Invasive alien plants and weeds in South Africa: a review of their applications in traditional medicine and potential pharmaceutical properties

LJ McGaw[1,2], AG Omokhua-Uyi[1,2], JF Finnie[1], J van Staden[1,*]

[1]*Research Centre for Plant Growth and Development, School of Life Sciences, University of KwaZulu-Natal, Private Bag X01, Scottsville 3201, Pietermaritzburg, South Africa*

[2]*Phytomedicine Programme, Department of Paraclinical Sciences, Faculty of Veterinary Science, University of Pretoria, Private Bag X04, Onderstepoort 0110, Pretoria, South Africa*

** Corresponding author e-mail address: rcpgd@ukzn.ac.za (J Van Staden)*

Tel.: +26 33 2605130

Author e-mails: LJ McGaw (lyndy.mcgaw@up.ac.za); AG Omokhua-Uyi (giftomokhua@yahoo.com); JF Finnie (finnie@ukzn.ac.za)

ABSTRACT

Ethnopharmacological relevance: Traditional pharmacopoeias are constantly evolving and adapting, hence the assimilation of alien plants and weeds into traditional systems of healing. Invasive plants are detrimental to the ecosystem, however they are also potential sources of secondary metabolites with useful biological activities.

Aim of the review: The aim of this review was to investigate published reports of traditional use and biological activity of declared invasive alien plants and other weeds in South Africa.

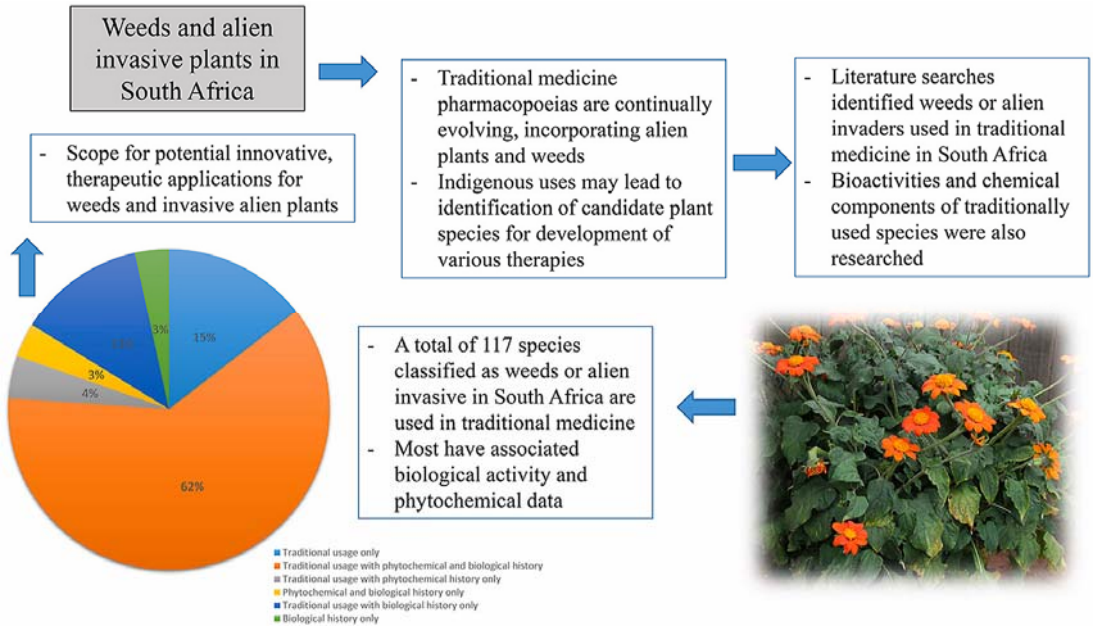
Materials and methods: Information was retrieved from scientific databases including Scopus, Web of Science, ScienceDirect, Google Scholar, PubMed, Chemical Abstracts Services and books, theses, dissertations and technical reports. Keywords used for the search engines were "South Africa" or "southern Africa" in conjunction with "(native weeds OR alien invasive)" AND "medicinal". Separate searches were conducted on the individual invasive plant species

recorded as having been used in ethnobotanical surveys to determine their known biological activities and chemical components.

Results: A total of 89 plant species regarded as invasive species or weeds in South Africa were identified as being used in traditional medicine. The most commonly mentioned plant family was the Asteraceae with a total of 15 species followed by the Fabaceae and Solanaceae with 6 species each. Of the 89 species recorded, 68% were reported to have traditional usage with both phytochemical and biological data available. A history of traditional usage coupled with biological data was available for 12% of species. Records of traditional usage alone were linked to 11% of species. Invasive alien species comprised 61% of recorded species, while native and non-invasive alien weeds formed the remaining 39%.

Conclusions: The exploration of alternative uses for weeds and particularly invasive plants, whether native or alien, as medicines for possible commercialisation may lead to innovative mechanisms for putting such species to good use.

Graphical abstract



Keywords: Weeds, Invasive plant species, Exotic, Alien, South Africa, Medicinal.

1. Introduction

The search for plants with useful medicinal properties has been predominantly associated with exploration of habitats such as tropical rainforests, but other areas including disturbed habitats are fertile areas for the discovery of potentially beneficial species (Stepp and Moerman, 2001; Lewu and Afolayan, 2009). The possibility exists that interesting new drugs remain to be discovered in invasive plants that may or may not be used in traditional medicine.

Southern Africa has an exceptionally rich plant diversity with more than 20 000 plant species belonging to 368 families (Williams et al., 2013), including more than 10% of the world's vascular plant flora on less than 2.5% of the earth's land surface area (Germishuizen and Meyer, 2003). Of these plant species, about 2 062 are used in traditional medicine, and in the region of 171 families are the most commonly used and traded (Williams et al., 2013). With such a wide variety of plant species from which to choose, coupled with a rich cultural diversity, it is not surprising that South African people to some extent rely on plant-based preparations for healing various ailments affecting themselves as well as their livestock and companion animals.

The number of practicing Traditional Health Practitioners (THPs) in South Africa has been estimated to range from 68 000 (full-time only) to 300 000 (full-time and part-time THPs) (Street et al., 2018 and references cited therein). Weaver et al. (2020) placed the estimate of THPs at 200 000, cautioning that this number cannot be verified as no THPs have been registered as yet, despite attempts made by the South African government to develop and implement regulation of THPs. This process was initiated with the THPs Act (22 of 2007) but to date, progress has been slow in implementation of this Act (Weaver et al., 2020). African traditional healing systems are thriving, and have revealed themselves to be dynamic and

adaptive, and may continue to incorporate newly discovered plant species, including invasive native or alien plants into their pharmacopoeias (Ahlberg, 2017).

Invasive plant species are mostly referred to by researchers as plants introduced to an area they are not native to and as such are called alien. Richardson et al. (2000) defined invasive plants as naturalised alien plants that produce reproductive offspring in large numbers, often far away from the parent plant, and thus have the potential to spread over large areas. However, some invasion biologists have argued that a plant does not have to be alien to be tagged invasive, as native plants can also be invasive due to their weedy nature (Valéry et al., 2013). Invasive alien plants often appear to be more competitive than native species, and after highlighting the paucity of tests of this hypothesis, published pair-wise experiments between invasive and native plant species were analysed (Vilà and Weiner, 2004). It was concluded that the available data suggest that the effect of invasive alien species on native species is usually stronger than *vice versa* (Vilà and Weiner, 2004). Invasive alien plants are often, but not always, aggressive growers, competing for water, nutrients, light and space, and may eliminate other species (Zengeya et al., 2020). In addition to competing with crops and other species for water and nutrients, they may also be toxic to humans and animals, adversely affect biodiversity, and act as hosts for plant diseases and pests (Zengeya et al., 2020). In the study of Pimentel et al. (2001), it was reported that more than 120 000 non-native species of plants, animals and microbes have invaded the United Kingdom, United States, Australia, South Africa, Brazil and India with many causing major economic losses in forestry and agriculture, and negatively impacting ecological integrity. It is likely that non-native species invasions in the six nations cause over US$ 314 billion per year in damages (Pimentel et al., 2001). South Africa has an increasing number of invasive alien plant species with an expanding distribution (Henderson and Wilson, 2017). It was reported that between 2000 and 2016, the number of quarter-degree

squares (qds) occupied by alien plants increased by approximately 50%, owing largely to ongoing sampling and to spread (Henderson and Wilson, 2017). The impact of invasive plants has been estimated to result in a loss of ZAR 12.9 billion annually (Zengeya et al., 2020). Invasion biology is a controversial topic among scientists that needs further studies for clarification and further classification. Invasion biology is not the focus of this review, hence we therefore herein refer to "invasive plants" as alien or native plants that are invasive and as such listed under legislation for the purpose of eradication or control.

The impact of invasive plants is severe and therefore deserves serious attention. It is not impossible that control through utilisation without propagation may be one of the options to consider. With this in mind, invasive plants may be good sources of medicinal compounds which may serve as alternatives to highly exploited plants with similar medicinal properties. Also, these plants may be developed into low cost, low technology plant-based remedies on a more commercial scale. It is known that clearing invasive alien plants may facilitate secondary invasion or dominance of weedy native species in place of native biodiversity recovery (Nsikani et al., 2020), and hence this review does not focus on recommendations for weed management.

Surveys and some reviews on the use of selected invasive plants in specific parts of South Africa exist (e.g. Maema et al., 2016a,b; Mbambala et al., 2017). However, a comprehensive review on the medicinal uses of plants listed under South African regulations; Conservation of Agricultural Resources Act (CARA) and National Environmental Management: Biodiversity (NEMBA) is lacking. Therefore, the aim of this review is to synthesize relevant literature that has documented traditional medicinal uses and biological activity, with emphasis on invasive plants of weedy nature listed under the South African regulations. Information on native weed

species with recorded traditional uses have also been included as these are potential sources of useful bioactive compounds.

2. Methodology

A literature search was conducted on invasive plant species of potential medicinal value in southern Africa. For the purposes of this review, plants declared as invasive in terms of national legislation (National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA), Conservation of Agricultural Resources Act (CARA, Act 43 of 1983), and other reliable sources (CABI Invasive Species Compendium and South African National Biodiversity Institute) were the primary focus. The traditional uses where applicable, as well as biological activity studies of extracts and purified compounds from weedy plants were included in the survey. In some studies on southern African weed species investigated for biological activity, species of interest were selected purely on the basis of their weedy nature in place of purported traditional use. Information was retrieved from scientific databases including Scopus, Web of Science, ScienceDirect, Google Scholar, PubMed and Chemical Abstracts Services. Books, theses, dissertations and technical reports contained in the libraries of the University of Pretoria and University of KwaZulu-Natal were also consulted. Keywords used for the search engines were “South Africa” or “southern Africa” in conjunction with “(weeds, native, alien OR invasive) AND “medicinal”. Separate searches were conducted on the individual weedy plant species recorded as having been used in ethnobotanical surveys to determine their biological activities studied and known chemical components.

