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Naturalised and invasive succulents of southern Africa

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by

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Captions to figures for *Naturalised and invasive succulents of southern Africa*

Front cover. *Opuntia ficus-indica* (L.) Mill. thriving on an inaccessible cliff ledge in the Karoo, Graaff-Reinet, South Africa. (Picture by Neil R. Crouch)

Half-title page. The exotic *Agave americana* L. var. *americana*, *Echinopsis schickendantzii* F.A.C.Weber and *Cylindropuntia pallida* (Rose) F.M.Knuth firmly established in South Africa's Karoo. (Picture by Helmuth G. Zimmermann)

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Foreword

Many books on plant invasions are published every year dealing with various aspects of the field, ranging from regional atlases to conference proceedings covering a variety of topics and compendia on theoretical issues related to invasion biology with chapters written by invited authors. The first question that a potential buyer or reader of this book would consider is whether they require yet another book on plant invasions, even if it is from South Africa, a country that is greatly impacted by invasive plants. In the current literature the majority of books on invasions focus on the ecology of the organisms. However, while this volume on invasive succulents does provide some ecological and historical background, it is primarily a taxonomic treatment, making it special among the plethora of books bearing the word "invasive" in their title.

Succulents are an important group in terms of their position amongst invasive plants. Although Weber's compendium of invasive plants of the world from 2003 lists only nine species of perennial succulents among more than 400 global invaders, the group includes some of the prominent invasive species. Everyone interested in biological invasions is aware of the control of *Opuntia* Mill. in Australia using the moth *Cactoblastis cactorum*, which was one of the first examples of successful biological control on invasive plants. In heavily impacted parts of the world, succulent invaders have transformed habitats, exerting a range of ecological and economic impacts. This is true both in South Africa and other parts of the world. Although most of the world's most noxious succulent invaders come from North America, South Africa itself has donated some prominent succulent invaders, such as *Carpobrotus edulis* (Fig. 1), *Mesembryanthemum crystallinum* or *Conicosia pugioniformis* to other parts of the world.

As a rule in biological invasions, only a few taxa from the whole species pool are successful as invaders. However, it is also important to be aware of those that are not successful, as future invaders could be recruited from taxa that are currently naturalised. Therefore, comprehensive regional accounts on alien species should be praised. This volume deals with about seventy succulent species that have become naturalised in South Africa and neighbouring countries, providing detailed descriptions and illustrations. However, it is not just an atlas of alien succulents because this information is placed into a wider ecological and historical context through chapters on their ecological impacts, the history of their invasion in South Africa, pathways of introduction and reasons for their invasiveness, and also legislation on invasive species in South Africa. An outline of the current classification of each of the families and genera is provided, along with dichotomous identification keys, and a guide on how to collect succulents for deposition in an herbarium.

Fig. 1. *Carpobrotus edulis* (L.) N.E.Br. subsp. *edulis* (sour fig) is an indigenous South African succulent that has become established in other parts of the world. (Picture by Neil R. Crouch)

The taxonomic emphasis present throughout the book highlights the role of taxonomy in current research on biological invasions. Field botanists and researchers in invasion biology are often confronted with new species that may have come to their regions from virtually any part of the world. The ability to identify new invaders is essential to develop an early warning system and facilitate immediate response to potential invasions that may cause problems in the future. Therefore, close cooperation between ecologists and taxonomists is vital for successful management of invasive species. This book exemplifies how fruitful such cooperation can be.

The authors state that the book is targeted at the general public, policymakers, fellow scientists, agricultural researchers, horticulturalists, customs officials, and commercial and subsistence farmers. Special consideration has been given to make it accessible to the general public. Indeed, one can imagine an enthusiastic amateur naturalist using the dichotomous keys contained in this book, as a guide on his or her field trips to identify the species he or she finds. Of equal importance is the fact that the user will *not* be able to identify some species, simply because they are not in the book and could therefore be future invaders. Fortunately the authors provide some guidance in such cases by providing information on how to collect an herbarium specimen and to seek expert help. Every collector knows how difficult it is to collect a succulent for an herbarium specimen resulting in succulents being fairly under-represented in herbaria. If the book contributes to improving this situation, it will gain even greater credibility.

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Abstract

Taxonomic information is provided for 69 exotic succulent plant species that have become naturalised or invasive - or may potentially do so - in South Africa and some of its neighbouring countries. Informative descriptive text and illustrations are provided for all the species, as well as synonymies and geographical distribution maps. Ancillary chapters cover brief introductions to the ecological impacts of invasiveness, a history of invasive succulents in South Africa, the means of introduction and reasons for their success, legislation governing invasive species in South Africa, and how to collect succulents for deposition in an herbarium. However, emphasis throughout is on the taxonomy of these species.

Keywords - alien species, early detection, eradication, invaders, naturalised, southern Africa, succulent plants

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1. About this book

The primary aim of this book is to provide taxonomic information on the alien succulent plant species that have become established as part of the naturalised flora of southern Africa. The formal taxonomy of the species which form the main part of the book therefore includes descriptions of families, genera and species, synonymies, illustrations, and distribution information and maps. As far as possible the taxonomy is complemented with natural history observations and cultural information applicable to the species within both its natural and adopted distribution ranges. Given the devastating impact aliens can have on the natural environment, and by implication on human livelihoods, one of the primary objectives of the book is to bring the scourge of alien plant invaders to the attention of many. This book targets the general public, policymakers, fellow scientists, agricultural researchers, horticulturalists, customs officials, and commercial and subsistence farmers. For this reason much of the text is written in non-technical language that is easy to read and understand. We have deliberately opted for a broad definition of what constitutes alien and invasive plants, and species that have contributed extensively to habitat transformation, e.g. *Opuntia stricta* (Haw.) Haw. (sour prickly pear, suurturksvy) (Fig. 2), listed as amongst the 36 worst invasive alien plant species globally (Lowe *et al.*, 2000), as well as those that are little more than troublesome garden or crop weeds, e.g. *Portulaca oleracea* L. (purslane) (Fig. 3), are included in the book.

Fig. 2. *Opuntia stricta* (Haw.) Haw. (sour prickly pear) has contributed to serious habitat transformation in several countries. (Picture by Neil R. Crouch)

Fig. 3. *Portulaca oleracea* L. (purslane) is a widely distributed weed of cultivated lands. (Picture by Neil R. Crouch)

As far as possible we have followed the latest classification and nomenclature applicable to the invasive alien succulents of southern Africa. However, in a few instances we have opted not to use the latest classificatory suggestions; for example we prefer to retain the species of *Agave* L. (century plants) in the family Agavaceae rather than including them in the very broadly conceived Asparagaceae of the most recent Angiosperm Phylogeny Group proposal. In some instances the taxonomies of alien succulents that are firmly entrenched in South Africa—and have been so for decades—remain poorly understood locally and sometimes even in their native ranges, particularly in the case of the Cactaceae (cactus family). This publication therefore reflects the current state of our knowledge of the taxonomy of these, as well as the rest of the exotic succulent plants that have become established in natural settings in South Africa and sometimes in neighbouring countries, and beyond. The descriptions of the families and genera provided in this book cover the full variation of the taxa and therefore include the characters of the taxa naturalised in southern Africa.

The geographic coverage of the book is mainly South Africa, but several of the included species have become more widely established, occurring in neighbouring countries, and often much further afield. Where the information was available to us, we have also reflected the occurrence of the species beyond the borders of South Africa.

Chapters in the first part of the book cover several topics that are relevant to studies of biological invasions. These include the ecological impacts of invasiveness, a history of invasive succulents in South Africa, e.g. the means of introduction and reasons for their success, legislation governing invasive species in South Africa, and how to collect succulents for deposition in an herbarium.

In the second part of the book all the species are provided with informative taxonomic descriptions that are useful in identifying them, with special emphasis on those characters important in distinguishing them from related or similar-looking entities, in particular those known to be indigenous to South Africa. An outline of the current classification within each of the families and genera is provided, along with dichotomous identification keys. Colour and black and white images, line drawings, where available, and geographical distribution maps reflecting the best available knowledge, are provided for each taxon.

Past and present species occurrence data (from individual casual aliens to naturalised or invasive stands) for South Africa were obtained from as many sources as possible, including personal observations, interrogating the Agricultural Research Council's Southern African Plant Invaders Atlas (SAPIA), *SAPIA Newsletters* and the South African National Herbarium Pretoria (PRE) Computerised Information System (PRECIS). For other southern African countries, books on invaders, national plant checklists and websites, for instance, Swaziland's Alien Plants Database (http://www.sntc.org.sz/alienplants/index.asp), were used. Standard reference works such as published volumes of the *Flora of Southern Africa (FSA)* and *'Contributions to the FSA'*, an occasional column included in *Bothalia*, were also used and are referenced in the various chapters where the families are treated taxonomically. In the absence of systematic surveys of many of these species, however, occurrence data usually remain scanty.

The following abbreviations are used throughout the book for the five countries included in the *Flora of Southern Africa* region: B-Botswana; L-Lesotho; N-Namibia; S-Swaziland; SA-South Africa.

It should be noted that some common names given in the book are better known in other parts of the world and not widely used in southern Africa. They are listed here for the sake of completeness.

2. Biology and impact of invasive succulent plants

by James S. Boatwright, Gideon F. Smith, Helmuth G. Zimmermann, Thulisile P. Jaca, Rethabile F. Motloung and Takalani D. Malotsha

2.1. Invasive succulent plants in South Africa

Alien or exotic (non-native) plants can be defined as those that occur in a given area outside of their known, natural distribution due to intentional or accidental introduction through human activity. These plants are only considered to be invasive once they have become naturalised (i.e. reproduce successfully without human intervention) and are able to produce reproductively viable offspring significant distances away from the parent population (see Text Box 1 for useful definitions; Richardson *et al.*, 2000). The effects of invasive plants are often destructive to the natural environment and threaten the biodiversity of areas on which they encroach (Richardson & Van Wilgen, 2004).

South Africa has an extremely rich biodiversity, the richest temperate flora in the world, with 20 456 species occurring in the region (Germishuizen *et al*., 2006; Raimondo *et al.*, 2009). Of these 2 577 taxa are threatened with regional or global extinction. These threats are mainly through agriculture, urbanization, habitat loss and encroachment of alien invasive species (Raimondo *et al*., 2009). Currently, in South Africa more than 550 plant species are known to be contributing to the widespread transformation of once pristine habitats. Approximately 550 naturalised alien species are listed by the Southern African Plant Invaders Atlas (SAPIA) (Henderson, 2007). Of these, approximately 70 are succulents with fat (green or non-green) stems (Fig. 4), leaves (Fig. 5) or caudices (Fig. 6), of which almost half are members of the family Cactaceae. These plants are generally spiny, almost invariably leafless succulents characterised by the presence of areoles. All cactus growth occurs from areoles (reduced axillary shoots) (Fig. 7), which are usually evident as small white, yellow or brown furry 'spots' on the cactus plant bodies (Barthlott & Hunt, 1993; Smith, 2006a). A high number of succulent invaders - almost 20% of the recorded invasive plants - is unsurprising, as most succulents, cacti in particular, require very little aftercare and maintenance once in cultivation, and much of the South African landscape is comprised of arid to semi-arid regions in which succulents thrive, such as the Succulent Karoo, Nama-Karoo and Desert Biomes (Mucina & Rutherford, 2006).

Fig. 4. *Myrtillocactus geometrizans* (Pfeiff.) Console is an example of a stem succulent. (Picture by Gideon F. Smith)

Fig. 5. *Bryophyllum daigremontianum* Haw. is an example of a leaf succulent. (Picture by Neil R. Crouch)

Fig. 6. *Phytolacca dioica* L. of which the stem, especially towards the base, is quite succulent, making it popular among succulent collectors with large gardens. (Picture by Geoff R. Nichols)

Fig. 7. *Cylindropuntia imbricata* (Haw.) F.M.Knuth has stems that are sparsely dotted with spiny areoles. (Picture by Neil R. Crouch)

Text Box 1. Definitions relating to plant invasion ecology (from Richardson *et al.*, 2000).

Alien plant: Plant taxa that occur in a given area due to intentional or accidental introduction through humans (syn. exotic plants, non-native plants).

Casual alien plants: Alien plants which thrive and even reproduce in an area, but need repeated introductions for their persistence and do not form self-replacing populations.

Naturalised plants: Alien plants which successfully reproduce in an area and sustain populations over numerous life cycles without direct human intervention.

Invasive plants: Naturalised alien plants or native plants which reproduce, often at high frequency, a significant distance from the parent population and can potentially spread over large areas (native plants that become invasive are often referred to as "densifiers").

Weeds: Plants that are not necessarily alien and grow in areas where they are not wanted, usually with detectable economic or environmental effects (syn. pest plants, problem plants). Mostly associated with "crop weeds".

Transformers: Those invasive plants that change the character, condition, nature or form of ecosystems over a considerable area relative to the extent of that ecosystem.

Of course not all succulents found in South Africa are exotic. South Africa and its four immediate neighbours (Namibia, Botswana, Swaziland and Lesotho) harbour the richest succulent flora globally with over 4 700 such species having been recorded for the subcontinent (Smith *et al*., 1997).

In the South African context, many of the succulent plants now established as invasives were originally introduced into the country for economic purposes. One such well-known example is the prickly pear, *Opuntia ficus-indica* (L.) Mill. (Fig. 8). This member of the Cactaceae, probably introduced into South Africa during early European settlement of the Cape in the seventeenth century, is a multi-use commercial crop for arid regions where the fruit are eaten and the cladodes (fleshy, leaf-like stems), which are regarded as delicacies in their native Mexico and elsewhere (Zimmermann & Zimmermann, 1987; Brutsch & Zimmermann, 1993), are used as livestock fodder and vegetables (Van Wyk & Gericke, 2000). It has now become a serious invader in not only South Africa, but also Saudi Arabia, Yemen, Eritrea, Ethiopia, Madagascar, Hawaii and other countries. The near-cosmopolitan common garden weed *Portulaca oleracea* L. or purslane, the natural origin of which remains unresolved, was established at the southern tip of Africa to provide a source of Vitamin C for seafarers rounding the Cape (Smith & Figueiredo, 2010). Both these species have spread rapidly across the subcontinent and beyond, with the former having contributed extensively to the transformation of large tracts of arid landscapes in the southern African interior. Some South African plants are similarly introduced into other parts of the world for their usefulness or economic gain. The South African succulent, *Carpobrotus edulis* (L.) N.E.Br. is now invasive in coastal dunes of Australia, New Zealand, USA, and southern and western Europe (Roiloa *et al*., 2010). It was, and still is, widely used to stabilise dunes and road cuttings. Interestingly, there is one documented case where an indigenous succulent plant, *Aloe spectabilis* Reynolds, has become successfully established as a viable colony elsewhere in the country following its translocation to a suitable habitat over 100 years ago (Klopper *et al*., 2010). However, this is rare among the succulents of South Africa.

Fig. 8. *Opuntia ficus-indica* (L.) Mill. was introduced into South Africa as a fodder plant and for its sweet, edible fruit, here shown together with fruit of *Opuntia monocantha* Haw. on the right. (Picture by Helmuth G. Zimmermann)

2.2. Biology and success of succulent invasives

Exotic succulents can easily become established in regions remote from their areas of origin as their general biology and lack of specific natural enemies greatly assist their survival and spread in adopted countries. Firstly, succulents are well adapted to easily survive periods of drought, while some can additionally thrive under such and other adverse environmental and climatic conditions, including very low temperatures. One adaptation to drought tolerance is the reduction of water loss through stomatal closure during the day. Most vascular plants concentrate carbon dioxide (CO_2) for photosynthesis through C_3 carbon fixation which limits them to growing in moderate temperatures as RuBisCO, an enzyme which facilitates carbon fixation, binds more oxygen than CO_2 at higher temperatures (photorespiration) thus limiting photosynthesis (Keeley & Rundel, 2003). However, many succulent plants concentrate CO_2 through Crassulacean Acid Metabolism (CAM). The advantage of CAM is that it gives plants the ability to survive in dry environments because the stomata only open at night to fix CO_2, and stomatal closure during the day significantly reduces water loss (Keeley & Rundel, 2003; Lüttge, 2004). The fixed CO_2 becomes available during the day and increases the efficiency of photosynthesis. Adaptations to CAM generally include thickening of the leaves along with an increase in cell and vacuole size, reduced intercellular air spaces (IAS) and reduced length of mesophyll surface exposed to IAS per unit (Nelson *et al*., 2005). Most succulents are able to reproduce both from seed and through rooting of severed vegetative parts (clonal reproduction). Species with edible fruit are spread by frugivores, which increases the spatial distribution and density of these plants, the dispersal of species of *Opuntia* Mill. by crows and pale- and red-winged starlings in the Karoo region of South Africa being an example (Dean & Milton, 2000). Others such as *Opuntia aurantiaca* Lindl. (jointed cactus) (Fig. 9) and *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb. (boxing glove cactus), an emerging alien invasive in South Africa, spread exclusively by vegetative means in their adopted country. These plants are small shrubs that produce stem segments that are easily dislodged and quickly root when they fall from the mother plant (Fig. 10). These thorny segments may be distributed by animals such as livestock through attaching to their fur, or by moving water (J.S. Boatwright, *pers. obs.*). Lastly, many invasive succulents are thorny to varying degrees possibly to escape herbivory in order to protect the water stored in their stems. These extremely thorny invasive cacti, for example the jointed cactus and all the chollas (species of *Cylindropuntia* (Engelm.) F.M.Knuth), can cause considerable harm to small livestock and wildlife, and make handling of specimens of these plants by botanists and others cumbersome. Hares and even small antelope get immobilised, preventing movement and feeding which eventually leads to death. Many birds and small reptiles get impaled on the thorns (Fig. 11; H.G. Zimmermann, *pers. obs.*). This is in stark contrast to the co-adapted local fauna living in the Sonoran Desert (North America) where the chollas are native. Many animal species use these thorny thickets for their own protection, coping well with the barbed spines (Fig. 12).

Fig. 9. *Opuntia aurantiaca* Lindl. cladodes (stem segments) easily snap off when passing animals brush against plants. This is the primary way in which it is vegetatively spread. (Picture by Helmuth G. Zimmermann)

Fig. 10. New populations of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth become established from severed stem segments. (Picture by Barbara K. Mashope)

Fig. 11. A bird that became impaled in the spines of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth. (Picture by Helmuth G. Zimmermann)

Fig. 12. An animal nesting/hiding in the protection of the spines of an *Opuntia* species. (Picture by Helmuth G. Zimmermann)

All invasive succulent species were introduced without any of their natural enemies that prevent them from becoming invasive in their countries of origin. None of the local native phytophagous insect fauna has switched hosts to any of the 28 invasive cactus species, despite their abundance and more than a century of exposure. Due to the uniqueness of the Cactaceae their associated insect fauna is equally uniquely adapted to feed on these plants and are thus often extremely host specific. This explains in part why the success rate of biological control projects on cactus invaders is often higher than those of other plant families.

2.3. Impacts and control of invasion

Le Maitre *et al.* (2000) estimated that approximately 10.1 millions hectares of South Africa and Lesotho have been invaded by alien plants in general. Of the eight biomes found in South Africa (see Rutherford *et al*., 2006), the Western Cape Province, which largely comprises the Fynbos biome is the most heavily invaded, particularly by woody shrubs and trees. This is followed by Mpumalanga, KwaZulu-Natal and the Limpopo Province. The largest total invader-transformed areas are those invaded by species of *Racosperma* Mart. (wattles), *Pinus* L. (pines) and *Prosopis* L., and *Lantana camara* L. These invasions deplete water resources (particularly woody invaders), affect delivery of ecosystem goods and services, over-utilise or alter natural resources (e.g. nitrogen addition), shift (often intensify) fire regimes, and affect sand movement and salt concentration (Richardson & Van Wilgen, 2004). Other effects include poisoning, for example *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz (Fig. 13) (= *B. tubiflorum* Harv.) and *B. pinnatum* (Lam.) Oken, succulent members of the Crassulaceae, which are both poisonous when ingested and cause heart failure. The flowers are five times more poisonous than the leaves and the poison can accumulate in body tissue. The impacts are primarily on livestock (Naughton & Bourke, 2005). To date no investigations have been done to measure the impacts of these two alien crassuloid species on the native flora and fauna.

Fig. 13. Ingestion by livestock of the flowers and leaves of *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz can lead to death by poisoning. (Picture by Geoff R. Nichols)

Eradication and control of invasive plants is extremely costly. This may be done either through labour intensive manual clearing, the use of chemicals (e.g. herbicides), or by the introduction of host-specific plant-feeding insects, mites and pathogens from the invader's country of origin, i.e. the plant's natural enemy or enemies, into a new country where the plants have become problematic (biological control or biocontrol) (Zimmermann *et al*., 2004). There is a risk of biocontrols themselves becoming invasive and attacking organisms that were not intended for targeting. The use of biocontrol agents requires very careful research before they are piloted to ensure that undesirable consequences are evaluated and avoided. The price of clearing invasive species may vary depending on the density of the invasion and also on the species being cleared. It was estimated that South Africa allocated approximately R355 million to alien invasive clearing during the 2002/2003 financial year (Marais *et al*., 2004). This highlights the importance of biological control as a comparatively inexpensive and effective means of eradicating alien invasives in the medium- to long-term as the biological control agents inflict damage and cause a decline in population densities, distribution and/or rates of spread of the problem plants. This reduces the costs of other management practices (Zimmermann *et al*., 2004). A total of 111 biological control agents have been released in South Africa against 67 invasive alien plants since 1913. These include 13 succulent species. Eighty-three agents have become established on forty-seven invasive plant species in 14 families. Thirty percent of the released agents inflict extensive damage to the weeds, including 11 succulents. Twenty-five percent resulted in considerable damage and 20% cause a moderate degree of damage to their target hosts (Klein, 2011). Targeting emerging weeds for biological control at an early stage of invasion could considerably increase the chances of success (Olckers, 2004). Preference for biological control agents is also highlighted by the adverse effects of chemical control. The side-effects and impacts on non-target species of the chemical control operations used against prickly pear, jointed cactus and other invasive cacti, for example, were severe. Arsenic pentoxide (sodium of arsenite) was widely distributed to farmers for the control of these cacti between 1893 and 1910. About 425+ tons of arsenic of soda were sold or issued to farmers in the Eastern Cape (Van Sittert, 2002). This most virulent poison was potentially as lethal to farmers' lands, livestock and labourers as it was to the targeted cacti. It caused considerable damage to thorn trees, shrubs, and herbage, as well as the health of livestock and humans while the overall hidden costs were high. Areas of spillage in the natural vegetation were free of all vegetation for more than forty years (Zimmermann, *pers. obs*.). Although the hormone weed killer (2,4,5-T diluted in illuminating paraffin) was less toxic to mammals, it was a potent tree and shrub killer. Between 1958 and 1979, 107 million litres of ready mix herbicide was distributed to farmers for the control of mainly jointed cactus (Moran & Annecke, 1979). This herbicide was later replaced by water based MSMA (Monosodium Methanearsonate, an organic arsenate) which was more selective and caused less harm to the environment. It was issued to landholders on a subsidised basis. Herbicide-dominated eradication of prickly pear took place during 1893 to 1930. Herbicide usage then shifted to jointed cactus between the years 1957 to about 1999 when full reliance was placed on biological control. The farmers were then issued with cochineal instead of herbicide to control the jointed cactus. During the 1970's considerable volumes of herbicides were also issued for the chemical control of the chain fruit cholla (*Cylindropuntia fulgida*). Recently, all support for the chemical control of this most vicious cactus was terminated when a highly successful biological control programme was launched.

3. History of invasive succulent plants in the region

by Helmuth G. Zimmermann

About 55% of all listed invasive plant species in South Africa are of horticultural origin. This is considerably more than the 6%, 11% and 13% that were introduced for forestry, agriculture and as barrier plants respectively (H. Klein, *pers. comm.*). Except for two *Agave* species, a *Furcraea* species (Fig. 14) and two *Opuntia* species (Fig. 15) practically all (about 300–400 species) of the introduced succulents came into the country as ornamentals. There are also a few that arrived in South Africa unintentionally. Presently there are only 24 succulent species on the CARA list (version 6 of 2007) of declared invasive plants. This figure is low compared to the many species that are now naturalised or widely cultivated as ornamentals. Certainly there must be some "sleeper" weeds amongst these that will become invasive in the years to come. Amongst these are several representatives of the Cactaceae, Crassulacaeae, Euphorbiaceae and other families. It is vitally important to identify these potential new invaders at an early stage and to prevent them from reaching harmful population numbers, in addition to preventing the introduction of new potentially harmful species. All these species need to be subjected to detailed risk analyses, which is now a new emerging science in botany (Richardson & Van Wilgen, 2004).

Fig. 14. *Furcraea foetida* (L.) Haw. was introduced into South Africa as a commercial fibre crop, but has escaped into natural vegetation. (Picture by Neil R. Crouch)

Fig. 15. *Opuntia robusta* Pfeiff. was introduced into South Africa as a fodder plant. (Picture by Gideon F. Smith)

According to Glen (2002) there are no less than 183 species in the Cactaceae that are cultivated in South Africa, while some succulent nurseries suggest that this figure is probably closer to 250 species. Except for *Rhipsalis baccifera* (J. Mill.) Stearn subsp. *mauritiana* (DC.) Barthlott (Fig. 16), an epiphyte, all species in the Cactaceae are alien to South Africa. Amongst the many introduced genera there are only a few that include species which have consistently shown tendencies to become invasive, such as *Opuntia*, *Cylindropuntia*, *Cereus* Mill., *Cleistocactus* Lem., *Harrisia* Britton, *Pereskia* Mill. and *Tephrocactus* Lem. Similar patterns are seen in Australia (J.R. Hosking, *pers. comm*.). Amongst the Crassulaceae, the genera *Kalanchoe* Adans. and *Bryophyllum* Salisb. could be identified as posing a threat to our environment because of the large number of species in these genera which show strong tendencies towards invasiveness. In contrast there are no indications, yet, of invasiveness in the genera *Sedum* L. and *Echeveria* DC. with more than 25 widely cultivated species recorded as occurring in South Africa. It is disconcerting that there are 61 and 7 species, respectively, in these two genera recorded as weedy in the Global Compendium of Weeds (Randall, 2010). It is highly probable that from amongst this pool new invasive succulents will emerge.

Fig. 16. *Rhipsalis baccifera* (J. Mill.) Stearn subsp. *mauritiana* (DC.) Barthlott is the only cactus indigenous to South Africa, indeed to Africa. (Picture by Neil R. Crouch)

Species in the genera *Opuntia* and *Cylindropuntia* stand out as being notoriously invasive not only in South Africa, but also in many other countries (Zimmermann *et al*., 2009). They all share certain characteristics which include heavy fruiting, vegetative reproduction, spines, good dispersal mechanisms and lack of natural enemies because of their taxonomic isolation. Not surprisingly it is now virtually impossible to obtain import permits for any species in these genera. The problems concerning Opuntieae are exacerbated where certain spineless cultivars of *O. ficus-indica* (L.) Mill. and O. *robusta* Pfeiff. are permitted because of their agricultural importance as fruit and fodder plants. These spineless cultivars are mutations which are then cloned and used for cultivation. Unfortunately with genetic recombination both species have reverted back to their wild spiny forms (Fig. 17, 18) which then become invasive. In the case of *O. ficus-indica,* this has resulted in a conflict of interest where some encourage and promote the species (spineless form) while others control and try to eradicate the same species (spiny form) (Beinart, 2003). This has serious legal implications as well as restricting the use of biological control which is often the only reasonable option. Resolving such conflicts of interest is difficult (Annecke & Moran, 1978; Middleton, 1999). *Cereus jamacaru* DC. is an aggressive invader in South Africa. In Israel, a member of the *C. hexagonus* complex referred to as *C. peruvianus* (Nerd *et al*., 2002) is cultivated for its fruit. This must be either *C. hildmannianus* or *C. jamacaru*, and it may be only a matter of time before selected cultivars are cultivated in South Africa giving rise to another potential conflict of interest issue.

Fig. 17. *Opuntia ficus-indica* (L.) Mill. plants reverting to the spiny form.
(Picture by Pieter J.D. Winter)

Fig. 18. *Opuntia robusta* Pfeiff. plants reverting to the spiny form. (Picture by Helmuth G. Zimmermann)

There are several potentially invasive alien succulents sold in nurseries as “sterile” cultivars, for example *Kalanchoe* selections and some *Echeveria* hybrids. This is certainly an option to lower the risk for unintentional invasions provided that the risk for reversion back to the wild forms is minimal. The cooperation of the nursery industry in determining these risks is vital. The Nursery Partnership Programme is aimed at minimizing the risk of releasing potentially invasive ornamentals into the environment. The so-called sterility of cultivars remain open to conjecture though.

Unlike other non-succulent invasive species e.g. in the genera *Campuloclinium* DC. and *Parthenium* L., succulents have generally a long lag phase before becoming invasive. It took close to 150 years for *Opuntia ficus-indica* to reach population levels which became harmful (Annecke & Moran, 1978; Von Sittert, 2002). *Opuntia aurantiaca* was introduced as an ornamental in 1843 but the first records of harmful invasions date from the 1890s (Moran & Annecke, 1979). The lag phase for *Harrisia martinii* (Labour) Britton (Fig. 19) and *Cereus jamacaru*

(Fig. 20) could be around 60 and 40 years respectively (Moran & Zimmermann, 1991a). *Agave americana* L. (Fig. 21) was deliberately introduced and cultivated in the Graaff-Reinet area in about 1850 but the plant has only been added to the CARA list as recently as 1980 (Henderson, 2001). Species with a long lag phase are particularly amenable for the early detection and rapid response programme which was recently launched in South Africa. Other succulent invaders, however, with a short lag phase are amongst the most aggressive species. The chain fruit cholla, *Cylindropuntia fulgida,* was first recorded in South Africa in the 1940s and extensive infestations were already present in the Douglas area during the 1960s. Despite intensive eradication programmes initiated by the Department of Agriculture in the early 1970s, the cactus continued to spread and develop dense populations. Other species in the genus *Cylindropuntia* show very similar tendencies. Unfortunately they are still sold by uninformed nurseries and are common rockery plants.

Fig. 19. *Harrisia martinii* (Labour) Britton had a lag phase of 60 years before it became a problem plant. (Picture by Gideon F. Smith)

Fig. 20. *Cereus jamacaru* DC. had a lag phase of 40 years before it became a problem plant. (Picture by Helmuth G. Zimmermann)

Fig. 21. *Agave americana* L. subsp. *americana* growing near Graaff-Reinet. Plants were introduced to that district in about 1850. (Picture by Neil R. Crouch)

4. Legislation and control programmes to manage unwanted invasions

by Helmuth G. Zimmermann

Nowadays virtually all countries have legislation to prevent the introduction and aid the control and management of unwanted species that impact negatively on agriculture and the environment. Invasive alien cacti in particular, are amongst the organisms that have had the most severe effects on agriculture in South Africa dating back almost 150 years. Legislation dealing with alien plants falls into two categories: (1) Acts that prevent the introduction of potentially invasive alien species into the country and (2) Acts that deal with the management and control of invasive alien plants already established in the country.

4.1. Acts that prevent introduction

There was no legislation prior to 1911 that prevented or controlled the introduction of unwanted organisms into South Africa. Several events or periods between 1652 and 1911 can be identified that were responsible for the introduction of many alien plant invaders. These events are well described by Wells *et al.* (1986). It was during this period, spanning 250 years, that many important cactus and at least one *Agave* species were deliberately introduced as part of the attempts of the European colonists and colonial rulers to "beautify" the colony and to establish new and useful plants species wherever possible. Annecke & Moran (1976), Moran & Annecke (1978) and Van Sittert (2002) give detailed accounts of the introduction and spread of prickly pear (*Opuntia ficus-indica*) and *O. aurantiaca,* the two alien weeds that have impacted greatly on the lives of humans and animals in the Western, Eastern and Northern Cape Provinces. The efforts are well known and documented, of individuals, like Baron Carl Ferdinand Heinrich von Ludwig (1784–1847) who resided in Cape Town and played a key role in receiving exotic plants from contacts in India, Europe and, in particular, Great Britain (often in exchange for members of the Cape flora) (Moran & Annecke, 1978). He has been credited with introducing *Cereus*, *Opuntia aurantiaca* and other *Opuntia* species (Bradlow, 1965). L.W. Sammons reports in Sam Sly's Journal dated October 1843 (see Moran & Annecke, 1978) that "the finest collection in this Colony of Mammillarias, Echinocacti, Cereus – Melocactus, Opuntia etc. lately arrived in Cape Town in the *Bosphorus* from England". The account also mentioned that plants for the Baron came mainly from the estates of Woburn Abbey and Chatsworth, and from the botanical gardens at Kew, Glasgow and Edinburgh. Woburn Abbey was known to have "the finest cactus collections in England". Forbes (1837) lists 315 species of cacti in the collection, including 81 species of *Opuntia* and *O. aurantiaca* is specifically mentioned. Other records of plant exchanges between the Baron and other famous gardens in Britain, e.g. Chiswick Gardens, that were "over-flowing with orchards and cacti" according to Fletcher (cited in Moran & Annecke, 1978), have been recorded. There is thus circumstantial evidence that *Opuntia aurantiaca* (and probably other cacti) arrived in Cape Town perhaps during 1843 and was passed on from the Ludwig's garden to the Cape Town Botanical Garden (not to be confused with the Kirstenbosch National Botanic Garden) between 1848 and

1858. The curator of the garden, J. McGibbon was in touch with missionaries who were often interested in botany and introducing new crops and novelties to their remote mission stations. Strange looking succulents were certainly novelty plants that have attracted much attention.

Text Box 2. Prominent legislation dealing with alien plants in South Africa.

DCA: The Divisional Council Act No. 40 of 1889
APA: Agricultural Pest Act No. 11 of 1911
The Cape Provincial Council Ordinance No. 18 of 1928
The Jointed Cactus Eradication Act No. 52 of 1934
The Weeds Act No. 42 of 1937
The Soil Conservation Act No. 76 of 1969
APA: Agricultural Pest Act No. 3 of 1973
APA: Agricultural Pest Act No. 36 of 1983
CARA: Conservation of Agricultural Resources Act No. 43 of 1983
ECA: The Environment Conservation Act No. 73 of 1998
NEMA: The National Environmental Management Act No. 107 of 1998
NEMBA: The National Environmental Management: Biodiversity Act No.10 of 2004

In summary it can be assumed that many cacti and other succulents from the New World were already introduced and established in South Africa by 1911 and that the spread of two of these, *Opuntia aurantiaca* and *O. ficus-indica,* had already reached alarming proportions in the Eastern Cape which urgently warranted control measures.

The first Agricultural Pest Act (APA), No. 11 was promulgated in 1911 and was aimed primarily at preventing the introduction of agricultural pests. Plants could only be imported into the country under the authority of a permit. The Act also provided special powers to control and eradicate pests of national importance affecting agriculture e.g. locusts. The emphasis was on crop security and protecting agricultural production. By this time the then Cape Province (now the Western, Eastern and Northern Cape Provinces) already had a history of almost 60 years of trying to cope with the serious invasions of prickly pear and jointed cactus and Government officials were sensitised towards other potentially dangerous invasive cacti in general. It would therefore have been difficult to legally introduce further jointed cactus-type plants. This Act was later replaced by the APA, Act 3 of 1973 and later by the APA, Act 36 of 1983 (with at least five amendments) which continued to regulate the importation of all “controlled goods” including plants. Species for introduction are subjected to pre-border and post-border weed risk assessments following guidelines provided by the International Plant Protection Convention (IPPC) (FAO, 2006). As with the previous Act, the emphasis was on protecting agriculture.

It was only after the Convention on Biological Diversity (CBD) was ratified in 1995 that new legislation controlling the importation of potentially invasive species was considered. There are three Acts, all mandated by the Department of Environmental Affairs, that affect the introduction and management of invasive alien species in some or other way with the emphasis on protecting the environment and biodiversity. These are (1) The Environment Conservation Act No. 73 of 1998 (ECA); (2) The National Environmental Management Act No. 107 of 1998 (NEMA) and; (3) The National Environmental Management: Biodiversity Act No.10 of 2004 (NEMBA). Chapter 5 of NEMBA deals specifically and comprehensively with the introduction and management of invasive alien species. The Regulations regarding established plants are based on lists that are divided into specific categories, each with its own particular management prescriptions. These lists match similar lists published under the Conservation of Agricultural Resources Act (CARA). Legal action and financial support to control invasive plants is only possible once a species has been listed. The NEMBA regulations, however, also provide for emergency interventions and for an early detection and rapid response programme to deal with new and emerging issues. New introductions of alien organisms can only occur under the authority of a permit after subjecting the species to an initial and/or a comprehensive risk assessment process. Harmonization between NEMBA and the two agricultural Acts (APA and CARA) regarding invasive plants is required. The environmental Acts are implemented mainly at provincial level while the agricultural Acts are implemented nationally. Two import permits from two different Government Departments will therefore be required in future, based on separate risk assessments, to introduce new ornamental succulents into South Africa.

The control of imported seeds through the postal services remains a challenge though. All seeds of ornamental cacti and many other succulents are small and can easily be sent by conventional air or surface mail. This challenge is compounded by the easy access to seeds through the internet trade.

4.2. Acts that deal with the management and control of invasive plants

There were a few Acts in place during the late nineteenth century that focused specifically on the control of three weeds. These were *Xanthium spinosum* L., *Opuntia aurantiaca* and *O ficus-indica.* Until 1911 *Opuntia ficus-indica* was undoubtedly the plant invader that had had the greatest impact on agriculture and the environment but it was never included in any Act that would assist in its management and control at a national (Cape Colony) level. The reason for this was the conflict of interest amongst landholders regarding the dangers and benefits of prickly pear. The farmers north of the Winterberg/Amatola line could benefit from the prickly pear because the plant was considerably less invasive in the climatically severe, and much colder Upper Karoo while severe invasions occurred south of this line. Until this day there has never been a weed that has generated so many discussions and produced so many reports as the prickly pear. The history of the introduction, invasion, impact and control of prickly pear in South Africa, and the conflicts around its weed status have been documented in detail by Annecke & Moran (1978), Beinart (2003) and Van Sittert (2002). No other plant has contributed more to creating a general awareness concerning the dangers of invasive plants, in particular the dangers of exotic cacti in this country.

Despite several efforts to pass a national law to enforce control measures for prickly pear, during the late nineteenth and early twentieth centuries, this never materialised. The last attempts occurred in 1906 but as in previous cases, the Director of Agriculture again refused to authorise a Prickly Pear Act on grounds that "it would be a hardship to (some) farmers and unfair towards the general taxpayer". Instead, the responsibility for control of prickly pears was devolved to local authorities such as the Divisional Councils. The 1889 Divisional Council Act (amended twice between 1889 and 1910) catered primarily for *Xanthium spinosum* but ignored prickly pear except in two districts where it was proclaimed a noxious weed. The Acts were toothless, were not backed with adequate finances to implement them, had limited powers and contributed little towards solving the prickly pear problem.

There was, however, no conflict of interest with jointed cactus, *Opuntia aurantiaca,* and expensive programmes were put in place to control this plant. The promulgation of the Cape Provincial Council Ordinance No. 18 of 1928 made the control of jointed cactus compulsory. This was followed by the more powerful Act No. 52 of 1934, the Jointed Cactus Eradication Act which placed the responsibility for control on the State Department of Agriculture. Under this Act teams of departmental labourers were employed to assist in the mechanical and chemical control of jointed cactus (Moran & Annecke, 1978; Pettey, 1948). This Act was eventually replaced by the Weeds Act of 1937 which continued to make State subsidies available for the control of mainly jointed cactus. A new subsidy scheme was put in place in 1957 to chemically control jointed cactus, prickly pear, imbricate cactus and chainfruit cholla (previously known as the rosea cactus) and later also other declared invaders e.g. nassella tussock grass. The subsidy scheme was later managed under the Soil Conservation Act of 1969. Eventually the Weeds and the Soil Conservation Acts were replaced by the Conservation of Agricultural Resources Act, better known as CARA (Act No. 43 of 1983) which continued with the subsidy schemes until 1999 when the Working for Water programme took over many of the initiatives on invasive plant control, including those on the invasive cacti.

The objectives of CARA were, *inter alia*, "the protection of the vegetation and the combating of weeds and invader plants". However, this role was to a large extent taken over by NEMBA which purports to "manage and control invasive species to prevent or minimise harm to the environment and biological diversity, and in particular where possible and appropriate, eradicate invasive species that may cause such harm". These two Acts do not only share the same objectives but also share similar lists of invasive alien plants that are declared and subjected to specific control measures. In order to take any action against any invasive plant species it must be listed and must fall into one of three or five categories respectively. The CARA list contains 198 species divided into three categories, each one with its own control and management prescriptions. There are 24 succulent species listed in CARA (version 6 of 2007), 17 of them belonging to the family Cactaceae. The proposed NEMBA list will have close to 345 species divided into five categories. There are over 30 succulent species in this list, 16 of them being cacti. A revised CARA list will reflect the same species and categories.

4.3. Control programmes

Historically, several national campaigns aimed at the control of some cactus and other invaders have been implemented in South Africa. Some date back to the late 19th century when mechanical clearing of invasive prickly pear in the eastern Cape Colony was instigated by the Cape colonial government sometime after 1883 (Annecke & Moran, 1976). This campaign was unsuccessful and was replaced by chemical control based on using a highly poisonous arsenic-based herbicide (arsenite of soda) which remained in use for some 50 years, against both prickly pear and jointed cactus. The environmental impact of this highly toxic compound on plants, animals and humans was horrendous (Van Sittert, 2002). Biological control followed which was shown to be most successful when a cochineal insect, *Dactylopius ceylonicus*, was obtained from India in 1913 which controlled the cactus weed, *Opuntia monacantha* Haw., along the southern coast of South Africa (Fig. 22). This, accompanied by the success of the biological control of *O. stricta* in Australia and supported by public pressure to act on the threat posed by *O. ficus-indica* and *O. aurantiaca*, convinced the minister of Agriculture of that time to embark on a biological control campaign which lasted for thirty years. Two natural insect enemies, the cactus moth, *Cactoblastis cactorum* and the cochineal, *Dactylopius opuntiae*, were introduced in the thirties to control prickly pear and, assisted by hand felling of infested plants, eventually cleared about 80% of the infestations by the late 1950s (Annecke & Moran, 1978). There was a strong lobby of Karoo farmers at the time that vehemently opposed biological control, contributing to a debate which continues to this day (Beinart, 2003). Fortunately it is still possible to successfully cultivate the commercial varieties of prickly pear despite the presence of the two biological control agents that are now regarded as pests in plantations and orchards. A similar successful campaign was also launched at about the same time against jointed cactus, *O. aurantiaca,* using another host-specific cochineal species, *Dactylopius austrinus* originally from Argentina, and introduced from Australia in 1935 (Moran & Annecke, 1978). The introduction of yet another cochineal, *D. tomentosus*, in 1958 for the control of the imbricate cactus, *Cylindropuntia imbricata,* and *C. leptocaulis,* followed (Moran & Zimmermann, 1991a). Recently, equally successful, biological control projects were launched against *Opuntia stricta* and *Cylindropuntia fulgida* using host-specific selected biotypes of *Dactylopius opuntiae* and *D. tomentosa,* respectively (Paterson *et al*., 2011; Zimmermann *et al*., 2004). The cactus mealybug, *Hypogeococcus pungens* (also known as *H. festerianus*), was also successful in controlling rampant invasions of *Harrisia martinii* and *Cereus jamacaru* in the 1980s and 1990s. Other biological control projects implemented against other succulent cacti, however, were less successful, for example *Pereskia aculeata* (Klein, 1999). In general, the track record of biological control against invasive cacti in South Africa is exceptionally good compared to attempts to control invasive representatives of other plant families in the same way. This is partly because of the host specificity of the cactus-feeding natural enemies as well as the fact that, with the exception of a single species of *Rhipsalis* Gaertn.*,* Africa is void of native species in this rather unique family of plants, allowing for a larger selection of host-specific insects to be used.

Fig. 22. About 100 years ago populations of *Opuntia monacantha* Haw. were biologically controlled by releasing a cochineal insect on them. (Picture by Helmuth G. Zimmermann)

Chemical control, using the highly toxic inorganic sodium of arsenite, was the only method available to kill invasive cacti for many years. Since 1957 a new hormone herbicide, 2,4,5-T diluted in illuminating paraffin was supplied to landholders gratis, provided that they used their own labour to treat the cacti. This scheme was primarily aimed at the control of jointed cactus but was later also used against other invasive cacti. 2,4,5-T was later replaced by Picloram which showed serious non-target effects because of the tendency of jointed cactus to grow under trees which are highly sensitive to this product. Currently another herbicide, namely an organic arsenate product, MSMA (monosodium methanearsonate) is registered for the control of cacti (Anonymous, 2004). Most succulents, and in particular cacti and *Agave* species, are very sensitive to any arsenical-based herbicide. MSMA which is relatively less expensive and considerably less toxic than the inorganic arsenites, is effective against all invasive cacti and has less non-target effects on other vegetation. Stem succulents such as prickly pear, *O. stricta* and *Agave* species, are effectively controlled with stem injections of small quantities of MSMA (Zimmermann, 1989). A second, but less effective, herbicide, namely glyphosate, is also registered for the control of some cacti but was never made available in any subsidy scheme.

