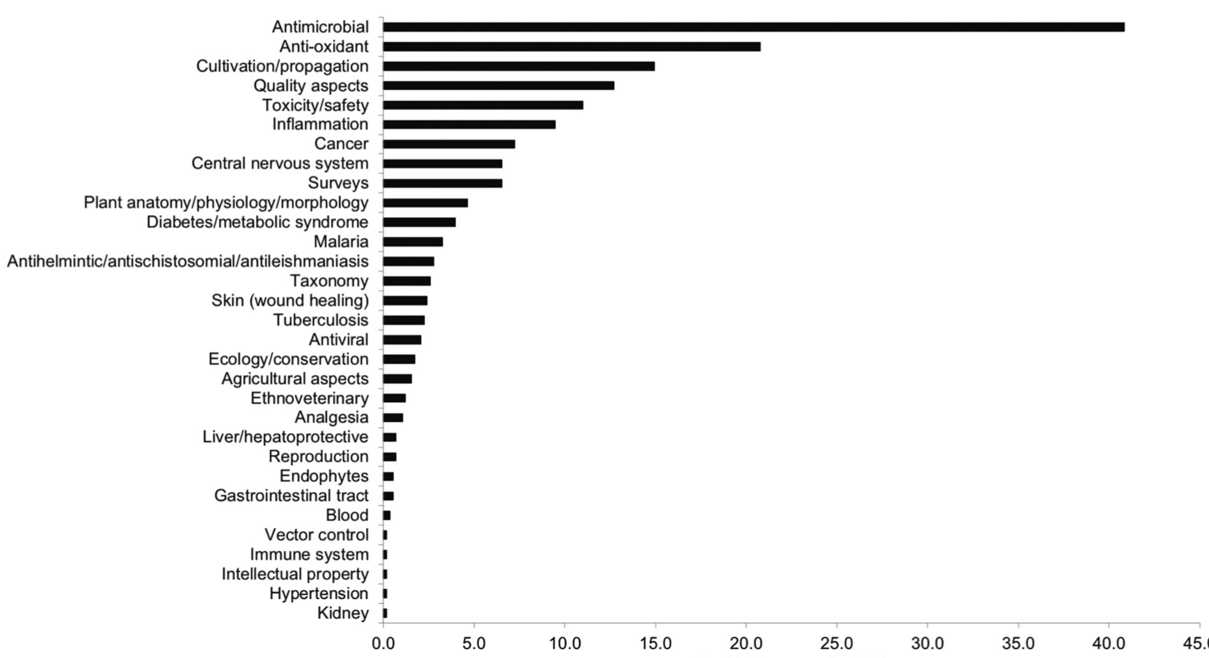

Fig.5. The relative percentage of the various topics covered in the 629 papers published on medicinal plants in the *South African Journal of Botany*.

common *invitro* microdilution assays which narrowly focus on the "killing effect" of plant extracts.

Closely associated with the green cluster is the blue cluster which represents research on the topic of anti-oxidants, cytotoxicity and anticancer screening. These studies became fashionable in the 2000's due to the rapid production of results and the ease of performing the assays. Globally, anti-oxidant studies have gained popularity due to the role of free radicals in disturbing pharmacological equilibrium. Considering the abundance of polyphenolics characterising most plant-extracts, it is a glimpse of the obvious that plant extracts will exert free-radical scavenging properties. Actually, it will be very rare to find a plant extract which does not exhibit anti-oxidant activity. So, the rationale of this approach is often questionable. The *SAJB* carried >>120 papers on anti-oxidants in which the research purpose seems to simply report antioxidant activity or to find extracts and compounds which exert a more superior activity compared to the positive control vitamin C, an abundant natural substance with excellent anti-oxidant activity. Due to this excessive increase in anti-oxidant studies, often without a relevant and novel research purpose, several journals have now limited the submissions in this area requiring stricter assessment criteria. *In vitro* studies should be followed up with *invivo* studies at relevant doses and the bioavailability of these compounds should be determined.