For the study selection, inclusion criteria were as follows. Publications describing the use of weeds as medicinal agents (alone or with a combination of other plants) either as part of ethnobotanical surveys, or as studies of the medicinal uses of weeds were included in the

review. The inclusion of data was assessed by the first two authors and then discussed with all authors. The first phase of the literature review involved retrieving potentially relevant articles based on titles and abstracts according to the keywords listed above. Then, the complete articles were downloaded and assessed for inclusion.

3. Results and discussion

3.1 Weeds as sources of medicinal compounds

Secondary compounds in plants serve various functions, including allelopathy, where the compounds inhibit germination and growth of other plants, and as chemical defence against herbivory (Harborne, 1993). The first of two main anti-herbivory chemical defence strategies in plants comprise metabolically inactive, immobile (quantitative) defences such as tannins and lignins of high molecular weight that reduce digestibility but are not biological toxins (Feeny, 1976). The second major anti-herbivory defence involves low molecular weight mobile, or qualitative, defence compounds such as terpenoids, alkaloids or cardiac glycosides which deters the herbivores or reduce palatability (Coley et al., 1985; Renwick, 1996; Sharma et al., 2017a; Ali et al., 2019). These compounds may be toxic and highly biologically active and may be a useful source of plant-derived pharmaceuticals (Stepp, 2004). Plants that are fast-growing, which includes many weeds, have been shown to rely on these potentially lethal compounds for protection (Coley et al., 1985). This is particularly relevant for native weed species, as introduced plants may have natural enemies that are not present in their new habitat. Also, plants with leaves that are short-lived, as is sometimes the case with weeds, are reputed to invest in toxic compounds while plants with long-lived leaves rely on immobile defences (Stepp, 2004). It is reasonable therefore to infer that short-lived weeds, as well as other short-lived plant species, will produce bioactive compounds as a defence mechanism against herbivory (Yactayo-Chang et al., 2020), as well as bacterial and fungal infections. We speculate

that valuable medicinal resources may be identified in these weeds, as these putative defence compounds may also have interesting biological activity and hence medicinal value in the treatment of various diseases. This deserves greater consideration in terms of focusing attention on harvesting and utilisation of such species as just one aspect of existing or proposed control strategies. This is applicable, in our opinion, to the development of low-cost, low technology remedies that have potential for commercial development.

3.2 Legislation and other documentation concerning alien and native weed species in South Africa

Alien and native weed species have been classified by the Conservation of Agricultural Resources Act (CARA, Act 43 of 1983), which is administered by the national Department of Agriculture (now the Department of Agriculture, Land Reform and Rural Development). Regulations 15 and 16 of this Act were amended in 2001 to list three categories of invasive plants (Department of Agriculture, 2001). Category 1 species are 'declared weeds' that are prohibited and must be eradicated. They are viewed as being harmful to humans, animals or the environment and have no economic purpose. Category 2 species are 'declared invader plants with commercial or utility value' and include invading species with some useful qualities, such as animal feed or soil stabilisation. They are permitted in demarcated areas under controlled conditions. Category 3 species are 'mostly ornamental plants' and are not allowed to be planted except with special permission, and no trade in propagative material is permitted. Existing plants do not have to be removed, except those near watercourses or in wetlands, but must be prevented from spreading.

The Department of Environmental Affairs (now the Department of Environment, Forestry and Fisheries) has also published lists of invasive and prohibited plant species by means of

regulations in terms of the National Environmental Management: Biodiversity Act 10 of 2004 (NEMBA). Additional species and different categories to those defined in CARA were proposed. Listed in the regulations of 12 February 2014 (Department of Environmental Affairs, 2014a) are 380 invasive plant species divided into the categories 1a, 1b, 2 and 3. The classification of species is as follows: category 1a plants are high-priority species requiring compulsory control, and breeding, growing, moving and selling are not permitted. Category 1b species are widespread invasive species controlled by a management programme. Category 2 plants are invasive species controlled by area and can be grown with a permit in a demarcated area, and breeding, growing, moving and selling is banned without a permit. Category 3 plants are ornamental and other species that are allowed on a property but may not be planted or sold in the future. The list was revised with very minor alterations on 1 August 2014 (Department of Environmental Affairs, 2014b) and lists 379 species. A review of legislative developments concerning invasive plants in South Africa provides more comprehensive information in this respect (Lukey and Hall, 2020).

The Southern African Plant Invaders Atlas (SAPIA) comprises records for over 500 invasive alien species in South Africa, Lesotho and Swaziland, containing information on their distribution, abundance and habitat types. A series of papers has provided more comprehensive analysis and discussions concerning the SAPIA (Henderson, 1998; Henderson, 2007; Henderson and Wilson, 2017). A proposed grouping of invasive alien plant species in South Africa aimed to assist with the prioritization of species for management, and classified species into 117 “major invaders” which were well-established with a substantial impact on ecosystems, and 84 “emerging invaders” which had less influence but potential for greater impact (Nel et al., 2004). In terms of the NEMBA, the South African National Biodiversity Institute (SANBI) is obligated to prepare reports on the status of biological invasions, as well

as the effectiveness of control measures and regulations to government, and the first such report was released in October 2018 (van Wilgen and Wilson, 2018). In May 2021, the Minister of the Department of Environment, Forestry and Fisheries released the second such report (https://www.environment.gov.za/speech/creecy_launchesinvasivespeciesstatusreport).

3.3 Ethnobotanical surveys on weeds used for medicinal purposes

A review investigating the medicinal importance of weeds in South Africa reported that 24 plant families and 34 species were used in curing 21 diseases by indigenous people in this country (Lewu and Afolayan, 2009). In the Eastern Cape Province of South Africa, it was noted that from a total of 130 species used in Xhosa traditional medicine, 33 were declared weeds, with a quarter of these being alien (Dold and Cocks, 2000). From a total of 214 plant species used for treating various human ailments, Bapedi THPs in the province of Limpopo, South Africa, reportedly used 35 invasive alien plant species, belonging to 34 genera and 21 families, most commonly the Apocynaceae, Asteraceae, Fabaceae and Solanaceae (Semenya et al., 2012). In reviewing the medical ethnobotany of Lesotho, it was discovered that 25 alien plant species from over 300 in total were used medicinally (Moteetee and Van Wyk, 2011). A key study published in 2004 revealed that of the 101 plant species associated with drug discovery, and from which 119 contemporary pharmaceuticals are derived, 36 are weed species occurring mainly in disturbed habitats (Stepp, 2004). These results were an order of magnitude higher than what would be predicted by random occurrence of weeds in the modern pharmacopoeia (Stepp, 2004). It is likely that because such weed species are naturally more abundant, they are more readily used medicinally and subsequently investigated for bioactivity as they are available year-round and in sufficient quantities.

As alluded to earlier, South African traditional medicine systems, in common with other systems of medicine, are adaptive and changing. More than twenty invasive plants were used to treat various diseases in the Capricorn District, Limpopo (Cherane et al., 2015). Among the ailments treated were chest complaints, infertility, hypertension, mental disorders, cough and swollen legs. Plant species belonging to nine families featured in the survey, with those of the Myrtaceae and Papaveraceae being dominant, and decoctions were the most common form of preparation (Cherane et al., 2015).

In the Vhembe District, Limpopo, a study was carried out to document invasive alien plants used to treat HIV/AIDS related symptoms (Mbambala et al., 2017). Traditional Health Practitioners interviewed revealed that 38 purported invasive alien plant species from 24 different families were used for treating HIV/AIDS related symptoms. Most of these plants belong to the Asteraceae family (16%) followed by the Fabaceae and Solanaceae both with 8%, then the Poaceae, Apocynaceae, Myrtaceae, Bignoniaceae and Passifloraceae with 5% each. The roots were the most frequently used plant part, closely followed by the leaves. Herbs were most commonly used, comprising 42% of the species, followed by trees (26%), shrubs (24%) and climbers (8%). The six most commonly used invasive alien plant species were *Solanum mauritianum*, *Ricinus communis*, *Melia azedarach*, *Eucalyptus paniculata*, *Argemone ochroleuca*, and *Agave sisalana*. Seventy-four percent (28) of the species recorded are listed under Regulation 15 of the CARA Act 43 of 1983. Of these, 79% (22) are listed as category 1 weeds of the CARA Act, 14% (4) as category 2, and 7% (2) are listed under category 3 (Mbambala et al., 2017).

An ethnobotanical survey was conducted to investigate the medicinal use of alien plant species in Mogalakwena Local Municipality of the Waterberg District, also in Limpopo, South Africa

(Maema et al., 2016a). The study reported the use of eight exotic plant species in treating various diseases. Two species (*Bidens pilosa* and *Tagetes minuta*) belong to the Asteraceae, while the remaining families were represented by a single species. The plant parts most used were roots (36.4%), followed by fruits (27.3%) and whole plants (18.1%), while leaves and flower contributed 9.1% each. Infusions (30%) and decoctions (30%) given orally were the most frequent methods used to administer the preparations. It was concluded that exotic plants are integral to the *materia medica* of Bapedi THPs (Maema et al., 2016a). *Schinus molle* was the most frequently used plant species for the treatment of various ailments in the study area (Maema et al., 2016a).

3.4. Biological activity of weeds used in traditional medicine

The rising importance of weeds as potential sources of medicinal treatments and lead compounds for pharmacological investigation is highlighted by three reviews in the past ten years on the genus *Tithonia*, particularly *T. diversifolia* (Chagas-Paula et al., 2012; Ajao and Moteetee, 2017; Tagne et al., 2018). *Tithonia diversifolia*, a shrub-like perennial or annual invasive plant, originates from North and Central America (Arias et al., 1982, cited by Witt et al., 2019). It is widely used in several countries especially in South America and Africa to traditionally treat a plethora of diseases such as diabetes, malaria, measles, gastric ulcer, menstrual pains, snake bites and wounds (Ajao and Moteetee, 2017). The potentially toxic, as well as therapeutic effects were attributed to bioactive principles in this species including sesquiterpene lactones, chlorogenic acid and flavonoids (Omokhua et al., 2018a; Tagne et al., 2018). The toxicological effects of *T. diversifolia* may be due to its ability to remediate heavy metals from the soil (Ajao and Moteetee, 2017). *Tithonia* (Asteraceae) species, including *T. diversifolia, T. rotundifolia* and *T. tubaeformis,* are well established in many parts of Africa and have potential to significantly increase their distribution, resulting in serious biodiversity

loss, as well as other negative effects such as impacting on crop yield and water availability (Witt et al., 2019). As is likely the case for many invasive alien plants, it was reported in a survey investigating socioecological impacts of *T. diversifolia* in Zambia that the plant was believed to reduce the abundance of medicinal and other valuable plant species (Witt et al., 2019). Control through utilisation has been proposed as a means of slowing the spread of the highly invasive *T. diversifolia*, but this is unlikely to be an effective management strategy, potentially causing further problems by generating dependency on a resource targeted for reduction to low levels (Witt et al., 2019).