4.4. Nursery Partnership Programme

Nurseries have been the origin and point of distribution of many invasive plant species in South Africa. There are well over 250 species of cacti, *Agave* and non-native, succulent and non-succulent *Euphorbia* L. cultivated in South Africa (Glen, 2002) most of which are found in, or originated from, the nursery trade (Fig. 23). Fortunately very few of these species show tendencies to naturalise or become invasive. Deliberate introductions by Botanical Gardens and Government departments also provided their share of invasives. It is a formidable but essential task to identify species at an early stage of invasion and then to take quick action. The Nursery Partnership Programme aims to do this by preventing the sale of potentially invasive species. It remains the State's duty to, firstly, prevent the introduction of potentially invasive succulents and secondly, to identify dangerous species already in the country that have the potential to become invasive and then to take quick action. The cooperation of the nurseries is essential in achieving this goal. CARA provides a list of "emerging species" that show tendencies towards invasiveness but which still lack the evidence to be categorised. Some of these species are still found in the nursery trade. The ideal is to convince all nurseries to join the South African Nursery Association (SANA) and to adhere to a code of conduct. Unfortunately there are still far too many nurseries that trade in listed and emerging species and the regulatory arm of the Government is not able to prevent this.

Fig. 23. A wide variety of cactus species are offered for sale in the nursery trade. Some of these may eventually become problematic. (Picture by Helmuth G. Zimmermann)

4.5. Early detection and rapid response programme

"Prevention is better than cure" and this is certainly the case for invasive alien species. It makes economic sense to deal with invasions at an early stage before they are out of control and when they can still be eradicated or contained. Considerable know-how and experience is required to identify those potentially aggressive invaders amongst hundreds of exotic succulent species in cultivation, that could justify a rapid response programme. These decisions are based on detailed risk assessment analyses which are supposed to predict the aggressiveness of an invader. Such an early detection and rapid response programme has recently been launched in South Africa managed by the South African National Biodiversity Institute (SANBI) supported by the Working for Water Programme. Since the inception of the project several new succulents e.g. *Bryophyllum pinnatum* (Fig. 24), *Cylindropuntia fulgida* var. *mamillata, Tephrocactus articulatus* (Pfeiff.) Backeb., *Opuntia salmiana* J.Parm. ex Pfeiff. and *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi have been identified and are now being targeted for rapid response actions. The Programme relies heavily on the experiences of other countries with similar climates, e.g. Australia, and on the participation of "spotters", the SAPIA programme and interested stakeholders to identify new invaders at an early stage of establishment.

Fig. 24. *Bryophyllum pinnatum* (Lam.) Oken has recently become a pest plant in South Africa. (Picture by Neil R. Crouch)

5. Collecting succulent plants for deposition in a herbarium

by M. Walters

5.1. What is a plant specimen?

A preserved plant specimen is a dried and mounted or pickled voucher that is the botanical world's equivalent to the zoologist's stuffed animals, skins or insect collections that are kept in natural history museums (Fig. 25). Plant specimens are housed in herbaria which are permanent repositories of specimen collections and their associated data.

Fig. 25. A preserved specimen of an indigenous succulent, *Aloe arborescens* Mill., kept in the National Herbarium of South Africa (PRE). (Picture by SANBI)

5.2. How are plant specimens useful?

Herbarium specimens in the vast collections held by Herbaria all around the world are extremely valuable for a number of reasons. Not only are specimens useful when trying to identify plant material, they also provide a record of where and when a particular species was found growing. The information that can be found on the specimen label is valuable too, and may give clues as to, for instance, soil substrate the plant was found growing in. As classifying plants is not a static process, and plant names may therefore change as species concepts change or as new evidence for re-classification is found, specimens can be used to verify past identifications. Label information on herbarium specimens is also used as a way of determining the area of occupancy (AOO) of species, which is an important parameter to determine their conservation status (Red List status) (Hernández & Navarro, 2007). This method results in more accurate, less overestimated determinations of AOO, and will as a result produce more useful and valuable Red List assessments.

5.3. Why bother collecting voucher specimens for exotics?

There are many more ways in which specimen collections are useful, but as far as alien plants are concerned, physical specimens can be of particular use, when investigating points of entry and range expansion of these species over time. They also aid in the development of predictive habitat models that may give clues about habitat preference and potential for future spread.

Most people know better than to touch a cactus with their bare hands. The spines and fine glochids, in the case of representatives of *Opuntia* (prickly pears) and their relatives, found on most species can be very irritating and quite painful when lodged under the skin. So when appeals are made for collecting and pressing these plants, a general lack of enthusiasm is usually shown by professional botanists and by the public alike. Preparing preserved specimens of these plants with their unwelcoming, prickly habit may seem like more effort than it is worth. For this reason, cacti are often not collected and are thus poorly represented in herbaria (Leuenberger, 1987). This is particularly true for southern Africa where, except for one species (*Rhipsalis baccifera* subsp. *mauritiana*), cacti do not comprise part of the indigenous flora and are thus mostly ignored, even by environmental consultants and other specialist collectors. Unfortunately, because of this, potentially valuable information about these plants does not reach the people responsible for monitoring and controlling their spread. The collection of herbarium specimens greatly enhances the quality of invasions biology as a whole by providing study material for current and future studies (Carter *et al*., 2007).

5.4. How to contribute to expanding herbarium plant collections

A basic 3-step process is followed to prepare useful herbarium specimens.

1. Collecting (Fig. 26)
2. Preparation and pressing (Fig. 27)
3. Identification and mounting

5.4.1. Collecting

Selecting the material

When selecting plants for pressing it is important to bear in mind that it is preferable for specimens to have flowers and/or fruit included to aid identification (Leuenberger, 1987; Victor *et al*., 2004). A specimen consisting of sterile material accompanied by the correct information, however, is better than nothing and may be useful in providing pieces of the puzzle for a taxon as a whole. A specimen of, for example, an exotic plant should therefore be made regardless of whether the plant is flowering or not. Adding an illustration (drawing, photograph, print of an electronic image) to the specimen can considerably enhance its value.

In the case of smaller plants, it is best to collect the entire plant, including underground parts, while for larger plants, representative parts should be collected. These should include mature and immature parts, lower and upper leaves, buds and coppice shoots (Victor *et al*., 2004).

Collecting

Once you have selected a plant it is best to place it in a plant press immediately or, if that is not possible, in paper bags. The use of plastic bags is discouraged as it causes sweating in succulent plants, which results in the formation of mould (Burgoyne & Smith, 1998). Large specimens can be bent or cut before placing them in a press. In the case of fat-bodied plants such as cacti, both longitudinal and cross-sections should ideally be prepared, pressed and dried. Care should be taken when working with spiny plants and it is advisable to wear protective gloves. Some plants (like those in the Euphorbiaceae) contain irritant plant sap and contact with the skin, mucous membranes and particularly the eyes should be avoided.

Fruits and flowers, as mentioned, are often critical for correctly identifying plants. This is particularly true for many cactus species, where dissection of the flowers or fruits facilitates correct identification. It is therefore often useful, not only to press, but also to collect whole fruits and flowers. These may be preserved —pickled— in jars with 50–70% diluted ethanol (Leuenberger, 1987).

To prevent the further spread of exotic plants, special care should be taken that no seeds or reproductive parts of the plant is dispersed during and after collecting (Carter *et al*., 2007). This means not only the careful checking of equipment but also clothing and the bottoms of shoes, shoe laces and especially any velcro.

Auxiliary information

Ideally a specimen should be accompanied by photographs of the plant while still growing in its natural habitat. These are valuable complimentary identification tools that provide information on habit or other characters not always visible on dried, preserved specimens (Leuenberger, 1987).

Fig. 26. Collecting plant material for deposition in a herbarium. (Picture by SANBI)

Other relevant data should also be recorded on field labels, in collecting books or in portable electronic data-capturing devices, where possible. Essential information includes: Name of collector, date of collection and where it was collected (with map or GPS coordinates). Other useful information includes: altitude, aspect, vegetation type, geology, soil type, abundance (frequent or rare), plant size and height, stem diameter as well as details that may be lost upon drying, such as flower or fruit colour, presence and colour of sap or latex and scent (Victor *et al*., 2004). It is not always possible to collect all this information but at the very least where, when and by whom the plant was collected should be recorded.

5.4.2. Preparation and pressing

While preparing a specimen of a herbaceous plant is reasonably straightforward, the same is not true for succulents, which are often bulky specimens. For a specimen of a succulent to be useful to taxonomists and other researchers it has to be handled and pressed correctly (Bridson & Forman, 1998; Victor *et al*., 2004). Unlike other plants, many succulents have to be treated before pressing (Smith, 1991; Eggli & Leuenberger, 1996; Burgoyne & Smith, 1998).

After collecting, field presses and/or paper bags containing succulents should be put in a freezer at c. -4°C for 24 hours (smaller plants require less time in the freezer) (Leuenberger, 1982; Burgoyne & Smith, 1998, and references therein).

The specimens should then be placed in a microwave for a period of 1–5 minutes (depending on the size of the specimen), a few at a time (though bundles should not exceed 50 mm in thickness), or larger plants on their own, at 80% power, which leaves them pliable and easy to manipulate (Burgoyne & Smith, 1998).

Fig. 27. Plant presses with specimens drying in the sun during a field collecting expedition. (Picture by SANBI)

Other methods for removing succulent plant tissues involve scraping out of inner plant tissues, or dipping plants in boiling water or organic liquids. The method described above, however, causes the cells to burst, allowing the resulting watery substance to simply be poured off (Burgoyne & Smith, 1998). Specimens should be removed from the microwave once they turn a dull green, at which point they are ready to be dried in a plant press. Note, however, that microwaving a specimen can yield it useless in further studies that require the removal of small sections of material for chemical or molecular analyses. The accompanying specimen label should therefore indicate whether material was microwaved. Many taxonomists actively discourage the use of a microwave oven in pre-treating specimens and prefer other less destructive methods when removing moisture from material intended for depositing in a herbarium.

Plants should be arranged in the press in such a way as to provide the most information to the user. All plant parts should be shown clearly, both sides of a leaf should be visible and the curling of leaves should be avoided. Attaching a jeweller's tag conveying the collector's name and collection number to the specimen will ensure that the specimen can eventually be associated with the correct field notes compiled by the collector.

The plant press should be packed in the correct sequence as follows (from Victor *et al*., 2004):

1. The wooden lattice frame
2. Corrugated cardboard or aluminium ventilator (corrugations run parallel to the short side)
3. Two sheets of drying paper (newspaper, cut to size, works well and is inexpensive)
4. Flimsy (thin, strong, slightly absorbent paper, such as unprinted newspaper) containing a specimen
5. Two sheets of drying paper, followed by flimsy containing a specimen
6. A ventilator after each 5–8 specimens, or after every second specimen, if the material is very bulky
7. Finish with a ventilator and the other wooden lattice frame

The drying process should not take place in too hot an environment and 45°C is considered ideal (Victor *et al*., 2004). Damp drying paper should be changed daily for about the first week after which longer intervals can be allowed, unless atmospheric humidity is very high. Damp cardboard ventilators should also be changed and care should be taken that flimsies, though not requiring changing, do not adhere to the specimens (Victor *et al*., 2004). A simple and rapid technique for drying damp newspaper flimsies and cardboard when out in the field is to spread these around on the dry ground in full sun securing them with stones. On sunny days they can be fully dried in 30 minutes or less.

5.4.3. Mounting and identification

At this point in the process specimens are usually handed over to experts as identification and mounting is done by herbarium staff. For more detailed information on the mounting of specimens please refer to Victor *et al.* (2004). Here we give a brief description of the process.

In the herbarium, the specimen is identified, a label is written, and these are then neatly arranged on a white mounting board (300–400 g and 270 × 420 mm) with the label in the lower right hand corner. Labels usually display at a minimum the unique collecting number, date and place of collection, the collector's name, the species and family names, and who determined (identified) the species. Specimens and plant parts are fixed to mounting boards with any or a combination of the following: envelopes, glue, strapping (strips of white, gummed or self-adhesive paper) or stitching.

Plant specimens may last indefinitely if they are properly prepared and cared for, kept away from water and protected against humidity and pests. In this regard it should be noted that all mounting sheets and paper used for preparing specimens and labels should be of archival quality. The same applies to the ink used for producing the labels. Each specimen is a permanent record of the occurrence of a species in time and space (Carter *et al*., 2007) and in this way immortalises the collector, who contributes to the wealth of knowledge held in herbaria to be used by future generations of plant enthusiasts (Burgoyne & Smith, 1998).

6. Invasive succulent plants

AGAVACEAE Dumort.

(Century plant family; *Garingboomfamilie*)

by

G.F. Smith

Robust, monocarpic, usually rosulate perennials arising from a short rhizome or short, erect caudex. **Stem** commonly with monocotyledonous type secondary growth. **Leaves** usually crowded in basal rosette or perched at top of stem, stiff, leathery to succulent, amplexicaul, persisting for many years, margins heavily armed or saw tooth-like; each vascular bundle with well-developed fibrous cap at phloem pole. **Inflorescence** terminal, tall, fast-growing, terminating in a panicle or spike-like panicle, often massive. **Flowers** bisexual, regular or somewhat irregular, tubular, pedicellate, 3-merous throughout. **Perianth** petaloid, 3 + 3, often fleshy, united below to form a tube. **Stamens** 3 + 3; anthers mostly dorsifixed, introrse, versatile, opening by longitudinal slits, linear to oblong. **Ovary** inferior or superior (tribe Yucceae), 3-locular, with septal nectaries; placentation axile; ovules in 2 vertical rows in each locule; style terminal; stigma 3-lobed. **Fruit** a loculicidal capsule or indehiscent berry. **Seeds** many, flattened, black.

References: Cronquist (1981), Dahlgren *et al.* (1985), Pedley & Forster (1986), Bogler & Simpson (1995), Verhoek (1998), Smith (2000), Reveal & Hodgson (2002), Smith (2003); Govaerts *et al*. (2009).

The Agavaceae (sometimes included in a broadly conceived Asparagaceae) is a medium-sized family consisting of c. 300 species of mostly leaf succulents from the New World, particularly Mexico, the southern United States of America, Caribbean Islands, Central America and northern South America (García-Mendoza, 1998). Eight genera are included in the Agavaceae: *Agave* L., *Beschorneria* Kunth, *Furcraea* Vent., *Hesperaloe* Engelm., *Manfreda* J.H.Salisb., *Polianthes* L., *Prochnyanthes* S.Watson, *Yucca* L. [including *Hesperoyucca* (Engelm.) Baker, a genus sometimes treated as monotypic].

The family is mostly adapted to desert-like conditions, and the vast majority of the species will survive under severe environmental conditions, particularly aridity and low temperatures, but they also do well in tropical and subtropical areas. Not surprisingly therefore, representatives of the family are widely naturalised in southern tropical Africa, Australia and Mediterranean Europe, among other places (Smith, 1997; Smith & Figueiredo, 2007; Smith & Van Wyk, 1999). Most species remain herbaceous, some becoming quite massive, with only a few attaining pronounced, tree-like dimensions and appearing to be 'woody'. Many representatives are rhizomatous, proliferating through basal suckers or from leaf axils (Smith, 2006b).

Flowers are tubular or campanulate, erect or dangling, lantern-like and clustered into racemes or panicles. However, in contrast to their lilioid look-alikes (for example aloes), the flowers of which all have superior ovaries, the flowers of representatives of only one group within the Agavaceae, the tribe *Yucceae*, consistently show this trait. In contrast, representatives of the tribe *Agaveae* all have inferior ovaries. Most species of the most speciose genus, *Agave*, as well as species of *Furcraea*, are monocarpic multiannuals that die after having flowered, usually after many years. However, most proliferate through basal or stem suckers, so perpetuating genetically identical offspring of the dying rosettes. These sprouts will in many instances form dense colonies that can preclude natural vegetation where they become established. Several species produce bulbils on their inflorescences, often during, but mostly immediately after, flowering is complete. These drop from the inflorescence and will easily strike root where they fall.

Much has been written about the human-agave interface, and representatives of the genus have provided an astonishing range of products that have been used since ancient times. For example, some species are useful as sources of fibre (including *Agave sisalana* Perrine and *A. fourcroydes* Lem.), while liquors such as tequila (produced from *A. tequilana* F.A.C.Weber in certain states of Mexico) and mescal are produced from others (for example *A. colorata* Gentry).

A total of eight species from two genera of the Agavaceae are naturalised in southern Africa.

Key to the two naturalised genera:

1. Flowers erect; perianth segments fused into a tube below the middle; filaments and style not swollen; bulbils plant-like. . . . . ***Agave***
1'. Flowers pendulous; perianth segments ± free; filaments swollen at base and style base dilated, bulbils globular. . . . . ***Furcraea***

Agave L.

Robust, monocarpic, usually rosulate, multi-annual perennials arising from short rhizome or short erect caudex. **Stem** commonly with monocotyledonous type secondary growth. **Leaves** usually crowded in basal rosette, leathery to succulent, amplexicaul, persisting for many years; each vascular bundle with well-developed fibrous cap at phloem pole. **Inflorescence** apical, tall, fast-growing, terminating in a panicle, often massive. **Flowers** bisexual, regular or somewhat irregular, tubular, pedicellate, 3-merous throughout. **Perianth** yellow or greenish, often with a reddish or brownish tint, petaloid, 3 + 3, often fleshy, united below to form a tube. **Stamens** 3 + 3, epipetalous; anthers mostly dorsifixed, introrse, versatile opening by longitudinal slits, linear to oblong. **Ovary** inferior, 3-locular, with septal nectaries; placentation axile; ovules in 2 vertical rows in each locule; style terminal; stigma 3-lobed. **Fruit** a loculicidal capsule. **Seeds** many, flattened, black.

References: Berger (1915), Standley (1920), Bailey (1958), Gentry (1972, 1978, 1982), Webb (1980), Espejo Serna & López-Ferrari (1993), Smith & Mössmer (1996), Irish & Irish (2000), Smith (2000), Thiede (2001), Smith (2006), Smith & Klopper (2007), Smith *et al*. (2008).

In terms of number of included species, c. 200, the genus *Agave* is the largest of the agavoid genera. *Agave* is a well known succulent plant genus of the New World being indigenous to Mexico, Central America, northern South America and the southern United States of America, as well as the West Indies. Representatives of the genus have been cultivated in southern Africa for several centuries, in both amenity and domestic horticulture. Two species have been used locally in agriculture, *Agave americana* as cattle fodder, and *A. sisalana* for fibres for use in rope making, for example.

To most people, some species of *Agave*, are best known as the source of sisal fibre and the alcoholic beverage tequila. A reversion to the beauty and practicality of natural fibres, has made carpets made from the near-indestructible sisal fibres essential products in modern interiors. On the other hand, two cocktails in particular, tequila sunrise and margaritas, of which especially the latter has produced numerous variations, contributed immensely to the current global popularity of tequila, which is essentially a type of mescal. Tequila is produced exclusively from *A. tequilana* F.A.C.Weber [nowadays sometimes referred to as *A. angustifolia* Haw. subsp. *tequilana* (F.A.C.Weber) A.G.Valenzuela-Zapata & G.P.Nabhan cultivar *azul*]. In addition, to be legally called tequila, the *Agave tequilana* 'pineapples' from which it is distilled must be harvested and produced in Mexico in one of five approved regions in the country: the entire state of Jalisco, and certain villages in the states of Nayarit, Tamaulipas, Michoacán, and Guanajuato.

Rosettes of most *Agave* species that produced a flowering pole will die. However, this does not mean the end of a specimen, as many species are proliferous through basal or stem suckers. These suckers will in many instances form dense colonies that can preclude natural vegetation where they become established. The leaves of species of *Agave* are usually crowded near the base of the plants into a sessile rosette, stiff, fleshy and armed with vicious teeth at their tips and along their margins. Smooth leaf-margined species are rare in *Agave*. In the very few species common in cultivation that have a true stem, for example *A. attenuata* Salm-Dyck, leaves are crowded near the tips of the stems.

Given that some *Agave* species are widely cultivated in southern Africa, they have been known to be problem plants locally for several decades (Wells, 1986).

Key to the *Agave* taxa naturalised in southern Africa:

1. Leaf margins devoid of teeth . . . . **5. *Agave sisalana***
1'. Leaf margins armed with small or large, sharp teeth **2**

2. Leaves distinctly light blue to glaucous green **3**
2'. Leaves light- to dark green, never blue **4**

3. Marginal leaf teeth inconspicuous, small, usually the same colour as the leaf surface . . . . **4. *Agave celsii* var. *albicans***
3'. Marginal leaf teeth prominent, usually brown **5**

4. Plants solitary . . . . **7. *Agave wercklei***
4'. Plants proliferous from the base **6**

5. Leaves often drooping to one side; plants massive . . . .**1. *Agave americana* subsp. *americana* var. *americana***

5'. Leaves erect to stiffly spreading; plants medium-sized to large . . . . **2. *Agave americana* subsp. *americana* var. *expansa***

6. Leaves dull green, armed with short, brown teeth; mid-rosette leaves spreading, closely packed on stem . . . . **3. *Agave angustifolia* var. *angustifolia***

6'. Leaves dark green, armed with prominent, greenish brown teeth; mid-rosette leaves erect, widely spaced on stem . . . . **6. *Agave vivipara* var. *vivipara***

1. *Agave americana* L. subsp. *americana* var. *americana*

In: *Species plantarum* 1: 323 (1753a).

=*Agave complicata* Trel. ex Ochot.
=*Agave felina* Trel.
=*Agave gracilispina* Engelm. ex Trel.
=*Agave melliflua* Trel.
=*Agave rasconensis* Trel.
=*Agave subzonata* Trel.
=*Agave zonata* Trel.

Common names: agave, American agave, American aloe, century plant (English); Amerikaanse aalwee, Amerikaanse aalwyn, blou-aalwee, blougaringboom, gareboom, garingboom, kaalgaarboom, makaalwyn (Afrikaans); lekhala (Sotho).

Large to massive, acaulescent or short-stemmed, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 2 m tall, profusely proliferous through basal suckers. **Leaves** erect at first, becoming spreading to reflexed, flopping over to one side, lanceolate, 1–2 m long, light blue; margins armed with numerous, straight to flexuose or variously recurved, simple teeth, up to 1 cm long; apical spine conical to subulate, 3–5 cm long. **Inflorescence** paniculate, 5–9 m tall, branched, never bulbiliferous. **Flowers** erect, 7–10 cm long, yellow to greenish yellow. **Stamens** with filaments 6–9 cm long; anthers 3–3.6 cm long, centric to excentric, yellow. **Fruit** a capsule, oblong, 4–5 cm long. **Seed** lunate to lacrimiform, 7–8 × 5–6 mm, shiny black. **Distribution**: B, L, S, SA. (Fig. 28).

References: Berger (1915), Gentry (1982), Pedley & Forster (1986), Couper & Cullen (1988), Smith & Mössmer (1996).

This large, almost invariably blue-leaved century plant (Fig. 29), grows to massive dimensions and is very widespread in southern Africa. Unlike those of *Agave americana* var. *expansa*, the leaves of the typical variety usually droop to one side (Fig. 30). Several names have been applied to variants of this species, but none are nowadays upheld (see for example Ochoterana, 1913; Trelease, 1914, 1920).

It has been proposed that the species was introduced into South Africa as discarded ship's ballast, and into local horticulture as an ornamental. It spreads easily from suckers produced from the base to form large clumps. Flowers of the species are pickled and sold as a savoury delicacy (Fig. 31). Physical removal seems to be the best way of eradicating plants.

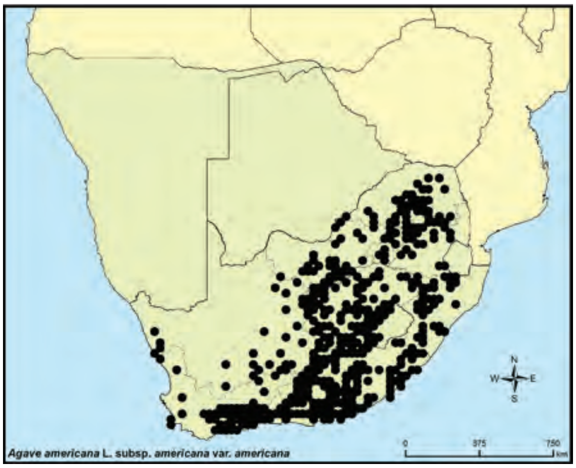

Fig. 28. Distribution map of *Agave americana* L. var. *americana.*

Fig. 29. A population of blue-leaved *Agave americana* L. var. *americana.* (Picture by Gideon F. Smith)

Fig. 30. Leaves of *Agave americana* L. var. *americana* usually droop to one side. (Picture by Neil R. Crouch)

Fig. 31. Pickled flowers of *Agave americana* L. var. *americana* are sold as a savoury delicacy. (Picture by Gideon F. Smith)

2. *Agave americana* L. subsp*. americana* var. *expansa* (Jacobi) Gentry

In: *The agave family in Sonora*, Agriculture Handbook No. 399: 80–84 (1972).

=*Agave abrupta* Trel.
=*Agave expansa* Jacobi

Common names: spreading century plant (English); skraalblougaringboom, skraalgaringboom (Afrikaans).

Large to massive, acaulescent or short-stemmed, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 2 m tall, profusely proliferous through basal suckers. **Leaves** remaining erect, not spreading or reflexed, never flopping over to one side, lanceolate, 1–2 m long, light blue; margins armed with numerous, straight to flexuous or variously recurved, simple teeth, up to 1 cm long; apical spine conical to subulate, 3–5 cm long. **Inflorescence** paniculate, 5–9 m tall, branched, never bulbiliferous. **Flowers** erect, 7–10 cm long, yellow to greenish yellow. **Stamens** with filaments 6–9 cm long; anthers 3–3.6 cm long, centric to excentric yellow. **Fruit** a capsule, oblong, 4–5 cm long. **Seed** lunate to lacrimiform, 7–8 × 5–6 mm, shiny black. **Distribution**: SA. (Fig. 32).

References: Gentry (1982), Forster (1986), Irish & Irish (2000), Thiede (2001), Reveal & Hodgson (2002), Vásquez-García *et al.* (2007), Reveal & Hodgson (2009).

Unlike the typical variety of the species, the leaves of plants of *Agave americana* var. *expansa* remain erect (Fig. 33, 34) and generally have a neater appearance. However as in the case of the *Agave americana* var. *americana* the flowering pole can reach a height of 8 m (Fig. 35). It is therefore likely that *Agave americana* var. *expansa* was introduced for its greater horticultural appeal as a much tidier-looking version of the typical variety (Jacobi, 1868). This variety is known to have become established in the Western Cape Province of South Africa, where it is grown as an architectural plant in large gardens on the Cape Peninsula. It is increasingly appearing in gardens and along roadsides beyond the Mediterranean climate parts of South Africa.

Fig. 32. Distribution map of *Agave americana* var. *expansa* (Jacobi) Gentry.

Fig. 33. Leaves of *Agave americana* var. *expansa* (Jacobi) Gentry tend to remain erect. (Picture by Gideon F. Smith)

Fig. 34. Close-up of the leaves of *Agave americana* var. *expansa* (Jacobi) Gentry. (Picture by Gideon F. Smith)

Fig. 35. Inflorescence of *Agave americana* var. *expansa* (Jacobi) Gentry. (Picture by Gideon F. Smith)

3. *Agave angustifolia* Haw. var. *angustifolia*

In: *Synopsis plantarum succulentarum*: 72 (1812).

=*Agave owenii* I.M.Johnst.
=*Agave pacifica* Trel.
=*Agave yaquiana* Trel.

Common names: kleingaringboom (Afrikaans).

Medium-sized, caulescent, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 1.2 m tall, proliferous through basal suckers. **Leaves** ascending to horizontal in mid-rosette, linear to narrowly lanceolate, 0.6–1.2 m long, light green to glaucous grey; margins armed with small teeth, curved or variously flexed, 2–5 mm long; apical spine conical to subulate, 1.5–3.5 cm long. **Inflorescence** paniculate, 3–5 m tall, branched, usually bulbiliferous. **Flowers** erect, 5–6.5 cm long, green to yellow. **Stamens** with filaments 3.5–4.5 cm long; anthers centric or excentric, 2–3 cm long, yellow. **Fruit** a capsule, ovoid, 3–5 cm long. **Seed** D-shaped, 9–12 × 7–8 mm, dull black. **Distribution**: SA. (Fig. 36).

References: Gentry (1982), Forster (1987–1988), Espejo Serna & Lopez-Ferrari (1993), Colunga-García Marín & May-Pat (1997), Steyn & Smith (2000).

With its fairly thin, flattish leaves densely arranged into medium-sized rosettes (Fig. 37), *Agave angustifolia* is a distinctive species that is slowly spreading into natural vegetation in South Africa. The leaves are armed with vicious marginal and terminal spines (Fig. 38). Clones established in southern Africa produce thousands of bulbils (Fig. 39) on their inflorescences (Fig. 40) and have the potential to become a real menace. Little is known about its introduction into the country.

Several names previously proposed for variants of *Agave angustifolia* are no longer upheld. Only three, *Agave pacifica* Trel., *A. yaquiana* Trel. and *A. owenii* I.M.Johnst. are listed here as possibly being applied to the species in South Africa (Trelease, 1920; Johnston, 1924).

Fig. 36. Distribution map of *Agave angustifolia* Haw.

Fig. 37. Dense, medium-sized rosettes of *Agave angustifolia* Haw. (Picture by Geoff R. Nichols)

Fig. 38. Leaves of *Agave angustifolia* Haw. armed with spines. (Picture by Geoff R. Nichols)

Fig. 39. Bulbils on the inflorescence of *Agave angustifolia* Haw. (Picture by Geoff R. Nichols)

Fig. 40. Inflorescence of *Agave angustifolia* Haw. (Picture by Neil R. Crouch)

4. *Agave celsii* Hook. var. *albicans* (Jacobi) Gentry

In: *Agaves of continental North America*: 223-224, f. 9.1-9.3, 9.7, t. 9.1 (1982).

=*Agave albicans* Jacobi

Common names: vaalgaringboom (Afrikaans).

Medium-sized to large, acaulescent or short-stemmed, rosulate, leaf succulent, perennial through proliferous axillary branching; rosettes up to 0.8 m tall. **Leaves** erect at first, becoming spreading to slightly reflexed, stout, cymbiform to somewhat lanceolate, 0.4–0.6 m long, light blue; margins armed with numerous weak, straight, recurved, simple or bicuspid teeth, up to 3 mm long; apical spine obsolescent. **Inflorescence** spicate, unbranched, 1.5–2.5 m tall, never bulbiliferous. **Flowers** erectly spreading, 5–6 cm long, basal part light green, tube creamy green with metallic lavender tinge. **Stamens** with filaments 7–8 cm long; anthers centric, 2 cm long, lavender when young, yellowish when mature. **Fruit** a capsule, ovoid-angular, 1.8–2.8 cm long. **Seed** hemispherical, 5 × 3 mm, black. **Distribution**: SA. (Fig. 41).

References: Irish & Irish (2000), Smith & Steyn (2002b).

The nomenclatural history of *Agave celsii* var. *albicans* is quite complex and recently it has been suggested (see for example Thiede, 2001) that the correct name of this taxon is *Agave mitis* Mart. var. *albidior* (Salm-Dyck) Ullrich. For the moment the variety is here treated under the name proposed by Gentry (1982).

The medium-sized rosettes consisting of numerous blue-green to almost white leaves (Fig. 42), as well as the unbranched inflorescences (Fig. 43), separate the taxon from other agaves naturalised in southern Africa. It is the least noxious of the problem agaves in South Africa, and can be easily eradicated by physical removal.

The species was probably introduced as a horticultural subject, and with its interesting leaf colour it is easy to see why.

Fig. 41. Distribution map of *Agave celsii* Hook. var. *albicans* (Jacobi) Gentry.

Fig. 42. Blue-green leaved rosettes of *Agave celsii* Hook. var. *albicans* (Jacobi) Gentry develop into dense clumps. (Picture by Gideon F. Smith)

Fig. 43. Unbranched inflorescence of *Agave celsii* Hook. var. *albicans* (Jacobi) Gentry. (Picture by Gideon F. Smith)

5. *Agave sisalana* Perrine

In: United States of America 25th Congress, 2nd Session, House of Representatives Report No. 564 (Tropical Plants): 8, 9, 16, 47, 60, 86 (1838a).

Common names: hemp plant, sisal, sisal hemp (English); garingboom, sisal (Afrikaans).

Medium-sized to large, acaulescent or short-stemmed, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 2 m tall; profusely proliferous through elongated rhizomes. **Leaves** erect throughout, lanceolate, 0.9–1.3 m long, dark green; margins generally lacking teeth; apical spine subulate, 2–2.5 cm long. **Inflorescence** paniculate, branched, 4–9 m tall, profusely bulbiliferous. **Flowers** erect, 5.5–6.5 cm long, greenish yellow. **Stamens** with filaments 5–6 cm long; anthers centric, 2.3–2.5 cm long, yellow. **Fruit** a capsule, generally lacking; plants sterile. **Seed** generally lacking. **Distribution**: SA. (Fig. 44).

References: Perrine (1838b), Trelease (1913), Berger (1915), Gentry (1982), Pedley & Forster (1986), Couper & Cullen (1988), Smith & Mössmer (1996).

Agave sisalana can hardly be confused with any of the other agaves naturalised or cultivated in southern Africa. The leaves are generally mid- to dark green and their margins are devoid of teeth (Fig. 45, 46).

The strong fibres extracted from the leaves of *Agave sisalana* have been widely used in weaving, and for manufacturing carpets and ropes (Fig. 47). It was therefore introduced as an agricultural crop and planted in vast numbers in plantations, particularly in areas that receive marginal rainfall (Fig. 48, 49). Once plants flower they produce thousands of bulbils (Fig. 50) on the side branches of the flowering pole, and sometimes also from the large bracts on the pole itself. These are easily transported and will strike root where they drop. These perfectly formed plantlets have been carried far and wide leading to the establishment of sparse or dense clusters of plants in many parts of the sub-region. It rates as one of the most invasive of the agaves naturalised in South Africa (Fig. 51).

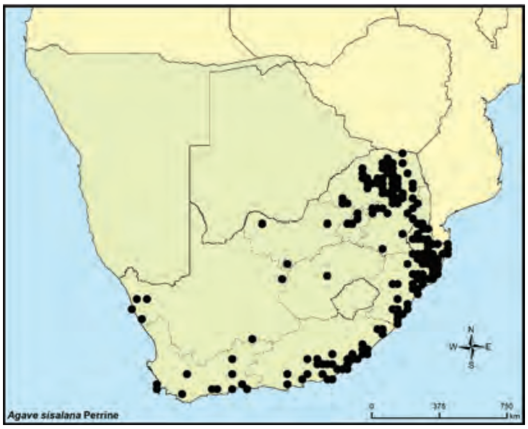

Fig. 44. Distribution map of *Agave sisalana* Perrine.

Fig. 45. Mid- to dark green leaves of *Agave sisalana* Perrine.
(Picture by Helmuth G. Zimmermann)

Fig. 46. Leaves of *Agave sisalana* Perrine do not have marginal spines. (Picture by Gideon F. Smith)

Fig. 47. Fibres of *Agave sisalana* Perrine collected for use in weaving. (Picture by Neil R. Crouch)

Fig. 48. Plantation of *Agave sisalana* Perrine from which leaves have been harvested. (Picture by Neil R. Crouch)

Fig. 49. Plantation of *Agave sisalana* Perrine. (Picture by Geoff R. Nichols)

Fig. 50. Bulbils of *Agave sisalana* Perrine
(Picture by Neil R. Crouch)

Fig. 51. *Agave sisalana* Perrine spreading into natural vegetation.
(Picture by Helmuth G. Zimmermann)

6. *Agave vivipara* L. var. *vivipara*

In: *Species plantarum*: 323 (1753a).

=*Agave decipiens sensu auct.* Smith & Steyn (1999b) *non* Baker.

Medium-sized, shortly caulescent, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 1.3 m tall; proliferous through subterranean stolons. **Leaves** rigidly spreading to recurving, narrowly lanceolate, 0.75–1 m long, dark green; margins armed with simple teeth, recurved, 1–2 mm long; apical spine conical, 1–1.5 cm long. **Inflorescence** paniculate, branched, 6–7 m tall, usually bulbiliferous. **Flowers** erect, 5–5.5 cm long, yellowish green. **Stamens** with filaments 4.5–4.8 cm long; anthers excentric, 2 cm long, light green with brownish red speckles. **Fruit** a capsule, ellipsoid to oblong, 3.5–5 cm long. **Seed** not seen. **Distribution**: SA. (Fig. 52).

References: Wijnands (1983), García-Mendoza & Chiang (2003), Jarvis (2007).

It should be noted that *Agave vivipara* var. *vivipara* has locally been confused with *A. decipiens* Baker. The latter has been recorded from tropical areas of the southeastern United States of America, for example the state of Florida. In South Africa the latter species has only been observed in cultivation in gardens of beach-front hotels in Durban in KwaZulu-Natal and in the industrial area of Springs in Gauteng, but has not escaped into nature. The climate in Springs is near-continental and winter temperatures regularly drop below freezing, which indicates the wide ecological amplitude of *Agave decipiens*.

Agave vivipara var. *vivipara* is one of two species of *Agave* naturalised in southern Africa of which its sword-shaped leaves are mid- to dark green (Fig. 53). However, the other one, *A. sisalana*, has smooth leaf margins, while those of *A. vivipara* var. *vivipara* are armed with prominent, greenish brown teeth. *Agave angustifolia*, on the other hand, has a somewhat similar growth form to that of *A. vivipara* var. *vivipara*, but the latter's leaves are generally broader in the middle. In addition, the mid-rosette leaves are carried more or less erect and are much more widely spaced on the short stem, making the leaf bases clearly visible (Fig. 54) [see e.g. Jarvis (2007: 121, plate on the left)]. Furthermore, García-Mendoza & Chiang (2003) showed that *Agave angustifolia* and *A. vivipara* warrant recognition as independent species, a proposal we follow here, as opposed to the treatments of Wijnands (1983) and Thiede (2001) that regarded these two species as conspecific (see also Smith & Steyn, 1999a).

The species was likely introduced for its horticultural potential as an accent plant in large gardens. It has the potential to become a real pest plant as a result of the vast number of bulbils formed on the inflorescences, after flowering.

Fig. 52. Distribution map of *Agave vivipara* L.

Fig. 53. Mid- of to dark green sword-shaped leaves *Agave vivipara* L. carry marginal spines, unlike those of *A. sisalana* Perrine.
(Picture by Gideon F. Smith)

Fig. 54. Leaf bases are visible in *Agave vivipara* L. while in *A. angustifolia* Haw. they are obscure. (Picture by Estrela Figueiredo)

7. *Agave wercklei* F.A.C. Weber ex Wercklé

In: *Monatsschr. Kakteenk.* 17: 71–72 (1907a).

=*Agave costaricensis* (This name, sometimes used for the species in the horticultural trade, is of unknown origin.)

Common names: bondelgaringboom (Afrikaans).

Medium-sized to large, acaulescent, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 2 m tall, non-surculose. **Leaves** rigidly spreading, ovate to lanceolate, short-acuminate, 0.7–1.5 m long, light greyish green, often with a whitish grey sheen; margins armed with simple teeth, straight or variously recurved, 3–4 mm long; apical spine conical, 2–3 cm long. **Inflorescence** paniculate, branched, 4–8 m tall, profusely bulbiliferous. **Flowers** erect, up to 8 cm long, basal part light green, tepals golden yellow. **Stamens** with filaments 9 cm long; anthers golden yellow, 1.6 cm long. **Fruit** a capsule, ovoid-angular, 2.2–3 × 1.5–1.8 cm. **Seed** hemispherical, 5 × 4 mm, black. **Distribution**: SA. (Fig. 55).

References: Wercklé (1907b), Thiede (2001), Smith & Steyn (2002a), Smith & Steyn (2003).

Interestingly, Carlos Wercklé, who did valuable work on the ferns and vegetation of Costa Rica, validated the name of this taxon that had been proposed to commemorate him by Weber and so *Agave wercklei* was named after himself (Wercklé, 1907a, b).

This is the only species of *Agave* naturalised in southern Africa that does not proliferate through basal or stem suckers before, or after, flowering (Fig. 56). To compensate for the lack of basal sprouts it produces thousands of bulbils (Fig. 57) on the tall branched inflorescence after flowering (Fig. 58). These drop to the ground and easily strike root where they fall (Fig. 59). The flowers are a pleasant bright yellow colour (Fig. 60).

Fig. 55. Distribution map of *Agave wercklei* F.A.C.Weber ex Wercklé.

Fig. 56. Rosettes of *Agave wercklei* F.A.C.Weber ex Wercklé are non-suckering. (Picture by Gideon F. Smith)

Fig. 57. Bulbils of *Agave wercklei* F.A.C.Weber ex Wercklé. (Picture by Neil R. Crouch)

It is unknown when and where the species was introduced into South Africa. It was more than likely brought in for its value as a horticultural plant, given that it will not sucker in a pot or the open ground, making it more manageable than species such as *Agave americana* and *A. sisalana*. The species was originally recorded from a single locality near the Baakens River Valley in Port Elizabeth in the Eastern Cape Province, but has more recently also been observed near Pietermaritzburg in KwaZulu-Natal.

Fig. 58. Branched inflorescence of *Agave wercklei* F.A.C.Weber ex Wercklé. (Picture by Neil R. Crouch)

Fig. 59. Bulbils of *Agave wercklei* F.A.C.Weber ex Wercklé rooting and forming a colony. (Picture by Neil R. Crouch)

Fig. 60. Bright yellow flowers of *Agave wercklei* F.A.C.Weber ex Wercklé. (Picture by Neil R. Crouch)

Furcraea Vent.

Robust, monocarpic, usually rosulate multi-annual perennials arising from short rhizome or short erect caudex, some species caulescent, palm tree-like. **Stem** up to 1.2 m tall, commonly with monocotyledonous type secondary growth. **Leaves** usually crowded in an apical or basal rosette, leathery to succulent, amplexicaul, persisting for many years, vibrant or glaucous green; each vascular bundle with well-developed fibrous cap at phloem pole. **Inflorescence** terminal, tall, fast-growing, terminating in a panicle, often massive. **Flowers** pendulous, campanulate, bisexual, regular or somewhat irregular, pedicellate, 3-merous throughout, often replaced by small, globular bulbils. **Perianth** white to greenish white, petaloid, 3 + 3, spreading, often fleshy, free, not forming a tube. **Stamens** inserted, 3 + 3, basally expanded; anthers mostly dorsifixed, introrse, versatile opening by longitudinal slits, linear to oblong. **Filaments** swollen below middle. **Ovary** inferior, 3-locular, with septal nectaries; placentation axile; ovules in 2 vertical rows in each locule; style stout, swollen basally with 3 prominent angles, inserted, terminal; stigma 3-lobed. **Fruit** a loculicidal capsule. **Seeds** many, black, flattened.

References: Ventenat (1793), Drummond (1907), Verhoek (2002), Crouch & Smith (2011).

Furcraea is a small genus in which only 21 species are included. Several attain tree-like dimensions, and their stems can reach a length of 1.2 m or more. The leaves are a vibrant or glaucous green colour and arranged in a terminal rosette, giving the plants a palm tree-like appearance when old. The flowers are pendulous, bell-shaped, and, in cultivated and naturalised forms often replaced by small, globular bulbils. The perianth is mostly free, forming a very short tube. The filaments are swollen below the middle. The style is stout and swollen basally with three prominent angles.

Most species have been introduced from tropical America, and one of these has become established in southern tropical Africa. This species, *Furcraea foetida* (L.) Haw. (=*F. gigantea* Vent.), escaped from sites of habitation and plantations established for fibre production, mainly in the bushveld (savanna) and subtropical eastern areas of the subcontinent. It is colloquially known as Mauritius hemp or green aloe, and is also naturalised in Zambia and Zimbabwe. Although not yet recorded from Angola, Malawi or Mozambique, it more than likely also occurs in the subtropical areas of these countries.