South Africa harbours a large number of aromatic plants, of which many are used as traditional medicines. This ignited research interest in the essential oils of several aromatic plants as represented in the purple cluster (Fig.4). Essential oil research, especially analytical methodology in the field has developed to the point where it can no longer be considered innovative to analyse an essential oil and publish a long list of compounds identified in the oil. If such studies are associated with some form of pharmacological screening or to assess the data from a chemotaxonomic perspective, it adds more value to the study and this should be encouraged.

The red cluster is an assemblage of papers focusing on taxonomy, conservation and ethnobotany (surveys). Very few research groups in South Africa have focused on ethnobotanical surveys, which have become crucially important due to the fragile nature and rapid disappearing of indigenous knowledge systems. Only 38 papers (7%) were published in this field of research. Although there have been bold initiatives through various funding agencies (*e.g.* National Research Foundation) and the Indigenous Plant Use Forum to promote and encourage research in the field of indigenous knowledge systems, it would appear that most studies still remain laboratory-based with fewer papers dedicated to ethnophamacological field studies. This discipline of medicinal plant research too has evolved past the point of inventories which simply list species and their uses in a certain region. Excellent guidelines on how primary ethnopharmacological field data needs to be collected and presented as well as the analyses of qualitative and quantitative data have recently been published (Weckerle, etal., 2018 and Heinrich etal., 2018).

The last dominant cluster in the term map represents research on propagation and cultivation of medicinal plants. Conservation concerns continue to haunt the current (mostly) unsustainable trade of African traditional species and several indigenous species are critically endangered. This cluster mostly reflects research done at the UKZN's Research Centre for Plant Growth and Development on germination and tissue culture protocols for the large-scale propagation of several medicinal plants. The term map is obviously constructed to display the major areas of research graphically. Fig.5 however shows in more detail the impressively broad range of topics published in *SAJB*. It is striking to see that diseases which plague the African continent such as malaria (3%) and tuberculosis (2%) seem to be neglected areas of research.

3.3. Relevance and impact

In 2011, Van Wyk published a paper listing the most important medicinal plants from South Africa with commercial potential and draws attention to the urgent need of basic and applied research on the identified plants. Many of these plants remain poorly researched, at least as reflected by the lack of papers published in *South African Journal of Botany*. For example, Table3 shows that only three papers have appeared on *Adansonia digitata* L. (Baobab), which has been hailed the new "super fruit" from Africa and identified for large-scale commercial development. Similarly, commercial interest in *Bulbine* species for its application in the cosmetic sector has intensified, yet only two papers have been published in *SAJB* on this important species. One of the most important phytomedicines commercialised from the South African flora remains *Pelargonium sidoides* DC. A Scopus search, broader than the one performed for *SAJB*, filters 251 published papers on this species, of which only 41 were authored/co-authored by South African researchers of which only 6 were published in *SAJB*.

Rooibos and Honeybush tea represent two commercial success stories from the South African flora. It is clear that basic research underpins any potential commercial development and the strong cohort of researchers in South Africa working on these herbal teas have greatly contributed to the solid scientific base developed over the years for these two important species. Table3 shows that 35 papers have collectively appeared in *SAJB* on these two species and the recent special issue dedicated to herbal tea research will further promote and encourage research on indigenous teas. It is encouraging to observe that collectively, 173 papers (representing 28% of all the papers considered in this assessment) have been published on the commercially important South African plants identified by Van Wyk (2011).

Citations is a common journal metric used to measure the impact in the field. Table1 lists the top 10 cited papers and their number of citations which collectively have attracted 814 citations. Of interest is that three of the papers (marked *) appear under the top 10 cited papers for the total number of papers contained in the Scopus database for *SAJB* irrespective of topic. The 629 papers considered in this appraisal

Table3
The number of papers published in South African Journal of Botany on the species which were identified by Van Wyk (2011) as species of high commercial importance.