Attention is being focused on the weed species, *Chromolaena odorata* (Asteraceae). This is a prolific invasive species that has significant negative impacts on the environment and local livelihoods, including detrimental effects on biodiversity, livestock and crop production, water supply and valuable plant species, including medicinal plants (Shackleton et al., 2017). A review on this species highlighted that two biotypes are present as weeds in sub-Saharan Africa, with the widespread Asian/West African biotype (AWAB) widely used in traditional medicine while the southern African biotype (SAB) is not so well-known by THPs (Omokhua et al., 2016). A comparison of the bioactivities and phytochemical composition of the two biotypes was subsequently conducted (Omokhua et al., 2017). The AWAB had the highest antibacterial activity, while the SAB had the highest antifungal activity. Minimum inhibitory concentration (MIC) values against the test bacteria ranged from 0.39 to 3.12 mg/ml for the AWAB and 0.78 to 6.25 mg/ml for the SAB. Extracts from young and mature non-flowering material of the SAB were the most active. The AWAB had the highest amount of phenolics and flavonoids while SAB revealed the highest amount of tannins. Extracts of young SAB plants had low cytotoxicity and none of the extracts of the three growth stages were mutagenic. This was the

first report suggesting that the SAB of *C. odorata* can be used as a source of medicine against microbial infections and other health problems, similar to the AWAB (Omokhua et al., 2017).

Similarities in cross-cultural uses of plants could indicate useful leads to prioritise for further pharmacological and phytochemical studies. For example, *Ricinus communis* (Euphorbiaceae) is used to treat sores by Bapedi THPs in Limpopo (Semenya et al., 2012), as well as by Xhosa people in the Eastern Cape (Dold and Cocks, 2000) and the Zulu people in KwaZulu-Natal (Hutchings et al., 1996). The use of the species against sores has also been reported generally in Southern and Eastern Africa (Watt and Breyer-Brandwijk, 1962), although recent references are not available to corroborate this statement.

3.5 Biological activity of weeds not selected based on traditional medicinal use

The antifungal efficacy of acetone extracts prepared from various plant parts of seven common invasive plants against a panel of phytopathogenic fungi was reported (Eloff et al., 2007; Mdee et al., 2009). The fungal species included *Penicillium janthinellum, Penicillium expansum, Aspergillus niger, Aspergillus parasiticus, Colletotrichum gloeosporioides, Fusarium oxysporum, Trichoderma harzianum, Phytophthora nicotiana, Pythium ultimum* and *Rhizoctonia solani*. Plant species extracted for testing were *Cestrum laevigatum* (flowers and leaves), *Nicotiana glauca* (flowers, leaves and seeds), *Solanum mauritianum* (fruits and leaves), *Lantana camara* (fruits, flowers and leaves), *Datura stramonium* (seeds), *Ricinus communis* (leaves) and *Campuloclinium macrocephalum* (leaves and flowers). Moderate to good activities were recorded against all the tested fungi, with leaf extracts more active in all cases than seed or flower extracts. It was concluded that, pending further rigorous testing, the extracts may be useful to protect organically grown crops against fungal infection.

In a further study against the same range of plant pathogenic fungi, the acetone crude extract of *Pseudognaphalium luteoalbum* leaves had strong antifungal activity, particularly against *Phytophthora nicotiana* and *Fusarium oxysporum* (Aderogba et al., 2014). Using bioassay-directed fractionation, two compounds were isolated and characterized from the active extract, namely hispidulin-7-O-glucopyranoside and stigmasterol-3-O-β-glucopyranoside (Aderogba et al., 2014). These purified compounds were in general not a great deal more active against the test fungi than the crude extract so it is likely that synergistic effects of a number of different compounds in the original extract that either possessed varying degrees of antifungal activity or enhanced efficacy were in evidence.

Food production and storage may be adversely affected by contaminants such as mycotoxigenic fungi. A study was undertaken to investigate the antifungal activity of four weedy plant extracts against different isolates of *Fusarium* and *Aspergillus* species, which are implicated in causing mycotoxicoses in humans and animals via production of toxic fumonisins and aflatoxins, respectively (Thembo et al., 2010). All four plant species (*Tagetes minuta, Lippia javanica, Vigna unguiculata* and *Amaranthus spinosus*) have been used in some way as a traditional medicine or food source. Extracts prepared using solvents of different polarities had a wide range of activity, and the fungal isolates showed varying degrees of sensitivity to the plant extracts, and it was concluded that the species tested may provide leads for novel bioactive compounds (Thembo et al., 2010).

3.6. Prospects for the use of weeds as medicines

The reported uses and biological activities of weeds in South Africa have been summarised in Table 1. The emphasis in this table is on CARA and NEMBA listed species although some other weed species with important uses have been included. Classification of plant species not

listed in the CARA or NEMBA lists as weeds in South Africa was confirmed using an authoritative reference (Bromilow, 2018). Potential uses of weeds and their bioactivities have been discovered based on traditional use of the species or as a result of random screening of plants, or targeted screening of weedy species for efficacy in various biological assays. Invasive alien species (those recorded as being introduced species listed in terms of CARA and/or NEMBA) comprised 61% of recorded species, while native and alien (non-invasive) weeds formed the remaining 39%. The Asteraceae family had the highest number of medicinally used weed species with a total of 15 species (Table 2). Of these species, 12 were recorded to be used traditionally, and had reported phytochemical and biological activity information. Two species had reports of biological activity only and one had only evidence of traditional use. The Asteraceae often features as a family to which many medicinal plant species belong, and biological activities of Asteraceae plant species have been recently reviewed (Bessada et al., 2015). Figure 1 illustrates the percentage representation of plant species with information on traditional usage, phytochemical analysis, biological activity and combinations of these categories. The majority (68%) of plant species had literature concerning traditional use, phytochemical and biological activity while 11% of species were recorded as having traditional use only.

The incorporation of weeds into the medicinal practices of indigenous South Africans is not a recent phenomenon, dating back to studies published as far back as the nineteenth century (Dold and Cocks, 2000). Medicinally valued weeds have often been used alone but may also be used in combination with other plant species (Semenya et al., 2012).

Although medicinal plant materials may be stored in a dried form, it is more important for commonly used medicinal plants to be easily accessible and abundant, so that when a person

is sick it does not take several days to locate a required component of the medication. This accessibility may be a reason for the widespread use of weeds and their significant representation in medicinal floras (Stepp and Moerman, 2001). Detailed screening of the many plant species considered to be weeds may yield a larger hit rate of medicinal compounds than a random screening (Stepp, 2004). The more well-known weeds perhaps have less interesting information to offer, having been studied more exhaustively than many other plant species, but it is likely that the application of such weeds as a possible source of pharmaceuticals has been overlooked.

It should be kept in mind that invasive plants, as is the case with other plant species used in traditional medicine, may contain toxic chemicals that could result in poisoning. As a result, detailed toxicological studies are necessary prior to recommending the use of such plants for traditional healing purposes, or for further commercialisation potential. It is widely held that pharmacology is merely toxicology at a lower dose, and also that toxic substances may present interesting pharmacological effects at lower, non-toxic doses (Vlietinck and Apers, 2001; McGaw and Eloff, 2005). A review of poisonous plants of importance to humans and animals was published in 2008 (Botha and Penrith, 2008). As cautioned by the authors, many of the plants mentioned in their review are also used ethnobotanically for treatment of disease in both humans and animals and thus it is critical to be mindful of their toxic potential. For example, *Melia azedarach* (Meliaceae) is an introduced ornamental plant that became established in natural pastures. Pigs are most susceptible to being poisoned by this species, especially the ripe drupes, which have also caused poisoning in children, but cases of poisoning have also occurred in sheep and cattle (Kellerman et al., 2005). *Argemone* spp. (prickly poppies) contain toxic isoquinoline alkaloids. They are unpalatable, spiny exotic weeds that are not intentionally eaten by livestock but cause poisoning when the plants are harvested with lucerne or wheat

(Botha and Penrith, 2008). *Datura stramonium* and *Datura ferox* are cosmopolitan weeds that contain parasympatholytic alkaloids such as atropine and hyoscine, and humans are extremely susceptible to their toxic effects (Botha and Penrith, 2008). *Nerium oleander* (oleander), a popular ornamental plant widely used in gardens, contains oleandrin which is extremely toxic (Botha and Penrith, 2008). Ricin, derived from the castor oil plant *Ricinus communis*, is one of the most toxic substances known, and other common species such as *Lantana camara*, are also potential toxicants. The production by *Lantana camara* of various metabolites in good yields, some of which have useful biological activities, led to a review of the species as well as other *Lantana* species to allow an evaluation of the potential for utilisation of the large biomass of *Lantana* available (Ghisalberti, 2000).

4. Future perspectives and conclusions

It is apparent that few studies specifically target weed species for investigations of medicinal value although interest is growing in this area. Weeds, particularly invasive alien species, have the potential to cause significant negative impacts on biodiversity and change in ecosystems. In terms of their possible medicinal uses, promotion of the use of weed species in traditional medicine could take pressure off threatened indigenous species used to treat similar ailments. However, this needs to be approached with caution as promoting the use of weeds, particularly invasive alien plants, in herbal medicine may have the unintended consequence of increasing spread of such species. Weeds are often plants that grow rapidly, hence producing a constant and readily available supply of material. When considering possible commercial preparations, crude extracts or valorised fractions may be preferential to purified compounds for therapeutic application, both in terms of cost of production and the likelihood of synergistic activity of a number of constituents in a fraction or extract. In this way, relatively low-technology and low-cost remedies may be developed from abundant weeds for use in human and animal health.

Declaration of competing interest

The authors of this review declare no conflict of interest.

Author contributions

LJM, AGO-U, JFF and JVS conceptualized the idea, LJM and AGO-U wrote the manuscript, all authors edited and approved the manuscript.