Furcraea foetida (L.) Haw.

In: *Synopsis plantarum succulentarum*: 73 (1812).

=*Agave foetida* L.
=*Furcraea gigantea* Ventenat

Common names: furcraea, green aloe, Mauritius hemp (English); furcraea, nooiensgaringboom (Afrikaans).

Large to massive, acaulescent or short-stemmed, multi-annual, monocarpic, rosulate, perennial, leaf succulent; rosettes up to 2.5 m tall, proliferous through stem suckers. **Leaves** erect at first, becoming spreading, stiff, lanceolate, 1.8–2.4 m long, verdant green to yellowish green; margins hard, distally smooth, armed with a few hooked, simple teeth towards base; apex a firm, blunt point. **Inflorescence** paniculate, branched, 5–12 m tall, always bulbiliferous. **Flowers** pendulous, 7–10 cm long, in clusters of 2–5, white to shades of greenish white. **Stamens** inserted; filaments short, basally expanded; anthers centric to excentric, 3–3.6 cm long, yellow. **Ovary** inferior, 1.2–1.5 cm long; style inserted, dilated, 3-lobed proximal to middle; stigma 3-lobed. **Fruit** a capsule, loculicidally dehiscent, infrequently produced. **Seeds** many, flat, in 2 rows per locule, black. **Distribution**: SA. (Fig. 61).

References: Howard (1979), Verhoek (2009), PIER (2010), Crouch & Smith (2011).

Plants can be easily distinguished from agavoid look-alikes as a result of their light green leaf colour (Fig. 62), leaf margins that are smooth along the distal half (Fig. 63), down-turned, bell-shaped flowers (Fig. 64), and round bulbils (Fig. 65). The inflorescence can reach a height of 12 m and typically has drooping lateral branches (Fig. 66). *Furcraea foetida* occurs naturally from Guadaloupe south through northern South America to Brazil and the Caribbean (Greater Antilles) (Crouch & Smith, 2011).

The arrival of *Furcraea foetida* in South Africa may be traced to its importation by the Natal Botanical Gardens (now the Durban Botanic Gardens) sometime before the early 1880's, c. 130 years ago (Crouch & Smith, 2011). Plants were previously established in plantations from where they have started escaping. Initial eradication efforts may have to be focused on the physical removal of plants. However, this labour intensive process may prove to be feasible in the case of isolated populations only.

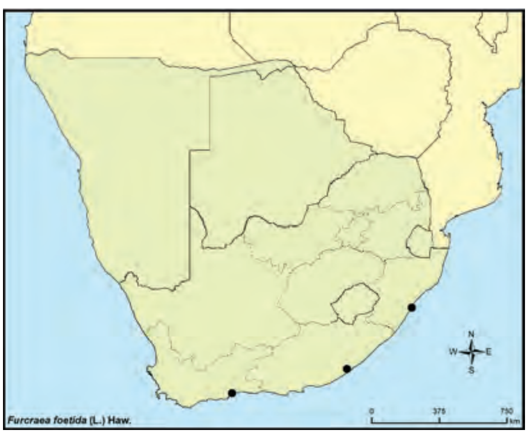

Fig. 61. Distribution map of *Furcraea foetida* (L.) Haw.

Fig. 62. Leaves of *Furcraea foetida* (L.) Haw. are verdant green. (Picture by Neil R. Crouch)

Fig. 63. The leaves of *Furcraea foetida* (L.) Haw. lack teeth at the distal end. (Picture by Neil R. Crouch)

Fig. 64. The flowers of *Furcraea foetida* (L.) Haw. are bell-shaped and drooping. (Picture by Geoff R. Nichols)

Fig. 65. Bulbils of *Furcraea foetida* (L.) Haw. (Picture by Neil R. Crouch)

Fig. 66. Inflorescences of *Furcraea foetida* (L.) Haw. (Picture by Geoff R. Nichols)

AIZOACEAE Martinov

(Ice plant family; *Vygiefamilie*)

by

M. Walters

Annual, biennial or perennial herbs, subshrubs or shrubs, rarely plants reduced to a single leaf-pair. **Stems** erect or prostrate and mat-forming, or underground. **Leaves** usually simple, often fleshy or scale-like, opposite or sometimes alternate, margins mostly entire; epidermis sometimes with bladder cells, often papillate to pubescent; blade flat, terete or triquetrous; true stipules absent, sometimes a stipuliform appendage present or leaves sessile or with leaf sheath. **Inflorescence** a terminal or seemingly axillary cyme, or flowers solitary; bracts present or absent. **Flowers** usually bisexual, rarely unisexual, actinomorphic, perigynous to hypogynous or epigynous, hypanthium present, with or without pedicel. Perianth consisting of sepals and petals or perigone. **Sepals** (3–)5(–8), sometimes petaloid and coloured, often with dorsal subapical appendage. **Petals** commonly absent or numerous, distinct or connate proximally, often 2–4 seriate, linear. **Stamens** 1–very numerous, free or connate at base, rarely connate with petals forming a tube; anthers bilocular, dehiscing by longitudinal slits. **Ovary** superior, inferior or semi-inferior, 1–5- or many- carpellate, syncarpous; ovules 1–many per carpel; styles 1–25 or absent, distinct or partly connate; stigmas 2–25. Nectaries absent, separate or in a ring around ovary. **Fruit** a hygrochastic loculicidal, rarely septicidal or xeromorphic capsule, with or without membranes covering the seeds, sometimes dehiscence circumscissile, or fruit a hard 1-seeded nut, or more rarely a drupe. **Seed** 1–many, usually ± ovoid, sometimes with aril, usually papillose.

References: Hartmann (2001a), Vivrette *et al*. (2003).

The family treatment here follows that of Smith *et al*. (1998) and Hartmann (2001a), and excludes the Molluginaceae while including groups sometimes considered families of their own, e.g. Sesuviaceae, Tetragoniaceae and Mesembryanthemaceae. The Aizoaceae, as treated here, consists of about 130 genera and 2 500 species (Vivrette *et al*., 2003).

Members of the Aizoaceae are found on all continents (except Antarctica) (Vivrette *et al*., 2003), throughout the tropics and subtropics with the centre of diversity (at species level) being in the southwestern part of Africa (Smith *et al*., 1998; Hartmann, 2001a). Species may occur in habitats as diverse as dry subtropical deserts, wet tropical coasts, and snow-covered subtropical mountains, but the highest number of genera and species inhabit semi-arid (100–400 mm annual precipitation) winter-rainfall areas (Hartmann, 2001a). Particularly the group popularly known as mesembs ('vygies' in Afrikaans; also known as fig-marigolds, flowering stones, ice plants and midday flowers), have diversified extensively in southern Africa's winter-rainfall area, with over 1 500 species being known from, and mostly restricted to, this region (Smith *et al*., 1998; Van Jaarsveld *et al*., 2000).

Many members of the family are of economic importance as ornamentals and are in cultivation worldwide resulting in a number of species occurring outside their natural distribution ranges e.g. *Carpobrotus edulis* (L.) N.E.Br., *Mesembryanthemum crystallinum* L. or *Disphyma crassifolium* (L.) L.Bolus (Vivrette *et al*., 2003). Some species are also used to stabilise sand dunes in coastal regions (Heywood *et al*., 2007), while others are important in the southern African medicinal plant trade (Smith & Crouch, 1999).

Only one species from a single genus is naturalised in southern Africa.

Tetragonia L.

Annual or perennial herbs or subshrubs, with shiny, translucent bladder cells, resulting in a white appearance of the leaves, glabrous, pilose, or papillate. Stems erect, ascending or prostrate, semi-woody at base. **Leaves** alternate, often opposite basally; petiole short to long; blade flat, ovate to almost linear, margins entire to slightly sinuate or shallowly lobed; epidermis with variously-shaped papillae, often of two types with one elongate and hairy; stipules absent. **Inflorescences** axillary clusters of flowers or flowers solitary, sessile or peduncled; bracts usually absent. **Flowers** bisexual or unisexual, inconspicuous, 0.5–1 cm in diameter, sessile or pedicellate. **Perianth** campanulate, adnate to ovary; lobes (3–)4(–7), green or yellow adaxially, basally united into a short tube. **Petals** and petaloid staminodia absent. **Stamens** 1–20, usually twice the number of the perianth lobes, perigynous. **Pistil** 3–10-carpellate. **Ovary** inferior, (1–)3–10-loculed; ovule 1 per locule, pendulous; styles 3–10; stigmas 3–10. **Fruit** a woody, indehiscent nut with persistent perianth, ridged, winged or tuberculate, usually with 4 rows of ornaments, often apically as horns, brown to black. **Seeds** 1–10, sub-reniform or pyriform, light brown, arils absent.

References: Adamson (1955), Taylor (1994), Hartmann (2001b), Lu & Hartmann (2003), Vivrette (2003).

Tetragonia consists of about 60 species (Lu & Hartmann, 2003; Vivrette, 2003) with representatives in Africa, South America, East Asia, Australia and New Zealand, where they prefer tropical climates though are also found in drier climates in the southern hemisphere (Taylor, 1994; Hartmann, 2001b). Some members of the genus have naturalised elsewhere (Lu & Hartmann, 2003; Vivrette, 2003).

The name for the genus comes from the Greek words *tetra* (four) and *gone* (reproductive organs), and refers to the four-angled or four-winged fruits found in many of the species (Hartmann, 2001b).

There are 32 species of *Tetragonia* in South Africa (Germishuizen *et al*., 2006). *Tetragonia tetragonioides* was classified in subgenus *Tetragonoides* DC. (Adamson, 1955). The subgenus is characterised by the simple fruit, 1–8-celled, with cells as many as fruit cells, stamens up to twice the number of perianth segments and ovary bulging above the insertion of the perianth (Adamson, 1955). *T. tetragonioides* can be distinguished from the other species in the subgenus that occur in South Africa with the following key [adapted from Adamson (1955)]:

Key to distinguish *T. tetragonioides*

1.	Flowers in groups of 3–5 or more **2**
1'.	Flowers solitary or in pairs **3**
2.	Flowers sessile, ovary projecting as a cone; fruit with 3–4 flat projections at the top . . . . **(*Tetragonia microptera*)**
2'.	Flowers shortly pedicellate; ovary with 2–3 obtuse projections around the styles; fruit ridged with spine-like outgrowths on the ridges . . . . **(*Tetragonia echinata*)**
3.	Fruit covered all over with spine-like outgrowths . . . .**(*Tetragonia acanthocarpa*)**
3'.	Fruit without spine-like outgrowths **4**
4.	Plant papillose-hairy all over; stamens as many as perianth segments; fruit ridged . . . . **(*T. caesia*)**
4'.	Plant glabrous-papillose; stamens twice as many as perianth segments; fruit smooth, with horn-like projections at the top . . . . ***Tetragonia tetragonioides***

Tetragonia tetragonioides (Pall.) Kuntze

In: *Revisio Generum Plantarum* 1: 264 (1891) (as "*tetragoniodes*").

=*Demidovia tetragonoides* Pall. (basionym)
=*Tetragonia expansa* Murray

Common name: New Zealand spinach (English).

Annual herbs, prostrate to ascending, up to 60 cm tall. Stems mat-forming; internodes with densely placed bladder cells when young. **Leaves** alternate; petiole 0.5–3 cm long, thick, winged; blade rhomboid-ovate or deltoid-ovate, 0.5–10.7 × 2.5–8 cm, base truncate, pale green abaxially, dark green adaxially, epidermis with large, globose papillae abaxially, fewer along the margins,. **Flowers** solitary, rarely 3, sessile or with pedicel up to 2 mm long. **Perianth** with tube 2–3 mm long; lobes spreading, usually 4, up to 2 mm long, ovate to semi-orbicular, papillate and green outside, bright yellow to yellowish green and minutely papillate inside. **Stamens** 10–13, clustered or scattered. **Fruit** turbinate, 0.8–1.2 cm long and 1 cm in diameter; horns 4–6. **Seeds** as many as locules, pyriform, smooth, amber to light brown. **Distribution**: SA. (Fig. 67).

References: Hartmann (2001b), Lu & Hartmann (2003), Vivrette (2003).

First collected from New Zealand, this plant became known as a food plant and has spread all over the world (Hartmann, 2001b), becoming naturalised in many regions (Lu & Hartmann, 2003; Vivrette, 2003). As the common name suggests, New Zealand spinach may be eaten, raw or cooked, as a leaf vegetable and is a delicious spinach substitute (Fig. 68) (Plants for a Future, 2008). Seeds require warm temperatures to germinate and plants are cultivated and sold as a summer spinach in temperate regions. In certain Asian cultures it is believed to be effective against enteritis and stomach ache (Sung *et al*., 1998), as well as stomach cancer and stomach ulcers (Kato *et al*., 1985).

It is naturalised in the coastal region of KwaZulu-Natal in South Africa. It is possible that the introduction of this species is due to plants being washed ashore from passing ships (Fox & Norwood Young, 1982). A place near Richards Bay is known as Spinach Point due to the fact that local Zulus would load their canoes with plant material from that area (Fox & Norwood Young, 1982). Plants are frost-sensitive (Plants for a Future, 2008) and unlikely to survive the cold winters of the South African interior above the Great Escarpment without protection under glass or in plastic tunnels. Thus far the species does not appear to be problematic and no eradication measures are necessary. However, where possible, known populations should be monitored for future expansion. Vegetatively plants (Fig. 69, 70) look similar to some representatives of what Smith *et al.* (1998) termed the 'weedy mesembs', but the flowers of *T. tetragonioides* are insignificant (Fig. 71), unlike the strawberry-red ones of the similar-looking *Aptenia cordifolia* (L.F.) Schwantes, for example.

Fig. 67. Distribution map of *Tetragonia tetragonioides* (Pall.) Kuntze.

Fig. 68. A dish prepared from *Tetragonia tetragonioides* (Pall.) Kuntze leaves. (Picture by Gideon F. Smith)

Fig. 69. Colony of *Tetragonia tetragonioides* (Pall.) Kuntze. (Picture by Neil R. Crouch)

Fig. 70. Plant of *Tetragonia tetragonioides* (Pall.) Kuntze.
(Picture by Neil R. Crouch)

Fig. 71. Flowers and crystalline leaf surface of *Tetragonia tetragonioides* (Pall.) Kuntze. (Picture by Neil R. Crouch)

BASELLACEAE Moq.

(Madeira-vine family; *Madeira-klimopfamilie)*

by

M. Walters

Usually glabrous vines or decumbent to procumbent herbs; roots and stem base fibrous to sometimes tuberous and thickened, entire plants fleshy to succulent; stems glabrous, rarely asperous (or puberulent when young). **Leaves** spirally arranged, petiolate (sometimes almost sessile), simple, entire (rarely dentate by glands), sometimes with reddish margin often softly succulent; stipules absent. **Inflorescence** an axillary or terminal spike, raceme, panicle or dichasium; bracts persistent or deciduous; pedicel present or absent; bracteoles 2 (rarely absent), opposite, at pedicel apex, sometimes displaced when pedicel lengthens, persistent or deciduous. **Flowers** sessile or pedicellate, actinomorphic, bisexual (rarely functionally unisexual), cleistogamous or chasmogamous, small. **Sepals** 2, valvate, opposite, free to the base or partly connate, fused with petals at least at the base, entire, persistent, often somewhat accrescent in fruit, membranous to thick (rarely fleshy), sometimes with dorsal wing or gibbous at the base, greenish, whitish, yellowish or reddish at anthesis or pale, brownish or ± black when in fruit. **Petals** usually 5, persistent, often somewhat accrescent in fruit, connate at the base only or up to ⅔ of their length, greenish, whitish, yellowish or reddish at anthesis or pale, brownish or ± black when in fruit, membranous to thick (rarely fleshy). **Stamens** 5, epipetalous, basally connate or fused up to ¾ of their length with the petals; anthers dorsifixed or basifixed, tetrasporangiate, 2-locular, dehiscent by longitudinal or apical slits. **Ovary** superior, 3-carpellate, syncarpous, 1-locular with a single basal ovule; styles 3 or 1 that is 3-partite to the base or almost so; stigmas linear to capitate or 3-lobed (rarely bifid). **Fruit** a thin-walled nutlet, indehiscent, smooth (sometimes rugose), surrounded at the base to completely enclosed by the persistent dry or fleshy perianth. **Seed** with a membranous testa, usually rust-coloured, embryo annular to cochleate.

References: Sperling & Bittrich (1993), Eggli (2002a), Vincent (2003), Eriksson (2007).

The Basellaceae is a small family consisting of four genera (*Anredera* Juss., *Basella* L., *Tournonia* Moquin-Tandon, *Ullucus* Caldas.) with 19 species of mostly succulent, short-lived, twining, scandent or trailing vines or herbs. Three genera (*Anredera*, *Tournonia* and *Ullucus*) are native to the tropics of the New World and the Andean regions of America. The genus *Basella* occurs in Madagascar, South and East Africa and one species, *Basella alba* L., has a pantropical distribution (Sperling & Bittrich, 1993; Eriksson, 2007).

Species in the Basellaceae are mostly distinguished by their reproductive parts. Flowers of *Basella* are sessile and arranged on generally unbranched spikes (*B. paniculata* Volkens is abundantly branched). *Anredera* and *Ullucus* have pedicellate flowers in racemes or panicles; *Tournonia* is distinguished by its axillary dichasia (Eriksson, 2007).

Most species prefer open, dry habitats (e.g. scrub, rocky slopes and sandy areas). The centre of diversity for the family is found in the Andean region, with some species preferring the lowlands while others may grow at altitudes of 3 500 m or more. Despite the number of species found in this region, the centre of origin for the family might actually be in southeastern Africa (Eriksson, 2007).

A few of the species in the family Basellaceae have economic importance as crops or ornamentals. Some of the species in the genus *Anredera* are cultivated as ornamentals. *Basella alba* is widely cultivated as a leafy vegetable and the cultivated forms of *Ullucus tuberosus* Caldas are an important, traditional food crop in the South American Andes (Sperling & Bittrich, 1993).

Two species from two genera of the Basellaceae are naturalised in southern Africa.

Key to the two naturalised genera [adapted from Sperling & Bittrich (1993)]:

1. Filaments outwardly reflexed in bud and anthesis, anthers dorsifixed, flowers shortly or distinctly pedicellate, sweet smelling . . . .***Anredera***
1'. Filaments straight in bud and anthesis, anthers basifixed, flowers sessile, unscented . . . .***Basella***

Anredera Juss.

Twining vines with or without tuberous roots; stems glabrous or puberulent when young. **Leaves** alternate, with a short to distinct petiole; blade slightly fleshy, entire, lanceolate to broadly elliptic, cordate or obovate, apex obtuse to acuminate. **Inflorescence** a raceme or panicle, shortly to distinctly pedunculate; bracteoles distinct, subtending the flowers, triangular to broadly ovate. **Flowers** shortly or distinctly pedicellate, minute and often cleistogamous, bisexual (rarely functionally unisexual), fragrant. **Sepals** rhombic or rounded, ovate to elliptic, free, apex obtuse, whitish, yellowish or reddish at anthesis or pale, brownish or ± black, ± dry when in fruit. **Petals** ovate or elliptic to obovate, connate at the base into a short tube or rarely completely free, apex obtuse, at anthesis whitish, yellowish or reddish or in fruit pale, brownish or ± black, ± dry when in fruit. **Stamens** 5; filaments reflexed in bud, connate into a short tube, fused with tepals; anthers dorsifixed and longitudinally dehiscent. **Ovary** globose to pyriform; style 1 (undivided to 3-partite) or 3; stigmas clavate to capitate or 3-lobed (rarely bifid). **Fruit** globose to pyriform, at the base surrounded or completely enclosed by the persistent perianth. **Seed** erect, laterally flattened to nearly globose.

References: Sperling & Bittrich (1993), Eggli (2002a), Vincent (2003), Eriksson (2007).

Anredera is a genus native to the New World occurring from Florida and Texas down to Argentina with the majority of species growing in the Andean region at altitudes between 1 500 and 3 500 m (Sperling & Bittrich, 1993; Eriksson, 2007). Some of the species with widespread distributions, however, also have wide altitudinal ranges. The genus encompasses 12 species, with a few grown as ornamentals throughout the world, some of which have become locally naturalised in other tropical or subtropical areas (Eriksson, 2007).

Anredera cordifolia (Ten.) Steenis

In: *Flora Malesiana*, Series I, Spermatophyta 5(3): 303 (1957).

=*Anredera baselloides* (Kunth) Baill.
=*Anredera cordifolia* (Ten.) Steenis subsp. *gracilis* Xifreda & Argimón
=*Boussingaultia baselloides* Kunth
=*Boussingaultia cordata* Sprengel
=*Boussingaultia cordifolia* Ten.
=*Boussingaultia gracilis* Miers
=*Boussingaultia gracilis* Miers var. *pseudobaselloides* (Hauman) L.H.Bailey

In South Africa the plant has been listed as *Anredera baselloides* (Wells, 1986; MacDonald *et al*., 2003), a name considered a synonym of *A. cordifolia* (Schatz *et al*., 2011).

Common names: bridal wreath, cascade creeper, lamb's tail, Madeira vine, mignonette vine (English); Madeiraranker (Afrikaans); indaba-ingehlele, madilika (Zulu).

A twining vine with glabrous stems, often producing aerial tubers; rootstock and stem base producing an irregularly lump-shaped caudex with smooth greenish to brownish bark; aerial stems annual, twining, to 6 m long, softly succulent. **Leaves** well spaced, petiole up to 2.5 cm long; blade ovate to cordate, 2.5–10 × 1.5–7.5 cm, with cordate base, sometimes truncate to rounded, apex acute (rarely obtuse), slightly fleshy, green. **Inflorescence** a usually lax and much-branched (sometimes unbranched) raceme up to 50 cm long; pedicels 0.5–3.5 mm long; bracteoles persistent, connate at the base forming a cup. **Flowers** bisexual, strongly sweet-scented. **Sepals** broadly ovate to broadly elliptic, patent, 1.5–3 × 1.5–2.5 mm, distinctly shorter than petals (rarely of almost equal length), white at anthesis, ± dark brown when in fruit. **Petals** uniform, patent, elliptic to obovate, 2–4 × 1.5–2.5 mm, whitish-yellow, turning ± dark brown after anthesis. **Stamens** opposite petals; filaments recurved in bud. **Style** 1, 3-partite, sometimes almost to the base. **Fruit** surrounded by persistent perianth. **Distribution**: L, S, SA. (Fig. 72).

References: Eggli (2002a), Eriksson (2007).

Anredera cordifolia is a very variable species but infraspecific taxa are not recognised. It is native to the southern and central parts of South America (South Brazil, Paraguay and northern Argentina). It grows well in tropical and subtropical areas of the world and is often naturalised outside its native distribution range (Eriksson, 2007).

In southern Africa the plant is grown as a garden ornamental (Wells, 1986; Glen, 2002) because of its large, branched inflorescences (Fig. 73) consisting of masses of showy, pedicellate, fragrant flowers (Fig. 74). (Eriksson, 2007). It is also grown for its edible tubers (Fig. 75), which are said to be rather tasteless, while elsewhere the leaves are cooked like spinach (Fig. 76) (Eggli, 2002a). *Anredera cordifolia* has been recorded as having anti-inflammatory properties (Vincent, 2003) while in South Africa it is used medicinally as a general anti-microbial agent (Von Ahlefeldt *et al*., 2003; Singh, 2006) and specifically by the Vhavenda for the treatment of gonorrhoea and syphilis (Tshikalange, 2003). Aqueous extracts of the plant are, however, considered poisonous (Henderson, 2001).

It is considered a declared weed in the sub-region and is listed in South Africa as a category 1 invader, meaning it must be controlled or eradicated where possible (Henderson, 2001). The plant grows very quickly and along with its ability to reproduce vegetatively by way of the tubers, has become rather difficult to control (Eriksson, 2007). In addition seeds germinate profusely (Fig. 77).

While chemical control methods are available for the management of *Anredera cordifolia*, they are considered unsuitable due to the risk to non-target species growing beneath the smothering vines (Fig. 78). The South African and Australian Governments have done some initial research on the use of a South American, leaf feeding beetle, *Plectonycha correntina,* as a biological control agent (Cagnotti *et al*., 2007; Biosecurity Australia, 2010). The risk to non-target species is considered negligible and no other potential consequences of the release were identified (Biosecurity Australia, 2010). During initial trials, *Basella alba* and *Anredera cordifolia* were among four plants allowing complete larval development (Biosecurity Australia, 2010), making this a potential biocontrol agent for the future.

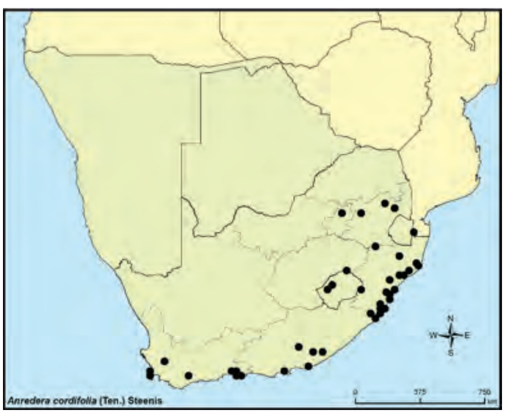

Fig. 72. Distribution map of *Anredera cordifolia* (Ten.) Steenis.

Fig. 73. Branched inflorescences of *Anredera cordifolia* (Ten.) Steenis.
(Picture by Geoff R. Nichols)

Fig. 74. Pedicellate, white flowers of *Anredera cordifolia* (Ten.) Steenis.
(Picture by Neil R. Crouch)

Fig. 75. Edible tubers of *Anredera cordifolia* (Ten.) Steenis. (Picture by Neil R. Crouch)

Fig. 76. Leaves of *Anredera cordifolia* (Ten.) Steenis. (Picture by Neil R. Crouch)

Fig. 77. Seedlings of *Anredera cordifolia* (Ten.) Steenis. (Picture by Neil R. Crouch)

Fig. 78. Vines of *Anredera cordifolia* (Ten.) Steenis smothering native plants. (Picture by Geoff R. Nichols)

Basella L.

Twining vines to procumbent or erect herbs with or without tuberous roots; stems glabrous or rarely puberulent when young, without tubers. **Leaves** alternate, slightly fleshy, with a short petiole; blade lanceolate to broadly elliptic or cordate, entire, apex obtuse to acuminate. **Inflorescence** a branched or unbranched spike, with or without peduncle; bracts ± triangular; bracteoles minute to distinct, subtending the flowers, triangular to ovate, free. **Flowers** sessile, bisexual, unscented and often chasmogamous or cleistogamous. **Sepals** ovate to elliptic, free or partly connate into a short tube, shorter than to equalling petal length, apex ± obtuse, greenish, whitish or reddish at anthesis, pale and ± dry or purple to black, thick and juicy in fruit. **Petals** uniform, ovate to elliptic, connate at the base or up to ⅔ of their length, apex ± obtuse, greenish, whitish or reddish at anthesis, pale and ± dry or purple to black, thick and juicy when in fruit. **Stamens** with filaments straight in bud (sometimes obscurely reflexed), connate and basally fused or fused into a short tube up to ¾ of their length; anthers dorsifixed and longitudinally dehiscent. **Styles** 3 or 1 that is 3-partite to the base or almost so. **Fruit** a globose to pyriform nutlet, at the base tightly enclosed (partly or completely) by the persistent perianth.

References: Sperling & Bittrich (1993), Eggli (2002a), Eriksson (2007).

The genus *Basella* comprises five species. Madagascar is home to three of these (*B. excavata* Scott-Elliot*, B. leandriana* H.Perrier and *B. madagascariensis* Boivin ex H.Perrier) with another, *B. paniculata* Volkens, being native to South and East Africa. *Basella alba* L. has a pantropical distribution which is probably a result of its widespread cultivation (Sperling & Bittrich, 1993; Eriksson, 2007).

The invasive *Basella alba* may be distinguished from the indigenous *B. paniculata* in the following way [adapted from Eriksson (2007)]:

1. Inflorescence usually unbranched, petals fused to form urceolate flower with petals usually longer than 3.5 mm, perianth whitish to reddish at anthesis . . . .***Basella alba***
1'. Inflorescence branched, petals almost free and usually shorter than 3.5 mm, perianth greenish at anthesis . . . .**(*Basella paniculata*)**

Basella alba L.

In: *Species Plantarum* 1: 272 (1753a).

=*Basella nigra* Lour.
=*Basella rubra* L.
=*Gandola alba* Rumph. ex L.
=*Gandola rubra* Rumph. ex L.

Common names: Ceylon spinach, Indian spinach, Malabar nightshade, Malabar spinach (English).

Stem twining vine to procumbent or erect herb up to 4–8 m long; stem slender, glabrous, green or purplish. **Leaves** alternate, simple, fleshy; petiole up to 9 cm long; blade cordate or sometimes ovate to broadly elliptic, 3–15 × 2.5–12 cm, base cordate to acuminate or obtuse, apex usually acute or somewhat acuminate or obtuse, dark green or purplish. **Inflorescence** an unbranched (sometimes with few branches) spike 1–20 cm long, hanging, with long peduncle; bracteoles distinct, ovate to triangular. **Flowers** bisexual, sessile, unscented, cleistogamous or sometimes chasmogamous, 5-merous. **Sepals** ovate to elliptic, ± erect, connate at base or up to ½ of their length, 3.5–5.5 × 2–2.5 mm, up to 7.5 mm long when fruiting, white to reddish at anthesis, purple to black in fruit, thick and juicy. **Petals** ovate to elliptic, ± erect, connate at base or up to ⅓–⅔ of their length, 3.5–5.5 × 1.5–2.5 mm at anthesis, up to 7.5 mm long when fruiting, white to reddish at anthesis, purple to black in fruit, very thick and juicy. **Stamens** 5, opposite petals; anthers pale. **Styles** 3 or 1 that is 3-partite to the base or almost so. Perianth persistent, fleshy, urceolate, tightly enveloping the fruit. **Fruit** a subglobose pseudo-berry, entire structure up to 7.5 × 10 mm, purplish black, containing a violet juice, 1-seeded. **Distribution**: SA. (Fig. 79).

References: Abukutsa-Onyango (2004), Eriksson (2007).

The native distribution of *Basella alba* is unknown though some consider it a native of southern Asia (Abukutsa-Onyango, 2004), while others feel it is indigenous to Africa (Verdcourt, 1968). The plant is commonly grown as an ornamental (Fig. 80) and leafy vegetable throughout the tropics and subtropics which has lead to widespread naturalization following escape (Eriksson, 2007).

Fig. 79. Distribution map of *Basella alba* L.

Fig. 80. *Basella alba* L. grown as an ornamental in India. (Picture by Stefan Neser)

Apart from it being grown as a vegetable, *Basella alba* fruits (Fig. 81) have been used for dyeing, as ink and cosmetics and for colouring foods (Abukutsa-Onyango, 2004). While no medicinal use for the species is recorded from southern Africa, a number of medicinal applications have been reported from elsewhere in Africa (Neuwinger, 2000; Abukutsa-Onyango, 2004). These include treatment for constipation, conjunctivitis, snake bite and headaches, to name but a few (Neuwinger, 2000). Red forms of Malabar spinach are planted as ornamentals, and have become popular in Europe and North America as pot plants (Abukutsa-Onyango, 2004).

Fig. 81. Fruits of *Basella alba* L. (Picture by Stefan Neser)

BEGONIACEAE C.Agardh.

(Begonia family; *Begoniafamilie*)

by

N.R. Crouch

Herbs or undershrubs, mostly fleshy, generally erect, sometimes creeping or climbing by means of adventitious roots, or acaulescent with a rhizome or tuber. **Leaves** alternate and spiralled, rarely distichous or subradical, petiolate, generally asymmetrical, digitately nerved, margins entire, toothed, lobed or dissected, sometimes peltate; stipules 2, conspicuous, persistent or caducous. **Inflorescences** axillary, cymose, bracteate, often long-pedunculate. **Flowers** unisexual but plants monoecious, regular or irregular, showy. **Male flowers**: tepals usually 2 or 4, rarely many or 0, petaloid; stamens numerous, filaments free or connate; anthers petaloid, 2-locular, opening with longitudinal slits or apical pores; staminodes 0 or rarely represented by glands. **Female flowers**: ovary inferior or rarely half-inferior, rarely 1-, 2-, or 5-locular, usually 3-locular and 3-winged or angled, ovules numerous on projecting simple or lobed axile placentas; styles (2)3(–5), free or connate at base, usually 2-fid, stigmas entire or branched, often twisted, papillose. **Fruit** usually a 3-winged or 3-angled loculicidal capsule, rarely a berry. **Seeds** numerous, minute, testa reticulate, endosperm scanty or absent, embryo straight.

References: Hilliard (1976), Bredenkamp (2000), Eggli (2002b).

The Begoniaceae consists of the monotypic *Hillebrandia* Oliv. from Hawaii and *Begonia* L., one of the largest genera of flowering plants, estimated variously to have roughly 1 400 (Smith *et al*., 1986) or as many as 1 600 species (Sands, 2001), which are distributed mainly throughout the world's tropical forests. Some authorities also recognise the genus *Symbegonia* Warburg as a small genus of 10 species endemic to New Guinea (Tebbitt, 1997). *Begonia* is comprised of mesophytic to somewhat succulent herbs or subshrubs and sometimes even climbers, with five representatives indigenous to the *Flora of Southern Africa* region (Hilliard, 1976). In this region they extend farther into the temperate zone than any other members of the genus, with the possible exception of some Chinese taxa (McLellan *et al*., 2009). Well over 200 begonias have been introduced to horticulture where they are variably employed as conservatory, window-garden and bedding subjects. Many are grown for their attractively marked foliage, others for their showy blooms, with many of the latter being treated as single pot subjects, although a few are used for bedding. More than ten thousand cultivars and hybrids have been developed (Tebbitt, 1997), including a range of hybrid tuberous pot-plant forms with double and triple blooms that display an enormous spectrum of bright colours.

Although many *Begonia* species possess stems that are succulent, or otherwise simply termed fleshy, they are essentially plants of mesic and sometimes very damp habitats, and so would suffer under conditions of drought stress, being poorly adapted to xeric conditions. Both species dealt with in the current account have succulent stems. Under drought conditions *Begonia hirtella* Link retires to seed until conditions become more mesic, whereas *B. cucullata* Willd. survives by virtue of both seed and its persistent stolons. Only two *Begonia* species are naturalised in southern Africa. Both taxa fit into the Semperflorens category, an artificial rather than natural system of classification for the genus, which groups species in terms of cultivation requirements and appearance.

Begonia L.

Caulescent or acaulescent herbs or undershrubs with succulent stems and leaves, generally erect, sometimes creeping or climbing, sometimes with rhizomes or tubers; stems aerial, often swollen and conspicuously jointed. **Leaves** alternate, rarely subradical, petiolate, usually asymmetrical, entire, lobed or partite, irregularly toothed, green or sometimes richly multicoloured or spotted. Small axillary bulbs sometimes present. **Male flowers**: tepals 2 or 4, rarely many or 0, petaloid; stamens numerous, filaments free or connate at the base. **Female flowers**: tepals often 5 or 6, sometimes 4, petaloid; ovary usually 3-, rarely 2-, 4- or 5-locular; ovules numerous, placentas axile, projecting, simple or lobed; styles usually as many as the loculi, free or connate at the base, 2-fid; stigmas entire or branched, often twisted, papillose. **Fruit** usually a capsule, 3-winged or 3-angled, rarely terete or 4-angled, or a berry. **Seeds** numerous, minute, without endosperm.

References: Hilllard (1976), Tebbitt (1997).

As only five native species occur in southern Africa (*Begonia dregei* Otto & A.Dietr., *B. geranioides* Hook.f., *B. homonyma* Steud., *B. sonderiana* Irmsch. and *B. sutherlandii* Hook.f.), both locally naturalised and indigenous species are included in the following key [adapted from Hilliard (1976)]:

1. Placentas bilamellate (appearing bifurcate in transverse section) **2**
1'. Placentas entire **4**

2. Stems hairy when young, leaf margin toothed but not, or scarcely, lobed . . . .**2. *Begonia hirtella***
2'. Stems glabrous when young; leaf margin lobed or not **3**

3. Leaf flat, margin lobed . . . . **(*Begonia sonderiana*)**
3'. Leaf hooded (cucullate) due to slightly inrolled base, margin not lobed . . . .**1. *Begonia cucullata***

4. Leaves nearly symmetrical, suborbicular, nearly all arising from the stem base . . . . **(*Begonia geranioides*)**
4'. Leaves mostly asymmetrical, arising along the aerial stem **5**

5. Flowers dark yellow, orange or orange-red, male tepals generally four . . . . **(*Begonia sutherlandii*)**
5'. Flowers white or pink, male tepals usually two **6**

6. Primary leaves up to 13 × 7 cm, seldom less than 7 × 3 cm, caudex up to 25 cm diameter . . . .**(*Begonia homonyma*)**
6'. Primary leaves up to 8 × 3.5 cm, usually 5 × 2 cm or less, caudex up to 8 cm diameter . . . . **(*Begonia dregei*)**

1. *Begonia cucullata* Willd.

In: *Species plantarum* 4(1): 414 (1805) **var. *cucullata*.**

=*Begonia cucullata* Willd. var. *hookeri* (A.DC.) L.B.Sm. & B.G.Schub.
=*Begonia nervosa* Humboldt
=*Begonia semperflorens* Link & Otto

Common names: clubed begonia, wax begonia (English).

Tuberous, stoloniferous, perennial herb; stems erect or ascending, glabrous, 10–100 cm tall. **Leaves** with petiole up to 2.5 cm long; blade slightly asymmetric, broadly ovate, up to 8 × 7 cm, base truncate and inrolled, obtuse, scalloped to sharply toothed (crenate-serrate), ciliate, palminerved, glossy, fleshy; stipules oblong, obtuse, 2–3 cm long, persistent, margins denticulate. **Inflorescence** an axillary, few- to many-flowered cyme, peduncle 3–5 cm long, pedicels slender; bracts persistent, ovate, 5 mm long, serrulate. **Male flowers:** tepals 4, outer pair suborbicular to reniform, 8–13 mm long, inner pair smaller and narrowly obovate, white or pink; stamens free, numerous; filaments short; anthers linear. **Female flowers**: bracteoles deciduous, elliptic to almost spathulate, 3.5–4 mm long, margin ciliate; tepals 4–5, obovate, 6–9 mm long, white or pink; ovary 3-locular, placentas axile, bifid; styles 3, partite; stigmas linear, spiral, continuous. **Fruit** a capsule, 24–30 mm long, unequally 3-winged, the largest wing triangular, subacute, wings acute in the typical variety; placentas split, appearing bifurcate in transverse section. **Seeds** numerous, minute. **Distribution**: SA. (Fig. 82).

References: Golding (1982), Tebbitt (1997), PIER (2010).

Fig. 82. Distribution map of *Begonia cucullata* Willd.

This species has in the past been confused in herbaria with the indigenous *Begonia homonyma* but this last mentioned species can be readily distinguished on account of its non-bilamellate ovary, and its large caudex (see also key above) (Fig. 83). Additionally, *B. homonyma* leaves are not cucullate or hooded as are those of this invader. Further distinguishing vein and leaf shape characters (Fig. 84) are provided by McLellan *et al*. (1996). At sites such as that on the Mzimvubu River on the Transkei coast these two species may be found co-occurring, the invasive species spreading by seeds dispersed from brown, 3-winged fruit (Fig. 85).

Fig. 83. *Begonia cucullata* Willd. lacks a large caudex. (Picture by Neil R. Crouch)

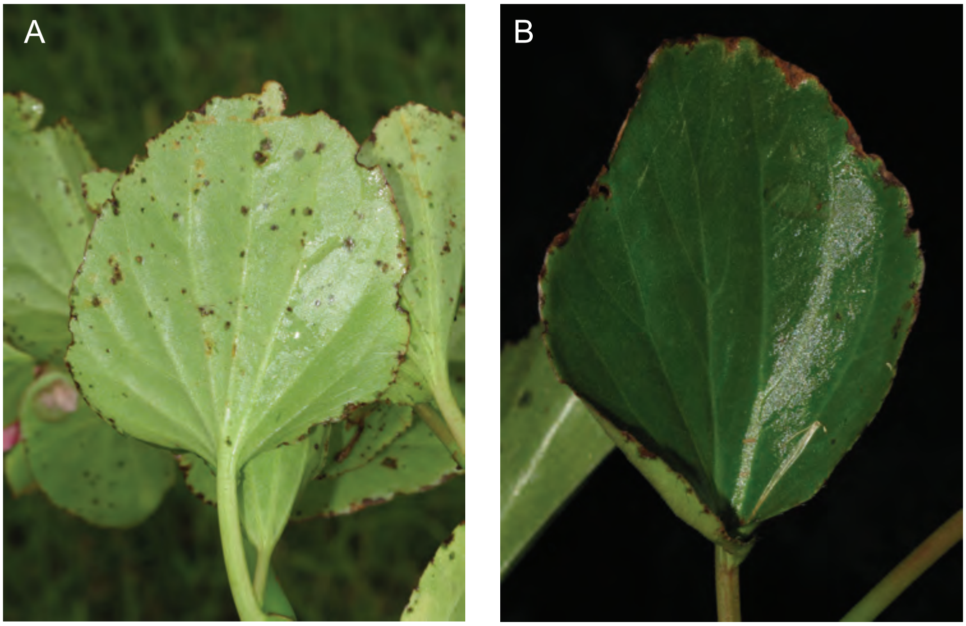

Fig. 84 . *Begonia cucullata* Willd. – A. Leaf venation; B. Cucullate leaf shape (Pictures by Neil R. Crouch)

Fig. 85. Winged capsules of *Begonia cucullata* Willd. (Picture by Neil R. Crouch)

Begonia cucullata is regionally a potential emerging invader, which due to its high seed set and persistent and stoloniferous rootstock has the potential to multiply rapidly under suitable conditions. Elsewhere it has been recognised as control-worthy when noted to have escaped from cultivation, such as in Australia (Randall, 2007) and the USA (Florida Invasive Plant Education Initiative, 2010).

This species, native to Brazil, Peru, Argentina, Paraguay and Uruguay, is noteworthy as a founding parent (together with *B. schmidtiana* Regel) of the immensely popular Semperflorens or wax begonias, used primarily as half-hardy bedding plants for landscaping. It is also known to have naturalised in Hawaii (Wagner *et al*., 2005), La Réunion (MacDonald *et al*., 1991), Puerto Rico, and both Florida and Georgia in the USA (Florida Invasive Plant Education Initiative, 2010). It has doubtless escaped from cultivation at several sites in South Africa, most prominently at Port St John's (Eastern Cape) (McLellan *et al*., 1996) and Gilletts near Durban (KwaZulu-Natal). It prefers exposed situations on moist banks (Fig. 86); both pink and white colour forms are invariably found growing together (Fig. 87). *Begonia cucullata* does naturalise though in forest situations under a partially open canopy (McLellan *et al*., 1996).

In Florida (USA) steps have been taken to limit the impact of this species on the environment, through the use of cultural, mechanical and chemical control measures. Authorities in that state have recommended that this species - likely the most widely known *Begonia* in cultivation - be removed from the landscape and not replanted (Florida Invasive Plant Education Initiative, 2010). A management plan for this species in Florida is available as a downloadable PDF (http://plants.ifas.ufl.edu/node/65).

Fig. 86. *Begonia cucullata* Willd. typically inhabits moist banks. (Picture by Neil R. Crouch)

Fig. 87. *Begonia cucullata* Willd. – A. Pink flowers; B. White flowers. (Pictures by Neil R. Crouch)

2. *Begonia hirtella* Link

In: *Enum. Hort. Berol*. 2: 396 (1822).

=*Begonia villlosa* Lindl.

Common names: bearded begonia, Brazilian begonia (English).

Erect, robust, branched, fibrous-rooted, annual herb; stems several from the base, up to 2 cm diameter, there branched, up to 75 cm tall, green or red-tinged, fleshy, thickly clothed in long coarse, white hairs, becoming glabrous or nearly so. **Leaves** widely spaced; petiole up to 9 cm long, pink, fleshy, villous; blade membranous, obliquely ovate, up to 10 × 8 cm, base shallowly cordate to truncate or nearly so, apex acute, margins irregularly crenate-serrate, not or scarcely lobed, green above, thinly villous, paler below, there hairs nearly confined to the main veins, with a red spot above where petiole joins the blade, palminerved; stipules ovate-lanceolate, c. 1 × 0.5 cm, membranous, apex acuminate, margin fimbriate-ciliate, whitish, eventually deciduous. **Inflorescences** in the upper leaf axils, few-flowered, pendent, in branched cymes; peduncles up to c. 5 cm long, usually shorter than the petiole; bracts persistent. **Male flowers**: tepals 4, outer pair ovate to almost circular, 2–8 × 2–6 mm, inner pair linear-oblong, 1–4 × 0.5–2 mm, white; stamens 10–15, arranged symmetrically, anther connectives projecting. **Female flowers**: bracteoles deciduous, elliptic to almost spathulate, 3.5–4 mm long, margin ciliate; tepals 5, unequal, ovate to ovate-oblong, 2–4 × 1–2 mm, white; ovary ovoid to ellipsoid, 4–8 × 2–5 mm, unequally 3-winged, whitish green, 3-locular, placentas axile, bifid; styles 3, partite; stigmas in a spiraled band. **Fruit** capsular, 3-winged, rounded-oblong to cuneiform in outline, 0.8 cm × c. 2 cm at the broadest part of the wings, placentas split, appearing bifurcate in transverse section. **Seeds** numerous, minute, without endosperm. **Distribution**: SA. (Fig. 88).