Species	Nr of papers
Cyclopia species	18
Aspalathus linearis (Burm.f.) R.Dahlgren	17
Sutherlandia frutescens (L.) R.Br.	11
Artemisia afra Jacq. ex. Willd	10
Lippia species	10
Agathosma species	8
Hypoxis hemerocallidea Fisch., C.A.Mey. & Avè-Lall	8
Warburgia salutaris (G.Bertol.) Chiov.	8
Sclerocarya birrea (A.Rich.) Hochst.	7
Pelargonium sidoides DC.	6
Trichilia emetica Vahl	6
Aloe ferox Mill.	5
Athrixia phylicoides DC.	5
Harpagophytum procumbens (Burch.) DC. ex Meisn.	5
Hoodia gordonii (Masson) Sweet ex Decne.	5
Kigelia africana (Lam.) Benth.	5
Ximenia species	5
Centella asiatica (L.) Urb.	4
Eriocephalus species	4
Sceletium tortuosum (L.) N.E. Br.	4
Siphonochilus aethiopicus (Schweinf.) B.L. Burtt	4
Adansonia digitata L.	3
Bulbine frutescens (L.) Willd.	2
Citrillus lanatus (Thunb.) Matsum. & Nakai	2
Leonotis leonurus (L.) R.Br.	2
Prunus africana (Hook.f.) Kalkman	2
Withania somnifera (L.) Dunal	2
Aloe arborescens Mill.	1
Aloe marlothii A.Berger	1
Carpobrotus edulis (L.) N.E.Br.	1
Olea europaea subsp. africana (Mill.) P.S.Green	1
Xysmalobium undulatum (L.) W.T.Aiton	1
Total	**173**

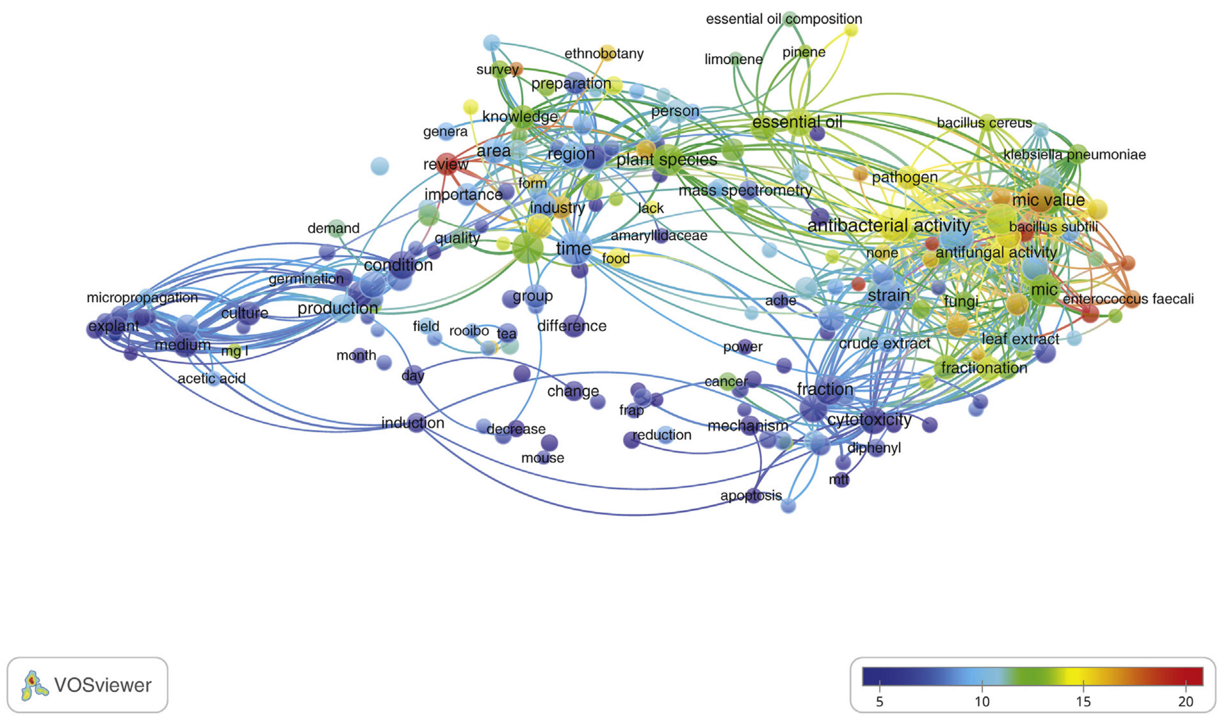

Fig.6. Average citations superimposed on the term map (Fig.4) to produce the overlay visualisation heat map.