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Table 1. Invasive alien plants and weeds in South Africa with potential medicinal uses, known biological activity and phytochemistry

Family	Species, common name and origin	CARA	NEMBA	CABI /SANBI	Traditional use[1]	Biological activity and phytochemistry
Agavaceae	*Agave americana* L. (American aloe, American agave, century plant) (Introduced)	-	3 in WC, not listed elsewhere	Invasive	Leaves used for skin problems; leaf decoction containing spines used to wash sore feet, (Moteetee and Van Wyk, 2011); sap is taken orally to treat diarrhoea, dysentery, leaves used to treat constipation, flatulence, jaundice, roots steeped in water to treat syphilis, bleeding gums, stomach pain, scurvy and to improve appetite (Tropical Plants Database, 2019a)	Leaves contain steroidal saponins and phenolic compounds (Almaraz-Abarca et al., 2013). Leaf extracts possess anti-inflammatory properties due to the presence of active saponin compounds such as cantalasaponin 1, hecogenin and tiogenin (Monterrosas-Brisson et al., 2013); It also possesses antioxidant and antibacterial activities (Almaraz-Abarca et al., 2013)
Agavaceae	*Agave angustifolia* L. *(Agave vivipara* L.) (Caribbean agave) (Introduced)	-	-	Not problematic	Roots used to treat gonorrhoea (Maema et al., 2016a); juice from cooked stems, leaves and roots infusions are taken orally to treat arthritis, dysentery, swelling, bruises, liver, kidney diseases and arthritis (Tropical Plants Database, 2019b)	The roots are rich in saponins and phenolic compounds (Tropical Plants Database, 2019b); Plant extracts showed antimicrobial and antioxidant activities (López-Romero et al., 2018)
Agavaceae	*Agave sisalana* Perrine (Sisal hemp, sisal) (Introduced)	2	2	-	Roots and whole plant used for gonorrhoea,	The plant is rich in flavonoids steroidal alkaloids and a number of steroid saponins.

					wounds and headache (Mbambala et al., 2017). It also used to treat for syphilis, leprosy sores and dysentery (Tropical Plants Database 2019c)	A saponin hecogenin from the plant has anti-inflammatory, antioxidant, anti-cancer and antiproliferative properties and gastroprotective effect which is mediated by K+ATP channels opening and the COX-2/PG pathway (Cerqueira et al., 2012; Tewari et al., 2014). Other activities include analgesic immunomodulatory, antimicrobial, anthelmintic properties (Tewari et al., 2014).
Amaranthaceae	*Achyranthes aspera* L. (Burweed, Prickly Chaff flower, Devil's Horsewhip) (Uncertain, localized)	1	-	-	Used to treat fever, wounds, tooth ache, arthritis, gynaecological disorders, urinary disorders, insect and snake bites, abdominal tumours, stomach pain, tonsillitis, head wounds, ringworm and a number of other ailments (Ndhlala et al., 2015) and references therein.	Various functional acids were detected in 80% methanol leaf extracts (Ndhlala et al., 2015). Water and acetone extracts had antibacterial, antifungal and anthelmintic activity (Ndhlala et al., 2015).
Amaranthaceae	*Alternanthera pungens* Kunth (Khaki weed) (Introduced)	-	-	Not problematic	Used to treat sexually transmitted infections (Semenya et al., 2013).	The plant contains phytochemical such as borneol, camphene, azulene, eudesmol, geraniol, limonene, linalool, pinene, terpineol and thujone and also exhibit diuretic properties (Gupta et al., 2012).
Amaranthaceae	*Amaranthus spinosus* L. (Spiny amaranth) (Introduced)	-	-	Not problematic	Cooked fresh or dry and eaten as a relish with maize porridge (Thembo et al., 2010). Plant used to treat diabetes and bronchitis menorrhagia, to induce abortion; bruised leaves used for treating	Extracts of aerial parts had antifungal activity against *Fusarium* spp. (Thembo et al., 2010). The plant is rich in amino acids, phenolic, flavonoid and saponin compounds. Extracts of plant possess anthelmintic, antibacterial, antitumor, antimalarial, anti-inflammatory, antitumor, hepatoprotective, anti-diabetic, analgesic,

					haemorrhoids, eczema, boils, burns, wounds and earache, jaundice; root is used to treat gonorrhoea and ash from plant is used to wash sores and sap to treat convulsion and ophthalmia. Also used as a febrifuge, sudorific, galactagogue, antidote to snake bites and seeds used as poultice for broken bones (Jansen, 2004; (Katerere and Eloff, 2006; Tanmoy et al., 2014)	immunomodulatory and laxative properties (Tanmoy et al., 2014).
Amaranthaceae	*Gomphrena celosioides* Mart (Bachelor's button) (Introduced)	-	-	-	Different parts of plant used to treat asthma, diabetes, coughs, colds, bronchitis, hay fever, sexually transmitted infections, liver diseases, malaria, dysmenorrhea, worm and kidney infections in humans and skin infections in cattle (Omokhua et al., 2018a)	The plant is rich in phenolics, flavonoids, tannins, and aurantiamide and aurantiamide acetate have been isolated. Antibacterial, antifungal, antimycobacterial, antioxidant and anti-inflammatory activities (Dosumu et al., 2014; Adeoti et al 2016; Omokhua et al., 2018a)
Anacardiaceae	*Schinus molle* L. (False pepper tree) (Introduced)	-	-	-	Different parts used to treat rheumatism toothache, menstrual disorders, urinary and respiratory tract infections. Leaf decoction used to treat influenza and fever (Dold and Cocks, 2000; Hutchings and van	Plant has antioxidant, antiviral, anti-inflammatory, antispasmodic, diuretic and wound healing properties (Muhd et al., 2015); Aerial part is rich in essential oils such as monoterpenes and sesquiterpenes which are cytotoxic against K562 and NCI-ADR/RES human tumor cells (Simionatto et al., 2011; Muhd et al., 2015) Isolated

					Staden, 1994). Leaves, bark and roots used to treat chest complaints, muscle pains and gonorrhoea (Maema et al., 2016b).	bicyclogermacrene is larvicidal (Muhd et al., 2015).
Apiaceae	*Foeniculum vulgare* Mill. (Fennel) (Introduced)	-	-	Not problematic	Many uses have been recorded in the Western Cape, mostly for treating poor appetite and indigestion (Rood, 2008; Watt and Breyer-Brandwijk, 1962). Fennel has been used since early times to treat symptoms of digestive disturbances (Grieve, 1967).	The fruit contains an aniseed-flavoured essential oil largely composed of phenylpropanoids, mainly anethole; various flavonoids and furanocoumarins are also present (Dictionary of Natural Products, 2008; Van Wyk et al., 2009). Anethole is toxic in high concentrations but has been used as a carminative in fennel water (Bruneton, 1995). The oil, especially anethole, has antispasmodic, carminative, anti-inflammatory, oestrogenic and antimicrobial properties and also promotes gastrointestinal motility (Bruneton, 1995; Choi and Hwang, 2004; Van Wyk and Wink, 2004). Anethole and fenchone have stimulant and secretolytic activity (Van Wyk and Wink, 2004).
Apocynaceae	*Catharanthus roseus* (L.) G.Don (Madagascar periwinkle) (Introduced)	-[a]	1b	Invasive	Diabetes (leaf infusion), rheumatism (Watt and Breyer-Brandwijk, 1962). Root used to treat gonorrhoea (Semenya et al., 2013; Semenya et al., 2012). Fresh bark soaked in cold water and sipped to treat diabetes (Dold and Cocks, 2000). Unspecified parts used to treat diabetes and	Toxic (Van Wyk and Wink, 2004; Wink and van Wyk, 2008). Alkaloids with hypoglycaemic effect include catharanthine, leurosine and vindoline (Marles and Farnsworth, 1995). Indole alkaloids, vincristine and vinblastine, have antitumour activity (Bruneton, 1995). Leaf extracts are genotoxic (Elgorashi et al., 2003). Extracts from of plant showed antidiabetic, antioxidant, anthelmintic and antidiarrheal and antimicrobial activities (Gajalakshmi et al 2013).

					gonorrhoea (Watt and Breyer-Brandwijk, 1962). Leaf used in treatment for menorrhagia and rheumatism (Hutchings et al., 1996). Roots and leaves used for gonorrhoea (Mbambala et al., 2017). Whole plant used to treat asthma (Maema et al., 2016b).	
Apocynaceae	*Nerium oleander* L. (Oleander) (Introduced)	1	1b (sterile cultivars or hybrids are not listed)	-	Leaves and bark used for wounds (Mbambala et al., 2017). Juice from different parts used to ulcer, warts and cancer, oil from root used to treat leprosy, skin diseases and rheumatism externally (Gupta and Mittal, 2010; Zibbu and Batra 2010).	Leaves contain cardenolide monoglycosides, pectic polysaccharide, flavonoids, diterpene and triterpenoid compounds (Gupta and Mittal, 2010; Zibbu and Batra 2010). Extracts showed antinociceptive, antimicrobial, anti-inflammatory, antileukemic, anticancer, immunomodulatory and diuretic activities (Gupta and Mittal, 2010; Zibbu and Batra 2010).
Asclepiadaceae	*Araujia sericifera* Brot. (Moth catcher) (Introduced)	1	1b	-	Roots used to treat mental illness (Dold and Cocks, 2000). Roots are used for wounds and headache (Mbambala et al., 2017).	Different parts of plant are rich in pentacyclic triterpenes. Cytotoxic activity was observed against human breast carcinoma MDA-MB-453 and MCF-7 and human colon carcinoma HCT-116 cells (Palomino-Schätzlein et al., 2017).
Asclepiadaceae	*Asclepias fruticosa* L. synonym *Gomphrena fruticosa* Dum.Cours. (Milkweed) (Native)	-	-	-	Leaves used as snuff to relieve headaches (Dold and Cocks, 2000). Used to treat intestinal troubles and pulmonary tuberculosis in southern Africa (Watt and Breyer-Brandwijk, 1962). Leaves	Leaves and seeds contain cardiac glycosides, coumarins, flavonoids (Gurib-Fakim, 2011). Latex showed proteolytic effect and methanol extract showed antiplasmodial activity (Gurib-Fakim, 2011).

					used to treat diarrhoea and stomach pain (Hutchings et al., 1996). A snuff and tincture from leaf is used for strength, to facilitate childbirth and to treat diabetes and hepatitis in southern Africa (Pujol, 1990).	
Asteraceae	*Ageratum conyzoides* L. (Invading ageratum) (Introduced)	1	1b	-	Leaves used for wounds (Mbambala et al., 2017). Unspecified parts used to treat fever, dyspnea and enteralgia (Kamboj and Saluja, 2008).	Plant contain pyrrolizidine alkaloids, sesquiterpenes, oleic, palmitic, stearic, linoleic, linolenic, fumaric and caffeic acids and hexadecenoic acid, aurantiamide acetate, and phytols and amino acids and essential oils (Kamboj and Saluja, 2008). Plant has antibacterial, analgesic, anthelmintic, wound healing, anti-inflammatory, radioprotective and nematicidal properties (Kamboj and Saluja, 2008; Singh et al. 2013).
Asteraceae	*Ageratum houstonianum* Mill. (Mexican ageratum) (Introduced)	1	-	Invasive	Roots used for gonorrhoea (Mbambala et al., 2017).	Plant has antifungal properties against plant fungal pathogens (Devkota and Sahu, 2019).
Asteraceae	*Bidens pilosa* L. (Blackjack) (Introduced)	-	-	Invasive	Leaves used for ringworm, astringents to cuts, wounds (De Wet et al., 2013; Pooley, 2003), fungal skin infections (Hutchings et al., 1996). Infusion of boiled leaves drunk to treat menstrual disorders and to promote conception (Mabogo, 1990). Infusion used for dysentery and diarrhoea	Leaf extracts have antibacterial (Rabe and van Staden, 1997) and anti-inflammatory (Jäger et al., 1996) activity. Infusion of aerial parts and isolated polyacetylenes have antimicrobial, anti-inflammatory and immunomodulatory activities and cytotoxicity effect against human epidermoid carcinoma (KB-3-1) cells (Pereira et al., 1999; Abajo et al., 2004).