References: Hilliard (1976), Wagner *et al*. (1999), Tebbitt (2005).

This species is unlikely to be confused with any other in South Africa, because of its hairy leaves (Fig. 89), hairy petioles (Fig. 90) and the presence of aerial stems (Fig. 91). Although some forms of *Begonia sutherlandii* possess hairy leaves they produce orange rather than white flowers (Fig. 92). Fruit of *B. hirtella* are light brown in colour and unequally 3-winged (Fig. 93). The only other hairy begonia with

Fig. 88. Distribution map of *Begonia hirtella* Link.

white flowers is *B. geranioides* which is stemless or usually so, normally producing its leaves so close to the base of the stem as to make them appear to come from the root; it is also tuberous, unlike *B. hirtella*. The leaves of *B. geranioides* are additionally suborbicular rather than obliquely ovate.

Fig. 89. Hairy leaves of *Begonia hirtella* Link. (Picture by Neil R. Crouch)

Fig. 90. Hairy petiole of *Begonia hirtella* Link. (Picture by Neil R. Crouch)

Fig. 91. Aerial stem of *Begonia hirtella* Link. (Picture by Neil R. Crouch)

Fig. 92. White flowers of *Begonia hirtella* Link. (Picture by Neil R. Crouch)

This species has not previously been listed as an invasive in South Africa, although it has been recognised as exotic (Bredenkamp, 2006).

The occurrence of *Begonia hirtella* in two Zululand forests remains unexplained and somewhat enigmatic, for although it appears natural when encountered, it has most likely escaped from cultivation. This species, a native of Brazil, Colombia, Peru and some Caribbean islands, has long been cultivated in North America and Europe, despite the fact that it is of little decorative value (Bailey & Bailey, 1976; Hillard, 1976). It has been collected from both Gwalaweni forest in the Lebombo mountains of northern KwaZulu-Natal—well away from sites of amenity horticulture—and in Dlinza forest situated in very close proximity to Eshowe, a town where it may at one time have been cultivated and have escaped. Notably though, Glen (2002) does not list it as a species known to have been grown previously in southern Africa. However, the species is known to have naturalised elsewhere in the world, including Hawaii (Wagner *et al*., 2005), and Sri Lanka where it is so invasive that it is now the most common *Begonia* species on that island (Tebbitt, 2005). Within the genus *Begonia*, *B. hirtella* belongs to section *Doratometra* from Central and South America: it is in the Semperflorens group. Although an annual, this species produces masses of fine seed which has resulted in it becoming a common weed of greenhouses in north temperate regions, as well as a colonist of disturbed habitats throughout the tropics (Tebbitt, 2005). Unusual for a begonia, this species is not only self fertile but also self-pollinating: the male flowers are positioned directly above the female flowers (Fig. 92) so allowing pollen to drop on to the stigmas and for seed to be set (Tebbitt, 2005). Little information is available for its ecological preferences in the two South African forest sites where it has been found so far; elsewhere (Hawaii) where it has invaded it has been recorded locally common in disturbed, wet, shaded sites, especially on moist banks at altitudes of between 450 and 940 m (Wagner *et al*., 1999).

Fig. 93. Mid-brown and unequally 3-winged fruit of *Begonia hirtella* Link. (Picture by Neil R. Crouch)

CACTACEAE Juss.

(Cactus family; *Kaktusfamilie*)

by

P.J.D Winter, H.G. Zimmerman and B.K. Mashope

Perennial herbs, shrubs, trees or climbers with variously modified, mostly succulent stems, often spiny; spines, branches, flowers and often glochidia (in subfamily Opuntioideae) arise from raised or sunken cushions (areoles). **Leaves** rudimentary or absent, rarely well-developed, persistent (*Pereskia*), succulent, those of the brachyblasts (short shoots/areoles) mostly modified into bristles, spines or glochidia. **Flowers** bisexual, actinomorphic, or rarely zygomorphic, axillary, sessile or rarely pedunculate (*Pereskia*), one or rarely more per areole. **Tepals** numerous, in a graded series from scale-like, through foliaceous to petaloid, free. **Stamens** usually numerous, in several rows, arising in calyx throat, sometimes adnate to base of tepals; anthers 2-locular. **Ovary** mostly submerged in a pericarpel of peduncular origin that often extends above the ovary into a hypanthium, inferior (except in some *Pereskia* spp.), 1-locular; ovules many on 3–20 parietal placentas; style terminal, simple; stigmas as many as placentas. **Fruit** a berry, rarely dry, naked, scaly, hairy, bristly or spiny, indehiscent or variously dehiscent. **Seeds** many, sometimes strophiolate, in subfamily *Opuntioideae* entirely encased by an often pale bone-coloured aril (funicular envelope); testa smooth, shiny, or tuberculate, often black-brown (virtually black).

References: Barthlott & Hunt (1993), Anderson (2001), N.P. Taylor (*pers. comm.*).

Members of Cactaceae are primarily characterised by the presence of areoles, and all except the most primitive members have the ovary enveloped in a pericarpel. They typically have fleshy, leafless, often spiny, photosynthetic stems (long shoots), and showy, sessile flowers. *Pereskia* Mill. is an exception, with well-developed leaves along non-fleshy stems, and a branching inflorescence with 'pedicellate' flowers (Barthlott & Hunt, 1993; Anderson, 2001). The roots can be fibrous or tuberous, e.g. *Peniocereus* (A.Berger) Britton & Rose. Fleshy stems have diversified into a wide spectrum of forms, branched or unbranched. The branches are cylindric or columnar, often ribbed, sometimes winged or flattened, often segmented and variously adorned with hairs and/or (more usually) spines. Where leaves are present, e.g. in *Austrocylindropuntia subulata* (Muehlenpf.) Backeb., (Fig. 94), they are spirally arranged, simple, entire and without stipules. Leaves, scales, calyx and corolla often form a more or less continuous gradation of organs from ± foliar to petaloid. The flowers are zoophilous.

Fig. 94. Leaves of *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. (Picture by Helmuth G. Zimmermann)

In response to extreme habitats, the Cactaceae have also evolved special physiological traits which relate to nocturnal stomatal opening and a Crassulacean Acid Metabolism (CAM) photosynthetic pathway (as well as CAM-cycling), leading to efficient use of limited soil water. Special water storage cells are found in the inner cortex or in the pith of most species. They act as water reservoirs and release water when the plants are water stressed. In addition, the photosynthetic stems of many species contain large quantities of mucilage (a hydrophilic carbohydrate) found in the inner cortex and pith which also affects water relations. The thick layer of white spines found in several species e.g. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth (Fig. 95) reflects incident sunlight and has a cooling effect. Many Cactaceae have a high tolerance for high temperatures. Of several species that have been assessed quantitatively, the tolerated high temperature averaged 68°C. Metabolic processes are severely curtailed in most plants at temperatures of 55 to 60°C. (Nobel, 1988). The roots of most cacti living in xerophytic conditions are shallow, no deeper than 15-30 cm below the soil surface but often extending laterally for considerable distances (Rundel & Nobel, 1991). This allows the plants to take full advantage of the limited precipitation typical for desert and desert-like climates. Combined with the morphological traits described above, these adaptations have allowed cacti to grow and survive in extreme hot and dry conditions (Nobel, 2002).

Fig. 95. Dense white spines of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth.
(Picture by Helmuth G. Zimmermann)

The approximately 1 438 species in 124 genera (Hunt, 2006) occur in North and South America, with a single species of *Rhipsalis* Gaertn. which is widespread in tropical America, extending to Africa, Madagascar and Sri Lanka (Obermeyer, 1976; Barthlott, 1983; Smith & Steyn, 1997; Smith *et al*., 1999). Various species, in the *Opuntioideae* in particular, are widely naturalised in warmer regions of the Old World (Parfitt & Gibson, 2003).

Cactaceae is closely related to families Anacampserotaceae and Portulacaceae *sensu stricto* (Nyffeler & Eggli, 2010). The fact that several taxa in the family appear to be of hybrid origin (Parfitt & Gibson, 2003) provides a challenge to attempts at improving its classification. Nomenclatural instability as a result of the general poor quality, or often total absence, of type material, is another obstacle that needs to be overcome by any student of this family. Cactaceae are generally poorly represented in herbarium collections, due to the extraordinary care required in preparing pressed and dried specimens. Spines and glochidia pose a hazard to those handling specimens. Ideally, stem parenchyma needs to be removed to speed up drying, since it contains a substance that releases water only with radical treatment e.g. microwave methods.

There are several species in the Cactaceae that are cultivated for fruit, fodder, ‘nopalitos’ (a green vegetable) and for cochineal production. The ornamental cactus trade has also developed into a formidable industry and is responsible for the inter-continental spread of many ornamental and useful cactus species. However, invasive or potentially invasive cactus species have been spread in this way (Fig. 96). In some countries spiny species are widely used as living fences (Fig. 97) which has also led to several species becoming invasive.

Economically, *Opuntia ficus-indica* (L.) Mill. is by far the most important species and it is widely cultivated as a drought tolerant crop for arid and semi-arid regions. Fruit production from many selected spineless cultivars is a fast growing industry. It is grown commercially for this purpose in at least 16 countries (Barbera *et al*., 1995). Their role in fodder production is regarded as even more important though. Globally, there are already c. 687 000 ha under cultivation exclusively for this purpose with Brazil the leading country (Mondragon-Jacobo & Perez-Gonzalez, 2001). Many thousands of hectares are also cultivated for cochineal (carmine) production based on the insect *Dactylopius coccus*. Peru, the Canary Islands, Chile, Bolivia and lately also Ethiopia are leading producers. Special cultivars have been developed in Mexico for the production of young leaf-pads, from which ‘nopalitos’ are produced. This product is consumed as a green vegetable in Mexico. For example, the consumption of ‘nopalitos’ is now also well established in Ethiopia and beyond. More than 10000 ha are cultivated for this purpose (Flores-Valdez, 1995).

New exotic, cactus-derived fruit crops are emerging which include the pitayas (pitahayas) from several columnar or vine cacti including the genera *Cereus* Mill., *Hylocereus* (A.Berger) Britton & Rose, *Selenicereus* (A.Berger) Britton & Rose and *Stenocereus* (A.Berger) Riccob. (Nerd *et al*., 2002). Some of these are now also seen on South African markets.

With global warming, land degradation and the need for food security in developing countries, cactus cultivation has been widely promoted by the FAO because of the ease of cultivation, drought tolerance and general resilience of the plants, making them some of the more promising new emerging crops.

A total of 29 species, with two infraspecific taxa, from 11 genera of the Cactaceae are known to be naturalised in South Africa. However, this list is expected to expand as soon as more people are able to identify cacti in the field and bring them to the attention of scientists. Obermeyer (1976) reported only 12 species for the same area 35 years ago. Glen (2002) has listed more than 200 species as being cultivated in southern Africa. In these works, some of the names are applied tentatively due to several sources of nomenclatural uncertainty. Though resolution of all these issues is beyond the scope of this treatise, we have attempted to highlight such problems, so that they can eventually be systematically dealt with. The listed taxa have been recorded in natural vegetation in southern Africa.

Fig. 96. Cacti are popular in the commercial horticultural trade. (Picture by Helmuth G. Zimmermann)

Fig. 97. Plants of the spiny *Echinopsis schickendantzii* F.A.C.Weber established as a living fence. (Picture by PPRI)

Key to the genera:

Notes: (1) Where only one species has been recorded for the region, the species name is given in full. (2) The indigenous *Rhipsalis baccifera* (J.Mill.) Stearn subsp. *mauritiana* (DC.) Barthlott is included for comparison. (3) *Cleistocactus* Lem. has been recorded as persisting in abandoned gardens in Lekgalameetse Nature Reserve and Zebediela. As older stems of *C. samaipatanus* (Cárdenas) D.Hunt can appear similar to those of *Peniocereus serpentinus*, and as there was an unconfirmed report of invasion around Graaff-Reinet, it has been included in the key.

1. Woody climber; stems not modified to cylindrical or flattened cladodes; more vigorous shoots with paired recurved spines specially adapted for climbing; leaves conspicuous in growing season, flat, more than 1.5 cm broad; glochidia absent (Pereskioideae). . . . . ***Pereskia aculeata***

1'. Shrublets, shrubs or small trees, or climbers with cladodes; shoots never with paired, recurved spines; leaves usually inconspicuous and caducous (except in *Austrocylindropuntia*), subulate or terete, less than 8 mm broad (Opuntioideae) or absent (Cactoideae); glochidia present or absent **2**

2. Glochidia absent; flowers either large (> 6 cm in diameter), white and often nocturnal, or narrower than 4 cm, red or white, and diurnal (Cactoideae) . **3**

2'. Glochidia present in areoles; flowers 3–7(–10.5) cm in diameter, coloured (rarely white) and diurnal (Opuntioideae) **10**

3. Branches cylindric, less than 7 mm wide, not ribbed; flowers usually 4 –10 mm across; fruit up to 8 mm wide, cream-coloured or somewhat translucent, smooth . . . .***Rhipsalis baccifera* subsp. *mauritiana***

3'. Branches winged, ribbed, or tubercled, more than 1 cm wide; flowers more than 2 cm across; fruit more than 8 mm wide, red, bearing scales (though these may be inconspicuous in *Myrtillocactus*) **4**

4. Branches scrambling or pendent (never erect or columnar), slender, often segmented, sometimes emitting aerial roots, 3–4(–7)-winged or angled, or 4–5-ribbed **5**

4'. Branches erect (sometimes columnar) or ascending, not scrambling, slender to very stout, not producing aerial roots, 3–4-winged or angled, or few- to many-ribbed, or tubercled **6**

5. Climbers; branches often emitting aerial roots; stem wings acute; spines absent or few, up to 7 mm long . . . . ***Hylocereus***

5'. Shrubs, usually scandent or clambering; branches not rooting aerially (except occasionally at tip); ribs obtuse or rounded; spines present, more than 1 cm long . . . .***Harrisia***

6. Stems columnar or arching, only rarely branched above 0.5 m from base; ribs usually 9–15; troughs between ridges obscured by radial spines extending over them and interlacing; pericarpel with many hair-spines or hairs; scales conspicuous to obsolete **7**

6'. Stems erect, columnar when young, later usually with at least some branching above 0.5 m from base; ribs usually 5–8; troughs between ribs exposed, radial spines not extending over them, not interlacing; pericarpel (at anthesis) nearly naked, or with scales only **9**

7. Stems less than 6 cm in diameter; flowers appearing over a considerable length of the stem **8**

7'. Stems (6–)8–10(–13) cm in diameter; flowers restricted to the top 10 cm of the stem; pericarpel and hypanthium with long, blackish hairs . . . .***Echinopsis schickendantzii***

8. Stems up to 1.5 m tall; rib margins virtually entire; spines pale yellow on active growth; pericarpel with dark hairs; perianth red, narrow (< 40 mm) . . . . ***Cleistocactus samaipatanus***

8'. Stems up to 3.0 m tall; rib margin ± tuberculate; spines white, purplish on active growth; pericarpel with white bristles; perianth white, broad (8–15 cm) . . . .***Peniocereus serpentinus***

9. Ribs 5–6, low; central spine 10–70 mm long, 3–6 mm broad at base; flowers diurnal, very small (c. 20 × 25 mm), up to 9 per areole; fruit 10–20 mm in diameter, dark purple . . . .***Myrtillocactus geometrizans***

9'. Ribs (3–)6–8(–12), prominent (irregularly broken and wavy in 'monstrous' forms); central spines 1–4, 1–5(–8) cm long, 1(–3) mm broad at base; flowers open from 20h00 to 10h00, large (15–29 cm long, 10–20 cm in diameter), solitary in each areole; fruit more than 4 cm in diameter, red, pink or orange . . . .***Cereus***

10. Spines with the epidermis separating either completely, or only at spine apex, as a deciduous papery sheath . . . . ***Cylindropuntia***

10'. Spines without a papery sheath **11**

11. Branches, including terminal ones, cylindric or globose; > 1.5 cm in diameter; flowers scarlet, orange, or white to pale pink .12

11'. Branches compressed, i.e. modified to cladodes (at least the terminal ones), or, if all branches cylindric, then only up to 1 cm in diameter; flowers yellow to orange . . . .***Opuntia***

12. Arborescent; branches not segmented, growth indefinite, cylindric; areoles not sunken; flowers (5–)6–7 cm long, scarlet to orange; fruit more than 5 cm long . . . .***Austrocylindropuntia***

12'. Low shrub; branches segmented, moniliform, segments with determinate growth, globose or cylindric, up to 5 cm long; areoles sunken; flowers up to 4.5 cm long, white or pale pink; fruit less than 2 cm long . . . .***Tephrocactus articulatus***

Austrocylindropuntia Backeb.

Shrubs or small trees. Branches cylindric, growth indefinite, sometimes divided into segments; furrow delimiting each tubercle sharply defined; roots more or less tuberous. **Leaves** 4–40(–120) mm long, succulent, terete, rather persistent, finally deciduous. Areoles with hairs, spines and glochidia. Glochidia flattened at the base, spines smooth, not sheathed. **Flowers** 5–7 cm long; tepals orange-red (scarlet), typically ¼–⅓ flower length. **Fruit** thick-walled, ellipsoidal (without pulp between the seeds in South Africa, often without seeds). **Seed** globose to pyriform, (3.5–)7(–c.10) mm long, laterally compressed, or with lateral ridges in some species, with smooth to slightly rugose funicular envelopes covered with fine hairs; funicular girdle rudimentary.

References: Anderson (2001), Hunt *et al.* (2006).

The genus consists of eight species from the Andes mountain range in South America (Argentina, Bolivia, Ecuador and Peru). It is distinguished from *Cylindropuntia* by shoots with indefinite growth, unsheathed spines, rhomboid to ovate tubercles with sharply defined delimiting furrows, and the typically large, isodiametric seeds. Of all southern African naturalised Cactaceae, the two *Austrocylindropuntia* species are the most conventionally tree-like when fully grown. Tepals are typically scarlet and ¼–⅓ flower length.

Fruit encountered in South Africa for *Austrocylindropuntia subulata* lacks pulp and is often also devoid of seeds. Individuals in South Africa may represent sterile clones derived from a minimal number of introductions. Lack of pulp renders fruit unattractive to birds. This also explains why this species is not spreading as effectively as similar, but seeding species, or those with seeds embedded in pulp. Fruits in South Africa are thick-walled and act as vegetative propagules.

Key to the two species of *Austrocylindropuntia* naturalised in southern Africa:

1. Leaves up to 1.5 cm long and tepals up to 1.7 cm long . . . . **1. *Austrocylindropuntia cylindrica***

1'. Leaves 4–8 cm long and tepals 2–3 cm long . . . . **2. *Austrocylindropuntia subulata***

Incomplete specimens may be difficult to distinguish from species of *Cylindropuntia* if spine sheaths are not well-developed in the latter. In *Austrocylindropuntia* stem tubercles are sharply defined, whereas in *Cylindropuntia* they are undulating.

1. *Austrocylindropuntia cylindrica* (Lam.) Backeb.

In: *Jahrbuch der Deutsche Kakteengesellschaft* 2: 12 (1942).

=*Opuntia cylindrica* (Lam.) DC

Shrub or small tree up to c. 2 m tall; trunk woody; branch segments distinctly rhomboid-tuberculate, c. 25 cm long, arising laterally from previous segments, not fragile, dark or bluish green. **Leaves** up to 1.1(–1.5) cm long, rather persistent, finally deciduous. Spines 2–5(–8), 10(–30) mm long, sometimes with later accruals on older growth, porrect, straight, terete or slightly flattened, yellowish; a few long hairs sometimes present. **Flowers** up to 7 cm long; pericarpel elongate-urceolate; areoles numerous, glochidiate; spines occasional, bristly. **Tepals** hardly spreading, c. ¼ flower length, scarlet. **Fruit** ellipsoid to oblong-urceolate, up to 9 cm long. **Seed** subglobose, 4–6(– c. 10) mm across, girdle narrow, not prominent. **Distribution**: SA. (Fig. 98).

References: Backeberg (1958), Anderson (2001), Hunt *et al.* (2006).

Fig. 98. Historical distribution of *Austrocylindropuntia cylindrica* (Lam.) Backeb.

The species with its snake-like, tuberculate stems (Fig. 99) is originally known from Ecuador (Pinchincha, Chimborazo and Cañar). In South Africa there are historical records from the Free State (Bloemfontein), KwaZulu-Natal (Black Umfolozi, Pietermaritzburg) and Eastern Cape (Katrivier catchment). Although most of these probably merely represent adventives, one herbarium specimen label records that it was becoming invasive in the Pietermaritzburg area in 1965. It is not a declared weed in South Africa.

Austrocylindropuntia cylindrica is also naturalised in Australia (Telford, 1984).

Fig. 99. Snake-like, tuberculate stems of *Austrocylindropuntia cylindrica* (Lam.) Backeb. (Picture by Helmuth G. Zimmermann)

2. *Austrocylindropuntia subulata* (Muehlenpf.) Backeb.

In: *Jahrbuch der Deutsche Kakteengesellschaft* 2: 12 (1942).

=*Austrocylindropuntia subulata* (Muehlenpf.) Backeb. subsp. *exaltata* (A.Berger) D.R.Hunt
=*Opuntia exaltata* A.Berger
=*Opuntia subulata* (Muehlenpf.) Engelm.

Common names: devil's rope, long-spine cactus (English); langdoringkaktus (Afrikaans).

Arborescent, 3–4(–5) m tall, abundantly branched, sometimes from below; branches elongate, tuberculate, up to 0.5 m long, green or somewhat glaucous. Tubercles in a few spirals, sharply defined, vertically rhomboid to decurrent-obovate. **Leaves** subulate, 4–8 cm long, persistent, with areoles at the upper extremities of tubercles. Spines (1–)2–4, strong, straight, up to 8 (–13) cm long, greyish-white (white or yellowish-brown when young). **Flowers** up to 6 cm long; pericarpel relatively long, tuberculate, with porrect, subulate bract-scales resembling small leaves. **Perianth** not widely flaring, a third of the flower length; tepals 2–3 cm long, scarlet, orange or yellowish. **Fruit** elongate, obovoid-oblong to clavate or ± spherical, ± spiny, sometimes successively proliferous (mostly sterile in South Africa). **Seeds** (1–)19, globose or isodiametric, 8–10 mm across. **Distribution**: N, SA. (Fig. 100).

References: Backeberg (1958), Obermeyer (1976), Anderson (2001), Henderson (2001), Hunt *et al*. (2006).

In parts of its natural distribution range (La Paz, Bolivia, to Junín, Peru), and elsewhere, this shrub or small tree is widely cultivated as a hedge. In South Africa it is known from Limpopo (Phalaborwa), North-West (Potchefstroom), Gauteng (Pretoria), Free State (Ficksburg, Bloemfontein), KwaZulu-Natal (Pietermaritzburg), Eastern Cape (Umzimkulu) and Western Cape (near Stellenbosch). It also occurs around Windhoek, in Namibia. This species has been proposed for classification as a category 1b species under NEMBA (National Environmental Management: Biodiversity Act) and CARA (Conservation of Agricultural Resources Act) (Anonymous, 2009). It is often cultivated as a barrier plant (living fence) in Namibia (Fig. 101), and has been recorded as an invader in Kenya, forming dense stands, impenetrable hedges or thickets, often around abandoned homesteads. It is also expected to be cultivated in other African countries. In ancient Peru, its spines (Fig. 102) were once used as needles (Anderson, 2001).

Seeds are usually sterile (Backeberg, 1958), and reproduction is mostly vegetative by means of proliferating fruit. Each fruit is capable of rooting on contact with the soil, and forming several plantlets. This may explain why the species is not spreading as fast as similar species with fertile seeds. Infestations are mainly clumpy and localised (Fig. 103).

Fig. 100. Distribution map of *Austrocylindropuntia subulata* (Muehlenpf.) Backeb., mostly as casual aliens.

Fig. 101. Living fence of *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. (Picture by Helmuth G. Zimmermann)

Fig. 102. Flowering branch of *Austrocylindropuntia subulata* (Muehlenpf.) Backeb., showing needle-like spines and furrows framing each tubercle (Picture by Helmuth G. Zimmermann)

Fig. 103. Localised infestation of *Austrocylindropuntia subulata* (Muehlenpf.) Backeb. (Picture by by Helmuth G. Zimmermann)

Cereus Mill.

Tree-like or shrubby, usually much branched; branches erect or ascending, strongly ribbed, often with annual constrictions, often glaucous; ribs 3–14, usually pronounced**.** Spines often numerous, acicular. **Flowers** medium to large, funnelform, nocturnal; pericarpel and hypanthium elongate, thick, naked or nearly so below, with scattered small scales above. Pericarpel areoles absent. **Perianth** broad, or moderately so, usually white. **Fruit** fleshy, globose, ovoid or oblong, usually red, sometimes orange, naked, splitting along one or more sides when mature to reveal white fruit pulp and small black-brown (virtually black) seeds, perianth remnant sometimes persistent (at least the style), blackening. **Seed** broadly ovoid, 1.8–4.0 × 1.1–3.0 mm, black-brown or brown, shiny or dull; smooth to tuberculate.

References: Taylor & Zappi (2004, 2006).

This genus consists of 25 species, from the Caribbean and South America (Taylor & Zappi, 2006). One or two members of subgenus *Cereus,* the largest subgenus with 13 species (Taylor & Zappi, 2006), are naturalised in southern Africa.

The extremely tall habit, mostly few-ribbed, cylindric or columnar stems with visible troughs between ribs, relatively large nocturnal flowers with virtually naked or merely scaly, spineless and glabrous pericarpel and hypanthium, and dehiscent fruit characterise locally naturalised representatives of this genus.

Species of *Cereus* have a history of cultivation spanning centuries, since they are popular garden plants with their attractive flowers, their popular fruit and their cylindric or columnar branches. This growth form sometimes leads to confusion with the indigenous and unrelated *Euphorbia ingens* E.Mey. ex Boiss. which can be found in many areas interspersed with *Cereus*. Cultivation almost inevitably leads to infestation of nearby savanna vegetation due to their attractive edible fruits, which are eagerly consumed by frugivorous birds. Seedlings are often found under fence lines and under trees and shrubs as a result of seed dispersal by birds.

In South Africa all naturalised populations belong to a group of five currently recognised species or subspecies (Taylor & Zappi, 2006), that appear closely related to, and include, *Cereus hexagonus* (L.) Mill., the type species of the genus. The other species in this group are: *C. jamacaru* DC. (two subspecies) and *C. hildmannianus* K.Schum. (two subspecies). Note that the image used to illustrate *C. hexagonus* in Anderson (2001) appears to be a species of *Stenocereus* (A.Berger) Riccob., judging by the densely areolate pericarpel, and rounded flowerbud apex.

Taylor & Zappi (1992) retained the name *Cereus jamacaru* so that it could be used in the usual sense, in case the entity was considered conspecific with *C. hexagonus*. Later they stated (Taylor & Zappi, 2006) that *C. jamacaru* appears to be closely related to *C. hexagonus*, which is said to usually have fewer branches and much shorter spines (the cultivated form being virtually spineless). The classification of Taylor & Zappi (2004, 2006) is followed in the present work.

As these taxa are difficult to distinguish from one another, particularly in the absence of dehiscing fruit, the group can be collectively referred to as the *Cereus hexagonus* species complex. Its known natural distribution range can be regarded as a geographical taxon replacement series, starting with *C. hexagonus* to the north of the Amazon River, from Venezuela, Trinidad and Tobago, to northern Brazil (Pará), in moist woodland (Taylor & Zappi, 2006). To the south and east of the Amazon, *C. hexagonus* is replaced by *C. jamacaru* (Taylor & Zappi, 2004). Continuing south- and westward, *C. hildmannianus* completes the series (Kiesling, 1982; Taylor & Zappi, 2004, 2006).

For many years the South African populations have been referred to the misapplied name *C. peruvianus* (Taylor & Walker, 1984), and more recently to *C. jamacaru* (Henderson, 1995). In the present work, two taxa (*Cereus hildmannianus* subsp. *uruguayanus* and *C. jamacaru* subsp. *jamacaru*) are considered naturalised or merely as casual aliens in South Africa.

A key to some taxa of the *Cereus hexagonus* complex is presented here as an aid to future interpretation of the variation in or among the populations that are naturalised in southern Africa [based on information in Anderson (2001) and Taylor & Zappi (2004, 2006)]:

Note: floral dimensions are as expected for fresh flowers.

Key to the *Cereus hexagonus* complex:

1. Flowers up to 18 cm long; fruit splitting along 3 lines . . . .**1. *Cereus hildmannianus* subsp. *uruguayanus***
1’. Flowers 20–29 cm long; fruit splitting along 1–3 lines **2**

2 Flowers 10–15 cm wide **3**
2’. Flowers 15–20 cm wide **4**

3. Mostly spineless; fruit splitting along 3 lines from apex . . . . **(*Cereus hildmannianus* subsp. *hildmannianus*)**
3’. Always spiny; fruit splitting from base along 1 line on the underside . . . .**(*Cereus jamacaru* subsp. *calcirupicola* (F.Ritter) N.P.Taylor & Zappi)**

4. Areoles 1.5–4 cm apart; tree with dense branching; dry woodland habitat; fruit dehiscence along 1 line on the underside . . . . **2. *Cereus jamacaru* subsp. *jamacaru***
4’. Areoles 1–2 cm apart; tree with few branches; moist woodland habitat; fruit dehiscence unknown . . . . **(*Cereus hexagonus*)**

1. *Cereus hildmannianus* K.Schum. subsp. *uruguayanus* (R.Kiesling) N.P.Taylor

In: *Cactaceae Consensus Initiatives* 6: 15 (1998).

=*Cereus peruvianus* sensu auctt. non L. (Mill.) var. *monstrosus* DC.

Common names: pitaya, queen of the night (English); nagblom (Afrikaans).

Treelike or shrubby, c. 15 m tall, with or without a well-developed trunk; branches 8–12 cm in diameter, glaucous when young; branch tissue highly mucilaginous; ribs very variable in number, (5–)6–9(–12), (3–)3.5–5(–7) × 1–3 cm; juveniles only 3–5-ribbed; areoles 1–2 cm apart, c. 6 mm in diameter. Spines 5–10, (1–) 1.5–2 cm long, reddish-brown to black. **Flowers** 15–18 × 10–14 cm; outer tepals brownish or olive green, inner tepals white. **Style** 10–11 cm long**. Fruit** 5–12 × 7–12 cm, yellow, orange or reddish, splitting open from apex along c. 3 lines; pulp white. **Seed** c. 3 × 2.8 mm. **Distribution**: SA. (Fig. 104)

References: Anderson (2001), Taylor & Zappi (2004, 2006).

Cereus hildmannianus occurs from Rio de Janeiro and southwestern Minas Gerais to Paraguay, Uruguay and eastern Argentina (Entre Ríos and Buenos Aires) (Taylor & Zappi, 2004). The subspecies *uruguayanus* has a natural range from southern Brazil (Santa Catarina and Rio Grande do Sul), through Uruguay to the Rio de la Plata estuary in Argentina (Kiesling, 1982; Taylor & Zappi, 2006). It is cultivated in South Africa, and should be treated at least as potentially invasive.

This taxon differs from *Cereus hildmannianus* subsp. *hildmannianus* and also from the other two species in the complex by its shorter flowers (Anderson, 2001; Taylor & Zappi, 2004, 2006). The flowers (Fig. 105) are furthermore narrower (10–14 cm wide) than those of *C. hexagonus* or *C. jamacaru* subsp. *jamacaru* (15–20 cm wide), presumably due to shorter tepals. The collecting of additional material from South Africa is required to confirm the identification of the taxon present in the country.

The name *Cereus uruguayanus* was first applied as a replacement name for the occasional monstrose form (Fig. 106) with interrupted and/or contorted ribs (Kiesling, 1982). Such forms seem to occur in *C. jamacaru* as well.

Fig. 104. Distribution map of *Cereus hildmannianus* K.Schum. subsp. *uruguayanus* (R.Kiesling) N.P.Taylor.

Anderson (2001) lists *Cactus peruvianus* as a synonym of *Cereus hildmannianus.* However, this is a misapplied name as *Cactus peruvianus* L. (which is the basionym of *Cereus peruvianus* (L.) Mill.) is a synonym of *Cereus repandus* (L.) Mill, a species in a different subgenus of *Cereus* (Hunt & Taylor, 1992; Taylor & Zappi, 2004, 2006).

Fig. 105. Flower of *Cereus hildmannianus* K.Schum. subsp. *uruguayanus* (R.Kiesling) N.P.Taylor. (Picture by Geoff R. Nichols)

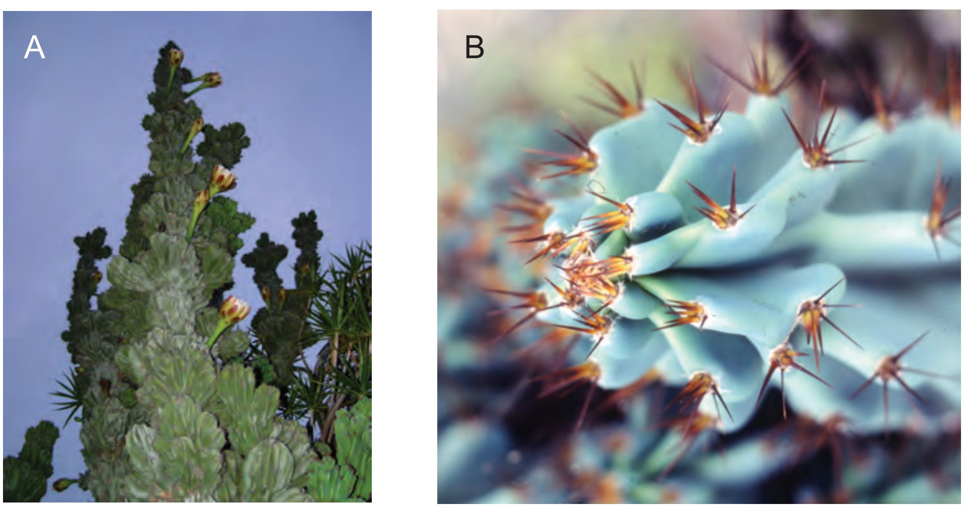

Fig. 106. *Cereus hildmannianus* K.Schum. subsp. *uruguayanus* (R.Kiesling) N.P.Taylor – A. Monstrose form; B. Spines. (Pictures by Geoff R. Nichols (A); Gideon F. Smith (B))

2. *Cereus jamacaru* DC.

In: *Prodromus Systematis Naturalis Regni Vegetabilis* 3: 467 (1828a), nom. cons., **subsp. jamacaru**.

Common names: Peruvian apple cactus, pitaya, queen of the night (English); bobbejaanpaal, môrester, nagblom (Afrikaans).

Tree-like, 3–10(–18) m high, up to 10 m across, often with a short (0.5–2 × 0.3–1 m) trunk; densely branched; branches 7–20 cm in diameter, often strongly glaucous when young, later dark blue-green, tissue scarcely mucilaginous; ribs (3–)6–8(–10), up to 6 × 1.8–4.5 cm; margins weakly to strongly crenate; areoles 4–8 mm at first, enlarging greatly on trunk and older branches, grey-felted, 1.5–4 cm apart. Spines few to many, sometimes absent on upper branches, yellow or brown when young, eventually turning grey to blackish; central spines 1–4 or more, 1–2(–6) cm long, up to 3 mm broad at base; radial spines (4–)7–8(–12), up to 3.5 cm long. **Flowers** funnelform, 21–30 × 15–20 cm**. Pericarpel** and hypanthium up to 16 cm long; green, bearing small, red or reddish scales. **Tepals** 8–10 × 2–2.7 cm, outer tepals greenish, sometimes tinged crimson, inner tepals white. **Stigmas** 12–16(–20), 1.1–1.9 cm long, greenish. **Stamens** oblique in mature flower. **Fruit** ellipsoid, 6–10 × 4–8 cm, crimson to pinkish red, dehiscent by a longitudinal slit from the base on the underside; pulp white. **Seed** black-brown (virtually black). **Distribution**: N, SA. (Fig. 107)

References: Anderson (2001), Henderson (2001), Taylor & Zappi (2004, 2006).

Cereus jamacaru ranges from northern Brazil (Maranhão and perhaps Pará, where records could not be determined unambiguously) and throughout eastern Brazil to central Minas Gerais, mainly in drier thorn savanna (‘caatinga’) (Taylor & Zappi, 2004). The southern periphery of this range in Bahia and Minas Gerais is occupied by subsp. *calcirupicola* (F.Ritter) N.P.Taylor & Zappi, which has not been recorded in South Africa but should be watched for. It differs from subsp. *jamacaru* in the following characters (Taylor & Zappi, 2004, 2006): ribs 5–8 (in young plants 0.1–1.0 m tall); branch segments broadest immediately above the constrictions; spines uniformly short, dark red–brown; flowers 10–15 cm diameter, pericarpel and hypanthium up to 21 cm long, with green to brownish scales; tepals 5–7 cm long.

Fig. 107. Distribution map of *Cereus jamacaru* DC. subsp. *jamacaru.*

Cereus jamacaru subsp. *jamacaru* is naturalised across a large part of the savanna biome of South Africa (Henderson, 2007), and is a declared weed due to the transformation of woodland by rendering it impenetrable to livestock (Fig. 108). It has also been recorded in other biomes, e.g. some in the Western and Eastern Cape Provinces (Henderson, 2007) and has been proposed for classification as a category 1b invader under NEMBA and CARA (Anonymous, 2009). The species is often confused with the indigenous *Euphorbia ingens* (Fig. 109) but easily distinguished on account of the large fragrant flowers (Fig. 110, 111).

Control of isolated plants is best using registered stem-injected herbicides (Anonymous, 2004). Large infestations should be manually infested with the South American mealybug, *Hypogeococcus pungens* (also known as *H. festerianus*) which causes gall-like distortions, arresting growth and fruiting and eventually results in the death of the plants. This natural enemy is host-specific to several genera in the Cactoideae. The second biological control agent is a longhorn beetle, *Alcideon cereicola,* introduced from Argentina in 1990. It is very localised and a poor disperser, but effective in killing large and small plants once infected (Klein, 1999). *H. pungens* is most damaging, and the growth distortions are conspicuous, mainly at the growth tips. The insects may take a few years to suppress the infestations to acceptable levels (Klein, 1999).

This species is known for its delicious and attractive red fruit (Fig. 112), referred to variously as jamacaru, mandacaru or pitaya. It is now being developed as a new fruit for commercial cultivation in Israel, mainly for export to Europe (Nerd *et al*., 2002).

Fig. 108. Impenetrable woodland with *Cereus jamacaru* DC. subsp. *jamacaru.* (Picture by PPRI)

Fig. 109. *Cereus jamacaru* DC. subsp. *jamacaru* (foreground) is often confused with *Euphorbia ingens* E.Mey. ex Boiss. (background). (Picture by Geoff R. Nichols)

Fig. 110. Flowers of *Cereus jamacaru* DC. subsp. *jamacaru.*
(Picture by Geoff R. Nichols)

Fig. 111. Flowers of *Cereus jamacaru* DC.
subsp. *jamacaru.*
(Picture by Geoff R. Nichols)

Fig. 112. Fruit of *Cereus jamacaru* DC. subsp. *jamacaru* is known as 'pitaya'.
(Picture by Lesley Henderson)

Cylindropuntia Mill.

Trees or shrubs, erect, much branched; branches articulate on ramification; branch segments cylindric to somewhat placate, glabrous, firmly attached to easily detached, distinctly to hardly tuberculate, furrow delimiting each tubercle broadly rounded, tubercles more or less elongated. Glochidia present, flattened at base. Spines with entire, papery, deciduous, epidermal sheaths. **Flowers** variously coloured, pink to dark purple. **Inner tepals** ligulate to spathulate**. Fruit** cylindric to subglobose or clavate, variously coloured, fleshy or dry, mostly sterile and/or proliferous. **Seed** usually thick-discoid or lenticular, 2.5–5 mm long, white to pale yellow or beige; funicular envelope glabrous or with thin unicellular trichomes; girdle well-developed.

References: Anderson (2001), Pinkava (2003a), Hunt *et al*. (2006).

This genus consists of 33 species, distributed in Central America and the Caribbean, extending into the southwestern USA and northwestern South America (Anderson, 2001; Pinkava, 2003a; Hunt, 2006).

Species of *Cylindropuntia* always have cylindrical, segmented branches, and sheathed spines. As in *Harrisia martinii*, most species have elongated, prominent tubercles that give the branch segments a 'plaited rope' look. The inner tepals are never orange or scarlet as they are in the *Austrocylindropuntia* species treated here, and the tubercles are not so clearly delimited.

The frequent occurrence of hybrids, polyploid series, and taxa of hybrid origin in its native range (Parfitt & Gibson, 2003; Pinkava, 2003a) complicates the taxonomy of this genus (Hunt, 2006).

Key to the species of *Cylindropuntia* in South Africa [based partly on Pinkava (2003a)]:

1. Terminal stem segments usually alternate, narrow, 0.7–1.4 cm in diameter; tubercles hardly apparent, never obscured by dense spines; large spines 0–4(–6) per areole . . . . **4. *Cylindropuntia leptocaulis***

1'. Terminal stem segments commonly whorled or subwhorled, thicker, usually 1.5–5.5 cm in diameter; tubercles distinct, in some species obscured by densely interlacing spines; large spines (0–)6–30 or more per areole **2**

2. Fruits smooth to shallowly tuberculate, green to yellow-green, sometimes tinged red to purple at maturity, usually forming long chains in large plants, sometimes simple . . . . **1 & 2. *Cylindropuntia fulgida***

2'. Fruits strongly tuberculate, yellow-green to yellow (sometimes tinged red to purple) or orange-yellow at maturity, simple (rarely with a secondary fruit produced in *C. imbricata*), clustered at end of terminal cladodes, but not proliferating in chains **3**

3. Distal stem segments easily detached from next segment; spines crowded, obscuring stem; flowers always rose coloured . . . . **5. *Cylindropuntia pallida***

3'. Distal stem segments firmly attached to next segment; spines scattered, not or little obscuring stem; flowers usually dark pink to magenta or purple-red **4**

4. Tubercles of stems usually 0.5–1.5 cm high, crowded; fruits with 28–50 or more areoles, tubercles longer in distal portion of fruit . . . . **6. *Cylindropuntia spinosior***

4'. Tubercles of stems usually 2–5 cm high, widely spaced; fruits with 18–30 areoles, tubercles nearly equal in length, or longer in proximal portion of fruit . . . . **3. *Cylindropuntia imbricata***

1. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth

In: Backeberg & Knuth *Kaktus-ABC*: 126 (1936) **var. *fulgida*.**

Common names: chain-fruit cholla (English) (previously wrongly identified as rosea cactus, *Cylindropuntia pallida*, in South Africa).

Shrub to small tree 1–3 m tall; trunk well developed; branching divaricate; branch segments ovoid to narrowly ovoid-cylindric, 6–23 × 2–3.5 cm, glaucescent, terminal segments easily detached; tubercles salient, 8–13(–19) mm tall, broadly ovoid, strongly mamillate, obscured by longer and denser spines than in var. *mamillata*, that are interlaced with spines from adjacent tubercles; areoles with gold or brown wool; glochidia 1–3 mm long, yellow. Spines (0–)c.12(–18), 2.5–3(–3.5) cm long, yellow, sheaths baggy, whitish to yellowish. **Flowers** opening late afternoon.

Tepals obovate to ligulate, usually recurved, pink to magenta. **Fruit** obconical, 2–5.5 × 1.3–4.5 cm, obscurely tuberculate, mostly spineless, fleshy, grey-green, proliferous. **Seed** aborted (sterile). **Distribution**: B, SA. (Fig. 113).

References: Henderson (2001), Pinkava (2003a), Hunt *et al*. (2006).