have collectively been cited 6313 times, an average of 10 citations per paper. It is important to note that 87% of all papers published on medicinal plants have at least attracted one or more citation. Overlaying the average number of citations on the term map (previously discussed as Fig.4) produced the heat map in Fig.6. The warmer colours denote the topics on the heat map which have attracted more citations. A general tendency is noted that the papers on antimicrobial studies have attracted more citations. As expected, the most highly cited papers are reviews, as denoted by the bubble in the top left of the heat map which is congruent with the data displayed in Table1. Reviews, however, only represent 6% of the total number of papers published in *SAJB* on medicinal plants.

3.4. General observations and final comments

It is clear that the *SAJB* has nurtured and promoted medicinal plant research in a most exemplary way. It is commendable and insightful of the editorial structure for promoting medicinal plant research as a topic of interest. The journal has clearly acted as an incubator to advance research in the area of ethnobotany and ethnopharmacology which in turn has served the journal and the country well in view of global collaborations and citation networks. It needs to be emphasised that the majority of papers published in this field of research in *SAJB* is of a preliminary nature. Although many papers sound optimistic and aim to resonate positively on drug development, often presented as a premise on which the research has been based, it is most unlikely that most results would be further explored by industry. Academic research of this nature is not focused on producing a finished product which requires a product-focused approach, substantial financial commitment and extensive drug development studies over an extended period of time.

Reading through most of the 629 papers (including our own), it is both exciting but also calls for caution that almost all results are positive, especially when reviewing the *invitro* assay data. Considering that 89% of experimental papers on medicinal plants published in this assessment have only applied *invitro* assays, the future application and development may be limited. Several papers have shown the limitations and pitfalls of *invitro* data. *In vitro* assays are often non-selective and prone to false-positive results, especially when dealing with complex plant extracts which limits the interpretation and future extrapolation of the data (*e.g.*Skowyra, 2014). Furthermore, the importance of metabolism and absorption are completely ignored in the *invitro* assays. The recent paper by Nelson et al. (2017) blows the lid off most research on curcuminoids from *Curcuma longa* (turmeric) showing that most of the assay data have not considered that the molecules are highly unstable and not bioavailable. This being noted, *invitro* assays remain an important phase in medicinal plant research and are valuable in training postgraduate students in routine laboratory methodology.

Papers where *invivo* (9%) experimental designs were employed represented the minority. The majority of papers (64%) assessed the bioactivities of crude extracts only and few papers drilled down deeper to explore the phytochemistry of promising extracts to compound level (19%). Papers where any form of chemical profiling (*e.g.* thin layer chromatography, liquid chromatography, gas chromatography *etc.*) was performed represented 49% of papers. A lack of chemical profiling would make it almost impossible to reproduce results due to the rampant chemotypic variation exhibited by most species and the inherent complexity characterising natural products research. It is noted that where studies have been more detailed, where active extracts were profiled and the phytochemistry was explored, the publications are targeted for higher impact journals where profiling is a journal requirement.

Clearly, impressive local capacity has been developed in South Africa on medicinal plant research as reflected through this bibliometric assessment. Although productive collaboration exists, the research remains narrowly focused and confined to the research infrastructure and expertise available at various institutions. Medicinal plant research will clearly benefit from closer collaboration between various groups in South Africa. By its very nature medicinal plant research is multidisciplinary which requires expertise in botany, natural product chemistry, pharmacy and pharmacology *etc.* Greater cohesion and a more synchronised approach will allow for high impact studies which should ideally focus on a research topic of academic interest and generate translational research to transform the many latent botanical assets into consumer products.

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