					(Watt and Breyer-Brandwijk, 1962). Roots used to treat infertility in women (Dold and Cocks, 2000). Whole plant used for wounds (Mbambala et al., 2017) and as a womb cleaner (Maema et al., 2016a).	
Asteraceae	*Campuloclinium macrocephalum* (Less.) DC. (Pompom weed) (Introduced)	1	1b	-	-	Leaf and flower acetone extracts have antifungal activity against plant pathogenic fungi (Mdee et al., 2009).
Asteraceae	*Chromolaena odorata* (L.) R.M. King & H.Rob. (Triffid weed) (Introduced)	1	1b	Invasive	Skin infections, wounds and inflammation (Bamba et al., 1993; Inya-Agha et al., 1987). Used against malaria, gonorrhoea, ulcers (Chakraborty et al., 2011), diarrhoea, coughs and skin eruptions (Amatya and Tuladhar, 2011).	Leaves have antifungal activity against ten plant pathogenic organisms (Meela, 2008; Omokhua et al., 2017) Leaves and flowers have antioxidant and various other activities (Amatya and Tuladhar, 2011; Omokhua et al., 2018a); Leaves, phenolic compounds and Eupolin, a commercial extract of *Chromolaena odorata* leaves, have wound-healing activity (Phan et al., 2001). Many compounds, including tannins, terpenoids, cardiac glycosides, saponins, flavonoids, anthraquinones and alkaloids, have been isolated (Akinmoladun et al., 2007; Anyasor et al., 2011; Panda et al., 2010; Vijayaraghavan et al., 2013); Omokhua et al., 2018a). Biological activities include anthelmintic, antioxidant, anti-inflammatory, antimicrobial, antimalarial and cytoprotective activities (Anyasor et al., 2011; Chakraborty et al., 2011; Ling et al., 2007; Ongkana, 2003; Panda et al., 2010; Raman et al., 2012; Suksamrarn et al.,

						2004; Taiwo et al., 1999; Vijayaraghavan et al., 2013).
Asteraceae	*Cichorium intybus* L. (Chicory) (Introduced)	-	-	-	Used in South Africa as a traditional tonic to purify blood, liver and kidneys and to improve appetite and digestion (Rood, 2008). The root is used in Europe as a tonic, laxative, diuretic, and also to enhance kidney function and relieve symptoms of digestive disturbances (Bruneton, 1995; Grieve, 1967; Watt and Breyer-Brandwijk, 1962).	The root contains many sesquiterpenoid lactones (Dictionary of Natural Products, 2008; Kisiel and Zielińska, 2001) with the main compound being lactucin. It has a high inulin content (Van Wyk et al., 2009). The bitterness, which possibly stimulates saliva and gastric juice secretion, therefore serving to enhance appetite, originates from the sesquiterpenoid lactones and lignin lactones (Dictionary of Natural Products, 2008; Van Wyk and Wink, 2004). The terpenoid lactones have anti-inflammatory activity (Van Wyk and Wink, 2004). Lactucin and lactupicrin have sedative, analgesic (Wesołowska et al., 2006) and antimalarial activity (Bischoff et al., 2004). Seeds are antihepatotoxic (Ahmed et al., 2003), and roots and leaves have antibacterial activity (Petrovic et al., 2004).
Asteraceae	*Conyza bonariensis* (L.) Cronquist (Asthmaweed) (Introduced)	-	-	Not problematic	Leaf decoction used for sore throat, ringworm (Moteetee and Van Wyk, 2011). Unspecified parts used to treat wounds and malaria (Araujoa et al., 2013).	Plant contains glycosides, phenolic, flavonoids and sesquiterpenic compounds and essential oils (Zahoor et al., 2010; Araujoa et al., 2013). Plant extracts showed antioxidant, antibacterial, antiviral, anti-inflammatory, antiproliferative, analgesic, antidiarrheic antischistosomal, and antiprotozoal activities (Araujoa et al., 2013).
Asteraceae	*Pseudognaphalium luteoalbum* (L.) Hilliard & B.L.Burtt (Jersey cudweed) (Uncertain)	-	-	Widespread	-	Two compounds isolated from leaves: 5,4′-dihydroxy-6-methoxy-7-O-β-glucopyranosideflavone (hispidulin-7-O-glucopyranoside) (1) and stigmasterol-3-O-β-glucopyranoside had antifungal activity

						against several plant pathogenic fungi, and low cytotoxicity (Aderogba et al., 2014).
Asteraceae	*Schkuhria pinnata* (Lam.) Kuntze ex Thell. (Dwarf marigold, false thread leaf) (Introduced)	-	-	-	Infusion drunk for stomachache (Moteetee and Van Wyk, 2011; Shale et al., 1999). Decoction of whole plant used for hypertension and as a blood purifier (Semenya et al., 2012).	Plant contain sesquiterpenes lactones (Kudumela et al., 2019). Leaves and roots had anti-inflammatory activity against cyclooxygenase-1 enzyme (Shale et al., 1999). Whole plant extract had in vitro hypoglycaemic activity (Deutschländer et al., 2009). Isolated compounds showed anti-inflammatory and antibacterial activities (Kudumela et al., 2019).
Asteraceae	*Tagetes minuta* L. (Wild marigold, kakiebos) (Introduced)	-	-	Uncertain	Medicinal tea drunk to treat various diseases (Ríos and Recio, 2005); Salehi et al., 2018). Whole plant used to treat wounds and for veterinary care (Maema et al., 2016a).	Plant is rich in essential oils; dihydrotagetone, (E)-β-ocimene, tagetone, (Z)-β-ocimene, limonene and epoxyocimene (Gakuubi et al., 2016). Extracts of aerial parts antifungal against *Fusarium* spp. (Thembo et al., 2010). Essential oils from the plant showed dose-depended inhibition of Gram- positive and Gram-negative bacterial strains and pathogenic fungal strains; anticancer, antioxidant, acaricidal, insecticidal, nematicidal and repellency activities have been reported (Gakuubi et al., 2016).
Asteraceae	*Taraxacum officinale* F.H.Wigg (Dandelion) (Introduced)	-	-	Not problematic	Leaf decoction used to remove body odour (Afolayan et al., 2014). Plant is used to treat malaria, coughs, tuberculosis, bacterial infections and as diuretic (Valenzuela et al., 2018).	Sesquiterpenes, monoterpenes, terpenes and coumarins have been isolated from hexane and ethyl acetate, and hexane extracts inhibited growth of Gram-negative strains (Díaz et al., 2018). Plant also has antioxidant, anti-inflammatory and anticancer activities (Díaz et al., 2018).
Asteraceae	*Tithonia diversifolia* (Hemsl.) A.Gray (Mexican sunflower) (Introduced)	1	1b	Invasive	Decoctions made from various parts used to treat indigestion, malaria, sore	

					throat, diabetes and menstrual pain (Kokwaro, 1976). Flower decoction used to treat eczema (Gurib-Fakim et al., 1996).	
Asteraceae	*Tithonia rotundifolia* (Mill.) S.F.Blake (Red sunflower) (Introduced)	-	1b	Invasive	Whole plant used for wounds and to treat fever (Mbambala et al., 2017); Omokhua et al., 2018).	The plant contains secondary chemicals such as flavonoids, tannins, diterpenoids and sesquiterpenoids (Chagas-Paula et al. 2012). Different extracts inhibited the growth of bacterial, mycobacterial and antifungal strains and also had antioxidant activity (Omokhua et al., 2018b)
Asteraceae	*Xanthium spinosum* L. (Spiny cocklebur) (Introduced)	1	1b	-	Decoction of whole plant used against syphilis and gonorrhoea (Moteetee and Van Wyk, 2011; Shale et al., 1999).	Leaf and root extracts had some antibacterial activity against a panel of bacteria (Shale et al., 1999).
Asteraceae	*Xanthium strumarium* L. (Large cocklebur) (Introduced)	1	1b	Widespread	Leaves and roots used for wounds (Mbambala et al., 2017).	Plant contains alkaloids, phenolics and flavonoids and essential oils; extracts inhibited growth of Gram-positive and Gram-negative bacterial strains and had antioxidant activity (Scherer et al., 2010; Ghahari et al., 2017).
Basellaceae	*Anredera cordifolia* (Ten.) Steenis (Madeira vine) (Introduced)	1	1b	Invasive	Crushed fresh leaves applied to septic wounds and to swollen feet and ankles caused by poor blood circulation or kidney/liver problems (Dold and Cocks, 2000).	Plant is rich in essential oils (Souza et al., 2014); Isolated flavonoid showed antioxidant activity (Djamil et al., 2012).
Bignoniaceae	*Dolichandra unguis-cati* (L.) L.G. Lohmann (also known as *Macfadyena unguis-cati*	-	1b	Invasive	Plant is used to treat malaria, inflammation, dysentery, rheumatism, venereal diseases and	Plant is rich in phenolics, flavonoid and tannins and extracts inhibited the growth of Gram- positive and Gram-negative bacterial strains, and showed antimycobacterial,

	(L.) A.H.Gentry (cat's claw creeper) (Introduced)				snakebites (Omokhua et al., 2018a)	antifungal and antioxidant activities (Omokhua et al., 2018a).
Bignoniaceae	*Jacaranda mimosifolia* D. Don (Jacaranda) (Introduced)	3	1b in G, KZN, L, MP and NW	Invasive	Leaves and bark used for fever gonorrhoea and syphilis (Mbambala et al., 2017).	Lupeol, ursolic, betulinic acids and 1-naphthaleneacetic acid have been isolated from the stem bark and extracts, fractions and compounds exhibited antifungal and antibacterial activities (Sidjui et al., 2014; 2016).
Bignoniaceae	*Tecoma stans* (L.) Juss. ex Kunth (Yellow bells) (Introduced)	1	1b	Invasive	Used traditionally in Mexico to treat diabetes (Winkelman, 1986).	Acetone leaf extracts had antifungal activity with average MIC value against ten phytopathogenic fungi of 0.55 mg/ml; one major active compound isolated, oleanolic acid, with average MIC = 0.13 mg/ml against ten fungi, and cytotoxicity against Vero cells gave LC50 of 0.13 mg/ml (Meela et al., 2008, 2017). Methanol leaf extract active against *Candida albicans* (Binutu and Lajubutu, 1994). Four alkaloids including tecomine and tecostanine isolated (Costantino et al., 2003). Aqueous extract of leaves exert antidiabetic effects by inhibiting intestinal alpha-glucosidase (Aguilar-Santamaría et al., 2009) and stimulating glucose uptake in adipocytes (Alonso-Castro et al., 2010).
Cactaceae	*Cereus jamacaru* DC. (Queen of the night) (Introduced)	1	1b	-	Anthelmintic in cows (Vatta et al., 2011).	In vitro antischistosomal (Yousif et al., 2007) and antimicrobial activity (Davet et al., 2009) Slight in vivo anthelmintic efficacy in sheep (Vatta et al., 2011). Extract showed antitumor and anti-cytotoxic activities (Dutra et al., 2018).
Cactaceae	*Opuntia aurantiaca* Lindl. (Jointed cactus) (Introduced)	1	1b	Invasive	Gel used to treat skin ulcers, to soften hair and protect facial skin (Afolayan et al., 2014).	Plant extracts showed antimicrobial and antioxidant activities (Otang and Afolayan, 2018).