This species is centred on the Gulf of California and the Sonoran Desert of northwestern Mexico and southwestern USA. The type variety (var. *fulgida*) occupies the northeastern portion of the range from Arizona (USA) to Sonora (Mexico), at 300–1100 m above sea level (Pinkava, 2003a). In South Africa infestations are known near Douglas (Northern Cape), Beit Bridge (near Musina, Limpopo Province) and also from adjacent Zimbabwe (Henderson and Zimmerman, 2003). It is thought to have been introduced into South Africa for horticultural purposes, and was previously used as a protective hedge around many homesteads.

It is often confused with *Cylindropuntia pallida* and *C. tunicata* (Lehm) Knuth*,* especially during the juvenile stage, when it has densely interlacing spines. This species can be differentiated from those two species by its indistinctly tuberculate fruit proliferating in chains (particularly long chains in larger plants) (Fig. 114), and showy darker pink to magenta tepals that curve backwards with age (Fig. 115). In South Africa it has been confusingly named rosea cactus and roseakaktus (Afrikaans). This resulted from its initial incorrect identification as *C. pallida*.

The name 'chain-fruit cholla' (Pinkava, 2003a) emphasises the formation of proliferating or 'chain' fruits, an important feature that distinguishes it from *C. pallida* and other naturalised chollas (Henderson & Zimmerman, 2003).

Alongside *Opuntia aurantiaca* this is probably the most dangerous cactus invader (Fig. 116) because of its formidable thorns which can cause severe injuries and even death to animals. It is not uncommon to find dead birds, reptiles and small mammals impaled on the thorns (Fig. 117). Livestock get the joints on their mouths or groins which prevent feeding and result in death if not removed. It is understandable why humans used it as a living fence.

This cactus is a declared a category 1 weed in South Africa which is prohibited and must be controlled. It has also been proposed for classification as a category 1b invasive alien plant under NEMBA and CARA (Anonymous, 2009). A registered herbicide is available for its control in South Africa (Anonymous, 2004). An effective biological control agent, a virtually host specific cochineal biotype of *Dactylopius tomentosus*, was collected in Mexico on *Cylindropuntia cholla* (F.A.C.Weber) F.M.Knuth, and released at a number of sites in Limpopo in October and November in 2008. This cochineal has been found to be very damaging to the chain-fruit cholla and is proving to be very successful in controlling this weed (Klein & Zimmerman, 2009). Shown are healthy (Fig. 118) and infected (Fig. 119) plants which clearly demonstrate the effectiveness of this biological control agent.

Fig. 113. Distribution map of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida.*

Fig. 114A. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida*. Chain fruit shown against healthy spiny plant (Picture by Helmuth G. Zimmermann)

Fig. 114B. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida*. Fruit and large plant showing scale. (Picture by Helmuth G. Zimmermann)

Fig. 115. Flower of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida.* (Picture by Helmuth G. Zimmermann)

Fig. 116. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida* is an aggressive invader. (Picture by Helmuth G. Zimmermann)

Fig. 117. Reptile impaled in *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida.* (Picture by Helmuth G. Zimmermann)

Fig. 118. Healthy plant of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida.* (Picture by Helmuth G. Zimmermann)

Fig. 119. Plant of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *fulgida* damaged by biological control agent. (Picture by Helmuth G. Zimmermann)

2. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb.

In: *Die Cactaceae, Handbuch der kakteenkunde* 1: 204 (1958).

=*Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb. forma *monstrosa* (J.M.Coult) P.V.Heath

Common names: boxing glove cactus (applied only to the crested morphotype, forma *monstrosa*), coral cactus (English).

In comparison to the type variety that appears very spiny from afar due to its dense, longer (2.5–3.5 cm long) spinescence, strongly interlacing with that of adjacent areoles, that obscures the strongly mamillate tubercles beneath, var. *mamillata* appears spineless or nearly so from afar, exposing the strongly mamillate tubercles, due to the sparse, short (1–2 cm long) spines, not or only slightly interlacing with those from adjacent areoles [note that the photograph in Anderson (2001) labelled *C. fulgida* var. *fulgida*, shows these features of *C. fulgida* var. *mamillata*]. The spine sheaths are tightly fitting in var. *mamillata*, while they are baggy in var. *fulgida* (Pinkava 2003a). **Distribution**: SA. (Fig. 120)

Reference: Pinkava (2003a).

Its strongly tuberculate fruit distinguishes *Cylindropuntia fulgida* var. *mamillata* from *C. imbricata* and from the rose to reddish purple-flowered forms of *C. spinosior*, in which proliferation is rare or absent. Fruits are strongly tuberculate. Hybrids of *C. fulgida* with *C. leptocaulis* and *C. spinosior* are known in North America (Pinkava, 2003a).

This variety has a wider range, extending further southwest than *Cylindropuntia fulgida* var. *fulgida*. It occupies both sides of the Gulf of California, in Baja California and the Sonoran Desert in Sonora and Sinaloa (Mexico), as well as the northern extension of the Sonoran Desert in Arizona (USA), where the two varieties occur sympatrically and intermediates can be found (Pinkava, 2003a). The variety is not recognised by some authors (e.g. Hunt, 2006).

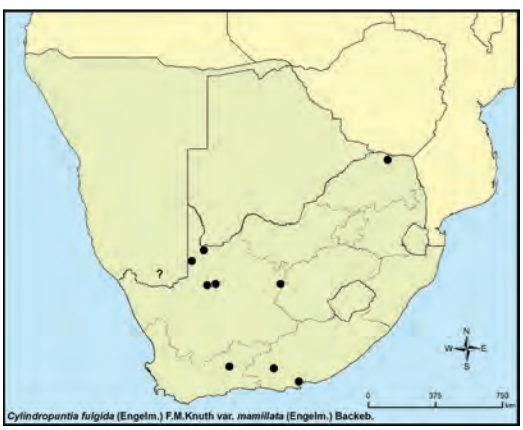

Fig. 120. Distribution map of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb.

The widely cultivated crested morph (Fig. 121) is native to south-central Arizona in the USA (Pinkava, 2003a). This form lacks strong, barbed spines and fertile seed and has been assumed therefore to be less aggressive than var. *fulgida*. Although the boxing glove cactus does not appear related to *C. fulgida* at first sight, there is a population near Hopetown (Northern Cape Province), showing all the features of *C. fulgida* var. *fulgida*, with several individuals showing characteristics of both varieties on one plant. It would appear as if var. *mamillata* can revert back to the much more aggressive var. *fulgida*. This justifies the control envisaged for var. *mamillata*, despite the fact that it otherwise appears to be less invasive.

Fig. 121. Crested form of *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb. (Picture by Debbie Sharp)

In southern Africa the crested morph has invaded arid vegetation at a fairly local scale in southern Namibia, Limpopo Province (around Musina), the Northern Cape Province (near Upington, Askham and Noenieput) (Fig. 122), and in the Eastern Cape (near Port Elizabeth). A small population has also been detected in the Western Cape (near Beaufort West, including in the Karoo National Park). It is naturalised in Australia in Queensland, South Australia and Western Australia, and recently also in New South Wales. As in Australia, it is estimated that this species has spread from original plantings, since it is a popular succulent ornamental suitable for planting in semi-arid areas. Its characteristic boxing glove-like cladodes seem to have made it a popular seller. It is thought that it is the ability of these cladodes to persist for months after they have been discarded that has caused them to start growing where discarded, e.g. at municipal refuse dumping sites. Localised dispersal is via movements of dislodged segments, especially by flood water. As it is the same species as *C. fulgida* var. *fulgida*, it is legally subject to the same control obligations as mentioned above.

Fig. 122. *Cylindropuntia fulgida* (Engelm.) F.M.Knuth var. *mamillata* (A.Schott ex Engelm.) Backeb. invasion. (Picture by Barbara K. Mashope)

3. *Cylindropuntia imbricata* (Haw.) F.M.Knuth

In: Backeberg & Knuth *Kaktus-ABC*: 125 (1936).

=*Cylindropuntia rosea* (DC.) Backeb.
=*Opuntia imbricata* (Haw.) DC.
=*Opuntia rosea* DC.

Common names: devil's rope pear, imbricate cactus (English); kabelturksvy, toukaktus (Afrikaans).

Shrub, often treelike, 1–3 m tall, often with short trunks; branch segments whorled or subwhorled, cylindric to subclavate, 8–25 × 1.5–4 cm, dull grey-green; tubercles prominent, giving the effect of a woven rope, 40 × 5 cm; widely spaced; areoles elliptic, with yellow to tan wool; glochidia 0.5–3 mm long, pale yellow. Spines 5–30, stout, up to 3 cm long, silver-grey to yellow to reddish or brown, sheaths silver-grey to yellow. **Leaves** subulate, 1–2 cm long, caducous. **Flowers** from Nov. to

Jan. **Tepals** obovate to spathulate, dark pink, magenta or reddish magenta. **Fruit** obovoid, 2.4–4.5 × 2–4 cm, fleshy, spineless, yellow, sometimes proliferous and mostly sterile. **Distribution**: B, N, S, SA. (Fig. 123)

References: Obermeyer (1976), Zimmerman (1983), Henderson (2001), Pinkava (2003a), Hunt *et al*. (2006), Scheinvar *et al*. (2009).

Cylindropuntia imbricata is similar to *C. spinosior*, which differs by its rose, reddish purple, bronze purple, whitish, yellow or salmon tepals (in *C. imbricata* usually dark pink to magenta, or rarely, only in its native range, white) (Pinkava, 2003a). Other characters are mentioned in the key to species of the genus.

The name *Opuntia rosea* has for a long time been incorrectly applied to *Cylindropuntia pallida*, following the Mexican usage, e.g. Bravo-Hollis (1978). Judging by the illustrations (Rowley, 1994) that were cited by De Candolle in his original description of the species, we follow Britton & Rose (1963) in placing it under *C. imbricata*. The illustration depicts sparse, short spines, a crimson flower with most tepals slightly recurved (Fig. 124), and a proliferating fruit (Fig. 125).

Cylindropuntia imbricata has a naturally wide distribution range in the Rio Grande catchment at (800–)1 100–1 800(–2 200) m above sea level, often dominant in the Chihuahuan Desert, spanning northern Mexico and the south-central United States, crossing over into the Mississippi catchment in southwestern Kansas and western Oklahoma (Pinkava, 2003a). In central Mexico it responds to overgrazing, forming dense and weedy populations. It is naturalised in Australia (Telford, 1984). In South Africa, it is a transformer of karoo, dry savanna (Fig. 126) and grassland vegetation.

This is a declared category 1 weed in South Africa, and the registered herbicide available for control can be found in the latest update of ‘A guide to the use of herbicides’ published by the Dept of Agriculture (2004). It has also been proposed for classification as a category 1b invasive alien plant under NEMBA and CARA (Anonymous, 2009).

Cochineal, *Dactylopius tomentosus*, was originally introduced from the USA in 1970. It provides reasonable control in hot and dry regions. Best results are achieved if well-infested plants are felled and heaped. The insect needs to be hand-dispersed to create new infestations. Isolated plants are best controlled chemically (Moran & Zimmermann, 1991b).

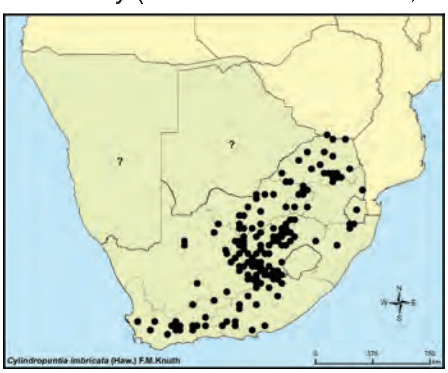

Fig. 123. Distribution map of *Cylindropuntia imbricata* (Haw.) F.M.Knuth.

Fig. 124. Flower of *Cylindropuntia imbricata* (Haw.) F.M.Knuth.
(Picture by Barbara K. Mashope)

Fig. 125. Proliferating fruit of *Cylindropuntia imbricata* (Haw.) F.M.Knuth.
(Picture by Gideon F. Smith)

Fig. 126. *Cylindropuntia imbricata* (Haw.) F.M.Knuth is a transformer of dry savanna. (Picture by Arrie Klopper)

4. *Cylindropuntia leptocaulis* (DC.) F.M.Knuth

In: Backeberg & Knuth *Kaktus-ABC*: 122 (1936).

Common names: desert Christmas cactus, desert Christmas cholla, pencil cactus (English); potloodkaktus (Afrikaans).

Shrubby or treelike, variously branched, 0.5–1.8 m, usually with numerous short, spineless stems along major axes; branch segments very slender, 20–80 × 3–5 mm, scarcely tuberculate, grey-green to purplish; areoles broadly elliptic, with white to yellow wool, becoming grey with age; glochidia 1.5 mm long, yellow to reddish brown. Spines 0–1(–3), 14–45 mm long, mainly at apical areoles, porrect, flattish at base, acicular above; sheaths grey, purplish grey, or yellow. **Flowers** pale to greenish yellow, sometimes with reddish tips. **Fruit** occasionally proliferating, obovoid, c. 15 × 6–7 mm, fleshy, spineless, yellow to red when ripe. **Distribution**: N, SA. (Fig. 127)

References: Pinkava (2003a), Hunt *et al*. (2006).

This species is widespread in the deserts, grasslands, shrublands and woodlands of the southern USA from Arizona to coastal Texas, and in Mexico from Sonora to Zacatecas and Tamaulipas (Pinkava, 2003a).

It is readily distinguished from the other naturalised *Cylindropuntia* species by its thin stems and indistinct tubercles (Fig. 128). *Cylindropuntia leptocaulis* *s*uperficially resembles *Opuntia salmiana*, from which it can be distinguished by sheathed, hard spines and short (5–8 mm long) pale to greenish yellow tepals (flowers 2–3.5 cm across and whitish in *O. salmiana*). Hybrids with *Cylindropuntia fulgida* and *C. spinosior* are known in North America (Pinkava, 2003a).

The pencil cholla became established in the Oudtshoorn district where it was spreading at an alarming rate during the seventies. The imbricate cactus cochineal, *Dactylopius tomentosus,* proved to be a very efficient biological control agent which has successfully controlled practically all known infestations. Isolated plants are still found around Oudtshoorn (Fig. 129) and beyond. No additional control measures are necessary.

Fig. 127. Distribution map of *Cylindropuntia leptocaulis* (DC.) F.M.Knuth.

Fig. 128. Fruits of *Cylindropuntia leptocaulis* (DC.) F.M.Knuth. (Picture by Helmuth G. Zimmermann)

Fig. 129. *Cylindropuntia leptocaulis* (DC.) F.M.Knuth.
(Picture by Helmuth G. Zimmermann)

5. *Cylindropuntia pallida* (Rose) F.M.Knuth

In: Backeberg & Knuth *Kaktus-ABC*: 122 (1936).

=*Opuntia pallida* Rose
=*Opuntia rosea* sensu auct. non DC. (misapplied name)

Common names: rosea cactus (in South Africa somewhat confusingly used for *C. fulgida* var. *fulgida*), Hudson pear (in Australia, J.R. Hosking, *pers. comm.*) (English); roseakaktus (in South Africa somewhat confusingly used for *C. fulgida* var. *fulgida*) (Afrikaans).

Shrub, branching basally with ascending stems, (0.2–)0.5–1 m tall (1.5 m in Australian form); branch segments cylindric, 10–15 × 1.6–2.5 cm, grey-green; tubercles distinct; areoles large, 2–3.5 cm apart; glochidia 2–5 mm long, yellow. Spines (1–)4–9, acicular, 1–4 cm long, yellow, reddish or grey; sheaths papery, yellowish, not completely covering the spines. **Flowers** 3.8–4 mm long, pink. **Fruit** obconical to obovoid, 1.6–1.8 × 1.1–1.4 cm, tuberculate, spiny, yellow. **Distribution**: B, N, SA. (Fig. 130)

References: Britton & Rose (1963), Anderson (2001).

Hunt *et al*. (2006) described *Opuntia pallida* as appearing to be 'a deep pink-flowered form of *C. tunicata*' and listed it as a synonym of *Cylindropuntia rosea*. *Cylindropuntia pallida* appears to be geographically isolated from *C. tunicata* of the Chihuahuan Desert (Pinkava, 2003a). The host-adapted cochineal insects also suggest that they are distinct species. The cochineal from *C. pallida* does not develop on *C. imbricata* and *C. tunicata* and the converse applies to the cochineal on *C. imbricata* (Mathenge *et al*., 2010). This strong specificity indicates that conspecificity or hybrid origin are unlikely.

This taxon has for a long time been treated under the name *Opuntia rosea*, following Mexican usage, e.g. Bravo-Hollis (1978). That name seems better placed as a synonym of *C. imbricata*, judging by the illustrations (Rowley, 1994) that were

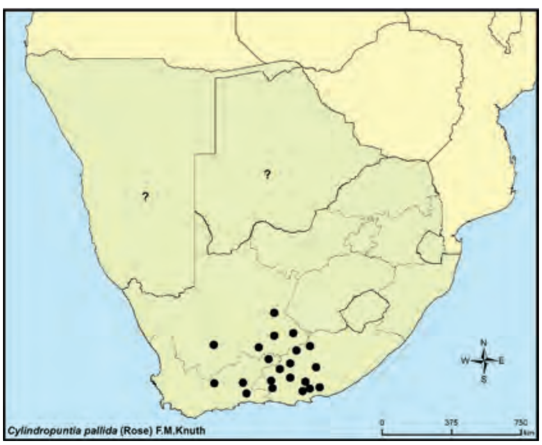

Fig. 130. Distribution map of *Cylindropuntia pallida* (Rose) F.M.Knuth.

cited by De Candolle (1828). As any changes from a name in wide and current use could cause disruption, an alternative to using the currently correct name *O. pallida*, is that the name *C. rosea* (based on a painting of *C. imbricata*) is formally proposed to be conserved with a new type, in order to fix the application of the name to the Mexican taxon that has been the subject of most literature treatments.

Although plants are usually low growing (Fig. 131), some plants have been reported to reach up to 1.5 m high in Australia (Hosking *et al*., 2007). In South Africa this species has sometimes been referred to under the name *C. tunicata* and it has also been confused with *Cylindropuntia fulgida*. The juvenile plants of these three cholla species are similar looking and with our current knowledge, can only be visually distinguished from each other by their flower tepal colour once they are mature enough to flower. *C. pallida* has pink (rose coloured) flowers (Fig. 132) whilst those of *C. tunicata* are yellow or yellowish green (Anderson, 2001; Hunt, 2006). *C. tunicata* is consistently low-growing as opposed to the taller *C. pallida.*

Cylindropuntia pallida is native to the provinces of Hidalgo, Mexico, Puebla and Tlaxcala of central Mexico. It can form dense stands in its natural range due to disturbance such as overgrazing. It has become invasive and has naturalised in New South Wales, Australia (Hosking *et al*., 2007).

The species is used as a barrier plant in Namibia, and has recently also been recorded in Botswana. In South Africa it is known to be cultivated for decoration in drier regions (Fig. 133). Low-growing plants recorded in the Northern and Eastern Cape near Addo, Jansenville, Cradock, Graaff-Reinet, Murraysburg and Victoria West may belong to this species, but require verification as either *C. pallida* or *C. tunicata*. Populations from Jansenville, and from the Western Cape near Oudtshoorn, have been confirmed as *C. pallida.*

Cylindropuntia pallida spreads by the movement of easily detachable segments, especially by flood waters. The plant has long spines with detachable sheaths that are a hazard to grazing animals. Since segments are easily detached, they can be dispersed (as burrs) via vehicle tyres. The fruit (Fig. 134) bears sterile (abortive) seeds but individual fruit can root and form new plants, enhancing vegetative spread.

This plant is currently not listed as a weed in South Africa. Research on biological control of *C. pallida* has commenced in Australia (as *C. rosea*) and South Africa could in future collaborate on this initiative. So far, *C. tunicata* is only known in South Africa as a horticultural subject, but has been proposed to be listed under CARA and NEMBA similarly to *C. pallida* or *C. fulgida* (Anonymous, 2009). This proposal is supported by the fact that *C. tunicata* has already become naturalised in Australia, Argentina, Chile, Ecuador and Peru (Hunt, 2006).

Fig. 131. *Cylindropuntia pallida* (Rose) F.M.Knuth has a low growing habit. (Picture by Barbara K. Mashope)

Fig. 132. Flower of *Cylindropuntia pallida* (Rose) F.M.Knuth. (Picture by Barbara K. Mashope)

Fig. 133. *Cylindropuntia pallida* (Rose) F.M.Knuth spreading from abandoned homestead. (Picture by Barbara K. Mashope)

Fig. 134. Fruit of *Cylindropuntia pallida* (Rose) F.M.Knuth. (Picture by Barbara K. Mashope)

6. *Cylindropuntia spinosior* (Engelm.) F.M.Knuth

In: Backeberg & Knuth *Kaktus-ABC*: 122 (1936).

Common names: cane cholla, spiny cholla (English).

Compact shrubs, tree-like, 0.4–2.0 m tall; branches whorled, segments 5–23 cm long, 1.3–3.5 cm in diameter, green to purplish; tubercles oval, usually 5–15 mm high, crowded; areoles often elliptical, wool yellow to tan, ageing darker; glochidia inconspicuous, 1–2 mm long, yellow to tan, ageing grey. Spines 4–24, on most areoles, interlacing, tan to pink to reddish brown; sheaths whitish, baggy. **Tepals** spathulate, rose, reddish purple, bronze purple, whitish, yellow or salmon-coloured. **Fruit** broadly cylindrical, 2–5 × 1.7–3 cm, fleshy, rarely proliferating, strongly tuberculate, with 28–50 or more areoles, tubercles longer in distal portion, yellow to almost orange when ripe, sometimes tinged with purple. **Distribution**: SA. (Fig. 135)

References: Hunt *et al*. (2006).

Cylindropuntia spinosior (Fig. 136, 137, 138) is very similar to *Cylindropuntia imbricata*, and differences are discussed under that species. Though its description is very similar to that of non-crested forms of *Cylindropuntia fulgida* var. *mamillata*, the latter is readily distinguished by its easily detached terminal segments, recurved tepals and proliferous fruit chains.

It occurs in dry grassland and desert in a range (Pinkava, 2003a; Hunt, 2006) between and overlapping those of *C. fulgida* to the west (Sonoran Desert), and *C. imbricata* to the east (Chihuahuan Desert), from Arizona and New Mexico (USA) to Sonora and Chihuahua (Mexico). Hybrids are formed in the overlapping areas, particularly with *C. imbricata* (Pinkava, 2003a).

Cylindropuntia spinosior is sometimes cultivated in South Africa, and has now been found to be naturalised near Hopetown and Pofadder (Northern Cape Province) and east of Beaufort West (Western Cape Province). Even though this species is not a declared weed in South Africa, it requires monitoring.

Fig. 135. Distribution map of *Cylindropuntia spinosior* (Engelm.) F.M.Knuth

Fig. 136. *Cylindropuntia spinosior* (Engelm.) F.M.Knuth.
(Picture by Helmuth G. Zimmermann)

Fig. 137. Flower of *Cylindropuntia spinosior* (Engelm.) F.M.Knuth.
(Picture by Helmuth G. Zimmermann)

Fig. 138. Fruit of *Cylindropuntia spinosior* (Engelm.) F.M.Knuth.
(Picture by Helmuth G. Zimmermann)

Echinopsis Zucc.

Shrubby, columnar; branches erect, ascending, sometimes toppling over, simple, distinctly ribbed, very spiny; ribs numerous. **Flowers** subapical, elongate-funnelform, nocturnal or diurnal, large; pericarpel and hypanthium with relatively narrow, often numerous scales; pericarpel areoles more or less densely hairy. **Stamens** numerous. **Fruit** globose, fleshy. **Seed** broadly ovoid to orbicular, 1.2–1.6 × 0.8–1.4 mm, black-brown, matt, relief flat to low-domed.

Reference: Hunt *et al*. (2006).

A large genus endemic to South America, but with uncertain and fluctuating limits involving over 500 species names. The number of accepted species has been reduced from Anderson's (2001) count of 128 to 77 (Hunt, 2006). This figure, despite a broader generic concept than earlier, is the result of combining taxa, reducing species to subspecies, or of rejecting names of irreconcilable application.

In South Africa, the genus is easily recognised by the clumps of densely reddish- to golden, spiny, simple, columnar stems usually more than 8 cm in diameter.

Echinopsis schickendantzii F.A.C.Weber

In: *Dictionnaire d'Horticulture* 473 (1896).

=*Trichocereus schaferi* Britton and Rose

Common names: columnar torch cactus, torch cactus (English); orrelkaktus (Afrikaans).

Multistemmed shrubs 1–1.7(–2.5) m tall; stems green, columnar, (6–)8–10(–13) cm in diameter, branching from base or below ground (rarely above ground); ribs 10–15, c. 1.3 cm high, margins relatively straight or evenly spiral; areoles c. 1–1.5 (–2.5) cm apart, with curly yellow wool. Spines straight, yellow or reddish yellow when young, ageing brown or whitish; central spine single, 1.1–2(–2.7) cm long, peripheral spines 8–10, (4–)6–10 mm long, thin, sharp. **Flowers** from Nov. to Mar., showy, 18–20 cm long, mouth up to c. 15 cm in diameter; tepals white; pericarpel and hypanthium covered with long, dark hairs; pericarpel areoles densely hirsute in upper half. **Fruit** spherical, c. 5 cm long, green, remaining clothed with long, dark hairs of pericarpel and conspicuous, persistent hypanthium, dehiscent along one side; pulp white. **Seed** small, dull black-brown (virtually black), more or less warty, mostly sterile. **Distribution**: B, N, SA. (Fig. 139)

References: Anderson (2001), Henderson (2001), as *Echinopsis spachiana* (Lem.) Friedrich & G.D.Rowley (sp. insufficiently known).

This species can be distinguished from other naturalised, densely spiny, columnar cacti in South Africa by the wide stems with subapical flowers, and long, blackish hairs obscuring the pericarpel (Fig. 140). This plant was previously known in southern Africa by the name *Echinopsis spachiana*, which appeared to have been distinguished from *E. schickendantzii* only by the height of the stem (Fig. 141),

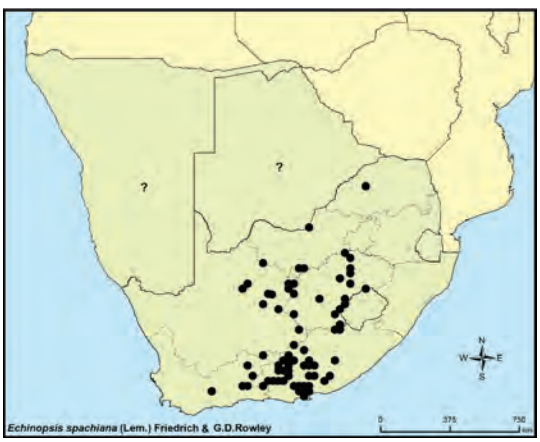

Fig. 139. Distribution map of *Echinopsis schickendantzii* F.A.C.Weber.

a character that is already variable in the species. It differs from the Bolivian *E. volliana* (Backeb.) Friedrich & G.D.Rowley in its longer flowers (12–15 cm in *E. volliana*).

Echinopsis schickendantzii is from Argentina (Hunt, 2006). The plant known as *E. spachiana* was said to have originated in western Argentina (Anderson, 2001) but Hunt *et al*. (2006) regard it as of 'uncertain' origin. Hunt *et al*. (2006) listed the name *E. spachiana* under the heading 'Names whose original application is indeterminate or debatable'. They regarded it as untypifiable, as no type material had been preserved, and treated it as a name 'best abandoned'. The type locality was simply given as 'Mexico', which is either a mistake or based on a cultivated plant.

Echinopsis schickendantzii is grown for ornamental purposes and as a hedge plant (Henderson, 2001) and the impressive mass display of its large white flowers (Fig. 142), all opening at the same time, makes it a very attractive and popular garden ornamental. Hunt (1989, 2006) points out the suitability of *Echinopsis schickendantzii*, *E. spachiana* and *E. volliana* for use as grafting stocks.

In South Africa it is a potential habitat transformer and a declared weed that is often encountered in dry savanna and karoo (Henderson, 2001, 2007). This species has been increasing in abundance over the last decade or two (Henderson, 2010). The white fruit pulp (Fig. 143) is eagerly consumed by birds, resulting in seedlings establishing under any suitable perch and even on roofs. Its spread could take on similar proportions to those of *Opuntia ficus-indica* in the early twentieth century, unless urgent action is taken to control its spread (Henderson, 2010).

Fig. 140. The pericarpels of *Echinopsis schickendantzii* F.A.C.Weber are obscured by blackish hairs. (Picture by Gideon F. Smith)

Fig. 141. *Echinopsis schickendantzii* F.A.C.Weber. (Picture by Neil R. Crouch)

Fig. 142. Flowers of *Echinopsis schickendantzii* F.A.C.Weber. (Picture by Neil R. Crouch)

Fig. 143. Fruit of *Echinopsis schickendantzii* F.A.C.Weber. (Picture by Lesley Henderson)

Harrisia Britton

Mostly shrubs, sometimes scandent or tree-like, up to 7 m tall; branches usually slender, ribbed, not segmented, not rooting aerially; ribs 3–5(–12). **Flowers** nocturnal, funnelform, 12–22 cm long; hypanthium elongate; perianth 8–17 cm broad, white; pericarpel areoles with hair-spines or merely felted**.** **Fruit** fleshy, areolate and scaly and/or spiny, yellow or orange and not splitting (subg. *Harrisia*), or red and usually splitting (subg. *Eriocereus*). **Seed** broadly ovoid, 1.5–4.0 × 1.2–1.8 mm, black-brown, semi-matt, periphery crested with larger cells, relief low-domed; hilum-micropylar region of medium size, basal, deeply impressed, forming a chamber.

References: Obermeyer (1976), Parfitt (2003), Hunt *et al*. (2006).

A member of the tribe Trichocereeae, *Harrisia* has a disjunct natural occurence in tropical America, with one or two species in subgenus *Harrisia* from Florida and across the Caribbean islands, and six or seven species in subgenus *Eriocereus* from South America in Brazil, Paraguay, Bolivia and Argentina (Anderson, 2001; Hunt, 2006).

The two species in South Africa are both in subgenus *Eriocereus*, and have long, flexible, narrow branches with areoles relatively far apart. The areoles lack glochidia. Pericarpel and hypanthium scales are numerous and relatively dense to overlapping, with hairy to villous axils.

Key to the two species of *Harrisia* naturalised in southern Africa:

1. Central spine 2.5–3 cm long; peripheral spines 1–2 cm long. Flowers 5–10 cm wide; pericarpel and hypanthium scales c. 2 cm long. Fruit up to 7 cm in diameter, with conspicuous scales with axillary villous hairs . . . . **1. *Harrisia balansae***

1'. Central spine 2–3 (–4) cm long; peripheral spines 1–3 mm long. Flowers 15–17 cm wide; pericarpel and hypanthium scales 2–3 mm long. Fruit c. 3 cm in diameter, scales not conspicuous . . . . **2. *Harrisia martinii***

1. *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi

In: *Cactaceae Consensus Initiatives* 3: 7 (1997).

Clambering shrub, 1–4 m, but reputedly up to 25 m tall; trunk up to 8 cm in diameter; branches segmented, obtusely 3–4(–5)-angled, 3–4(–5) cm in diameter. Spines c. 6, 1 stouter and longer (2.5–3 cm long) than the rest (1–2 cm long). **Flowers** large, 15–20 × 5–10 cm; pericarpel and hypanthium scales c. 2 cm long, without spines, numerous and relatively dense to overlapping on the hypanthium, with hairy to villous axils; flowering areole nearly naked. **Fruit** 4–7 cm in diameter, strongly tuberculate, each tubercle topped by a persistent scale, axils villous-hairy**. Seed** large (c. 2.5 mm long), rugose, black-brown (virtually black). **Distribution**: SA. (Fig. 144)

Reference: Kiesling (1996).

This account follows Hunt *et al*. (2006), who rejected the name *Harrisia bonplandii,* (Pfeiff.) Britton & Rose, considering it a source of confusion as it could not be satisfactorily typified, despite a thorough analysis by Leuenberger (2001).

This plant has previously been misidentified as *Acanthocereus tetragonus* (L.) Hummelinck of the tribe *Pachycereeae*, which has smaller hypanthium scales that are set further apart (fewer), the axils of which are felted and sometimes spiny, though not hairy. It also has branches sharply 3–5(–7)-winged or -angled, pericarpel scale axils that are usually spiny, and a stout, rigid, markedly flared hypanthium.

Fig. 144. Distribution map of *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi.

In contrast, *Harrisia balansae* has a relatively slender hypanthium, with numerous scales (relatively dense) the axils of which are villous-hairy and without spines (Fig. 145). Its branches rarely have as many as 5 obtuse ribs or angles (Fig. 146), and its pericarpel scale axils are also villous-hairy, without spines.

It can further be confused with *Hylocereus triangularis* (L.) Britton & Rose, with spines only up to 7 mm long borne on crenations, and it bears a superficial resemblace to *H. undatus*, which has branches with much thinner, acute, horn-rimmed wings that are broadly crenate between areoles.

Harrisia balansae is native to Bolivia and Paraguay and adjoining parts of Brazil (Mato Grosso do Sul) and Argentina (Gran Chaco) (Anderson, 2001). In South Africa it has been recorded in two localities: one in North-West Province near Groot Marico (Fig. 147), and a doubtful record of a few plants near Rust de Winter, Limpopo Province. This is an emerging invader and could be subject to a rapid eradication response programme in view of its potential risk and limited distribution.

Harrisia balansae is susceptible to infection by the mealybug *Hypogeococcus pungens* (Fig. 148). However, further observations are needed to verify if additional control measures are required, since infested plants produce fruits that are eagerly consumed by frugivorous birds. The seeds of infested plants are therefore still dispersed.

Fig. 145. Fruit of *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi. (Picture by Helmuth G. Zimmermann)

Fig. 146. Branches of *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi are rarely up to 5-ribbed. (Picture by Helmuth G. Zimmermann)

Fig. 147. *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi in Groot Marico. (Picture by Helmuth G. Zimmermann)

Fig. 148. *Harrisia balansae* (K.Schum.) N.P.Taylor & Zappi damaged by mealy bug infection. (Picture by Helmuth G. Zimmermann)

2. *Harrisia martinii* (Labour.) Britton

In: *Addisonia* 2: 55, pl. 68 (1917).

=*Eriocereus martinii* (Labour.) Riccob.

Common names: harrisia cactus, Martin's harrisia, moon cactus (in Australia) (English); toukaktus (Afrikaans).

Sprawling or clambering shrub, capable of resprouting from an underground rootstock, c. 0.8(–2) m tall; stems much-branched, often arching; branches dark green, (1.5–)2–2.5(–4) cm in diameter, not rooting aerially; ribs 4–5, low, lending the stems an appearance of plaited rope; areoles seated on broad tubercle, 1.5–2.5(–3.5) cm apart. Central spine 1(–2), 2–3(–4) cm long; peripheral spines 1–3 (–7), up to 3 mm long. **Flowers** nocturnal, from Nov. to Mar., 15–22 × 15–17 cm; scales broadly triangular-subulate, 2–3 mm long; pericarpel areoles felted and more or less hairy; outer tepals narrow, greenish white; inner tepals white or pale pink. **Fruit** from Dec. to May, globose, c. 3 cm in diameter, tuberculate and very shortly spiny, red, splitting down one side; pulp white. **Seed** black-brown (virtually black). **Distribution**: N, SA. (Fig. 149)

References: Obermeyer (1976), Zimmerman (1983), Telford (1984), Kiesling (1996), Henderson (2001), Hunt *et al*. (2006).

Harrisia martinii (Fig. 150, 151) originates from the Gran Chaco region of Paraguay and Argentina (Anderson, 2001; Hunt, 2006), probably in seasonally arid savanna habitats similar to the invaded habitats in South Africa. In Argentina it occurs in Chaco, Corrientes, Entre Ríos, Formosa and Santa Fé provinces (Kiesling, 1996; Hunt, 2006).

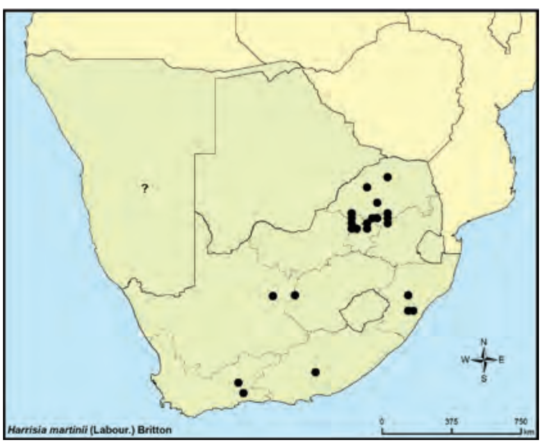

Fig. 149. Distribution map of *Harrisia martinii* (Labour.) Britton.

Fig. 150. Flower of *Harrisia martinii* (Labour.) Britton. (Picture by Pieter J.D. Winter)

Fig. 151. Fruit of *Harrisia martinii* (Labour.) Britton. (Picture by Pieter J.D. Winter)

The harrisia cactus was a serious invader in Australia (Fig. 152) and parts of South Africa (KwaZulu-Natal, Limpopo, Northern Cape and North-West Province) (SAPIA data). It is sporadically naturalised across the savanna biome of South Africa (Henderson, 2001, 2007) and is a declared weed (Henderson, 2001) (category 1), due to the transformation of woodland. Chemical control is difficult because of the underground tubers which are hard to reach. South Africa profited from a successful biological control programme in Australia in the late seventies. The two natural enemies, originally from Argentina, were eventually also introduced to South Africa where they also provide good control. They are the mealybug, *Hypogeococcus pungens*, released in 1983, and the long-horn stemborer, *Alcidion cereicola*, released in 1990 (Klein, 1999).

Fig. 152. *Harrisia martinii* (Labour.) Britton was an invader in Australia. (Picture by Stefan Neser)

Hylocereus (A.Berger) Britton & Rose

Climbers or scramblers, often epiphytic or epilithic (lithophytic); often much more than 5 m high; branches usually 3-winged or angled, segmented, green or glaucous, the margins often horny, producing aerial roots. Spines short or rarely absent. **Flowers** usually very large, funnelform, nocturnal, white or rarely red; pericarpel and hypanthium stout; scales typically broad, triangular, sometimes small or rudimentary; pericarpel areoles naked or spiny. **Stamens** numerous in a continuous series. **Style** thick; stigma lobes sometimes bifid. **Fruit** large, globose, ovoid or oblong, fleshy, with broad scales. **Seed** ovoid or broadly ovoid, c. 2.5 × 1.5–2 mm, black-brown, smooth; hilum-micropylar region of medium size, oblique, superficial; mucilage sheath present, covering entire seed.

References: Parfitt (2003), Taylor & Zappi (2004), Hunt *et al*. (2006), N.P. Taylor, (*pers. comm*.).

As currently circumscribed, *Hylocereus* comprises 14 species from tropical America, only one of which has become naturalised in southern Africa. They climb or scramble high into trees or over lower vegetation, aided by climbing aerial roots that often form dense mats around a supporting tree trunk. The branch segment wings are acute and usually spineless or with short spines less than 7 mm long, whereas branch segments of *Harrisia* are obtuse or rounded in transverse section and have spines more than 1 cm long. The nocturnal flowers are amongst the largest in the family (N.P. Taylor, *pers. comm*.).

Hylocereus undatus (Haw.) Britton & Rose

In: Britton, *Flora of Bermuda*: 256 (1918).

Common names: belle of the night, conderella plant, dragon fruit, night blooming cereus, red pitahaya, strawberry pear (English).

Climber 4–10 m high (sometimes epiphytic or epilithic): branches usually segmented, 3-ribbed, 4–7.5 cm in diameter, producing aerial roots; ribs compressed, thin, acute, margin crenate; areoles in the notches between teeth, usually 4–5 cm apart. Central spine absent or present, conical, 3–6 mm long, grey-brown; peripheral spines 0–2, 2–4 mm long. **Flowers** 25–30 × 15–25 cm; scales broad, imbricate; outer tepals lorate to linear, reflexed, bases greenish or yellowish, apices acuminate, red; inner tepals spathulate, up to 14 cm long, apices acute, fimbriate, white. **Stamens** of mature flower roughly parallel to perianth. **Style** cream; stigma lobes c. 24. **Fruit** globose-oblong, 10–15 × 10–12 cm, red; fruit scales long-pointed, up to 2.5 cm long, fleshy; pulp white. **Seed** black-brown (virtually black), shiny. **Distribution**: SA. (Fig. 153)

References: Anderson (2001), Parfitt (2003), Taylor & Zappi (2004), Hunt *et al*. (2006).

Fig. 153. Distribution map of *Hylocereus undatus* (Haw.) Britton & Rose.

This species may be confused with *Harrisia balansae*, which also has 3-ribbed branches. *H. balansae* differs in its lower, rounded ribs. *Hylocereus triangularis* differs by its angles not horn-rimmed, and the areoles borne on the crenations rather than in the sinuses between crenations. Its flowers are shorter (14–25 cm long), and the fruit is also smaller (7–10 × 3–5 cm) (Hunt, 2006).

Hylocereus undatus is probably native in tropical America, perhaps Mexico and Central America (Taylor & Zappi, 2004). Originally introduced to South Africa as an ornamental because of its spectacular, large, white, nocturnal flowers (Fig. 154), *Hylocereus* undatus and related species are becoming important commercial fruit plants in many countries, particularly in the tropics. The fruit is known as dragon fruit (a name also applied to fruit of *Hylocereus triangularis* (L.) Britton & Rose as produced in SE Asia — N.P. Taylor, *pers. comm.*) and is very attractive, with its red colour, large size and white pulp (Fig. 155). Dragon fruit (Fig. 156) is now becoming available in fresh produce markets in South Africa.

Hylocereus undatus is recorded as invasive in mesic, low-lying areas of KwaZulu-Natal (Fig. 157), Mpumalanga (Fig. 158) and Eastern Cape. Elsewhere individual plants persist where planted, but do not seem to reproduce. Infestations are still small and localised, originating mainly from homestead gardens from where they have escaped. The plant spreads by cuttings or vegetative parts that root to form new plants and with the aid of birds that spread the seeds. Control is not difficult. It is currently not a declared invader in South Africa, but should be proposed to be listed as a category 2 invader under NEMBA and CARA, as it has valuable commercial potential (L. Henderson, *pers. comm.*).

Fig. 154. Flower of *Hylocereus undatus* (Haw.) Britton & Rose.
(Picture by Geoff R. Nichols)

Fig. 155. Fruit of *Hylocereus undatus* (Haw.) Britton & Rose.
(Picture by Geoff R. Nichols)

Fig. 156. Fruit of *Hylocereus undatus* (Haw.) Britton & Rose (dragon fruit) is commercially traded. (Picture by Helmuth G. Zimmermann)

Fig. 157. *Hylocereus undatus* (Haw.) Britton & Rose is invasive in KwaZulu-Natal. (Picture by Geoff R. Nichols)

Fig. 158. *Hylocereus undatus* (Haw.) Britton & Rose is invasive in Mpumalanga. (Picture by Lesley Henderson)

Myrtillocactus Console

Arborescent or shrubby; branches numerous, stout, ascending, few-ribbed, spiny. **Flowers** diurnal, up to 9 at each areole, small; scales small; hypanthium very short; perianth rotate; pericarpel areoles slightly woolly. **Stamens** relatively few. **Fruit** globose, small, fleshy, purple. **Seeds** broadly ovoid, 1.6 × 1.3 mm, black-brown, dull, relief low-domed; hilum-micropylar region of large size, basal, impressed.

References: Anderson (2001), Hunt *et al*. (2006).

This small genus is endemic to Guatemala and Mexico. It comprises four species that appear to be quite closely related (Hunt, 2006). It is unusual in its small flowers with few tepals that are borne in fascicles. The branches bear a slight resemblance to those of naturalised *Cereus* species, as well as to *Euphorbia ingens* E.Mey. ex Boiss., but the ribs are fewer, not as prominent, and wider at the base, and the spines are generally shorter and stouter.

Myrtillocactus geometrizans (Pfeiff.) Console

In: *Bollettino delle Reale Orto Botanico di Palermo* 1: 10 (1897).

Common names: bilberry cactus, whortleberry cactus (English); rosyntjiekaktus (Afrikaans).

Shrub or tree up to 4–5 m; trunk short; branches numerous, upcurving, 6–10 cm in diameter, blue-green; ribs 5–6, smooth, low, rounded; areoles 5–30 mm apart. Central spine 1, 1–7 cm long, dagger-like and sometimes 6 mm broad at the base, almost black; radial spines 5–9, 2–10 mm long, red-brown to blackish at first, fading to grey. **Flowers** c. 2 × 2.5–3.5 cm, creamy or greenish white. **Fruit** globose, spineless, 1–2 cm in diameter, dark red or purple, very tasty. **Distribution**: N, SA. (Fig. 159)

References: Anderson (2001), Hunt *et al*. (2006).