Cactaceae	*Opuntia ficus-indica* (L.) Mill. (Sweet prickly pear, Mission prickly pear) (Introduced)	1	1b	Invasive	Root boiled in water and taken orally for hypertension and gonorrhoea (Semenya et al., 2012, 2013). Fresh leaf is baked on open fire and inner jelly applied to sores between toes and occasionally fingers (Dold and Cocks, 2000). Leaf poultice used for ulcers, sores and boils (Watt and Breyer-Brandwijk, 1962). Whole plant used for mouth sores and wounds (Mbambala et al., 2017). Roots used to treat chest complaints (Maema et al., 2016b).	Phenolic and flavonoid compounds have been identified and α-tocopherol is reported as main constituent and antispasmodic and antioxidant activities reported (Lanuzza et al., 2017); Wound-healing activity (Park and Chun, 2001) and, anti-hypertensive (Chauhan et al., 2010)
Cactaceae	*Opuntia stricta (*Haw.) Haw. (Australian pest pear, common prickly pear) (Introduced)	1	1b	Invasive	Latex of cut cladode used to treat boils (De Wet et al., 2013). Roots and leaves used to treat stroke and toothache (Maema et al., 2016b).	Cladode extracts contain phenolic, flavonoid and tannin compounds and extracts showed anti-inflammatory and antioxidant activities (Izuegbuna et al., 2019); Fruit contains terpene alcohols and compounds showed antioxidant and antibacterial activities (Koubaa et al., 2015).
Cannaceae	*Canna indica* L. (Indian shot) (Introduced)	1	1b (sterile cultivars and hybrids not listed)	Invasive	Roots and leaves used to treat wounds (Mbambala et al., 2017); Different parts used to treat diarrhoea, yaws, headache, acute hepatitis, fever, eye infections, nose	Plant contains alkaloids, saponins, flavonoids, terpenes, cardiac glycosides, steroids and essential oils; plant showed immunomodulatory, antibacterial, anthelmintic, molluscicidal, anti-inflammatory, antiviral, antidiarrhea, analgesic,

					bleeding, as poultice and diuretic (Al-Snafi 2015)	cytotoxic, hemostatic, hepatoprotective and antioxidant activities (Al-Snafi, 2015).
Caprifoliaceae	*Sambucus canadensis* L. (Canadian elder) (Introduced)	-	1b	Invasive	Leaves used to treat erectile dysfunction (Maema et al., 2016b).	
Casuarinaceae	*Casuarina cunninghamiana* Miq. (Beefwood) (Introduced)	2	2 (1b in some areas)	-	Fruits used to treat gonorrhoea (Mbambala et al., 2017).	
Chenopodiaceae	*Chenopodium album* L. (Goosefoot) (Introduced)	-	-	Widespread	Decoction of whole plant drunk as vermifuge (Moteetee and Van Wyk, 2011). Laxative, blood purifier, liver and spleen disorders, hook worms, burns and ulcers (Agrawal et al., 2014).	Extracts and compounds showed antinociceptive, hypotensive, antifungal and antipruritic activities (Agrawal et al., 2014).
Chenopodiaceae	*Chenopodium ambrosioides* L. (Wormseed) (Introduced)	-	-		Infusion of plant used to treat colds and stomachache (Moteetee and Van Wyk, 2011).	Extracts showed antimicrobial activities (Sousa et al., 2012).
Chenopodiaceae	*Exomis microphylla (Thunb.) Aellen* (Hondebossie) (Native)	-	-	Not problematic	Root decoction given to infants to clear phlegm, and cold-water infusion taken orally to treat rash (Dold and Cocks, 2000). Leaf decoction given to children against constipation and nausea (Dold and Cocks, 2000). Leaf recorded as treatment for epilepsy (Watt and Breyer-Brandwijk, 1962) and leaf decoction used to treat wind, cramp and	

					convulsions in infants (Van Wyk and Gericke, 2000).	
Convolvulaceae	*Ipomoea alba* L. (Moonflower) (Introduced	**1** in NP[b], KZN, MP; 3 in rest of SA	1b	Invasive	-	Plant contains saponins, alkaloids, coumarins, flavonoids, steroids and tannins (Lawson et al., 2017); showed antifungal activity against ten plant pathogenic organisms, (Meela, 2008); antibacterial activity against human pathogens, anticancer activity against MDA-MB-231 and Hs 578T cells (Lawson et al., 2017); and anti-adipogenic effect in 3T3-L1 adipocytes cells (Mengue N'dille et al., 2019).
Crassulaceae	*Bryophyllum delagoense* (Eckl. & Zeyh.) Druce (Chandelier plant) (Introduced)	1	1b	-	-	Leaf fraction is rich in phenolic compounds (Katrucha et al., 2020); fraction exhibited antidiabetic activity (Katrucha et al., 2020).
Cucurbitaceae	*Citrullus lanatus* (Thunb.) Matsum. & Nakai (Wild watermelon) (Native)	-	-		Used to treat sexually transmitted infections (Semenya et al., 2013).	Ethanolic seed extract contains phenolics, flavonoids, tannins and sterols (Varghese et al., 2013). Plant juice exhibited radioprotective effects in rats exposed to oxidative damage induced by low dose X-ray exposure (Mohammad et al., 2014); extracts form seeds showed antibacterial activity (Nwankwo et al., 2014).
Euphorbiaceae	*Jatropha curcas* L. (Physic nut, purging nut) (Introduced)	-	2	-	Nuts and seeds are taken in a small quantity as a purgative (Hutchings et al., 1996; Watt and Breyer-Brandwijk, 1962). Root decoction taken for erectile dysfunction (Semenya et al., 2012).)	Seed oil contains irritant diterpenoids (Adolf et al., 1984) and seeds contain a toxic lectin, curcin (Watt and Breyer-Brandwijk, 1962). Latex has coagulant activity when undiluted but is anticoagulant at high dilutions (Osoniyi and Onajobi, 2003).

Euphorbiaceae	*Ricinus communis* L. (Castor oil plant) (Introduced)	2	2	Invasive	Oil extracted from seeds is a well-known purgative (Van Wyk et al., 2009). Fresh leaves are used as a bandage to soothe pain and swelling and as an antiseptic after circumcision; boils and abscesses are treated with fresh green leaves (Dold and Cocks, 2000). Leaf infusions administered orally or as enemas for stomachache; root and leaf poultices applied to wounds, sores and boils, amongst many other uses (Hutchings et al., 1996; Watt and Breyer-Brandwijk, 1962). Whole plant used for wounds and gonorrhoea (Mbambala et al., 2017). Leaves used to treat swollen legs (Maema et al., 2016b).	Leaf acetone extract has antifungal activity against plant pathogenic fungi (Mdee et al., 2009). Castor oil contains a fatty acid, ricinoleic acid, and seeds contain the alkaloid ricinine and the lectin ricin, both highly toxic (Bruneton, 1995). Ricinoleic acid reduces net absorption of fluids and electrolytes and stimulates intestinal peristalsis (Van Wyk et al., 2009).
Fabaceae	*Albizia lebbeck* (L.) Benth. (Lebbeck tree) (Introduced)	1	1b	Invasive	Leaves and seeds used to treat wounds (Mbambala et al., 2017).	Different plant parts contain phytochemicals such as phenolics, flavonoids, sterols, alkaloids, saponins and triterpenes (Abd El-Ghany et al., 2015); Plant extracts have promising hepatoprotective, antioxidant, cardiotonic, antimicrobial, antihistamine and hypoglycemic activities (Abd El-Ghany et al., 2015).

Fabaceae	*Bauhinia variegata* L. (Orchid tree) (Introduced)	3	**1b** in EC, KZN, L and MP. **3** in FS, G, NW, NC and WC	-	Leaves and bark used to treat diabetes, goitre, dysentery, diarrhoea (Parekh and Chandra, 2007).	Anti-inflammatory activity (Rao et al., 2008), immune modulatory activity (Ghaisas et al., 2009). Compounds isolated include kaempferol, ombuin,kaempferol 7,40-dimethyl ether-3-O-b-D-glucopyranoside, kaempferol 3-O-b-D-glucopyranoside, isorhamnetin 3-O-b-D-glucopyranoside, hesperidin, 3-b-trans-(3,4-dihydroxycinnamoyloxy) olean-12-en-28-oicacid (Rao et al., 2008).
Fabaceae	*Caesalpinia decapetala* (Roth) Alston (Mauritius thorn) (Introduced)	1	1b	Invasive	Root boiled in water and taken orally to treat gonorrhoea (Semenya et al., 2013; Semenya et al., 2012). Leaves, roots and bark used for wounds and coughing (Mbambala et al., 2017).	Caesaljapin, a cassane diterpenoid (Ogawa et al., 1992); extracts showed antibacterial, and antifungal and antioxidant activities (Sharma et al., 2017b).
Fabaceae	*Leucaena leucocephala* (Lam.) de Wit (Leucaena) (Introduced)	-	-	Invasive	Used in Mexico to treat diabetes and inflammatory conditions (Andrade-Cetto and Heinrich, 2005; Singhal et al., 1982).	Epicatechin-3-O-gallate, apigenin, two quercetin glycosides: quercetin-3-O-arabinofuranoside and quercetin-3-O-rhamnoside with antioxidant activity and low cytotoxicity isolated from leaves (Aderogba et al., 2009).
Fabaceae	*Senna didymobotrya* (Fresen.) H.S.Irwin & Barneby (Peanut butter cassia) (Introduced)	3	1b in EC, KZN, L, MP, WC. Not listed elsewhere.	-	Leaf decoction taken for blood clotting (Semenya et al., 2012). Leaves used to treat wounds (Mbambala et al., 2017).	Emodin, chrysophanol, physcion, knipholone and two new bianthraquinones, 10-hydroxy-10-(physcion-7′-yl)-chrysophanol anthrone and 5,10-dihydroxy-2-methyl-9-(physcion-7′-yl)-1,4-anthraquinone, reported from the pods (Alemayehu et al., 1996). Extracts showed antimicrobial activity (Korir et al., 2012).
Fabaceae	*Sesbania punicea* (Cav.) Benth. (Red sesbania) (Introduced)	1	1b	Invasive	Root decoction taken for menstrual disorders (Semenya et al., 2012).	

Hypericaceae	*Hypericum perforatum* L. (St John's Wort, Tipton weed) (Introduced)	2	2	-	Above-ground parts are used as an antidepressant, diuretic, antidiarrhoeal, and against rheumatism and gout (Bruneton, 1995; Ernst, 1995; Grieve, 1967). Leaves and bark used to treat wounds and coughing (Mbambala et al., 2017).	The antidepressant effect was previously thought to be linked to hypericin but the effect is more strongly associated with hyperforin (Beerhues, 2006), which also has antiviral (Hamburger and Hostettmann, 1991), antibacterial and antitumoral activity (Henderson and Anderson, 1966).
Lauraceae	*Cinnamomum camphora* (L.) J. Presl(Camphor tree) (Introduced)	**1** in NP[b], KZN, MP	**1b** in EC, KZN, L, MP. Not listed for trees declared National Heritage Trees or National Monuments in EC, KZN, L, MP, WC. **3** in WC.	-	Colds and inflammatory complaints in Europe (Grieve, 1967). Heart conditions, infections, fevers, pneumonia, hysteria, diarrhoea (Grieve, 1967; Watt and Breyer-Brandwijk, 1962). Bark used to treat fevers, colds, influenza; infusion of dried leaves used as Zulu ritual emetic (Van Wyk et al., 2009).	Toxic in large doses (Van Wyk et al., 2009). Antiseptic, counter-irritant, stimulant, spasmolytic, carminative and analeptic properties (Van Wyk et al., 2009). Leaf extracts have anti-inflammatory and antioxidant activity (Lee et al., 2006).
Malvaceae	*Malva parviflora* L. (Cheeseweed mallow) (Introduced)	-	-		Dried powder or infusion of leaves and roots used in Lesotho to clean wounds and sores; hot leaf poultice used to treat wounds and swelling; incorporated into lotion to treat bruised and broken limbs (Shale et al., 1999). Leaves used by Xhosa for	Leaf and root extracts had antibacterial and anti-inflammatory activity against cyclooxygenase-1 (Shale et al., 1999, 2005). Malvalic acid (= halphen acid), an unsaturated fatty acid, may contribute to toxic effects (Watt and Breyer-Brandwijk, 1962).

					swollen, inflamed, purulent wounds (Watt and Breyer-Brandwijk, 1962). Pulped leaf used as a bandage to heal cuts, wounds and boils and leaf decoction used as gargle for toothache (Dold and Cocks, 2000). Unspecified parts recorded as treating uterine problems, as a poultice for wounds and swellings and to treat tapeworm (Watt and Breyer-Brandwijk, 1962). Possibly toxic, causing mortality in foraging livestock, such as sheep, horses and cattle (Watt and Breyer-Brandwijk, 1962).	
Meliaceae	*Melia azedarach* L. (Syringa) (Introduced)	3	1b (3 in urban areas)	Invasive	Bark and whole plant used to treat wounds and gonorrhoea (Mbambala et al., 2017). Roots are used as a blood purifier (Maema et al., 2016b).	Plant contains essential oils, extract and essential oils have insecticidal activity (Ntalli et al., 2014).
Myrtaceae	*Eucalyptus* spp. (Introduced)	2	1b with exceptions	-	Leaf decoction for steaming to treat colds and flu (Moteetee and Van Wyk, 2011). Used to heal wounds, fungal infections, as an analgesic, to treat cold,	Extracts contain saponins, tannins, phenols and flavonoids and also rich in essential oils (Sebei et al., 2015; Kaur et al., 2019); Plant essential oils have promising antibacterial potential (Sebei et al., 2015).

					flu, and sinus (Otang et al., 2012). Fresh leaves used as mosquito repellent and to treat coughs, colds, dysentery and pimples (Watt and Breyer-Brandwijk, 1962).	
Myrtaceae	*Eucalyptus camaldulensis* Dehnh. (Red river gum) (Introduced)	2	1b in certain areas, e.g. riparian areas	Invasive	Leaf decoction used to treat tuberculosis (Semenya et al., 2012).	Methanol extract of fruits with moderate antiproliferative activity afforded the new triterpene, 3β-acetoxy-urs-11,13(18)-dien-28-oic acid along with triterpenoids 3β-hydroxy-urs-11-en-28,13β-olide, 3β-acetoxy-urs-11-en-28,13β-olide, 3-acetylbetulinic acid, oleanolic acid, ursolic acid, β-amyrin acetate, β-sitosterol and sitosterol 3-O-β-D-glucopyranoside (Topçu et al., 2011). Leaf extracts have antibacterial activity (Abubakar, 2010).
Myrtaceae	*Eucalyptus paniculata* Sm. (Grey ironbark) (Introduced)	2	-	-	Leaves and roots used to treat flu-like fever and wounds (Mbambala et al., 2017).	Plant is rich in essential oils (Dellacassa et al., 1990).
Myrtaceae	*Psidium guajava* L. (Guava) (Introduced)	2	2 in EC, KZN, L, MP, NW; not listed elsewhere	Invasive	Leaves commonly used to treat diarrhoea as well as diabetes, fever, cough, ulcers, boils and wounds (Hutchings et al., 1996; Watt and Breyer-Brandwijk, 1962). Root decoction used for diarrhoea and hypertension (Semenya et al., 2012). Roots, leaves and bark used to treat	Tannins and other phenolic compounds, notably amritoside, a glycoside of ellagic acid identified; ellagic acid, a known intestinal astringent and haemostatic, possibly explains therapeutic value of species against diarrhoea (Bruneton, 1995). Hypoglycaemic effects have been documented (Oh et al., 2005). Phytochemistry, pharmacology and uses extensively reviewed by (Gutiérrez et al., 2008).

					wounds (Mbambala et al., 2017).	
Papaveraceae	*Argemone mexicana* L. (Yellow-flowered Mexican poppy) (Introduced)	1	1b	-	Root decoction mixed with *Rubus pinnatus* root used as enema to cure kidney pain (used immediately after preparation) (Dold and Cocks, 2000). Used as a narcotic, wound dressing, application for warts and treatment for eczema in southern Africa (Watt and Breyer-Brandwijk, 1962).	Very rich in alkaloids, phenolic, flavonoids, alcohols, and amino acids, steroids, terpenoids and aromatic compounds Antibacterial, anti-infertility, anti-inflammatory, wound healing, anti-allergic and anti-infertility activities (Brahmachari et al., 2013).
Papaveraceae	*Argemone ochroleuca* Sweet (White- flowered Mexican poppy) (Introduced)	1	1b	-	Sap from stem used for sore eyes; used to treat pulmonary tuberculosis, period pains; steam from boiling decoction of whole plant used for fever; aperients (Moteetee and Van Wyk, 2011). Whole plant, leaves or roots used to treat gonorrhoea, wounds and sore teeth (Mbambala et al., 2017). Roots used to treat asthma (Maema et al., 2016b).	Extracts showed antibacterial and antifungal activities (Reyes et al., 2011).
Passifloraceae	*Passiflora suberosa* L. (Devil's pumpkin, Indigo berry) (Introduced)	1	1b	-	-	Antifungal activity against ten plant pathogenic organisms (Meela, 2008).
Passifloraceae	*Passiflora subpeltata* Ortega (Granadina) (Introduced)	1	1b	Invasive	Roots used to treat wounds and to help with	Antifungal activity against ten plant pathogenic organisms (Meela, 2008).

					giving birth (Mbambala et al., 2017).	
Phytolaccaceae	*Phytolacca americana* L. (American pokeweed) (Introduced)	-	1b	Invasive	Leaf paste used to treat boils (Afolayan et al., 2014).	Extracts showed antibacterial and antioxidant activities (Nabavi et al., 2009; Patra et al., 2014).
Pinaceae	*Pinus patula* Schiede ex Schltdl. & Cham. (Mexican weeping pine, Patula pine) (Introduced)	2	2 (exempted for an existing plantation)		Roots used to treat wounds (Mbambala et al., 2017).	Plant is rich in essential oils, and its essential oils exhibited antifungal activity (Amri et al., 2011).
Poaceae	*Cortaderia jubata* (Lem.) Stapf (Pampas grass) (Introduced)	1	1b	Invasive	Roots used to treat wounds (Mbambala et al., 2017)	
Poaceae	*Lolium multiflorum* Lam. (Italian rye grass) (Introduced)	-	-	Uncertain	Whole plant decoction used for kidney problems (Semenya et al., 2012).	Shoots and roots contain flavonoids, benzoic acids and cinnamic acids (Ponce et al., 2009); fractions showed antioxidant, anti-inflammatory and antiseptic activities (Choi et al., 2017).
Poaceae	*Phragmites mauritianus* Kunth. (Giant reed) (Introduced)	-	-	Not problematic	Roots used to treat wounds (Mbambala et al., 2017).	
Polygonaceae	*Emex australis* Steinh. (Doublege) (Native)	-	-	Invasive	Root decoction given to infants to treat restlessness and constipation (Dold and Cocks, 2000). Leaf used to relieve biliousness and to stimulate appetite (Watt and Breyer-Brandwijk, 1962).	
Polygonaceae	*Rumex acetosella* L. (sheep's sorrel) (Introduced)	-	1a on Prince Edward and Marion Islands.	-	Root decoction used to bathe wounds and bruises (Shale et al., 1999); leaf decoction used to treat flatulence in livestock,	Leaf and root extracts had some antibacterial activity against a panel of bacteria (Shale et al., 1999).