This species occurs in Guatemala and throughout the central and northern central parts of Mexico (Anderson, 2001; Hunt, 2006). In South Africa it has been recorded near Groot Marico (North-West Province) (Fig. 160) and in the Addo Elephant National Park (Eastern Cape Province).

Fig. 159. Distribution map of *Myrtillocactus geometrizans* (Pfeiff.) Console.

Fig. 160. *Myrtillocactus geometrizans* (Pfeiff.) Console. (Picture by Helmuth G. Zimmermann)

The botanical and English vernacular names allude to the resemblance of fruit (Fig. 161) to that of true myrtle, *Myrtus communis* L. (Anderson, 2001), or of billberry or whortleberry, *Vaccinium myrtillus* L. The fruit is widely eaten in Mexico, both fresh and dried like raisins, and is known as 'garambullo' (Anderson, 2001). The Afrikaans common name indeed translates as 'raisin cactus'.

Originally introduced as an ornamental, it is very easily confused with small *Euphorbia ingens* plants, also sharing the same habitat with this species. It can be distinguished from *E. ingens* by the absence of milky latex and cyathia (flower shown in Fig. 162), and the presence of an areole with a stout central spine and some radial spines as opposed to a spine shield with or without a pair of spines. Although its fruit is delicious, it is not widely consumed by humans in South Africa.

Fig. 161. Fruit of *Myrtillocactus geometrizans* (Pfeiff.) Console.
(Picture by Gideon F. Smith)

Fig. 162. Flower of *Myrtillocactus geometrizans* (Pfeiff.) Console.
(Picture by Gideon F. Smith)

Opuntia Mill.

Shrubs or trees with segmented branches; branch segments usually flattened above (cladodes), sometimes cylindric, rarely somewhat tuberculate, often glaucous, sometimes tomentose. **Leaves** usually very small, subulate, caducous; glochidia present. Spines acicular, subulate or bristly, not sheathed. **Flowers** usually on the edges of the branch segments, diurnal. **Pericarpel** with leaves, areoles, glochidia and often spines, often produced into a short hypanthium beyond the ovary. **Perianth** rotate or spreading, rarely erect, yellow, pink, red or off-white. **Stamens** touch-sensitive. **Style** often more or less expanded near base. **Fruit** fleshy or dry. **Seed** compressed, orbicular to broadly ovate in outline, 3–9 mm long; funicular envelope ('aril') brown to off-white, surface bony.

References: Anderson (2001), Parfitt & Gibson (2003), Hunt *et al*. (2006), N.P. Taylor (*pers. comm*.).

Most *Opuntia* species are readily recognised by their compressed branches, i.e. they are modified to cladodes (at least the terminal ones). In *O. salmiana*, some or all branch segments are cylindric, but then narrower than those of *Austrocylindropuntia* or *Cylindropuntia*, only up to 1 cm in diameter, and with softer spines or bristles. Flowers of species in southern Africa are yellow to orange (off-white or cream in *O. salmiana*).

There are 75 species of *Opuntia* currently recognised in North and South America and the West Indies (Hunt, 2006). Twelve species are naturalised in southern Africa (four from South America, eight from Mexico, USA or the West Indies). Several of these are often widespread in southern Africa and cause serious infestations and transformation of vegetation.

Key to the species of *Opuntia* naturalised in southern Africa [based partly on Obermeyer (1976)]:

1. At least some stem segments slender, cylindric or semi-cylindric, up to 2.5 cm wide **2**
1'. All stem segments flattened (cladodes), more than 3 cm wide **3**

2. Terminal stem segments (cladodes) slightly flattened; spines sturdy, rigid; flowers deep yellow; fruit purplish, red or green, 3–4 cm wide . . . . **1. *Opuntia aurantiaca***
2'. Terminal stem segments mostly cylindric (not flattened); spines bristle-like; flowers pale yellow to almost white; fruit bright red, c. 1 cm wide . . . . **10. *Opuntia salmiana***

3. Cladode surface minutely velvety, hairs clearly visible with a 10x lens . **4**
3'. Cladode surface smooth (or minutely papillose in *O. spinulifera*, papillae not visible with a 10x lens) **5**

4. Areoles not prominent, in addition to glochidia, bearing many pale yellow spines and flexible white bristles becoming longer (up to 75 mm) and appearing more dense on older segments, sebaceous or filiform, white, almost covering the stem, particularly in young plants . . . . **6. *Opuntia leucotricha***

4'. Areoles prominent, bearing numerous glochidia but without spines (rarely one), long white bristles absent . . . . **7. *Opuntia microdasys***

5. Cladodes orbicular (not more than 1.5x as long as broad) **6**

5'. Cladodes obovate or elliptic, attenuate towards the base (usually more than 1.5x longer than broad) **8**

6. Cladodes up to 2 cm thick; spines less than 1 mm thick, c. 1.5 cm long, in sunken areoles less than 2 cm apart; fruit yellowish with pale pulp . . . . **11. *Opuntia spinulifera***

6'. Cladodes 1.5–4 cm thick; spines absent or more than 1 mm thick, more than 2 cm long, in sunken or slightly raised areoles more than 2 cm apart; fruit red to purple with similarly coloured pulp **7**

7. Arborescent, (1.5–)3(–5) m tall; cladodes up to 40 cm in diameter; areoles somewhat sunken; glochidia few or inconspicuous; fruit broadly obovoid to globoid, 7–8 cm long and as wide, long-tuberculate (at least while green) . . . . **9. *Opuntia robusta***

7'. Shrub with branches close to the ground, 0.4–1.5 m tall; cladodes less than 25 cm in diameter; areoles somewhat raised; glochidia unusually large,prominent in areoles of upper half of cladode, particularly along the distal margin; fruit obovoid or ellipsoid, c. 7 cm long and c. half as wide, smooth . .**3. *Opuntia engelmannii***

8. Cladodes glaucous, dull; pericarpel scales and outer tepals green or yellowish, at most with a reddish tinge **9**

8'. Cladodes not glaucous, green, often shiny or tinged purple; pericarpel scales and outer tepals uniformly red **12**

9. Procumbent shrublets up to 0.3 m high; fruit narrowly obovoid, less than 3 cm wide . . . . **5. *Opuntia humifusa***

9'. Shrubs or trees; fruit wider than 30 cm **10**

10. Tall shrubs or trees 1.8–3(–5) m tall; cladodes 20–60 cm long; pericarpel with many areoles; fruit ellipsoid or obovoid, greenish to orange or red, with pale pulp . . . .**4. *Opuntia ficus-indica***

10'. Low spreading bushes 1–1.6(–2) m tall; cladodes 10–20 cm long; pericarpel with few or no areoles; fruit obovoid or pyriform, narrowed at the base, smooth, red-purple with deep red-purple pulp **11**

11'. Areoles less than 8 mm across, with few (0–3), thinner, yellow to greyish spines, mostly along the cladode margin; glochidia inconspicuous; pericarpel and fruit usually straight . . . . **13. *Opuntia stricta* var. *stricta***

11. Areoles more than 8 mm across, with 4–7(–11) coarse, hard, yellow to brown spines, not concentrated along cladode margin; glochidia conspicuous; pericarpel and fruit often curved . . . .**12. *Opuntia stricta* var. *dillenii***

12. Cladodes less than 4x as wide as thick; tubercles not apparent; cladode margin straight or convex between areoles; inner tepals bright orange . . . .**2. *Opuntia elata* var. *elata***

12'. Cladodes more than 8x as wide as thick; tubercles prominent, cladode margin concave between some tubercles/areoles; inner tepals yellow . . . . **8. *Opuntia monacantha***

1. *Opuntia aurantiaca* Lindl.

In: *Botanical Register* 19: t. 1606 (1833).

Common names: jointed cactus, tiger pear (English); katjie, litjieskaktus, suurtjie (Afrikaans).

Low spreading spiny shrub up to 0.3(–1) m high; subterranean parts developed into tubers; lower (older) branch segments almost cylindric, upper segments (cladodes) somewhat compressed, 6–15(–20) × 1.5(–2.5) × 1 cm, not tuberculate, easily detached, bright green, sometimes tinged reddish-purple. Spines usually 2–3 per areole, sturdy, rigid, 1–3 cm long, pale brown, barbed. **Flowers** from Nov. to Jan., 2.5–4 cm across, deep yellow. **Fruit** up to 3 cm long, purple-red or green and seedless, with few spines (upper pericarpel areoles may generate further fruit, thus forming short chains); detached fruit may regenerate vegetatively through the formation of roots and shoots. **Distribution**: S, SA. (Fig. 163)

References: Moran *et al*. (1976), Obermeyer (1976), Zimmerman (1983), Anderson (2001), Henderson (2001), Hunt *et al*. (2006).

The epithet '*aurantiaca*' is a misnomer, as this species never has orange flowers (Moran *et al*., 1977). It is usually identified by its narrow, slightly flattened, rigidly spiny stems, of which the terminal segments are somewhat flattened and easily detached (Fig. 164). The name 'tiger pear' (used in Australia) presumably alludes to the common stem colouring, green with darker purplish areas on the edges, and around, but particularly extending in a stripe below, each areole.

Jointed cactus is originally from central and eastern Argentina and Uruguay in South America (Zimmermann, 1983). Hunt *et al*. (2006) tentatively grouped it with *Opuntia salmiana* from southeastern South America, in their informal '*Aurantiacae*' group, but noted that it resembles taxa in his more widespread '*Curassavicae* & *Pumilae'* group.

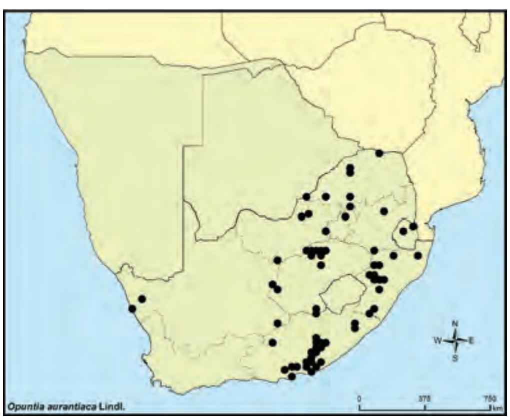

Fig. 163. Distribution map of *Opuntia aurantiaca* Lindl.

In South Africa the species (Fig. 165) is found in dry parts of the savanna biome (Henderson, 2007) from Limpopo Province to the far eastern part of the Northern Cape, as far east as Swaziland, and south to the Eastern Cape. Some outlying infestations have been recorded from Namaqualand (SAPIA data). It is classified as a category 1 invader (Henderson, 2001) and has been proposed for listing as a category 1b species under NEMBA and CARA (Anonymous, 2009). It is also naturalised in Australia (Telford, 1984). *Opuntia aurantiaca* spreads vegetatively by means of easily detached small branch segments or fruit that attach to animals, vehicles and farm equipment by needle-sharp, barbed spines (Fig. 166). Both branch segments and fruit have the capacity to root and give rise to plantlets from their areoles (Zimmermann, 1983). This was the most expensive and damaging cactus invader in South Africa for many years. It was introduced from Argentina via England by 1856. It is a declared weed, as it transformed pastoral land with karroid, savanna, and thicket vegetation, rendering it virtually useless especially for small stock farming (Zimmermann, 1983). Millions of rands were spent on its chemical and mechanical control between 1957 and 1999.

Fig. 164. *Opuntia aurantiaca* Lindl. has flattened terminal stem segments. (Picture by Neil R. Crouch)

Fig. 165. *Opuntia aurantiaca* Lindl. Note sterile fallen fruit propagules.
(Picture by Neil R. Crouch)

The introduction of the cochineal insect, *Dactylopius austrinus*, in 1932 contributed substantially to its biological control, but its efficacy was not acknowledged and chemical control persisted until a few years ago. Research on the host plant-insect interaction contributed to a better understanding of biological control so that chemical control is now largely replaced by biological control (Fig. 167). The cochineal performs best in warm, dry regions.

Herbicidal control is still practiced in sensitive areas and where the cochineal performs poorly. For registered herbicides consult the Department of Agriculture's guide to the use of herbicides (Anonymous, 2004; Grobler, 2005).

Fig. 166. Easily detached stem segments of *Opuntia aurantiaca* Lindl. attach to humans and animals. (Picture by Helmuth G. Zimmermann)

Fig. 167. Biological control of *Opuntia aurantiaca* Lindl. by means of its own cochineal (*Dactylopius austrinus*) and a caterpillar. (Picture by Helmuth G. Zimmermann)

2. *Opuntia elata* Salm-Dyck

In: *Hortus Dyckensis* ou *Catalogue des Plantes*: 361 (1834) **var. elata**

Shrub 1–1.5 m tall; cladodes oblong-elliptic or narrowly obovate, up to 25 cm long and usually more than 2 cm thick, green, often with purple blotches, along the cladode margin and around areoles, particularly below them; areoles sparse, wool white; glochidia virtually absent, not prominent. Spines 0–3, unequal, 2–3.5(–6) cm. **Leaves,** scales and sepaloid tepals crimson-red, caducous. **Flowers** c. 5 cm across, orange. **Stamens** whitish. **Stigma** whitish. **Fruit** obovate to oblong, 6 cm long, spineless; pulp pale. **Seed** 6 mm long, fertile. **Distribution**: N, SA. (Fig. 168)

References: Telford (1984), Anderson (2001), Leuenberger (2002), Hunt *et al*. (2006).

Fig. 168. Distribution map of *Opuntia elata* Salm-Dyck var. *elata.*

Opuntia elata belongs with *O. monacantha* in series *Armatae*. It is readily distinguished from that species by its shorter, thicker (more than 2 cm) cladodes (Fig. 169) and orange, not yellow, inner tepals (Fig. 170) (Leuenberger, 2002). The South American species tend to have stem colouring in various shades of green, though not glaucous or greyish as in most species from further north.

The natural distribution range of *Opuntia elata* is centred on the Entre Rios region of southeastern South America, along the mid to lower reaches of the Paraná and Uruguay rivers, and includes parts of Paraguay, Argentina (Corrientes, Entre Ríos, Santa Fé), Brazil (Rio Grande do Sul) and Uruguay. In South Africa, it has been present as an ornamental for at least fifty years, but has only recently (in 2008) been recorded as an emerging invasive plant in the Western Cape Province (Leeugamka and Beaufort West) (Fig. 171, 172). It is also known to be naturalised in the Coega area near Port Elizabeth (Eastern Cape), and in Namibia. The dry conditions in which most invading populations are found in southern Africa are surprising considering its origin from an area with over 1 000 mm annual precipitation, though this is explained by their native occurrence on rock outcrops (N.P. Taylor, *pers. comm.*). The species is also naturalised in Australia (Telford, 1984).

This species is not yet a declared invader in South Africa. The eastern seaboard may be most vulnerable to invasion, given the similarity to its native conditions, and the naturalised range of its closest relative in South Africa, *O. monacantha*, should be used as a guideline. It is not known whether it is susceptible to *Dactylopius ceylonicus*, like some of its close relatives from South America.

Fig. 169. *Opuntia elata* Salm-Dyck var. *elata* has short thick cladodes. (Picture by Helmuth G. Zimmermann)

Fig. 170. Flower of *Opuntia elata* Salm-Dyck var. *elata.* (Picture by Pieter J.D. Winter)

Fig. 171. *Opuntia elata* Salm-Dyck var. *elata.* (Picture by Pieter J.D. Winter)

Fig. 172. *Opuntia elata* Salm-Dyck var. *elata* is a common ornamental plant. (Picture by Pieter J.D. Winter)

3. *Opuntia engelmannii* Salm-Dyck

In: *Cacteae* in *Horto Dyckensi Cultae*. Anno 1849: 235–236 (1850).

=*Opuntia engelmannii* Salm-Dyck var. *lindheimeri* (Engelm.) B.D.Parfitt & Pinkava
=*Opuntia lindheimeri* Engelm.
=*Opuntia tardospina* Griffiths (sometimes spelled '*tardispina*')

Common names: small round-leaved prickly pear (English); kleinrondeblaarturksvy (Afrikaans).

Shrub, ± erect to decumbent, 0.8–1.5 × 1–5 m; trunk usually absent; cladodes orbicular or broadly obovate, 15–20 × 12–20 cm, more or less tuberculate, glabrous, often glaucous; areoles elliptic, 4.5 × 3 mm, 5–8 in a row diagonally across the centre of the cladode, 2.5–4 cm apart, wool tawny, ageing blackish; glochidia yellow, becoming brown. Spines 1–3(–6), sometimes absent from lower areoles, subulate, slightly flattened, most curved and thus lying near the stem surface, up to 4(–5) cm long, yellow or paler, becoming brown or grey with age. **Leaves** 3–9 mm long. **Flowers** from Oct. to Dec., 5–8 × 5–7.5(–10.5) cm, yellow, rarely red. **Fruit** obovoid to very broadly obovoid, almost spineless, 3–7 cm, purple or red; pulp reddish purple (not green in southern Africa). **Seeds** subcircular to deltoid, flat, 2.5–6 × 2–5 mm wide, tan to grayish; girdle protruding 0.3–0.5 mm. **Distribution**: N, SA. (Fig. 173)

References: Obermeyer (1976), Anderson (2001), Henderson (2001), Parfitt & Gibson (2003), Hunt *et al*. (2006).

Not only is *Opuntia engelmannii* very variable (Fig. 174, 175), it also hybridises with *O. stricta*, *O. phaeacantha* Engelm. and *O. littoralis* (Engelm.) Cockerell in the USA (Pinkava, 2003a), thus creating blurred species boundaries. In cultivation it may hybridise more widely, particularly within series *Phaeacanthae*, and such hybrids may become invasive. Some variants that have previously been formally recognised as *O. tardospina* and *O. lindheimeri* occur in South Africa, mainly in the Eastern Cape Province.

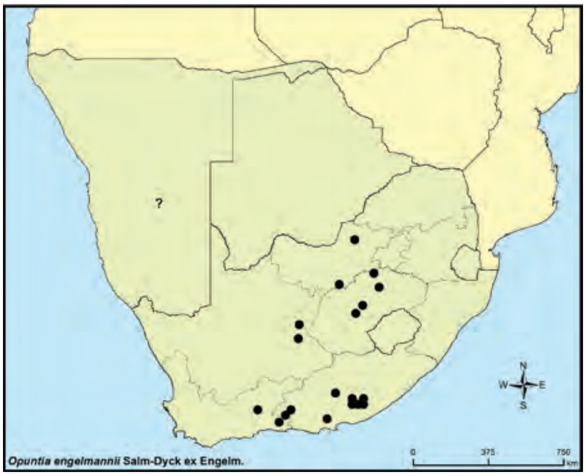

Fig. 173. Distribution map of *Opuntia engelmannii* Salm-Dyck. More invasions in the Gariep - and Vaal River basins are suspected.

Fig. 174. Flower of *Opuntia engelmannii* Salm-Dyck. (Picture by Pieter J.D. Winter)

Fig. 175. Fruit of *Opuntia engelmannii* Salm-Dyck. (Picture by Pieter J.D. Winter)

Future identifications in South Africa should also consider the probability of other members of series *Phaeacanthae* having become naturalised. Other names from this Mexico-USA centred group previously used in southern Africa include *O. ×occidentalis* Engelm. & J.M.Bigelow (a complex involving *O. engelmannii, O. littoralis* and *O. phaeacantha*), *O. macrocentra* Engelm. (including the synonym *O. violacea* Engelm. ex B.D.Jacks.) and *O. phaeacantha* var. *major* Engelm.

Opuntia engelmannii occurs in Mexico from Chihuahua east to Tamaulipas and as far south as Hidalgo. In the USA it has a range from California to Texas, and as far north as the southern parts of Nevada and Utah. It has a wide altitudinal range from 100 m to 2 700 m above sea level (Pinkava, 2003a). It is naturalised in Australia (Telford, 1984).

Although this species is widely used in Texas as a source of fodder for stock and wildlife (spines and glochids are singed with flame throwers to make them edible), this is not the case in southern Africa, and is not considered to be a sustainable practice. It was presumably introduced into southern Africa as an ornamental.

Infestations are known from along the lower reaches of the Vaal River in North-West Province (Bloemhof area), Free State (Vredefort Dome, Brandfort and Kroonstad areas to Bloemfontein) (Fig. 176, 177), and in the Northern Cape (Douglas and further southwest as far as Strydenburg). In the Western Cape it has been recorded from the Prince Albert and Uniondale districts of the Great Karoo, and in the Eastern Cape from the Willowmore district and between Cradock and Alice in the Fish River basin (SAPIA data). An unidentified population in the Limpopo Province north of Lebowakgomo, where plants have many, long, reddish brown spines and reddish brown glochidia up to 1 cm long, could be a lesser known form, perhaps from Mexico. The species is also naturalised in Namibia.

Hybrids with *Opuntia stricta* (known as *O. ×alta* Griffiths) are suspected in cases (Free State, KwaZulu-Natal) where plants have few or no spines other than on the cladode margin, and fruit with less than 15 areoles (Pinkava, 2003a).

Though a declared weed in South Africa, it was until recently, and at a local scale in the Eastern Cape, considered a minor weed due to biocontrol (Henderson, 2001; L. Henderson, *pers. comm.*), before the plant causing invasions of vast extent in the northern Free State and adjacent areas was identified as the same species. Although the prickly pear cochineal (*Dactylopius opuntiae*) and the cactus moth (*Cactoblastis cactorum*) can damage these plants, the effect is not adequate to keep this species under control, and chemical control is recommended. A more aggressive and host-adapted cochineal biotype may be introduced from the USA in future to improve on biological control.

Fig. 176. *Opuntia engelmannii* Salm-Dyck encroaching onto koppie.
(Picture by Pieter J.D. Winter)

Fig. 177. *Opuntia engelmannii* Salm-Dyck invades grassy-karroid habitat.
(Picture by Helmuth G. Zimmermann)

4. *Opuntia ficus-indica* (L.) Mill.

In: *Gardener's Dictionary*, Edition 8 [unpag.] (1768).

=*Opuntia megacantha* Salm-Dyck

Common names: Indian fig, mission prickly pear, prickly pear, sweet prickly pear (English); boereturksvy, doringturksvy, grootdoringturksvy, turksvy (Afrikaans).

Large shrub or small tree up to 5(–7) m tall, mostly with a trunk up to 1 m in diameter; cladodes obovate to oblong 20–60 × 10–20(–40) × 2.5–5 cm, dull green or blue-green, base attenuate. Spines variable, absent or 1–2 or more, the longer up to 2.5 cm long, white or off-white. **Leaves** caducous. **Flowers** from Oct. to Dec., 6–7 × 5–7 cm, orange or yellow. **Pericarpel** areoles dense, with a few long glochidia (c. 1 cm) in addition to numerous short glochidia. **Fruit** ellipsoid, 5–10 × 4–9 cm, yellow, orange, red or purple in different cultivars. **Seeds** suborbicular, 4–5 mm across, warped, pale tan; girdle only slightly protruding. **Distribution**: B, L, N, S, SA. (Fig. 178)

References: Britton & Rose (1963), Obermeyer (1976), Zimmerman (1983), Anderson (2001), Henderson (2001), Taylor & Zappi (2004), Hunt *et al*. (2006).

This species can be identified by its often narrowly obovate or oblong cladodes (Fig. 179), typically longer than 30 cm, white spines (Fig. 180), orange flowers (Fig. 181) [there are yellow-flowered forms too (Fig. 182), but these are rare in southern Africa], and areolate, ellipsoid fruit with a pale pulp (Fig. 183, 184).

Opuntia ficus-indica is considered to be of hybrid origin and derived from species endemic to the central Mexican Plateau, where it was domesticated and selected for spinelessness and fruit quality (Griffiths, 1909; Pimienta-Barrios, 1990; Nobel, 1994; Griffith, 2004; Reyes-Agüero *et al*., 2005).

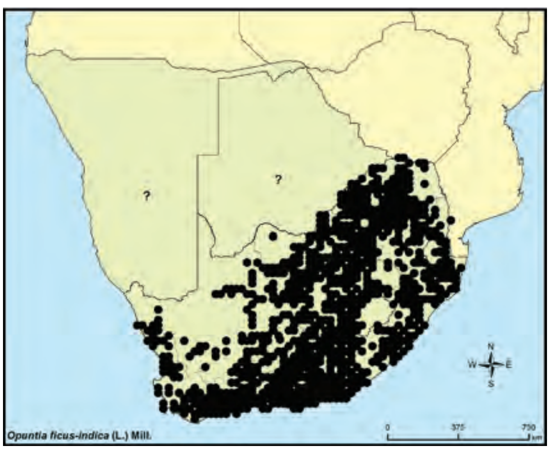

Fig. 178 . Distribution map of *Opuntia ficus-indica* (L.) Mill. These data mostly reflect casual aliens. In South Africa, actual invasions are limited to pockets in the Uitenhage, Ohrigstad and Polokwane areas.

Fig. 179. *Opuntia ficus-indica* (L.) Mill. has oblong cladodes. (Picture by Helmuth G. Zimmermann)

Fig. 180. White spines of *Opuntia ficus-indica* (L.) Mill. (Picture by Gideon F. Smith)

Fig. 181. Orange flowers of *Opuntia ficus-indica* (L.) Mill. (Picture by Neil R. Crouch)

Fig. 182. Yellow flowers of *Opuntia ficus-indica* (L.) Mill.
(Picture by Neil R. Crouch)

Fig. 183. Unripe fruit of *Opuntia ficus-indica* (L.) Mill.
(Picture by Geoff R. Nichols)

Fig. 184. Reddish fruit on spineless form of *Opuntia ficus-indica* (L.) Mill. (Picture by Helmuth G. Zimmermann)

Spiny forms have been known under a range of names (Annecke & Moran, 1978) in southern Africa (e.g. *Opuntia elatior* Mill., *O. maxima* Mill., *O. megacantha* Salm-Dyck, *O. schumannii* Weber, *O. tuna* Haw.). While these are mostly misapplied, some, such as *O. elatior*, *O. schumannii* and *O. spinulifera,* represent additional species that were perhaps at one stage naturalised in South Africa, or that still are. The invasive form with orange to red flowers was at one stage referred to as *O. megacantha*.

In the Americas the fruits of these plants are eaten and the juvenile cladodes are consumed as a vegetable. This multi-purpose plant has also been introduced in various arid and semi-arid countries for use as an emergency source of feed for animals (Felker & Inglese, 2003). In South Africa it is cultivated for edible fruits, animal fodder and is often used as a form of security hedging.

Many spineless cultivars are cultivated in South Africa, but only the spiny form is reported to be invasive. The spineless forms (Fig. 185) are eaten by stock and wildlife. There are a few cases where it appears as if a spineless form is ‘invasive’ but this is because it grows inside spiny cactus thickets where animals cannot reach it. The plant also undergoes significant genotype-environment interaction which affects identification based on phenotypic traits.

Fig. 185. Spineless form of *Opuntia ficus-indica* (L.) Mill. (Picture by Gideon F. Smith)

The spineless forms were introduced into the rest of the world by Spaniards from Nueva Espana (Mexico) as far back as about 1500. These were soon cultivated all around the European Mediterranean basin. Annecke & Moran (1978) mention that it was introduced into the Cape shortly after Jan van Riebeeck landed. These introductions were still spineless. Once widely established in the Eastern Cape, spiny forms emerged through cross pollination and genetic recombination, reverting back to the spiny forms (seeds taken from a spineless fruit and germinated result in a high proportion of spiny seedlings). The spineless forms were often protected by the spiny forms and could proliferate.

Opuntia ficus-indica invades many habitats, but is mainly a potential transformer in dry and rocky places in savanna, thicket and karoo (Fig. 186), widespread through most of South Africa. During the late 19th century the spiny form invaded huge areas in the Eastern Cape (South Africa) (Fig. 187), Tigray in Ethiopia and in Saudi Arabia. It has never reached full invasive potential in Australia, thanks to early introduction of appropriate biocontrol agents.

Spiny types are declared category 1 (transformers) weeds in South Africa, and have been proposed for category 1b of NEMBA and CARA (Anonymous, 2009). The infestations in South Africa have been successfully controlled to manageable levels using three natural insect predators, namely the cactus moth, *Cactoblastis cactorum*, the cochineal, *Dactylopius opuntiae* (Fig. 188) and the weevil, *Metamasius spinolae* (Annecke & Moran, 1978). Although the use of these biological control agents is the most economical form of control, there are currently also two herbicides registered for use in South Africa (Anonymous, 2004; Grobler, 2005)

Ethiopia has opted to control rampant populations by promoting their utilization as a source of human food (fruit and vegetable), fodder and for the production of the red colourant (carmine) from the cochineal insect *Dactylopius coccus*.

Infestations have now stabilised in South Africa after seventy years of biological control. The biocontrol agents manage to prevent resurgences of prickly pear in previously invaded areas. But some small infestations persist in a few isolated areas e.g. around Uitenhage, Patensie, Grahamstown, Ohrigstad and Polokwane. These are now widely utilised for their fruit and form the basis for an important informal fruit industry. Byproducts made from fruit, including confectionaries, syrups, jams, iqhilika (local brew) and ‘nopalitos’ are supporting and benefiting many small enterprises, and these are gaining in importance (Beinart, 2007). Control of prickly pear is still practiced in conservation areas and in these cases the preferred and most economical form of control remains biological, though sometimes in combination with chemical control.

In general, *Opuntia ficus-indica* populations have stabilised at acceptable levels and pose no further threat to agriculture and the environment despite the few pockets of infestations in some nature reserves. Its invasive species ranking remains high mainly because of its past history and its wide distribution. The aggression and past impact on agriculture in South Africa still looms high in the memories of farmers and conservationists.

Fig. 186. *Opuntia ficus-indica* (L.) Mill. growing on a cliff ledge. (Picture by Neil R. Crouch)

Fig. 187. Invasion by spiny form of *Opuntia ficus-indica* (L.) Mill.
(Picture by Helmuth G. Zimmermann)

Fig. 188. *Opuntia ficus-indica* (L.) Mill. infected with the cochineal *Dactylopius opuntiae.* (Picture by Helmuth G. Zimmermann)

5. *Opuntia humifusa* (Raf.) Raf.

In: *Medical Flora* 2: 247 (1830).

Common names: creeping prickly pear, large-flowered prickly pear (English).

Procumbent herb, forming clumps or mats 10-30 cm × 2 m or more; cladodes procumbent, elliptic to obovate or orbicular, 5–12.5 × 4–10 cm, pale green, often tinged purple; areoles with dense glochidia. Spines usually absent, sometimes 1–2, especially on marginal areoles in the upper half of the cladode, up to 2.5 cm long, acicular, not flattened. **Leaves** subulate, 4–7 mm long, caducous. **Flowers** from Oct. to Dec., 4–6 × 4–6 cm, yellow, often with red centre. **Fruit** narrowly clavate or obovoid, purple or red, 2.5–4 × 2–3 cm, fleshy, purple inside. **Seed** fertile. **Distribution**: N, S, SA. (Fig. 189)

References: Britton & Rose (1963), Anderson (2001), Henderson (2001), Partiff & Gibson (2003), Hunt *et al*. (2006).

Opuntia humifusa (Fig. 190, 191, 192, 193) is probably the most widespread of North American *Opuntia* species (Majure, 2010), occuring in Ontario (Canada) and from the Mississippi catchment, throughout the entire eastern part of the USA (Pinkava, 2003a).

In South Africa it occurs throughout the drier western part of the grassland biome (Henderson, 2007), extending from there into more arid areas to the south (Free State, Great Karoo and Camdeboo) and west (southeastern Botswana; Griekwastad; De Aar). It is also naturalised in Namibia and in Australia (Telford, 1984).

This garden escapee has been known to be naturalised since the early 1980s (L. Henderson, *pers. comm.*) and is now spreading rapidly due to bird dispersal of the seeds. It is a declared weed that is a potential transformer of dry grassland, savanna and karoo. It is easily controlled with herbicides (Anonymous, 2004). Except for the cactus moth, which is not a very effective biocontrol agent, there are no other natural enemies that can keep the weed under control.

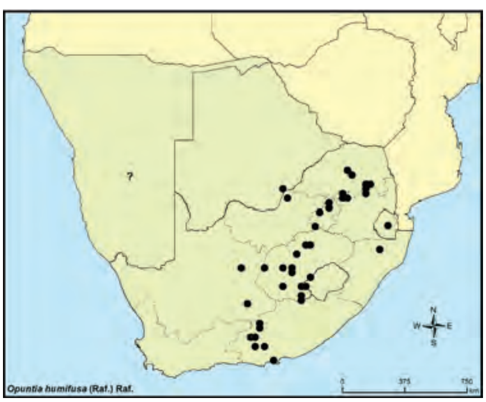

Fig. 189. Distribution map of *Opuntia humifusa* (Raf.) Raf. Gross undersampling is suspected, particularly in the rest of South Africa's Great Karoo.

Fig. 190. *Opuntia humifusa* (Raf.) Raf. (Picture by Neil R. Crouch)

Fig. 191. Flower of *Opuntia humifusa* (Raf.) Raf. (Picture by Neil R. Crouch)

Fig. 192. *Opuntia humifusa* (Raf.) Raf. growing on a rock ledge.
(Picture by Gideon F. Smith)

Fig. 193. Fruit of *Opuntia humifusa* (Raf.) Raf. (Picture by Neil R. Crouch)

6. *Opuntia leucotricha* DC.

In: *Mémoires du Muséum d'Histoire Naturelle* 17: 119 (1828b).

Common names: Aaron's beard prickly pear (English).

Large shrub or small tree 3–4 m tall; cladodes oblong to broadly ovate, up to 25 × 12 cm, c. 1 cm thick, velvety; areoles less than 2 cm apart, spines 1–6, 1–2 cm long, becoming longer (up to 7.5 cm) and appearing more dense on older segments, sebaceous or filiform, white, almost covering the stem, particularly in young plants. **Leaves** small, subulate, aristate, velvety, caducous, red, later green and arista white. **Flowers** c. 5 × 5 cm, yellow. **Fruit** yellowish green, spineless to clothed with long, wispy, filiform spines (particularly during the early stages of development); spines or even complete areoles caducous to varying degrees. **Distribution**: N, SA. (Fig. 194)

References: Britton & Rose (1963), Anderson (2001), Hunt *et al*. (2006), Scheinvar *et al*. (2009).

The shrubby to tree-like *Opuntia leucotricha* (Fig. 195) is characterised by a velvety cladode surface (Fig. 196), combined with the presence of yellow radiate spines (Fig. 197) and a flexuose deflexed white central spine that continues growing to a considerable length (up to 7.5 cm), lending the older cladodes a white bearded appearance (Fig. 198). Flowers are yellow (Fig. 199) sometimes with a orange hue in old flowers, and fruits are yellowish green (Fig. 200).

Opuntia leucotricha in its natural situation is distributed across the Altiplano of central Mexico (Durango, Zacatecas, San Luis Potosí, southern extreme of Nuevo León, western Tamaulipas, northeastern Jalisco, Guanajuato, Querétaro, Hidalgo, Tlaxcala, Puebla) at (839–)1 680–2 100(–2 700) m above sea level (Anderson, 2001; Hunt, 2006; Scheinvar *et al*., 2009). It is a very popular ornamental plant in Mexico and the USA and is often used by landscape architects. This species was also one of the main exports from a nursery in the Dominican Republic to Miami and possibly served as a vector for the cactus moth, *Cactoblastis cactorum,* to mainland America (Zimmermann *et al*., 2007).

Fig. 194. Distribution map of *Opuntia leucotricha* DC.

Even though it is not a declared weed in South Africa, it is considered an emerging invasive plant, particularly since it tends to persist where planted or discarded. It has been recorded from the Rust de Winter area, Hammanskraal, Brits area, Pretoria outskirts, Klerksdorp and outskirts of Bloemfontein. It is also naturalised in Namibia. It was recorded as an invader in Australia.

Fruit from what is most likely a single clone on the outskirts of Pretoria was sterile or had up to three seeds. Another possible clone was recorded 51 km toward Rustenburg along the N4 Platinum highway, and was confined to a single bushclump. The trunk shows the vestiture of long, white, flexible bristles, yet the fruit lacked (or had already shed) the similar 'vestiture' shown in Anderson's (2001) figure. In fire-prone savanna habitat in South Africa, the trunk vestiture is often burnt off, complicating the correct identification of specimens.

Scheinvar *et al*. (2009) treated this taxon as *Opuntia spinulifera*, and applied the name *O. leucotricha* only to plants lacking the long, bristly 'vestiture' on fruit and trunk. However, intermediate plants found in South Africa do not fit that distinction, therefore the name *O. leucotricha* is here applied in a broader concept. Further research is needed on this group of Mexican species.

Fig. 195. *Opuntia leucotricha* DC. (Picture by Pieter J.D. Winter)

Fig. 196. Velvety cladode surface of *Opuntia leucotricha* DC.
(Picture by Pieter J.D. Winter)

Fig. 197. Young cladode of *Opuntia leucotricha* DC. with small, subulate leaves and reddish glochidia. (Picture by Pieter J.D. Winter)

Fig. 198. Old bearded cladode of *Opuntia leucotricha* DC. (Picture by Pieter J.D. Winter)

Fig. 199. Flower of *Opuntia leucotricha* DC. (Picture by Pieter J.D. Winter)

Fig. 200. Fruit of *Opuntia leucotricha* DC. (Picture by Pieter J.D. Winter)

7. *Opuntia microdasys* (Lehm.) Pfeiff.

In: *Enumeratio Diagnostica Cactearum hucusque Cognitarum*: 154 (1837).

=*Opuntia rufida* Engelm.

Common names: angel’s wings, bunny-ear prickly pear, teddy bear cactus, yellow teddy-bear cactus (English).

Shrub, forming thickets 0.4–0.6 m or more tall; cladodes oblong, obovate or suborbicular, 6–15 × 6–12 cm, green, velvety; areoles prominent, 8–13(–16) per diagonal row across midstem section; glochidia many, typically yellow, reddish brown (in the form previously known as *O*. *rufida*) or white. Spines absent, rarely 1, very short **Flowers** numerous on each cladode, c. 4 × 4 cm, yellow, ageing apricot to orange (in the form previously known as *O*. *rufida*); outer tepals often tinged red. **Pericarpel** densely glochidiate. **Fruit** nearly globose, c. 3 cm in diameter, fleshy, red or purple-red. **Distribution**: N, SA. (Fig. 201)

References: Britton & Rose (1963), Anderson (2001), Parfitt & Gibson (2003), Hunt *et al*. (2006).

Opuntia microdasys is widespread throughout the Chihuahuan Desert of central and northern Mexico, at 600–1300 m (*O. rufida* extending into Texas), or 1 700–2 100 m above sea level (Pinkava, 2003a). It cannot be confused with any other species, with its low habit (Fig. 202), velvety epidermis, and numerous spineless areoles packed with short glochidia (Fig. 203). *Opuntia rufida* is here included in this species as a northern form (but see Pinkava, 2003b). It differs from the typical form by its reddish glochidia (Fig. 204). A population that appears to fit this description has been recorded in the Northern Cape Province, on the Victoria West townlands, invading natural Karoo vegetation. The tepal colour was a dirty salmon-pink, and the possibility of hybridization needs to be considered.

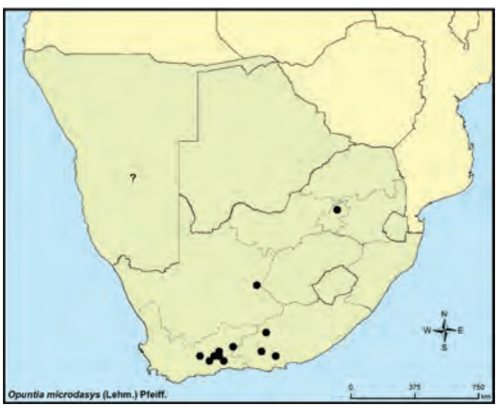

Fig. 201. Distribution map of *Opuntia microdasys* (Lehm.) Pfeiff.

Fig. 202. *Opuntia microdasys* (Lehm.) Pfeiff. (Picture by PPRI)

Fig. 203. Cladodes of *Opuntia microdasys* (Lehm.) Pfeiff. have numerous areoles with glochidia. (Picture by PPRI)

Fig. 204. Form of *Opuntia microdasys* (Lehm.) Pfeiff. with reddish glochidia. (Picture by Pieter J.D. Winter)

In South Africa *Opuntia microdasys* is a common horticultural specimen, especially during the juvenile phase when it displays its characteristic bunny-ear-like pads. It is commonly cultivated as a rockery ornamental in the drier parts of South Africa (Smith *et al*., 2011) because of its pads and flowers (Fig. 205). It forms large clumps, often escaping from gardens or growing near rubbish dumps where plant parts have been disposed of. It has thus naturalised in very localised areas, usually close to habitation, since it does not spread by seeds. To date, it has been recorded (SAPIA data) from northern Gauteng, Northern Cape (near Hopetown), Western Cape (throughout the Great Karoo) and Eastern Cape (Sundays River basin and near Steytlerville). It is naturalised in Namibia. Collectors and the nursery trade are probably the main causes for its dispersal. It is a very popular garden ornamental almost throughout the world and is listed as an invader in Australia.

This species is currently not a declared weed in South Africa, but has been proposed for classification as category 1b under NEMBA and CARA (Anonymous, 2009).

Fig. 205. Flowers of *Opuntia microdasys* (Lehm.) Pfeiff. (Picture by Debbie Sharp).

8. *Opuntia monacantha* Haw.

In: *Supplementum Plantarum Succulentarum*: 81 (1819).

=*Opuntia vulgaris* sensu auct. non Mill. (misapplied name)

Common names: cochineal prickly pear, drooping prickly pear (English); Engelse turksvy, luisiesturksvy, suurturksvy (Afrikaans).

Erect shrub up to 2(–3) m high, sometimes with a short trunk; cladodes oblong to obovate, 10–30 × 7.5–10(–12.5) cm, tapered towards the base, fairly thin, bright green when young. Spines 1 or 2, unequal, the longer 2–4 cm long, brown towards tip and base, off-white between, more numerous on trunk. **Flowers** from Oct. to Apr., 5–7.5 × 7.5–10 cm, yellow or orange-yellow; outer tepals tinged red. **Fruit** pyriform, 5–7.5 × 4–5 cm, green with red-purple shades, edible. **Distribution**: S, SA. (Fig. 206)

References: Obermeyer (1976), Anderson (2001), Henderson (2001), Taylor & Zappi (2004), Hunt *et al*. (2006).

Opuntia monacantha is best identified by its large, attractive and edible pear-shaped fruit (Fig. 207), drooping appearance (Fig. 208), thin, shiny cladodes (Fig. 209) with often only one or two rigid thorns per areole (Fig. 210) and large attractive flowers (Fig. 211).

It is originally from eastern coastal South America (southern Brazil to northern Argentina) (Leuenberger, 2002). In South Africa, this cactus prefers sandy soils in coastal bush and moist savanna. It is found mainly on the coastal plain from Maputaland to the Eastern Cape, but also occurs sporadically in thicket communities in the Western Cape, and occasionally elsewhere (SAPIA data). It is naturalised in Swaziland.

It was also a serious invader in Australia, India, Sri Lanka, Madagascar and Mauritius before the introduction of a cochineal species, *Dactylopius ceylonicus* (Zimmermann *et al*., 2009). There are claims that the destruction of this species could have contributed to the severe famine in southern Madagascar in the 1920's, as a result of the collapse of vast populations of the cactus that were used for fodder and human consumption (Middleton, 1999).

This was a common and aggressive invader in South Africa during the late 19th century forming dense thickets along the coast between Mossel Bay and Durban. Though a declared weed, it was brought under full and sustainable biocontrol by *Dactylopius ceylonicus* that was released in 1913, so that it is now considered a minor weed. There are occasionally flare-ups of populations, often along the Eastern Cape coast. No other control measures, besides biological control, are necessary. The cactus moth, *Cactoblastis cactorum,* is also effective in reducing regrowth by killing young plants.

Fig. 206. Distribution map of *Opuntia monacantha* Haw.

Fig. 207. Fruits of *Opuntia monacantha* Haw. are pear-shaped and edible.
(Picture by PPRI)

Fig. 208. *Opuntia monacantha* Haw. plants have a characteristic drooping appearance. (Picture by Helmuth G. Zimmermann)

Fig. 209. Shiny young cladodes of *Opuntia monacantha* Haw. Note the tiny, subulate, red leaves. (Picture by Neil R. Crouch)

Fig. 210. *Opuntia monacantha* Haw. with one or two rigid thorns per areole and uniformly red pericarpel scales and outer tepals. (Picture by Neil R.Crouch)

Fig. 211. Flower of *Opuntia monacantha* Haw. (Picture by Geoff R. Nichols)

9. *Opuntia robusta* Pfeiff.

In: *Enumeratio Diagnostica Cactearum hucusque Cognitarum*: 165–166 (1837).

Common names: blue-leaf cactus, robusta, robusta blue-leaf opuntia (English); bloublad, robusta, robusta turksvy, turksvy (Afrikaans).

Shrub or tree, usually 2–5 m high; cladodes more or less orbicular, massive, c. 40 × 40 × 4–5 cm, waxy pale blue; areoles sparse, impressed and often sunken. Spines absent (in some cultivars) or 2–12, unequal, filiform, up to 5 cm long, white, pale brown or yellow below. **Flowers** 5 × 5–7 cm, yellow. **Fruit** globose to ellipsoid, 7–8 cm long, long-tuberculate while still green, areoles with a few long glochidia (c. 1 cm) in addition to numerous short glochidia, deep red to purple; pulp purple, sour. **Seeds** numerous, fertile. **Distribution**: B, SA. (Fig. 212)

References: Britton & Rose (1963), Hunt *et al*. (2006).

Opuntia robusta has characteristic large, orbicular, bluish green cladodes with areoles widely scattered (Fig. 213), and yellow flowers (Fig. 214).

This cactus is widely distributed to the north of the Sierra Volcánica Transversal range in central Mexico (Hunt, 2006). In South Africa it is naturalised in a few localities, mainly in the semi-arid interior (SAPIA data) (Fig. 215). It is cultivated by farmers for use as an emergency feed for livestock during drought and not for its edible fruit, which is sour (Fig. 216). It is naturalised in Botswana. It is also sporadically naturalised in Australia where it is known as the wagon wheel cactus (Telford, 1984).

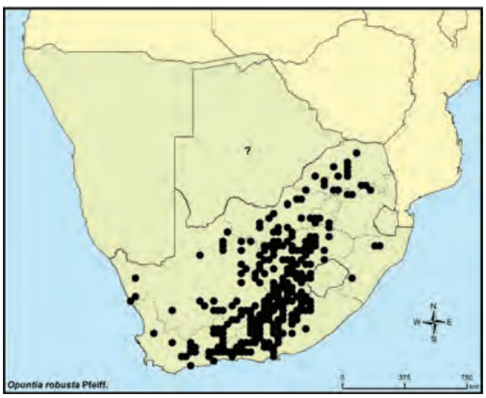

Fig. 212. Distribution map of *Opuntia robusta* Pfeiff. Most of these data reflect cultivated plants or casual aliens. Actual invasions are estimated at less than 3% of records.

Fig. 213. Cladodes of *Opuntia robusta* Pfeiff. are large, orbicular and a typical bluish green colour. (Picture by Gideon F. Smith)

Fig. 214. Flowers of *Opuntia robusta* Pfeiff. (Picture by Neil R. Crouch)

Fig. 215. *Opuntia robusta* Pfeiff. has a tree-like habit. (Picture by Gideon F. Smith)

Fig. 216. Fruits of *Opuntia robusta* Pfeiff. (Picture by Lesley Henderson)

Luther Burbank was a famous cactus breeder in California who used *O. robusta* from Mexico as the main parent for his spineless 'robusta' fodder cultivars. Several of these cultivars were introduced to South Africa during the 1920's and one of these cultivars, 'Robusta' was widely and successfully cultivated as an emergency drought fodder plant in the Karoo. Over time the plant has reverted to the original spiny form (Fig. 217) at a few localities, comparing well with the wild *O. robusta* in Mexico. The cultivated robusta blue-leaf opuntia has become a common sight in the drier parts of South Africa and it is often grown as an ornamental. Although the spineless *O. ficus-indica* is more widely cultivated as a fodder plant in other parts of the world, the 'robusta-blue-leaf', until recently, was the preferred species in South Africa because it is more drought-tolerant and is fairly resistant to the cactus cochineal, *Dactylopius opuntiae* (De Kock & Aucamp, 1970).

Although generally treated as a tall shrub or tree, as has been done here, some Mexican authors have applied this name to a low shrub, that is here treated as *Opuntia spinulifera* (Hunt, 2006). Both taxa have impressed areoles.

Opuntia robusta is not a declared weed in South Africa, but the spiny form has been proposed for classification as a category 2 invasive alien plant under NEMBA and CARA (Anonymous, 2009).

Fig. 217. *Opuntia robusta* Pfeiff. reverting to the spiny form.
(Picture by Helmuth G. Zimmermann)

10. *Opuntia salmiana* J.Parm. ex Pfeiff.

In: *Enumeratio Diagnostica Cactearum hucusque Cognitarum*: 172 (1837).

Low shrub 0.3–0.5 m or more, much branched; branch segments terete, up to 25 × 1 cm, not tuberculate, often tinged red. Spines absent or 3–5, bristle-like, up to 1.5 cm long, barbed. **Leaves** very small, 1–2 mm long, tinged purple, caducous. **Flowers** produced rather freely, 2–3.5 cm across, white or pale yellow. **Stamens** sensitive. **Fruit** oblong-ellipsoid, c. 1 cm wide, bright red, barren in cultivated plants, but proliferous (upper pericarpel areoles generate small, very spiny stem segments while still attached to parent plant). **Distribution**: SA. (Fig. 218)

References: Britton & Rose (1963), Anderson (2001), Hunt *et al*. (2006).

The disproportionately large, white flowers (Fig. 219) compared to the narrow, terete stems are diagnostic for this taxon, as are the vegetative propagules that are formed by the upper pericarpel areoles at the time of fruit ripening (Fig. 220). This species has long been enigmatic in *Opuntia*, and molecular data have been used to suggest that it should be recognised as a separate genus (Griffith & Porter, 2009).

Opuntia salmiana is associated with the Gran Chaco region in South America, from Bolivia, Paraguay and Argentina (Jujuy and Salta, south to Catamarca and Santiago del Estero, and San Luis to Entre Rios) (Hunt, 2006).

This is an emerging invader, currently known from one locality only, north of Brits, in the North-West Province in South Africa (Fig. 221). It can form dense thickets and the small bristle-spiny cladodes can adhere to any animal brushing past, spreading the cactus vegetatively over considerable distances. Attempts should be made to eradicate this newcomer that has not yet been declared, nor proposed, for invader classification in South Africa.

Fig. 218. Distribution map of *Opuntia salmiana* J.Parm. ex Pfeiff.

Fig. 219. Flowers of *Opuntia salmiana* J.Parm. ex Pfeiff. (Picture by Helmuth G. Zimmermann)

Fig. 220. Propagules developing from the top of the fruit in *Opuntia salmiana* J.Parm. ex Pfeiff. (Picture by Helmuth G. Zimmermann)

Opuntia salmiana is a preferred host for the cactus moth, *Cactoblastis cactorum*. Feeding damage is conspicuous and is recognized by the white papery shells left behind after the larvae have eaten out the contents of the cladodes. Unfortunately this damage is not sufficient to prevent spread and densification. This species is attacked in its native distribution range by a unique cochineal insect (*Dactylopius salmianus)* that appears to be restricted to feeding on this species only, in some way supporting the uniqueness of this cactus and the proposal to regard it as a new genus.

Fig. 221. *Opuntia salmiana* J.Parm. ex Pfeiff. is an emerging invader. (Picture by Helmuth G. Zimmermann)

11. *Opuntia spinulifera* Salm-Dyck

In: *Hortus Dyckensis ou Catalogue des Plantes*: 364 (1834).

=*Opuntia heliabravoana* Scheinvar

Common names: saucepan cactus (English); grootrondeblaarturksvy (Afrikaans).

Spiny shrub, much-branched, 1.7–2 × 3–6 m, not arborescent; cladodes flattened, orbicular, 20–40 cm in diameter, or up to 60 cm wide, mostly less than 2.5 cm thick, apex often truncate to emarginate, glaucous-green, glabrous; areoles sunken, dense (8–20 mm apart), sub-spirally arranged in 18–21 series. Spines 1–2(–6?), up to c. 2 cm long, thin, rigid, reflexed, whitish. **Flowers** from Nov. to Dec., yellow. **Fruits** widely barrel-shaped or globose, c. 3 cm in diameter, yellow**. Seeds** up to 90 per fruit, 2.5–3 mm in diameter. **Distribution**: SA. (Fig. 222)

References: Britton & Rose (1963), Obermeyer (1976), Henderson (2001), Scheinvar (2009).

This species is similar to *Opuntia robusta* in its wide cladodes (Fig. 223), though these are thinner in *O. spinulifera* and the areoles are much closer set, with more reflexed spines (usually absent in *O. robusta*). *O. robusta* furthermore has red fruits instead of yellow (Fig. 224). In the density of areoles this species resembles *O. leucotricha*, but has wider cladodes, and lacks the velvety stem epidermis, as well as the flexuose, filiform spines. The spines are thin, rigid, reflexed and whitish (Fig. 225) and the flowers are yellow (Fig. 226).

The classification of Britton & Rose (1963) is followed here in the application of this name. Hunt *et al*. (2006) consider *O. spinulifera* a name of uncertain status, as no type specimen is known (Britton & Rose, 1963). Because it was described from unsourced sterile material, and not known (presumably in the wild) by Britton & Rose, it is considered indeterminate (Hunt, 2006). Wild plants of what appears to be the same entity were described with the name *O. heliabravoana* Scheinvar, here treated as a synonym.

Fig. 222. Distribution map of *Opuntia spinulifera* Salm-Dyck.

Fig. 223. *Opuntia spinulifera* Salm-Dyck has wide cladodes.
(Picture by Pieter J.D. Winter)

Fig. 224. Fruits of *Opuntia spinulifera* Salm-Dyck. (Picture by Lesley Henderson)

Fig. 225. Reflexed spines of *Opuntia spinulifera* Salm-Dyck projecting from sunken areoles. (Picture by Pieter J.D. Winter)

Fig. 226. Flowers of *Opuntia spinulifera* Salm-Dyck. (Picture by Geoff R. Nichols)

The natural and perhaps partly naturalised range of *Opuntia spinulifera* is the Valley of Mexico (states of Hidalgo, Mexico, Puebla and Tlaxcala) (Scheinvar *et al*., 2009, as *O. heliabravoana*).

The species is a declared weed, currently with the invasive status of potential transformer, since it invades savanna and grassland (Fig. 227). In South Africa it was previously well known from the Katrivier basin, and it has recently been recorded from the Bergville and Pietermaritzburg districts in Kwazulu-Natal, and as persisting individuals planted near Ga-Molepo, Limpopo.

It is not known if any of the introduced cactus-feeding insects feed on *Opuntia spinulifera.* The herbicides registered for other *Opuntia* invaders should be effective also on this species.

Fig. 227. *Opuntia spinulifera* Salm-Dyck invades grassland.
(Picture by Lesley Henderson)

12. *Opuntia stricta* (Haw.) Haw. var. *dillenii* (Ker Gawl.) L.D.Benson

In: *Cactus and Succulent Journal (US)* 41: 126 (1969).

=*Opuntia dillenii* (Ker Gawl.) Haw.

Spreading shrub, 0.5–1.3 (–2) m high, thicket-forming; cladodes broadly to narrowly obovate or oblong, 10–20 × 7.5–1.4 cm, blue-green, usually tuberculate (areoles prominent). Spines 4–7(–11) on most areoles, not restricted to marginal areoles, stout, commonly curved, flattened, usually 1.5–4 cm long, yellow, often with brown bands. **Flowers** 5–6 × 5–6 cm, yellow. **Fruit** narrowly obovoid and stipitate, 4–6 × 2.5–3 cm, fleshy, red turning purple; pulp purple inside, sour. **Distribution**: B, N, S, SA. (Fig. 228).

References: Obermeyer (1976), Anderson (2001), Parfitt and Gibson (2003).

Opuntia stricta var. *dillenii* differs from var. *stricta* mainly by the number of spines per areole (4–7 and rarely up to 11) and their general dispersion among all areoles, whereas in var. *stricta* the few spines are more or less restricted to the cladode margin.

The variety occurs naturally from the Mexican east coast to the West Indies. Some authors, e.g.Telford (1984), claim that it occurs as far north as South Carolina in North America, while others consider it to be restricted to the Caribbean. It has been recorded in South Africa only from near Pietermaritzburg and the Nagle Dam (Kwazulu-Natal) (Obermeyer, 1976) (Fig. 229). It has become a serious invader in Ghana, Ethiopia and possibly Madagascar, as well as in Australia, where intermediates with var. *stricta* are reported (Telford, 1984). It is currently a declared invader by being listed as a synonym of *O. stricta*.

Fig. 228. Distribution map of *Opuntia stricta* (Haw.) Haw. var. *dillenii* (Ker Gawl.) L.D.Benson

Fig. 229. *Opuntia stricta* (Haw.) Haw. var. *dillenii* (Ker Gawl.) L.D.Benson.
(Picture by Helmuth G. Zimmermann)

13. *Opuntia stricta* (Haw.) Haw.

In: *Synopsis plantarum succulentarum*: 191 (1812) **var. *stricta.***

Common names: Australian pest pear, sour prickly pear (English); suurturksvy (Afrikaans).

Spreading shrub, 0.5–1.3 (–2) m high, thicket-forming; cladodes broadly to narrowly obovate or oblong, 10–20 × 7.5–14 cm, blue-green, usually tuberculate (areoles prominent). Spines absent, or 1, then restricted to marginal areoles, usually stout, straight, flattened, 1.5–4 cm long, yellow. **Flowers** 5–6 × 5–6 cm, yellow. Pericarpel with 0–4(–8) areoles, smooth. **Fruit** narrowly obovoid and stipitate, 4–6 × 2.5–3 cm, fleshy, red turning purple; pulp purple inside, sour. **Distribution**: B, N, S, SA. (Fig. 230).

References: Britton & Rose (1963), Obermeyer (1976), Zimmerman (1983), Telford (1984), Parfitt & Gibson (2003), Anderson (2001), Henderson (2001), Hunt *et al.* (2006).

The relatively smooth pericarpel with 0–4(–8) areoles (Fig. 231) distinguishes this species from other naturalised species in South Africa. In addition, the yellow spines (unless absent) and obovate (more than 1.5 times longer than wide) cladodes (Fig. 232) characterise this species. The flowers are yellow (Fig. 233). In cases where cladodes are more orbicular, less tuberculate (evidenced by a smoother rim), fruits not narrowed toward the base, and glochidia conspicuous and longer than 4 mm, hybridization with *Opuntia engelmannii* (then known as *O.* ×*alta* Griffiths) can be suspected.

The natural range of *Opuntia stricta* var. *stricta* is considered (Howard & Touw, 1982; Anderson, 2001; Hunt, 2006) to be the southeastern USA (Florida, Mississipi, Alabama, southeast Virginia, Louisiana, Texas), eastern Mexico and Cuba in the West Indies.

It is naturalised in most provinces of South Africa, especially in the northeastern parts. *Opuntia stricta* var. *stricta* invades savanna (Fig. 234), as the seedlings seem to need the protection of shrubs or trees to establish (Mann, 1970). In southern Africa is has also been recorded as naturalised in Botswana, Namibia and Swaziland.

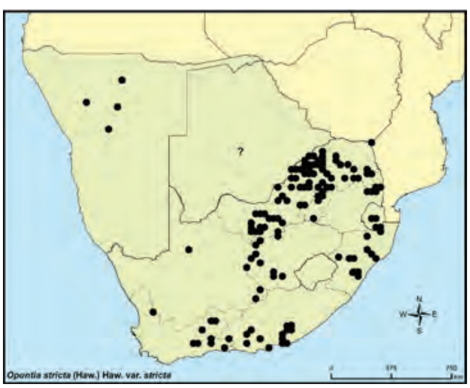

Fig. 230. Distribution map of *Opuntia stricta* (Haw.) Haw. var. *stricta.*

The species was severely invasive in Australia and was considered to be Australia's worst ever weed covering almost 24 million ha of Queensland and New South Wales under a mat that was up to 2 metres deep. *O. stricta* var. *stricta* has also become a serious invader in Angola, Madagascar, Ethiopia, Yemen and Saudi Arabia.

Except for its fruit, this invader is not utilised by stock or wild animals. Whereas numerous ungulates and elephants devour invasive (even spiny) *Opuntia ficus-indica* in the Addo Elephant National Park in South Africa, no feeding occurs on *O. stricta* var. *stricta* plants in the Kruger National Park (KNP) despite heavy feeding pressure during droughts. Baboons and elephants, however, eat the ripe fruit and contribute to the rapid spread and densification of this species in the KNP (Foxcroft & Rejmanek, 2007).

In South Africa *Opuntia stricta* var. *stricta* is a declared weed (category 1 invader) and has the status of a transformer (Henderson, 2001). A recommended herbicide for its chemical control is available in South Africa (Anonymous, 2004). It has been proposed to be classified as category 1b under NEMBA and CARA (Anonymous, 2009). An effective biological control programme using the cactus moth (*Cactoblastis cactorum*) and the host-specific biotype of the cochineal insect (*Dactylopius opuntiae*) has been responsible for its successful control in the KNP (Zimmerman *et al*., 2009). Chemical control in the KNP is now limited to outlying isolated plants and small populations while the dense infestations are left or biological control (Foxcroft *et al*., 2004).

Fig. 231. Stipitate fruits of *Opuntia stricta* (Haw.) Haw. var. *stricta.*
(Picture by Pieter J.D. Winter)

Fig. 232. Cladodes of *Opuntia stricta* (Haw.) Haw. var. *stricta* showing prominent tubercles. (Picture by Pieter J.D. Winter)

Fig. 233. Flower of *Opuntia stricta* (Haw.) Haw. var. *stricta.* (Picture by Pieter J.D. Winter)

Fig. 234. *Opuntia stricta* (Haw.) Haw. var. *stricta.* invades savanna.
(Picture by Pieter J.D. Winter)

Peniocereus (A.Berger) Britton & Rose

Erect, prostrate or scandent shrubs; root thickened, tuberous, or turnip-shaped; branches with few articulations, slender, ± cylindric, epidermis hairless or papillose-downy, often tinged purple or with white spots; ribs 9–15(–17). Spines conspicuous, white to brown. **Flowers** nocturnal; pericarpel areoles with bristles or spines; hypanthium long and slender, with soft spines. **Perianth** funnelform. **Fruit** narrowly ovoid to subglobose, tapered at apex, fleshy, red. **Fruit** bristles/spines more or less caducous. **Seed** broadly ovoid, 1.4–4.6 × 1.2–3.3 mm, shiny or matt black-brown (virtually black), sides flat to low-conical, periphery undifferentiated or crested with larger cells, surface smooth.

References: Telford (1984), Anderson (2001), Hunt *et al*. (2006).

The genus comprises 20 species from USA (southern Arizona) extending southwards through Central America as far as Costa Rica (Hunt, 2006).

Some species in this genus appear similar to some species of *Echinopsis* or *Cleistocactus* in their columnar or arching stems that are only rarely branched above 0.5 m from base, in their usually 9–15 ribs with troughs between ridges obscured by radial spines extending over them and interlacing, and in the pericarpel with many bristles or hairs. It differs from *Echinopsis* by having thinner stems (less than 6 cm in diameter) that can grow taller, and by flowers appearing over a considerable length of the stem, not only the top 10 cm. Both *Echinopsis schickendantzii* and *Cleistocactus samaipatanus* have a soft, dark, hair covering of the pericarpel and hypanthium, while *Peniocereus* has stiffer, white bristles on those parts. *Cleistocactus* has much smaller, red flowers, and stems no taller than 1.5 m.

Peniocereus serpentinus (Lag. & Rodr.) N.P.Taylor

In: Hunt & Taylor in *Bradleya* 5: 93 (1987).

=*Nyctocereus serpentinus* (Lag. & Rodr.) Britton & Rose

Common names: Mexican night-blooming cereus, serpent cactus, snake cactus (English); slangkaktus (Afrikaans).

Shrub, stems erect or arching, up to 2(–3) m tall, branching from base; root more or less tuberous; branches (2.5–)3–5 cm in diameter, green; ribs 10–12(–17), slightly rounded, tubercles absent to ± prominent; areoles c. 1 cm apart. Spines soft, 10–14, unequal, white to brown, often tinged red or purplish when young; radial spines 10–13, needle- or bristle-like, (4–)10–15 mm long; central spine absent or single, stouter, up to 3 cm long. **Flowers** nocturnal, (12–)15–20(–25) × 8–10 (–15) cm, white, tinged red outside; tepals narrow, acute; outer tepals reflexed; pericarpel and hypanthium with white bristles. **Stamens** exserted; anthers yellow. **Style** exserted. **Fruit** ovoid to globose, up to 4 cm long, red; scales acute; areoles many, with whitish hairs. **Distribution**: SA. (Fig. 235).

References: Telford (1984), Anderson (2001), Hunt *et al*. (2006).

This species, with stems of similar diameter and rib and spine density (Fig. 236) to that of *Cleistocactus samaipatanus* in the tribe Trichocereeae, has been recorded in South Africa in the Limpopo Province (in the Lekgalameetse Nature Reserve and near Rust de Winter), and in KwaZulu-Natal (Pietermaritzburg, Tugela valley and near Greytown).

Fig. 235. Distribution map of *Peniocereus serpentinus* (Lag. & Rodr.) N.P.Taylor.

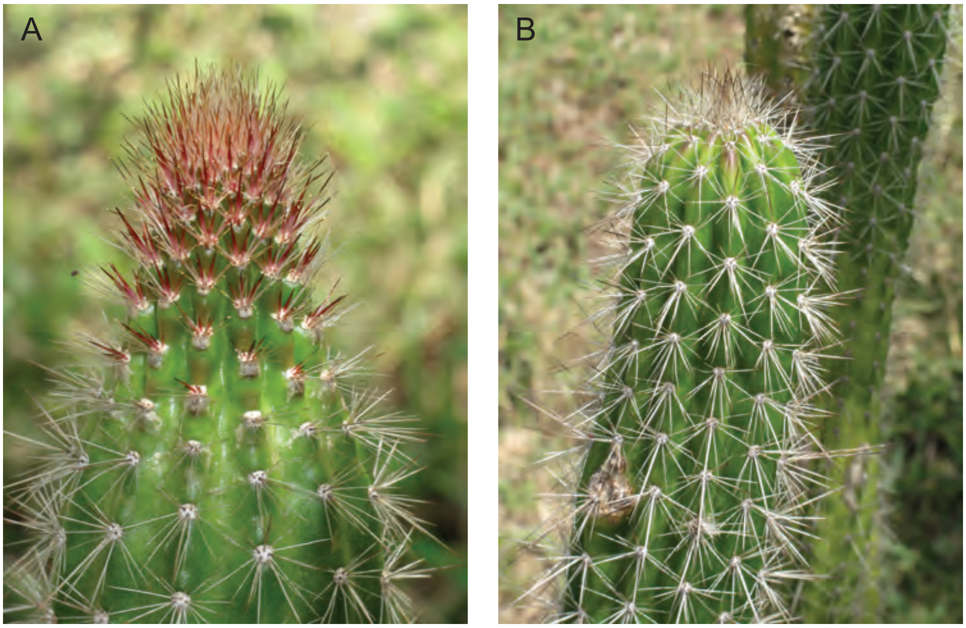

Fig. 236. *Peniocereus serpentinus* (Lag. & Rodr.) N.P.Taylor – A. Young stem; B. Older stem. (Pictures by Neil R. Crouch)

In the only plant seen dug up, the root does not appear to be tuberous. The columnar, erect stems (Fig. 237) are taller (2–3 m), than those of *Cleistocactus* (0.5–1.5 m). Spines on new growth of *C. samaipatanus* are pale yellow, not white or tinged purplish. Fruit is more than 1 cm in diameter, with pale bristles, compared to the smaller fruit with soft, dark hairs in *C. samaipatanus*. Tuberous roots, or specimens with mature fruit, are required to confirm the identification. A range of plants should be dug out to assess whether plants recruited from seed have a more tuberous root than those established through formation of adventitious roots from stem sections in contact with the soil. *Cleistocactus* species are commonly cultivated for their attractive, bright red, zygomorphic flowers, and may still emerge as naturalised populations in future.

Peniocereus serpentinus is a widely cultivated Mexican (Sinaloa to Querétaro, also Oaxaca) cactus of the tribe Echinocereeae, popular due to its relatively large, white, nocturnal flowers. It has been recorded as naturalised in Australia (Telford, 1984).

Fig. 237. *Peniocereus serpentinus* (Lag. & Rodr.) N.P.Taylor has erect columnar stems. (Picture by Neil R. Crouch)

Pereskia Mill.

Shrubs or woody climbers; roots sometimes tuberous; branches not conspicuously succulent, cylindric, unsegmented, not ribbed or tubercled; glochidia absent. **Leaves** present, broad, flat, thin, not or only slightly succulent, deciduous or sub-persistent. Spines usually numerous. **Flowers** in paniculate inflorescences, or clustered, or solitary, pedicellate or sessile, diurnal. Pericarpel receptacle with few to many scales; areoles with wool, often hairs, and rarely spines; hypanthium absent. **Perianth** rotate, spreading or rarely erect, white. **Ovary** semi-inferior or inferior. **Fruit** baccate, sometimes with persistent scales; pericarpel juicy or tough, indehiscent, fruit pulp present or absent. **Seed** more or less circular or obovate to reniform; 1.7–7.5 mm long, black-brown (virtually black), shiny, relief flat.

References: Obermeyer (1976), Anderson (2001), Taylor & Zappi (2004), Hunt *et al*. (2006).

These plants are very unlike most other cacti in having more conventional, true leaves (Fig. 238), and an inflorescence that is not as congested and reduced (Fig. 239, 240).

There are 17 species in this genus, native to Central and South America. *Pereskia* is currently considered to be a paraphyletic group, with the Andean (including the widespread *P. aculeata* Mill.) and southern South American *Pereskia* clades more closely related to the core cacti than they are to the northern group of mainly Caribbean species (Edwards *et al*., 2005).

Fig. 238. Leaves and spines of *Pereskia aculeata* Mill. (Picture by Gideon F. Smith)

Fig. 239. Young inflorescence of *Pereskia aculeata* Mill. (Picture by Neil R. Crouch)

Fig. 240. Inflorescence of *Pereskia aculeata* Mill. (Picture by Geoff R. Nichols)

Pereskia aculeata Mill.

In: *Gardeners Dictionary*, Edition 8 [unpag] (1768).

Common names: Barbados gooseberry, leaf cactus, lemon vine, pereskia (English); pereskia, Barbadosstekelbessie, bougainvilleakaktus (Afrikaans).

Climbing shrubs 3–15 m tall; basal branches cane-like, 2–3 cm thick; distal branches c. 4 mm thick, green, terete. **Leaves** lanceolate to elliptic or ovate, up to 7–11 × 4 cm, shortly petiolate, usually subtended by a pair of small, persistent claw-like spines, 4–8 mm long. Normal spines 1–3, charcoal-grey, developing at areoles on older growth only, numerous on trunk, straight. **Flowers** numerous, in panicles, 2.5–5 cm in diameter, scented. Pericarpel areole with hairs and often small spines; scales few, elongated, foliaceous; outer tepals 4–7, greenish; inner tepals 7–12, white or nearly so, apices obtuse**. Stamens** of mature flower oblique. **Ovary** more or less inferior, surface with spines, a hollow at the style base, dark green. **Fruit** c. 2 cm in diameter, skin smooth, sometimes spiny, fleshy, pale yellow to orange (ripe). **Seed** black-brown (virtually black). **Distribution**: S, SA. (Fig. 241).

References: Obermeyer (1976), Leuenberger (1986), Anderson (2001), Henderson (2001), Taylor & Zappi (2004), Hunt *et al*. (2006).

This species is readily distinguished from other invasive cacti by its generic features (see above), and by the paired recurved spines, specially adapted for climbing, on the more vigorous shoots. It is the most widespread of the *Pereskia* species, from Mexico, the West Indies and Florida (USA), south to northern and eastern South America as far as Argentina (Anderson, 2001; Taylor & Zappi, 2004; Hunt, 2006). The fruit (Fig. 242) has been used to make jam. Flowers are in panicles (Fig. 243) and the trunk has numerous, straight spines (Fig. 244).

Fig. 241. Distribution map of *Pereskia aculeata* Mill.

Fig. 242. Fruits of *Pereskia aculeata* Mill. (Picture by Geoff R. Nichols)

Pereskia aculeata is a garden escape, and has become a serious pest in KwaZulu-Natal coastal forests, as well as the Port St. Johns and Port Alfred areas (Eastern Cape) in South Africa. Isolated infestations also occur in the Limpopo and Mpumalanga Provinces. In South Africa it is a declared category 1 invader, and a registered herbicide is available for its control (Anonymous, 2004). One biological control agent, a chrysomelid beetle (*Phenrica guerini*) has been released against this plant, but has proved to be ineffective (Klein, 1999). It is also listed as naturalised in Swaziland. It is considered an invader in Australia (Telford, 1984). A golden-leaved horticultural cultivar is widely grown and has the potential to escape, although it has not been documented yet (Fig. 245).

Fig. 243. Panicles of flowers of *Pereskia aculeata* Mill. (Picture by Geoff R. Nichols)

Fig. 244. Trunk of *Pereskia aculeata* Mill. with spines. Note the pair of short, stout, recurved spines at the base of the upper left node. (picture by Geoff R. Nicholls)

Fig. 245. Golden leaved cultivar of *Pereskia aculeata* Mill. (Picture by Geoff R. Nichols)

Tephrocactus Lem.

Shrubs; branching moniliform; branch segments globose, cylindric or obovoid, easily detached; roots fibrous. **Leaves** tiny, cylindric, caducous; areoles ± immersed, with hairs and glochidia, spines 0–4. **Flowers** apical. **Stamens** usually numerous, sensitive. **Fruit** dry, dehiscent; pulp none. **Seed** highly specialised, extremely variable in shape, laterally compressed, 2.5–9.5 mm long, yellowish white to brown; aril (funicular envelope) glabrous, girdle strongly protruding, spongy.

References: Anderson (2001), Hunt *et al*. (2006).

The characteristic growth pattern with globose, easily detached segments, usually spineless but with conspicuous glochidia, the dry, dehiscent fruits and the unique seed structure are diagnostic for this genus of seven species endemic to western Argentina in South America.

Tephrocactus articulatus (Pfeiff.) Backeb.

In: *Cactus (Paris)* 8(38): 249 (1953).

=*Opuntia glomerata* sensu auct. non Haw.

Common names: paper-spine cholla, pine cone cactus (English); papierdoringkaktus (Afrikaans).

Dwarf shrub, erect, up to 20–30 cm long; branch segments globose to oblong, usually 2.5–5 × 2.5–5 cm, easily detached; glochidia dark brown or maroon, conspicuous. Spines lacking or 1–4, up to or more than 50 × 7 mm, flat, papery or raffia-like, pale brown or white. **Flowers** 3–4 cm in diameter, white or pale pink. **Fruit** 1–1.5 cm long, terminal, persistent, often sterile. **Seed** winged and corky. **Distribution**: N, SA. (Fig. 246).

References: Anderson (2001), Hunt *et al*. (2006).

Tephrocactus articulatus is widely distributed across the dry north-central and northwestern parts of Argentina, from Catamarca and Santiago del Estero, south to Mendoza and San Luis (Hunt, 2006).

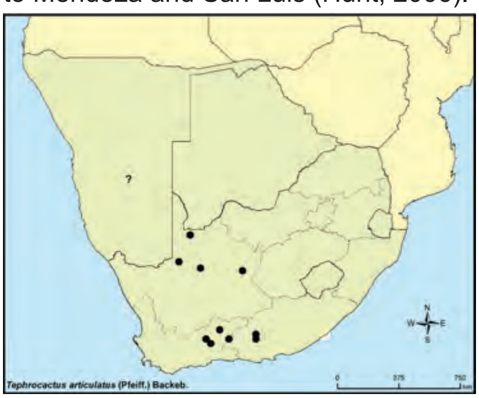

Fig. 246. Distribution map of *Tephrocactus articulatus* (Pfeiff.) Backeb.

It is thought to have been introduced into South Africa as a horticultural specimen especially for succulent gardens (Fig. 247). It has been recorded sporadically from Askham and Upington in the Northern Cape, the Great Karoo of the Western Cape, and around Jansenville in the Eastern Cape (Fig. 248). It is also widely distributed as an ornamental and garden escape in Namibia. Dispersal is by segments that are easily detached (Fig. 249). Elsewhere it produces winged and corky seeds (L. Henderson, *pers. comm*.) that are easily dispersed by wind and water.

This species is currently not a declared weed in South Africa, however it has been recommended for classification as a category 1a invasive species under NEMBA and CARA (Anonymous, 2009).

Tephrocactus articulatus spreads by dislocated cladodes that root and grow, forming dense thickets. Some cladodes, although fairly heavy, may be washed away longer distances. It is not spread by animals. The main cause for long-distance dispersal is humans who find it an attractive rockery plant.

Fig. 247. *Tephrocactus articulatus* (Pfeiff.) Backeb. is common in succulent gardens. (Picture by Barbara K. Mashope)

Fig. 248. *Tephrocactus articulatus* (Pfeiff.) Backeb. invading karoo. (Picture by Pieter J.D. Winter)

Fig. 249. Stem segments of *Tephrocactus articulatus* (Pfeiff.) Backeb. are easily detached. (Picture by Pieter J.D. Winter)

COMMELINACEAE Mirb.

(Spiderwort family; *Wandelende jood-familie*)

by

N.R. Crouch

Perennials or annuals, often somewhat succulent; the perennials of diverse habits, sometimes rhizomatous or stoloniferous, very rarely forming a small bulb; roots adventitious, fibrous, thin or tuberous; stems with prominent nodes and internodes. **Leaves** basal and/or cauline, alternate, distichous or spirally arranged, with a basal, usually closed sheath enveloping stem, often ciliate at mouth; blade simple, entire, often petiolate. **Inflorescence** terminal, terminal and axillary or rarely all axillary, composed of cymes which may be few, or many and aggregated into thyrses, sometimes subtended by or enclosed in spathaceous bracts. **Flowers** bisexual or bisexual and male, actinomorphic or zygomorphic, occasionally cleistogamous. **Sepals** 3, free or united at base, usually ± equal and sepaloid, occasionally petaloid, often boat-shaped and keeled, persistent. **Petals** (2–)3, free or basally connate to form a tube, equal or unequal, caducous. **Stamens** in 2 whorls, 3 + 3, all fertile or 1–4 modified into staminodes and bearing variously shaped antherodes, hypogynous or united with corolla; filaments glabrous or bearded; anthers basifixed, dorsifixed or versatile, opening with longitudinal slits or rarely by basal or apical pores. **Ovary** superior, 2–3-locular with 1–many axile ovules in each locule; ovules uniseriate or biseriate; style simple, usually slender; stigma apical, simple or rarely 3-lobed, small or capitate, rarely enlarged**.** **Fruit** a 2–3-valved capsule, loculicidal, rarely indehiscent, or a berry. **Seeds** 1–many per cell, hilum dot-like or elongate, embryotega circular, dorsal to lateral, rarely terminal, endosperm copious.

References: Obermeyer & Faden (1985), Faden (1998), Fish (2000), Hong & DeFilipps (2010).

The family comprises c. 650 species in c. 40 genera. It is predominantly distributed in tropical regions, with far fewer species known from subtropical and temperate zones (Hong & DeFilipps, 2010).

Four species from two genera of the Commelinaceae are naturalised in southern Africa.

Key to naturalised genera [based on Hunt (1984) and Faden (2010)]:

1. Leaves very succulent; involucral bracts inconspicuous, spreading or sheathlike, never spathaceous; capsule 2-valved . . . . ***Callisia***

1'. Leaves semi-succulent; involucral bracts conspicuous, spathaceous, paired; capsule 3-valved . . . . ***Tradescantia***

Callisia Loefl.

Herbs, perennial or rarely annual; roots thin, rarely tuberous, rhizomes absent. **Leaves** spirally arranged or distichous (2-ranked); blade sessile. **Inflorescence** terminal and/or axillary, composed of sessile cymes in pairs (often aggregated into larger spike-like or panicle-like units), umbel-like, contracted, subtended by bracts; bracts inconspicuous, less than 1 cm long; spathaceous bracts absent; bracteoles persistent. **Flowers** bisexual (bisexual or male in *C. repens*), actinomorphic; pedicels very short or well developed; sepals 2–3, free, subequal; petals 2–3, free, equal, not clawed, lanceolate, white or pink to rose (rarely blue). **Stamens** 6 or 3, all fertile, 1 or more becoming staminodes, subequal; filaments glabrous or bearded; anther locules rounded, longitudinally dehiscent, connectives broad and square, triangular or oblong, rarely narrow. **Ovary** oblong, subtrigonous, 2–3-locular; ovules (1–)2 per locule, 1-seriate. **Fruit** a capsule, 2–3-valved, 2–3-locular. **Seeds** 1–2 per locule, minute, with dot-like hilum.

References: Hunt (2001), Faden (2010), Hong & DeFilipps (2010).

This genus is closely related to *Tradescantia* but generally lacks the paired bracts subtending the inflorescence, and differs in seed characters (Hunt, 2001).

Callisia repens (Jacq.) L.

In: *Species plantarum* ed. 2: 62 (1762).

=*Hapalanthus repens* Jacq.
=*Spironema robbinsii* C.Wright
=*Tradescantia callisia* Sw.

Common names: creeping inch plant (English).

Herbs, perennial, mat-forming; stems prostrate, much branched, rooting at nodes, flowering stems ascending. **Leaves** distichous, gradually becoming smaller distally along flowering shoots; blade ovate to lanceolate or lanceolate-oblong, 1–4 × 0.6–1.2 cm (distal leaf blades much narrower than sheaths when sheaths opened, flattened), base clasping, subcordate or obtuse, apex acuminate, glabrous except for scabrid margins and apex. **Inflorescence** ascending, sessile in axils of distal leaves of flowering stems, composed of pairs of sessile cymes (sometimes reduced to single cymes). **Flowers** bisexual or male, odorless, subsessile. **Sepals** green, linear-oblong, 3–4 mm long, hirsute along midvein, margin scarious. **Petals** inconspicuous, lanceolate, 3–6 mm long, white. **Stamens** 3; filaments glabrous and long-exserted; connectives broadly deltoid. **Ovary** oblong, subtrigonous, 2-locular, apex pilose; ovules 2 per locule; style filiform; stigma penicillate. **Fruit** an oblong capsule, 2-valved, c. 1.5 mm long; seeds 2 per valve, 1 mm long, rugose, brown. **Seeds** 1–2 per locule, minute, with dot-like hilum. **Distribution**: SA. (Fig. 250).

References: Hunt (2001); Faden (2010); Hong & DePhilipps (2010).

Callisia comprises c. 20 species from the USA through to tropical America, with a major centre of diversity in Mexico (Faden, 2010). The compactness of plants of *C. repens* (Fig. 251) and the relatively small size of its thickly fleshy and broadly pointed leaves (Fig. 252) should prevent its confusion with any other member of the Commelinaceae in southern Africa, whether native or naturalised.

Callisia repens is grown as a horticultural subject, particularly in hanging baskets where under water-stressed conditions the leaves turn an attractive purple colour. It spreads vegetatively from the smallest of cuttings, making it extremely difficult to eradicate once introduced (Fig. 253). *Callisia repens* displays a wide range of ecological tolerances for it will grow in the shade of forest floors (Fig. 254), or in full sun. The clone commonly cultivated appears to rarely flower in southern Africa (Fig. 255), and in Europe is reportedly non-flowering (Hunt, 1984).

Fig. 250. Distribution map of *Callisia repens* (Jacq.) L.

Fig. 251. *Callisia repens* (Jacq.) L. has a compact habit. (Picture by Neil R. Crouch)

Fig. 252. Leaves of *Callisia repens* (Jacq.) L. are broadly pointed.
(Picture by Geoff R. Nichols)

Fig. 253. *Callisia repens* (Jacq.) L. invasion. (Picture by Geoff R. Nichols)

Fig. 254. Shade form of *Callisia repens* (Jacq.) L. (Picture by Neil R. Crouch)

Fig. 255. Inflorescence of *Callisia repens* (Jacq.) L. (Picture by Geoff R. Nichols)

Tradescantia L.

Perennial herbs; stems simple to diffusely branched, erect or trailing, sometimes rooting at nodes; roots thin or tuberous. **Leaves** distichous or spirally arranged, oblong-ovate to linear, sessile or rarely petiolate. **Inflorescence** terminal and/or axillary, of paired, sessile cymes, each pair subtended by foliaceous or spathaceous bracts; bracteoles persistent. **Flowers** few to many, bisexual, actinomorphic, pedicels very short or well developed. **Sepals** free, subequal, rarely basally connate (in *T. zebrina*), green or coloured. **Petals** free, equal, rarely clawed, rarely basally connate, obovate to orbicular, white to pink, blue or violet. **Stamens** 6, equal, all fertile; filaments bearded or smooth. **Ovary** 3-locular, with 2(–1) superposed ovules in each cell. **Fruit** a loculicidally dehiscent 3-valved capsule. **Seeds** variable; hilum oblong to linear; embryotega dorsal.

References: Obermeyer & Faden (1985), Fish (2000), Faden (2010).

Common names: spider-lily, spiderwort, wandering-jew (English); wandelende jood (Afrikaans).

Tradescantia is a genus of c. 70 species occurring in North, Central and South America (Obermeyer & Faden, 1985; Faden, 2010). The various species tend to hybridise freely when growing together which has resulted in some taxonomic confusion. Much early taxonomic literature and even current horticultural works reflect the exclusion of *Zebrina* Schnizl. and *Setcreasea* K.Schum. & Sydow from *Tradescantia*, a situation that has since changed (Hunt, 1975, 1986). Several tradescantias are grown as pot plants, and as ground covers given their rapid growth and mat-forming tendencies. The three species naturalised in South Africa have escaped from cultivation, with *T. fluminensis* the most widespread and abundant. In moist regions of the subtropical East Coast such as Kloof and Hillcrest this species may be found occupying many hectares of forest undergrowth, where it displaces the native flora.

Key to the species of *Tradescantia* naturalised in southern Africa [based on Hunt (1984) and Faden (2010)]:

1. Flowers subsessile; petals clawed, claws connate at least basally; stamens epipetalous **2**
1'. Flowers distinctly pedicellate; petals neither clawed nor connate; stamens free . . . . **1. *Tradescantia fluminensis***

2. Leaves 2-ranked, bases oblique; blade usually variegated; sepals connate basally into a slender tube . . . . **3. *Tradescantia zebrina***
2'. Leaves spirally arranged, bases symmetric, blade not variegated but usually purplish violet; sepals distinct . . . . **2. *Tradescantia pallida***

1. *Tradescantia fluminensis* Vell.
In: *Fl. Flumin*: 140 (1829).

=*Tradescantia albiflora* Kunth

Common names: small leaf spiderwort, white-flowered wandering jew (English).

Glabrescent herb with decumbent, slender, leafy stems, rooting at nodes. **Leaves** distichous, blade lanceolate-eliptic to ovate-acuminate, 2.5–5 × 1–2 cm, abruptly narrowed at base into a short, broad, open, ciliate sheath, apex acute, margins ciliolate, green above, green or purplish beneath. **Inflorescence** composed of few-flowered cymes, terminal and/or terminating abbreviated side branches, each pair of cymes subtended by 2 foliaceous subequal bracts. **Flowers** distinctly pedicellate, pedicels 1–1.5 cm, glandular-pilose. **Sepals** ovate-acuminate, with a ciliate keel, 5–7 mm long, green. **Petals** free, ovate, not clawed, 8–9 mm long, white. **Stamens** 6; filaments 8 mm long, white, bearing long beaded hairs in lower half; anthers with an obtriangular connective, locules spreading outwards towards apex. **Ovary** 3-locular, oblong-globose, with 2 ovules per locule; style terete or somewhat swollen in middle; stigma capitate. **Fruit** a capsule, 2 mm long, chartaceous. **Seed** reticular, hilum linear. **Distribution**: L, S, SA. (Fig. 256).

References: Obermeyer & Faden (1985), Hunt (2001), Faden (2010).

This species belongs to section *Austrotradescantia*, a wholly South American section centred in southeastern Brazil (Hunt 1980). It is native to South America, from Argentina through to central Brazil (Obermeyer and Faden 1985).

The uniformly green adaxial leaf blades (Fig. 257) of this species separate it from other *Tradescantia* species occurring in southern Africa, all of which are exotic. It should be noted though that several clones are cultivated, including some variegated ones (Hunt 1984) that are not yet known to have escaped in South Africa.