			Not listed on mainland or other offshore islands		toothache; crushed roots used for skin rash (Moteetee and Van Wyk, 2011).	
Polygonaceae	*Rumex crispus* L. (curled dock) (Introduced)	-	-		Leaf decoction taken to alleviate chronic coughing (Dold and Cocks, 2000). Root used as purgative and treatment for skin diseases, eczema, ringworm and leprosy (Watt and Breyer-Brandwijk, 1962).	Plant is rich in phenolics, flavonoids and tannins, and showed antioxidant activity (Idris et al., 2017).
Rosaceae	*Eriobotrya japonica* (Thunb.) Lindl. (Loquat) (Introduced)	3	1b in WC, not listed elsewhere	Invasive	Leaf decoction used for hypertension and tuberculosis (Semenya et al., 2012). Leaves used to treat hypertension (Maema et al., 2016b). Used in Asia to treat fever, chronic respiratory diseases, and gastroenteric disorders (Lee et al., 2004; Liang et al., 1990).	Contains triterpenes, sesquiterpenes, flavonoids, tannins, megastigmane glycosides, and phenolic compounds; possesses anti-tumor, anti-viral, hypoglycemic, anti-diabetic, anti-inflammatory and immune stimulatory properties (Kim et al., 2011).
Rosaceae	*Rubus cuneifolius* Pursh (American bramble) (Introduced)	1	1b	-	Leaves used for wounds (Mbambala et al., 2017).	
Salicaceae	*Salix babylonica* L. (Weeping willow) (Introduced)	2	-	-	Bark and leaves used for treating wounds (Mbambala et al., 2017).	Flavonoid compounds isolated, and extracts showed antibacterial activity (González-Alamilla et al., 2019).

Sapindaceae	*Cardiospermum grandiflorum* Swartz (balloon vine) (Introduced)	-	1b	-	Plant parts used to treat fever, chest problems and dermatological troubles Omokhua et al., 2018b).	Extracts contain phenolics, flavonoids and tannin compounds; and also showed had antimicrobial activity (Omokhua et al., 2018b).
Solanaceae	*Cestrum laevigatum* Schltdl. (Inkberry) (Introduced)	1	1b	-	-	Leaf and flower acetone extracts have antifungal activity against plant pathogenic fungi (Mdee et al., 2009).
Solanaceae	*Datura stramonium* L. (Common thorn apple) (Introduced)	1	1b	-	Much used in traditional medicine, commonly to reduce pain and relieve asthma (Van Wyk et al., 2009). Leaf rolled up and smoked for asthma and bronchitis; fresh green fruit applied locally for toothache, sore throat and tonsillitis (Watt and Breyer-Brandwijk, 1962). Fresh warmed leaf used as poultice to relieve rheumatism, gout, boils, abscesses and wounds (Afolayan et al., 2014; Dold and Cocks, 2000; Watt and Breyer-Brandwijk, 1962). Two major alkaloids used commercially: atropine as ingredient of eyedrops, and hyoscine to treat motion sickness and injection to treat Parkinsonism and painful visceral spasms (Bruneton, 1995). Hot	Seed acetone extract has antifungal activity against plant pathogenic fungi (Mdee et al., 2009). Datura species contain tropane alkaloids, mainly atropine (±hyoscyamine) and (-)-hyoscine (scopolamine) (Van Wyk et al., 2002). The alkaloids are toxic and increase the heart rate, relax smooth muscles, decrease saliva, paralyse certain eye muscles and increase intra-ocular pressure (Wink and van Wyk, 2008). At low doses they are depressant and sedative but high doses may cause hallucinations, mental confusion and insomnia, with some human fatalities recorded (Wink and van Wyk, 2008).

					leaves used for bruises and boils (Moteetee and Van Wyk, 2011). Seed used for stroke (Semenya et al., 2012). Fresh leaves used as bandage to soothe pain and swelling and as antiseptic after circumcision operation (Dold and Cocks, 2000). Leaf used to treat asthma and headaches (Hutchings and van Staden, 1994). Roots and leaves used for wounds (Mbambala et al., 2017). Roots used to treat infertility (Maema et al., 2016b).	
Solanaceae	*Nicotiana glauca* Graham (Wild tobacco) (Introduced)	1	1b	-	Snuff given to children with head cold to make them sneeze (Moteetee and Van Wyk, 2011). Warmed leaf strapped over boil or abscess to draw out infection (Dold and Cocks, 2000). Leaf poultice used to relieve headaches, sore throat and painful, tired feet (Van Wyk and Gericke, 2000).	Leaf, flower and seed acetone extracts have antifungal activity against plant pathogenic fungi (Mdee et al., 2009).
Solanaceae	*Solanum mauritianum* Scop. (Bugweed) (Introduced)	1	1b	Invasive	Fruit chopped and macerated in water and used for cleaning kidneys (Semenya et al., 2012). Dried root decoction	Leaf and fruit acetone extracts have antifungal activity against plant pathogenic fungi (Mdee et al., 2009). Leaf ethanol extracts had anti-inflammatory activity (Jäger et al., 1996). Contains solasodine

					given to a cow after miscarriage or difficult calving to restore health (Dold and Cocks, 2000). Roots used for excessive menstrual bleeding (Hutchings et al., 1996) and leaf used to treat headaches (Hutchings and van Staden, 1994). Whole plant used to treat wounds (Mbambala et al., 2017).	(Drewes, 1994), a compound with known anti-inflammatory activity (Lewis, 1989).
Solanaceae	*Solanum nigrum* L. (black nightshade) (Introduced)	-	-		Roots and leaves used to treat wounds (Mbambala et al., 2017).	Plant parts showed antimicrobial activity (Shahiladevi and Jegadeesan, 2017).
Solanaceae	*Solanum seaforthianum* Andrews (Potato creeper) (Introduced)	1	1b	Invasive	-	Antifungal activity against ten plant pathogenic organisms (Meela, 2008).
Urticaceae	*Urtica urens* L. (Dwarf nettle, annual nettle) (Introduced)	-	-	Widespread	Leaf decoction used to treat asthma; used for tuberculosis, heart problems, intestinal ulcers, heartburn, wounds, iron deficiency (Moteetee and Van Wyk, 2011).	Plant contain phenolics, flavonoids and tannins and extracts showed antioxidant and antibacterial activity (Mzid et al., 2017).
Verbenaceae	*Lantana camara* L. (Lantana, tickberry) (Introduced)	1	1b	Invasive	Root decoction taken for hypertension (Semenya et al., 2012), to relieve lower back or abdominal pain and used as enema to treat gonococcal infection and urinary problems (Dold and Cocks, 2000). Leaves used against coughs, colds, jaundice and	Leaf, flower and seed acetone extracts have antifungal activity against plant pathogenic fungi (Mdee et al., 2009). Contains ursolic and oleanolic acids (Ghisalberti, 2000) and cardioactive glycosides (Qaisar et al., 2009).

					rheumatism (Watt and Breyer-Brandwijk, 1962). Leaves used for sore eyes and coughing (Mbambala et al., 2017).	
Verbenaceae	*Lippia javanica* (Burm.f.) Spreng. (Lemon bush) (Native)	-	-	Invasive	Used by Vhavenda as an anthelmintic; Xhosa use it to disinfect anthrax-infected meat (Viljoen et al., 2005).	Essential oil has toxic and/or repellent effects against insects when used as fumigants in granaries (Omolo et al., 2005). Extracts of aerial parts antifungal against *Fusarium* spp. (Thembo et al., 2010).
Verbenaceae	*Verbena rigida* Spreng. (Veined verbena) (Introduced)	-	1b	-	Root decoction used to treat heartburn, colic (Jacot Guillarmod, 1971).	
Zingiberaceae	*Hedychium flavescens* Carey ex Roscoe (Yellow ginger lily) (Introduced)	1	1b	-	Roots used to treat wounds and fever (Mbambala et al., 2017).	Rhizomes are rich in phenolics, saponins, glycosides, alkaloids, tannins, phlobatannins and terpenoids (Raphael and Madhavan, 2013)
Zygophyllaceae	*Tribulus terrestris* L. (Puncture vine, devil's thorn) (Introduced)	-	-	Uncertain	Used to treat rheumatism (Jacot Guillarmod, 1971). Leaf decoction used against scabies and hair loss (Afolayan et al., 2014). Used to treat sexually transmitted infections (Semenya et al., 2013).	Glycoside, saponin and flavonoids compounds identified, and plant has antidiabetic, antiurolithic, immunomodulatory, aphrodisiac, anti-inflammatory, diuretic, hypolipidemic, antispasmodic, analgesic, hepatoprotective, anticancer, anthelmintic, antibacterial and larvicidal activities (Chhatre et al., 2014).

[a]- = not listed, [b]NP = Northern Province, KZN = KwaZulu-Natal, MP = Mpumalanga, EC = Eastern Cape, L = Limpopo, WC = Western Cape, FS = Free State, G = Gauteng, NW = North-West, NC = Northern Cape, SA = South Africa, - = no information

Table 2. Number of weed species in each plant family

Plant family	A	B	C	D	E	F
Agavaceae	-	3	-	-	-	-
Amaranthaceae	-	4	-	-	-	-
Anacardiaceae	-	1	-	-	-	-
Apiaceae	-	1	-	-	-	-
Apocynaceae	-	2	-	-	-	-
Asclepiadiaceae	-	2	-	-	-	-
Asteraceae	1	12	-			2
Basellaceae	-	1	-	-	-	-
Bignoniaceae	-	3	-	-	-	-
Cactaceae	-	2	-	-	2	-
Cannaceae	-	1	-	-	-	-
Caprifoliaceae	1	-	-	-	-	-
Casuarinaceae	1	-	-	-	-	-
Chenopodaceae	1	1	-	-	1	-
Convolvulaceae	-	-	-	1	-	-
Crassulaceae	-	-	-	1	-	-
Cucurbitaceae	-	1	-	-	-	-
Euphorbiaceae	-	2	-	-	-	-
Fabaceae	1	5	-	-		-
Hypericaceae	-	1	-	-	-	-
Lauraceae	-	-	-	-	1	-
Malvaceae	-	1	-	-	-	-
Meliaceae	-	1	-	-	-	-
Myrtaceae		3	1	-	-	-
Papaveraceae	-	1	-	-	1	-
Passifloraceae	-	-	-	-	1	1
Phytolaccaceae	-	-	-	-	1	-
Pinaceae	-	1	-	-	-	-
Poaceae	2	1	-	-	-	-
Polygonaceae	1	1	-	-	1	-
Rosaceae	1	1		-	-	-
Salicaceae	-	1	-	-	-	-
Sapindaceae	-	1	-	-	-	-
Solanaceae		2	-	-	3	1
Urticaceae	-	1	-	-	-	-
Verbenaceae	1	2	-	-	-	-
Zingiberaceae	-	-	1	-	-	-
Zygophyllaceae	-	1	-	-	-	-

A = Traditional usage only; B = Traditional usage with phytochemical/biological history; C = Traditional usage with phytochemical history only; D = Phytochemical/biological history with no recorded traditional usage; E = Traditional usage with biological history only; F: Biological history only.

Figure 1. Percentage representation of plant species with information on traditional usage, phytochemical analysis, biological activity and combinations of these categories.