South Africa is not the only country in which this favoured pot plant has escaped; in New Zealand it is reportedly a common weed (Obermeyer and Faden 1985), and it has also been reported from Australia and the USA (Faden 2010). Although this species prefers the shade of moist forest floors (Fig. 258) it may also be found in more xeric environments such as the banks of seasonally dry streams in Valley Bushveld. In such situations the plants lose most of their leaves over the dry period, perennating as a succulent stem at soil level. Although attractive the feathery while flowers are quite small (Fig. 259).

Fig. 256. Distribution map of *Tradescantia fluminensis* Vell.

Fig. 257. Leaf blades of *Tradescantia fluminensis* Vell. are uniformly green adaxially. (Picture by Neil R. Crouch)

Fig. 258. *Tradescantia fluminensis* Vell. invades moist forest floor. (Picture by Neil R. Crouch)

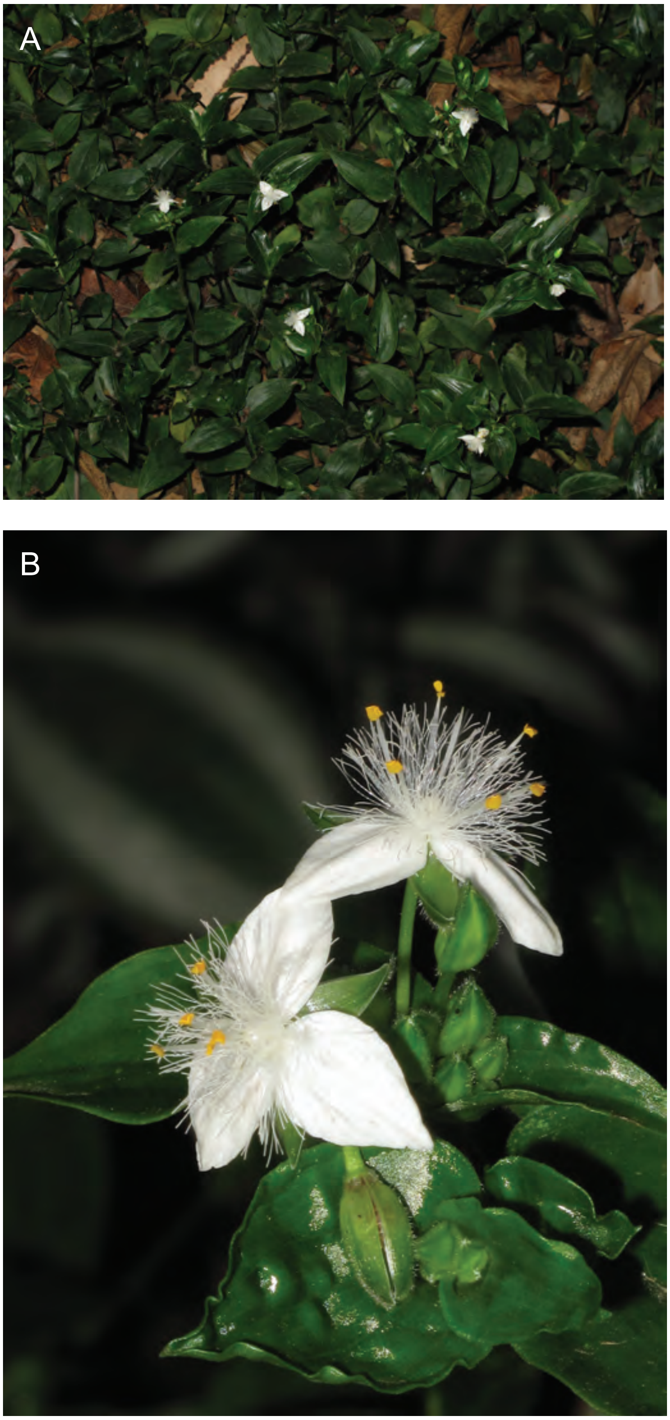

Fig. 259. *Tradescantia fluminensis* Vell. – A. Feathery white flowers;
B. Flower close-up. (Pictures by Neil R. Crouch)

2. *Tradescantia pallida* (Rose) D.R.Hunt

In: *Kew Bull*. 30: 452 (1975).

=*Setcreasea pallida* Rose
=*Setcreasea purpurea* Boom

Common names: purple heart, purple queen (English).

Perennial herb with succulent stems up to 40 cm long, ascending or decumbent, suffused with purplish violet. **Leaves** spirally arranged; blade trough-shaped, lanceolate-oblong to oblong-elliptic, (4–)7–15 × 1.5–3 cm (distal leaf blades wider or narrower than sheaths when sheaths opened, flattened), base symmetric, rounded to broadly cuneate, apex acute, margins ciliate or ciliolate, not variegated, suffused with purplish violet, glabrous or glabrescent. **Inflorescence** terminal, often becoming leaf-opposed, pedunculate; peduncles (3.5–)4–13 cm long; bracts similar to leaves (also folded and keeled) but usually greatly reduced. **Flowers** subsessile; pedicels 4–9 mm long, densely white-pilose at summit. **Sepals** distinct, 7–10 mm long, pilose basally. **Petals** ± connate at base, clawed, 1.5–2 cm long, pink. **Stamens** slightly epipetalous; filaments very sparsely bearded. **Fruit** a capsule, c. 3.5 mm long, glabrous. **Seed** 2.5–3 mm long. **Distribution**: S, SA. (Fig. 260).

References: Hunt (2001), Faden (2010).

This species belongs to section *Setcreasea*, which is distributed from Mexico to Texas in the USA (Hunt, 1980).

The widely grown form with dark purple stems and leaves ('Purple Heart' or 'Purpurea') (Fig. 261) and pink flowers (Fig. 262) is that which has escaped on occasion in South Africa. It was an introduction to horticulture from Mexico, but like *Tradescantia zebrina*, it is not known in the wild (Hunt, 1984, but see Faden, 2008).

Fig. 260. Distribution map of *Tradescantia pallida* (Rose) D.R.Hunt.

Fig. 261. *Tradescantia pallida* (Rose) D.R.Hunt. (Picture by Geoff R. Nichols)

Fig. 262. Flower of *Tradescantia pallida* (Rose) D.R.Hunt. (Picture by Neil R. Crouch)

3. *Tradescantia zebrina* Heynh. ex Bosse

In: *Vollst. Handb. Bl.-gartn*., ed. 2, 4: 655 (1849).

=*Zebrina flocculosa* G.Brückn.
=*Zebrina pendula* Schnizlein
=*Zebrina purpusii* G.Brückn.

Common names: wandering jew (English); wandelende jood (Afrikaans).

Perennial herb with decumbent or prostrate, slender, leafy stems rooting at nodes, often forming dense mats or colonies. **Leaves** distichous, sessile; blade lanceolate-elliptic to ovate-elliptic, 3–10 × 1.5–3.2 cm, fleshy, base oblique, cuneate, apex acute to acuminate, adaxially variegated, silver/white-striped green, occasionally with additional dark red stripes, abaxially reddish purple, glabrous or sparsely pilose on both surfaces, leaf sheath 8–12 × 5–8 mm, membranous, long-ciliate at mouth (distal leaf blades wider or narrower than sheaths when sheaths opened, flattened). **Inflorescence** terminal, consisting of pairs of sessile cymes enclosed in sheaths of spathaceous bracts, pedunculate; spathaceous bracts foliaceous, reduced, ciliate. **Flowers** subsessile. **Sepals** lanceolate to oblong-lanceolate, basally connate, 4–8 × 1.5 mm, hyaline. **Petals** clawed, claws basally connate forming slender white tube to 10 × 1.3 mm, lobes free, ovate, apex obtuse, 5–10 × 3–7 mm, pink. **Stamens** 6; filaments epipetalous, white, bearded below. **Fruit** a capsule, 3-locular, locules 2-seeded. **Seed** rugulose. **Distribution**: SA. (Fig. 263).

References: Faden (2010), Hong & DeFilipps (2010).

This species belongs to section *Zebrina*, which is represented in southern Africa by only this species. Although *Tradescantia zebrina* has been reported by some authors (e.g. Hunt, 2001) to not definitely be known in the wild state, it has more recently (Faden, 2008) been described as widespread and common in its native range within Mexico.

Fig. 263. Distribution map of *Tradescantia zebrina* Heynh. ex Bosse.

The flowers (Fig. 264) appear at irregular intervals throughout the year. With its prominently striped leaves (Fig. 265) and mat-forming habit (Fig. 266) it is unlikely that this species could be confused with any indigenous species. This species has naturalised in many warm countries—including China and Taiwan (Hong & DeFilipps, 2010)—on account of it being cultivated for its decorative leaves (Hunt, 2001). Several clones are cultivated, including 'Purpusii' with unstriped dark-red or red-green leaves and 'Quadricolor' with leaves metallic-green, striped with red, green and white (Bailey & Bailey, 1976; Hunt, 1984).

Fig. 264. Flowers of *Tradescantia zebrina* Heynh. ex Bosse. (Picture by Geoff R. Nichols)

Fig. 265. Leaves of *Tradescantia zebrina* Heynh. ex Bosse are striped.
(Picture by Neil R. Crouch)

Fig. 266. *Tradescantia zebrina* Heynh. ex Bosse invasion.
(Picture by Neil R. Crouch)

CRASSULACEAE J.St.-Hil.

(Stonecrop, Orpine or Houseleek family; *Plakkiefamilie*)

by

M. Walters

Perennial (rarely annual or biennial) herbs, subshrubs or shrubs (rarely aquatics, or tree-like, or epiphytic, or scandent), always with more or less fleshy leaves, sometimes with succulent stems, rhizomes, underground caudices or succulent roots. **Leaves** opposite and decussate or alternate and whorled, often arranged into rosettes, usually sessile/ subsessile rarely petiolate, simple (pinnate in *Bryophyllum*), usually entire, or crenate, rarely lobed or imparipinnate, glabrous or covered in hairs, papillae, bristles or wax; stipules absent. **Inflorescence** usually a many-flowered axillary or terminal cyme, corymb, or rarely true spike, raceme or panicle. **Flowers** bisexual or unisexual (then plants dioecious or rarely gynodioecious), actinomorphic (except *Tylecodon grandiflorus*), 3- to 32-merous (though often 5-merous). **Sepals** free or basally connate, persistent. **Petals** free or basally connate to form a short to long corolla tube. **Stamens** as many (in 1 series) or twice as many (in 2 series) as petals, free or fused to the petals; anthers 2-locular, basifixed, longitudinally and laterally dehiscent. **Ovary** superior or semi-inferior; carpels equal in number to petals, free or slightly fused basally, with a small to conspicuous nectary scale at or near the base; styles gradually tapering, short or elongated; ovules few to many. **Fruit** usually a dehiscent group of follicles, capsular. **Seeds** small, 1–20+ per carpel, elongate, up to 1.5–3 mm long, smooth, papillate to longitudinally ridged, mostly brownish, with little or no endosperm.

References: Eggli (2003), Heywood *et al.* (2007), Thiede & Eggli (2007), Moran (2009).

There are c. 1 500 species from c. 35 genera (Heywood *et al*., 2007) in Crassulaceae making it the third largest succulent plant family (after *Aizoaceae* Martynov. and *Cactaceae* Juss.; orchids excluded). Seven of these genera occur in southern Africa i.e. *Aeonium* Webb & Berthel., *Adromischus* Lem., *Bryophyllum* Salisb., *Cotyledon* L., *Crassula* L., *Kalanchoe* Adans. and *Tylecodon* Tölken. Of these, *Adromischus* and *Tylecodon* are endemic to the region, while *Bryophyllum* and *Aeonium* are entirely exotic genera. The Crassulaceae are distributed worldwide but have centres of endemism in South Africa, Madagascar, East Asia, Mexico and Macaronesia, while being poorly represented in the wet tropics, Australia and South America (Thiede & Eggli, 2007; Heywood *et al*., 2007).

There is still some uncertainty around the generic boundaries in this family. The family was traditionally divided into six subfamilies, a division long recognised as unnatural, but more recent work resulted in a division into only three subfamilies i.e. Crassuloideae Burnett [*Crassula* (including *Tillaea* L., *Rochea* DC., *Dinacria* Harv. & Sond. and *Pagella* Schönland) and *Hypagophytum* A.Berger], Kalanchoideae A.Berger (*Adromischus, Bryophyllum, Cotyledon, Kalanchoe* and

Tylecodon) and Sempervivoideae Arnott (all remaining genera) (Thiede & Eggli, 2007; Takhtajan, 2009).

Most members of the Crassulaceae prefer warm, dry regions and are frequently found in arid and/or rocky habitats. The most notable exceptions are the adaptation to aquatic environments some species display, and the adaptation to frosty conditions of others (Heywood *et al*., 2007).

Many species in the Crassulaceae are popular in the horticultural trade. The plants are frequently hardy and thus make good garden subjects. One species, *Hylotelephium spectabile* (Boreau) H.Ohba*,* is sometimes grown commercially for its flowers (Eggli, 2003). Plants of this family are extremely popular with succulent plant collectors and are well-known for their ability to grow easily from cuttings or even from single leaves, which has undoubtedly facilitated the movement of some species to gardens, window-boxes and pots throughout the world.

Many members of the Crassulaceae are eaten and/or used medicinally in many parts of the world (Plants for a Future, 2008; Arnold *et al*., 2002). Locally, however, they are used largely as medicinal plants. In southern Africa the genus *Crassula* is the largest and accordingly contains more medicinal species than the other genera. *Cotyledon orbiculata* L., however, is arguably the best known and most popular species for medicinal use in the region, where it is, for instance, frequently used for treating a number of skin conditions (like warts and boils).

Four species from two genera [*Aeonium* (1) and *Bryophyllum* (3)] are naturalised in southern Africa with a further four species having potential as garden escapes.

Key to the genera of Crassulaceae occurring in southern Africa [adapted from Dreyer and Makwarela (2000)]:

1. Stamens equal in number to petals . . . . **(*Crassula*)**
1'. Stamens at least twice as many as petals **2**

2. Petals numbering 4 or 5 . . . .**3**
2'. Petals numbering 6 or more . . . . ***Aeonium***

3. Leaves opposite (rarely whorled) **4**
3'. Leaves spirally arranged **5**

4. Flowers 5-merous . . . .**(*Cotyledon*)**
4'. Flowers 4-merous **6**

5. Leaves persistent; inflorescence a spike-like thyrse, rarely branched. . . . .**(*Adromischus*)**
5'. Leaves caducous; inflorescence a single-flowered to branched thyrse . . . .**(*Tylecodon*)**

6. Flowers pendulous . . . . ***Bryophyllum***
6'. Flowers erect . . . . ***Kalanchoe***

Aeonium Webb & Berthel.

Biennial or mostly perennial shrubs, subshrubs or herbs, glabrous or pubescent. **Stems** ascending, simple or densely- to few-branched, woody or fleshy, often with distinct leaf scars. **Leaves** persistent, often in rosettes at ends of branches, spirally arranged, simple, sessile; blade obovate or obovate-spathulate, sometimes ovate, elliptic or trullate, 3–15 cm long, base broad, cuneate rarely attenuate, apex acute, acuminate or rounded, margins ciliate to pectinate, fleshy to succulent, green or yellowish green, sometimes pinkish or reddish variegated, veins not conspicuous. **Inflorescence** a terminal cyme, often semiglobose, ovoid or conical, with distinct, often densely leafy peduncle; pedicels 1–16 mm long, glabrous, puberulent or pubescent. **Flowers** erect or spreading, (6–)7- to 12-(–16) or 18- to 32-merous. **Sepals** fleshy, connate basally, equal, glabrous or pubescent. **Petals** free, spreading or somewhat recurved, distinct or nearly so, apex acute or acuminate, cream to deep yellow or whitish and then often reddish variegated. **Stamens** twice as many as petals; filaments adnate on corolla base, glabrous or puberulent. **Ovary** with rounded base; pistils erect; carpels as many as petals. Nectary scales small, mostly square or rectangular, or sometimes absent. **Fruit** many-seeded erect follicles. **Seed** ellipsoid, ribbed, brownish.

References: Thulin (1993), Nyffeler (2003), Moran (2009).

The genus *Aeonium* is indigenous to Macaronesia (Canary Islands, Cape Verde Islands and Madeira), southwestern Morocco, East Africa (Ethiopia, Somalia, Kenya, Tanzania and Uganda) and Yemen (Nyffeler, 2003). It comprises c. 39 species with centres of endemism in the Canary Islands and Madeira (Thulin, 1993).

Species of this genus are popular with succulent enthusiasts and have found their way into the horticultural trade. Some species, like *Aeonium glandulosum* Webb & Berthel. and *A. glutinosum* (Aiton) Webb & Berthel., are used medicinally within their natural distribution range (Rivera & Obón, 1995) but no uses for southern Africa have been recorded.

The genus name is derived from the Greek word 'aionion' meaning everliving plant (Nyffeler, 2003).

Aeonium arboreum (L.) Webb & Berthel.

In: *Histoire Naturelle des Îles Canaries* 3(2,1): 185 (1836).

Common name: tree aeonium (English).

Perennial subshrubs, rather open, up to 2 m high; stems branched, erect or ascending, 1–4 cm in diameter, fleshy; bark smooth. **Leaves** arranged in dense rosettes of 50–75-leaves 1–2.5 cm in diameter but smaller in the dry season, concave or flattish with young leaves tightly adpressed to each other, 5–15 × 1–4.5 cm, 1.5–3 mm thick; blade obovate to oblanceolate, apex acuminate, base cuneate, bright green often purplish variegated, shiny, glabrate, marginal cilia curved. **Inflorescence** a dense cyme, ovoid, 10–25 × 10–15 cm; peduncle up to 20 cm long; pedicels puberulent. **Flowers** 9- to 11-merous, 2 cm in diameter. **Sepals** pubescent. **Petals** spreading, oblong to lanceolate, apex acuminate, 5–7 × 1.5–2 mm, bright yellow. **Filaments** glabrous. **Distribution**: SA. (Fig. 267).

References: Nyffeler (2003), Moran (2009).

Aeonium arboreum (Fig. 268) comprises three varieties. Material found naturalised in Kommetjie and Paternoster near Cape Town, in the Western Cape Province of South Africa (E. van Jaarsveld & U. Eggli, *pers. comm.*), belong to the typical variety, which can be distinguished from var. *holochrysum* H.Y.Liu and var. *rubrolineatum* (Sventenius) H.Y.Liu on pubescent pedicels and sepals (Nyffeler, 2003). Var. *arboreum* is native to Gran Canaria (Canary Islands) where it grows at altitudes of 200–1 200 m (Nyffeler, 2003), while on the Californian coast, where it is also naturalised, it grows at altitudes of 0–100 m (Moran, 2009). It is also naturalised in southern Europe and northern Africa, along the Mediterranean coast and in Australia (Forster, 1996; Moran, 2009).

The tree aeonium is of commercial value in the horticultural trade with several cultivars common in cultivation (Nyffeler 2003), some having beautiful variegated or dark purple-black foliage.

Fig. 267. Distribution map of *Aeonium arboreum* (L.) Webb & Berthel.

Fig. 268. The black-leaved form of *Aeonium arboreum* (L.) Webb & Berthel., known as ‘Swartkop’, is widely cultivated in South Africa, but it is the regular, green-leaved one that has become naturalised in South Africa. (Picture by Gideon F. Smith)

Bryophyllum Salisb.

Biennial or perennial succulent herbs (rarely subshrubs or shrubs or liana-like), sometimes suckering at the base; roots fibrous. **Stems** usually erect, succulent. **Leaves** persistent, usually opposite and decussate (rarely 3-whorled), simple and unlobed or lobed to pinnatifid, petiolate or rarely sessile, basally subclasping, usually flat but sometimes terete; blade obovate or triangular to lanceolate or elliptic-oblong, fleshy-succulent, sometimes with bulbils along the margins or apices, 2–50 cm long. **Inflorescence** a terminal cyme, lax to dense, sometimes with bulbils. **Flowers** 4-merous, large, numerous, usually pendent, pedicellate, bisexual, mostly brightly coloured. **Calyx** cylindrical to campanulate, sometimes basally dilated, persistent, accrescent in fruit. **Corolla** gamopetalous; tube tubular to urceolate, more or less distinctly 4-angled; lobes ovate, semi-circular or triangular, spreading or reflexed, usually shorter than the corolla tube, orange, yellow-green marked with lavender, pale yellow flecked with red, orange-red, scarlet, pink, lavender, yellow-green flecked with violet-red, or greenish white with maroon distally, corolla throat frequently basally constricted against pistils. **Stamens** 8 in 2 whorls, inserted at the base or below the middle of the corolla-tube; filaments more or less exserted. **Carpels** erect, free; style 2–4 times the length of the ovary. Nectary scales 4, free, suborbicular, quadrate or linear. **Fruit** consisting of erect follicles. **Seeds** many, ellipsoid, usually grooved, ridged or rugulose, small.

References: Fernandes (1983), Wickens (1987), Fu & Ohba (2001), Descoings (2003), Moran (2009).

The genus *Bryophyllum* is included in the subfamily Kalanchoideae of the Crassulaceae which contains c. 230 species. It is also sometimes included in the genus *Kalanchoe*, which then consists of the section *Bryophyllum* along with sections *Kalanchoe* and *Kitchingia* (Descoings, 2003; Thiede & Eggli, 2007). For the purposes of this book, we follow the classification of Berger (1930) and treat it as a separate genus. It consists of of c. 25 species that are endemic to Madagascar (Rauh, 1995; Descoings, 2003). Some species are widely naturalised elsewhere (e.g. Australia, Africa, Central and South America, China).

Species of the genus *Bryophyllum* are known for their ease of cultivation and can be easily grown from stem cuttings or rooted leaves (Descoings, 2003). Some species produce bulbils or plantlets on the margins or apices of their leaves, or on their inflorescences. This interesting reproductive trait has undoubtedly contributed to their popularity as garden plants. Some species are garden escapes in many parts of the world with a few becoming aggressive invaders, undoubtedly as a result of their ease of reproduction and propagation. The name *Bryophyllum* comes from the Greek words for ‘sprout’ and ‘leaf’ i.e. leaf-sprouter, which is certainly very apt (Gledhill, 2008).

Key to the 3 naturalised and 3 potential garden escapes from the genus *Bryophyllum* [adapted from Staples *et al*. (2002)]:

1. Leaves (at least lower ones) cylindrical or pencil-like, apex flaring, petiole absent or not distinct from blade. . . . . **1. *Bryophyllum delagoense* (=*B. tubiflorum*)**
1'. Leaves with a broad blade set off from narrower petiole **2**

2. All (or at least some) leaves compound **3**
2'. All leaves simple **4**

3. First leaves simple, rest mostly pinnate to 3- to 5-foliate, streaked with purple, with orange-red margins, leaflets petiolulate, cuneate to truncate at the base . . . . **2. *Bryophyllum pinnatum***
3'. Leaves pinnatisect or pinnate, margins often purple, leaflets sessile on rachis or almost so, asymmetrical and decurrent at the base . . . . **3. *Bryophyllum proliferum***

4. Leaves small, up to 5 cm long, blade broadest at or above middle, apex rounded . . . . **5. *Bryophyllum fedtschenkoi***
4'. Leaves medium to large, 5–50 cm long, blade broadest near base, apex acute **5**

5. Leaves large, 13–50 cm long, brownish-green markings on both surfaces, crowded near base, with sinuate to coarsely crenate margins. . . . . **6. *Bryophyllum gastonis-bonnieri***
5'. Leaves medium sized, 5–25 cm long, purple-blotched on lower surface, evenly spaced, with serrate margins . . . . . . **4. *Bryophyllum daigremontianum***

1. *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz

In: *Mémoires de l'Herbier Boissier* 10: 38 (1900).

=*Bryophyllum tubiflorum* Harv.
=*Bryophyllum verticillatum* (Scott-Elliot) A.Berger
=*Geaya purpurea Costantin* & Poisson
=*Kalanchoe delagoensis* Eckl. & Zeyh.
=*Kalanchoe tubiflora* (Harv.) Raym.-Hamet, nom. illeg.
=*Kalanchoe verticillata* Scott-Elliot

Common names: chandelier plant, mother of millions, pregnant plant (English); kandelaarplant (Afrikaans); indunjane (Zulu).

Biennial or semi-perennial herbs, monocarpic, pale green with violet-brown markings, glaucous, often forming dense stands; stems erect (sometimes procumbent), unbranched, terete, 0.2–1.2 m tall, sometimes suckering from the base**. Leaves** ternate or alternate in adult plant, opposite on young shoots, evenly spaced, simple, ± caducous when flowering, seemingly sessile; blade narrowly oblong, subcylindric with adaxial groove, erect to nearly horizontally spreading, with 2–9 small conical teeth at apex frequently with bulbils borne in their axils, 3–15 cm × 3–6 mm, reddish green to gray-green with dark green or reddish brown spots, surfaces not glaucous. **Inflorescence** a terminal, rounded thyrse, with densely clustered dichasia, up to 20 cm in diameter with long peduncles; pedicels 5–30 mm long. **Flowers** pendulous, conspicuous. **Calyx** campanulate, 8–16 mm long, reddish to green striped with red; tube 3–6 mm long; lobes triangular-lanceolate, apex acute, 5–10 × 3.7–5.7 mm. **Corolla** much exceeding the calyx, 2.2–4 cm long, pale orange to deep purpulish red; tube funnel-shaped, constricted just above the carpels and widening in middle and at throat; lobes oblong-obovate, obtuse or truncate, apiculate, spreading, 7–12 × 6–9 mm. **Stamens** included, inserted below the middle of the corolla tube; anthers broadly ovate, 2–2.5 mm long. **Carpels** ovate-oblong, 5.5–6.5 mm long, fused for c. 1.6 mm; styles up to 2 cm long. Nectary scales semicircular to trapeziform, tip rounded, 0.7–2 × 0.8–1.4 mm. **Seed** obovoid, 0.6–2.5 mm long. **Distribution**: B, L, N, S, SA. (Fig. 269).

References: Fernandes (1983), Tölken (1985), Rauh (1998), Descoings (2003), Moran (2009).

Bryophyllum delagoense (Fig. 270, 271) is endemic to Madagascar, occurring mainly in the central and southern regions, where it is commonly found in open wooded grasslands, rocky slopes, and on sandy or rocky ground (Descoings, 2003). It is naturalised in many countries with warmer climates possibly including every country in southern Africa and also in southern Europe, Africa, Asia, Australia, New Zealand, southern USA and Hawaii, West Indies, northern South America and Macaronesia (PIER, 2010). In Brazil it is sometimes even pollinated by hummingbirds despite being exotic and regarded as non-ornithophilous (Mendonça and Anjos 2005). In South Africa, where it was introduced as a garden ornamental (Wells 1986) around 1765 (Witt *et al*., 2004; Witt & Nongogo, 2010), it is naturalised in all 9 provinces (Fig. 272).

The plant is poisonous to both humans and livestock (Henderson, 2001; Kellerman *et al*., 2005). In Australia *Bryophyllum delagoense* has been reported to cause stock losses and was found to effect myocardial degeneration (McKenzie & Dunster, 1986). Further investigation showed the cardiac glycosides (bufadienolides) responsible to be bryotoxins, also present in four other naturalised *Bryophyllum* species (McKenzie *et al*., 1987; Steyn & Van Heerden, 1998). Despite its reported toxicity to livestock, no stock losses by *B. delagoense* have been reported in South Africa.

Fig. 269. Distribution map of *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz.

Fig. 270. *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz.
(Picture by Neil R. Crouch)

Fig. 271. Flowers of *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz.
(Picture by Neil R. Crouch)

Bryophyllum delagoense is traded in South Africa (Von Ahlefeld *et al*., 2003) as a protective charm as it is a species that is 'hard to kill', with obvious reference to its drought tolerance. Many Crassulaceae, both indigenous and exotic, are cultivated around homesteads, including this species, to confer protection, e.g. from lightning, disease or evil spirits, on the inhabitants (N.R. Crouch, *pers. comm.*, October 2010).

Bryophyllum delagoense grows very easily and reproduces by means of seed, basal suckers and abundantly produced leaf bulbils (Fig. 273) thus facilitating its spread to new areas. Severed leaves and bulbils root very easily and it is often found spreading from sites where garden waste is dumped.

In South Africa this species is a declared weed (Henderson, 2001) which means it is prohibited and must be controlled. For areas of small infestations simply pulling the plants up by hand will be sufficient, but care has to be taken not to dislodge the bulbils or leave any parts behind as it will simply resprout. It is best to burn unwanted material to prevent further spread. In a recent study Witt and Nongogo (2010) found that high intensity and low intensity fires were respectively found to kill 89 and 45% of plants. Plants may grow tall with a tree-like habit. Taller plants and those growing in dense stands were more likely to escape destruction. They speculate that fire has prevented this species from becoming a major weed in South Africa as it is in Australia, where fires have a lower frequency and intensity.

Bryophyllum delagoense is a potential target for biological control. Two species of stem-boring weevils (*Alcidodes sedi* and *Osphilia tenuipes*) were recently identified as candidate biocontrol agents (Witt, 2004; Witt *et al.*, 2004). These weevils are, however, not host-specific and can complete their development on other Crassulaceae species in the region. They can also complete their life cycle on commercially grown *Kalanchoe blossfeldiana* Poelln., thus constituting a possible threat to horticultural businesses. It may be considered an option for use in Australia as there are very few indigenous Crassulaceae species that could serve as alternative hosts (Witt, 2004). Further studies are required to determine whether the weevils are safe for release in southern Africa.

Plants may be distinguished from other similar species in the region by their terete leaves (Fig. 274) measuring no more than 6 mm in width. The other *Bryophyllum* species have flatter and broader leaves, which are sometimes pinnately lobed with three or more 'leaflets'. The plants cannot be confused with any indigenous species.

Fig. 272. *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz invasion.
(Picture by Neil R. Crouch)

Fig. 273. Bulbils are produced at the apex of leaves of *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz. (Picture by Neil R. Crouch)

Fig. 274. Leaves of *Bryophyllum delagoense* (Eckl. & Zeyh.) Schinz are tubular. (Picture by Geoff R. Nichols)

2. *Bryophyllum pinnatum* (Lam.) Oken

In: *Allgemeine Naturgeschichte* 3(3): 1966 (1841).

=*Bryophyllum calycinum* Salisb.
=*Cotyledon pinnata* Lam.
=*Kalanchoe pinnata* (Lam.) Pers.
=*Verea pinnata* (Lam.) Spreng.

Common names: air plant, Canterbury bells, cathedral bells, curtain plant, floppers, Goethe Plant, good luck leaf, Hawaiian air leaf, leaf of life, life plant, Mexican love plant, miracle leaf, miracle plant, monkey ears, monkey's ear, mother-in-law, mother-of-thousands, never die, resurrection plant, sprout leaf plant, sprouting leaf, tree of life (English).

Perennials, completely glabrous, succulent, monocarpic; stems up to 2 m tall, stout, nearly woody below, erect or ascending, terete, simple or little branched, with red stripes or spots. **Leaves** decussate, scattered, petiolate, first leaves simple, the rest mostly pinnate to 3- to 5-foliate, sometimes some or all reduced to terminal leaflet, leathery-fleshy, green, streaked with purple, edged with orange-red; petiole subterete, amplexicaul, broadened towards the base, 2.5–10 cm long; blade of simple leaf ovate to oblong, up to 10 × 5 cm, apex obtuse, base cuneate to truncate, margins broadly crenate, doubly crenate or crenate-dentate, with bulbils produced in the notches of leaf margins; compound leaf leaflets ± as the simple leaves or oblong-circular, 6–20 × 4–12 cm, terminal leaflet the largest. **Inflorescence** a lax paniculate cyme, 1–8 dm in diameter with branches up to 12 cm; pedicels 1–2.5 cm long. **Flowers** pendulous. **Calyx** campanulate, inflated, thinly succulent /herbaceous at anthesis, becoming papery, pale yellow to green with red to violet lines; tube 2–4 cm long; lobes ovate-triangular, apex acute-acuminate, 7–11 mm long. **Corolla** ± cylindrical, tube greenish white where hidden by the calyx, the rest red or maroon to greenish-reddish; tube basally contracted, 2.5–4 cm, sometimes somewhat glandular-pubescent; lobes oblong-ovate to triangular, apex acute-acuminate, 9–14 × 4–6.5 mm. **Stamens** inserted below the middle of the corolla tube, mostly included; anthers ovate, 2.5–3 × 1.6–2.2 mm. **Carpels** ovoid, 1.2–1.4 cm long, basally connate; style up to 3 cm long. Nectary scales ± rectangular, 1.8–2.6 × 1.4–1.8 mm, apex obtuse or emarginate. **Seed** obovate, obtuse, c. 0.8 mm long. **Distribution**: S, SA. (Fig. 275).

References: Descoings (2003), Moran (2009).

Bryophyllum pinnatum is endemic to Madagascar but is naturalised in many regions of the world (with the exception of temperate and temperate-cold regions as it does not stand frost) e.g. southern Europe, Africa, Asia, Australia, North, Central and South America, and many islands (GBIF, 2010; PIER, 2010).

This species is the best-known in the genus (Descoings, 2003). It has large light green leaves with marginal indentations (Fig. 276) and flowers are lantern-shaped, pale yellow to green with red to violet lines that turn denser as they mature (Fig. 277, 278). It is widely grown as an ornamental and medicinal plant. No medicinal uses have been recorded for southern Africa but it is used extensively elsewhere, for instance, further north in Africa (Githens, 1949; Burkill, 1985a; Oliver-Bever, 1986; Neuwinger, 2000), Brazil (Muzitano *et al*., 2006) and the West Indies and India (Ayensu, 1981; Oliver-Bever, 1986). Conditions treated vary widely and include skin conditions (e.g. abscesses, ulcers and inflammation), deafness, snoring, epilepsy, whooping cough and it even features in an incantation for the acquisition of money (Burkill, 1985a; Oliver-Bever, 1986; Neuwinger, 2000).

Bryophyllum pinnatum is a garden escape and has naturalised in coastal KwaZulu-Natal, South Africa (Fig. 279), where it is a proposed category 1 plant and no new planting, trade or propagation is permitted (ARC-PPRI, 2007).

Fig. 275. Distribution map of *Bryophyllum pinnatum* (Lam.) Oken.

Fig. 276. Leaves of *Bryophyllum pinnatum* (Lam.) Oken have indentations.
(Picture by Geoff R. Nichols)

Fig. 277. Lighter flowers of *Bryophyllum pinnatum* (Lam.) Oken.
(Picture by Neil R. Crouch)

Fig. 278. Darker flowers of *Bryophyllum pinnatum* (Lam.) Oken.
(Picture by Neil R. Crouch)

Fig. 279. *Bryophyllum pinnatum* (Lam.) Oken invasion. (Picture by Helmuth G. Zimmermann)

3. *Bryophyllum proliferum* Bowie ex Hook.

In: *Botanical Magazine* t. 5147 (1859).

=*Bryophyllum rubellum* Baker
=*Kalanchoe prolifera* (Bowie ex Hook.) Raym.-Hamet

Common names: blooming boxes, green mother of millions (English).

Succulent perennials, stout, up to 3 m tall, glabrous; stems robust, up to 5 cm in diameter, erect to procumbent, ± 4-angled, simple, almost woody below, with basal offsets. **Leaves** decussate, petiolate, pinnatisect or pinnate (rarely undivided), up to 30 cm long, fleshy, green; petiole broadened at the base, amplexicaul, up to 16 cm long; segments or leaflets asymmetrical and decurrent at the base, oblong, lanceolate to ovate-elongate, 7–15 × 1.5–5 cm, apex obtuse, margins crenate to dentate, often purple. **Inflorescence** a very large compound panicle, 40–80 × 20–40 cm, frequently with numerous aborted flowers and bulbils; pedicels thin, 8–15 mm long, densely papillose. **Flowers** pendulous. **Calyx** inflated, campanulate, 4-angled, green, papillose; tube 13–16 mm long; lobes semi-orbicular, acuminate-cuspidate, 3–4 × 5–7 mm. **Corolla** tubular, green where hidden by calyx, the rest red; tube constricted above carpels, suburceolate above constriction, 1.5–2.5 cm, greenish yellow; lobes subovate, acuminate-cuspidate, 2.7–4 × 3–4 mm. **Stamens** inserted below the middle of the corolla tube, exserted; anthers ovate, 2–2.6 × 1.3–1.4 mm. **Carpels** basally connate, 7–8 mm long; styles 1.7–2 cm long, exserted. Nectary scales orbicular to trapeziform, 1.3–1.6 × 2–2.5 mm. **Fruit** not seen. **Distribution**: SA. (Fig. 280)

Reference: Descoings (2003).

Bryophyllum proliferum is one of the largest plants (Fig. 281) in the genus and native to Madagascar where it grows on the Central Plateau (Rauh 1995). It is cultivated as an ornamental (Wells 1986) probably for its pretty box-like flowers (Fig. 282), pinnatisect or pinnate leaves (Fig. 283) and the tendency to produce a proliferation of bulbils on the inflorescence (Fig. 284). It has become widely naturalised in numerous countries, including throughout the tropics, as a garden escape (Fernandes 1983; Rauh 1995).

Green mother of millions is used medicinally in Madagascar for treatment of local abscesses and rheumatism (Githens 1949). No medicinal use has been recorded for southern Africa (Watt and Breyer-Brandwijk 1962), but the plant is grown around rural homesteads (Fig. 285) as an intelezi plant i.e. protecting the inhabitants from any harm.

In South Africa it is a proposed category 1 plant and no new planting, trade or propagation is permitted (ARC-PPRI 2007). These plants establish easily from discarded material and it is preferable to burn or bury any unwanted plants.

Fig. 280. Distribution map of *Bryophyllum proliferum* Bowie ex Hook.

Fig. 281. *Bryophyllum proliferum* Bowie ex Hook. (Picture by Neil R. Crouch)

Fig. 282. Flowers of *Bryophyllum proliferum* Bowie ex Hook. (Picture by Neil R. Crouch)

Fig. 283. Leaves of *Bryophyllum proliferum* Bowie ex Hook. (Picture by Neil R. Crouch)

Fig. 284. Inflorescence of *Bryophyllum proliferum* Bowie ex Hook. produces bulbils. (Picture by Neil R. Crouch)

Fig. 285. *Bryophyllum proliferum* Bowie ex Hook. grown around rural homestead. (Picture by Neil R. Crouch)

Species of Crassulaceae to keep an eye on:

The following three species of *Bryophyllum* and one *Kalanchoe* are present and cultivated ornamentally in southern Africa. All of them have become invasive elsewhere, outside of their natural distribution ranges, and are included here as species to watch for future signs of potential naturalisation.

4. *Bryophyllum daigremontianum* (Raym.-Hamet & H.Perrier) A.Berger

In: *Die natürlichen Pflanzenfamilien*, Zweite Auflage 18a: 412. (1930).

=*Kalanchoe daigremontiana* Raym.-Hamet & H.Perrier

Common names: alligator plant, devil's backbone, maternity plant (English).

Perennial, glabrous, monocarpic herbs, with purple blotches; stems stout, mostly unbranched, erect or decumbent, terete, 5–25 dm × 0.5–2 cm. **Leaves** opposite, evenly spaced, succulent, simple, larger leaves subpeltate; petiole subterete, 1–5 cm long; blade triangular to oblong-lanceolate, 5–25 × 3–12 cm, margins serrate, apex acute, purple-blotched on lower surface, surfaces glaucous, with bulbils produced in the notches of leaf margins. **Inflorescence** a lax paniculate cyme, branches up to 15 cm long; pedicels 5–15 mm. **Flowers** pendulous or spreading, 4-merous, large, bisexual. **Calyx** not inflated, gamosepalous, 6–10 mm long, green or purplish; tube 3–4 mm; lobes triangular, acute, 3–7 × 2–4 mm, glabrous. **Corolla** campanulate, 20–30 mm long, pinkish to reddish or purple; lobes obovate, acute, 6–8 × 3.5–4.5 mm. **Stamens** inserted below the middle of corolla-tube, upper parts exserted. **Carpels** 4; ovules numerous per locule; style 11–14 mm long. Nectary scales rectangular, c. 0.6 × 1 mm. **Seed** oblong, longitudinally ridged, 0.6–1 × 0.2–0.3 mm.

References: Sarwar (2002), Descoings (2003), Moran (2009).

Bryophyllum daigremontianum (Fig. 286) is native to Madagascar, but a declared noxious weed in Australia (PlantNET, 2010) and an aggressive weed in parts of the USA (Moran, 2009). It has serrate leaves, that are purple-blotched on the lower surface (Fig. 287). It has been reported naturalised in other regions like parts of tropical and subtropical Africa and Asia. In Australia the hybrid between *Bryophyllum daigremontianum* and *B. delagoense*, known as *Bryophyllum ×houghtonii* (D.B.Ward) P.I.Forst., is widely naturalised in the Queensland and New South Wales regions (Moran, 2009; PlantNET, 2010).

Fig. 286. *Bryophyllum daigremontianum* (Raym.-Hamet & H.Perrier) A.Berger.
(Picture by Neil R. Crouch)

Fig. 287. Leaves of *Bryophyllum daigremontianum* (Raym.-Hamet & H.Perrier) A.Berger. (Picture by Neil R. Crouch)

5. *Bryophyllum fedtschenkoi* (Raym.-Hamet & H.Perrier) Lauz.-March.

In: *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* 278: 2508 (1974).

=*Kalanchoe fedtschenkoi* Raym.-Hamet & H.Perrier

Common names: kalanchoe stonecrop, lavender-scallops (English).

Perennial, tuft-forming herbs, up to 50 cm tall, gray-green to green to purple, glabrous, sometimes glaucous; stems thin, branched, erect to prostrate, often creeping and rooting, terete, up to 80 × 1 cm, frequently purple. **Leaves** opposite, evenly spaced, densely arranged, succulent, simple; petiole short, 1–6 mm long; blade obovate-subcircular, obovate or obovate-oblong, 1–5 × 0.5–2.5 cm, base cuneate, apex rounded to obtuse, margins crenate throughout or only in upper half, often red-purple, with a purplish waxy bloom, with bulbils sometimes produced in the notches of leaf margins, mostly of fallen or damaged leaves. **Inflorescence** a lax paniculate corymb, up to 20 cm in diameter, with branches up to 5 cm long; pedicels 7–10 mm long. **Flowers** pendulous, 4-merous. **Calyx** yellow-green with red to blue or violet flecks; tube 12–14 mm long; lobes deltoid, 4–7 × 6–6.5 mm, apex acute. **Corolla** subtubular to subcampanulate, basally contracted, orange-red with red streaks; tube 17–19 mm long; lobes obovate, obtuse to rounded, 5–8 × 4.2–4.6 mm. **Stamens** inserted below the middle of corolla-tube, upper parts exserted; anthers subreniform, c. 1 mm long. **Carpels** 9–10 mm long; styles 13–15 mm. Nectary scales semi-orbicular, c. 0.8 × 1 mm. **Seed** obovate, c. 0.6 mm long.

References: Descoings (2003), Moran (2009).

Lavender scallops (Fig. 288, 289) is endemic to Central and southeastern Madagascar where it grows on siliceous rocks. It is widely encountered in cultivation and a variegated form with whitish-yellowish leaves is particularly popular (Descoings, 2003). It is naturalised in several countries (e.g. USA, India, Australia, Galapagos) where it most commonly spreads from waste places and gardens (Moran, 2009; PIER, 2010). In South Africa it is persistent and vegetatively spreading on the periphery of old homesteads (Fig. 290).

Fig. 288. *Bryophyllum fedtschenkoi* (Raym.-Hamet & H.Perrier) Lauz.-March.
(Picture by Neil R. Crouch)

Fig. 289. Flowers of *Bryophyllum fedtschenkoi* (Raym.-Hamet & H.Perrier) Lauz.-March. (Picture by Neil R. Crouch)

Fig. 290. *Bryophyllum fedtschenkoi* (Raym.-Hamet & H.Perrier) Lauz.-March. on the periphery of an old homestead. (Picture by Neil R. Crouch)

6. ***Bryophyllum gastonis-bonnieri*** **(Raym.-Hamet & H.Perrier) Lauz.-March.**

In: *Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences* 278: 2508 (1974).

=*Kalanchoe adolphi-engleri* Raym.-Hamet
=*Kalanchoe gastonis-bonnieri* Raym.-Hamet & H.Perrier
=*Kalanchoe gastonis-bonnieri* Raym.-Hamet & H.Perrier var. *ankaizinensis* Boiteau ex Allorge-Boiteau

Common names: donkey ears, life plant, palm beachbells (English).

Perennial or sometimes biennial herbs, monocarpic, glaucous or not; stems mostly simple and usually short, terete, glabrous. **Leaves** subrosulate, crowded near base, simple, thick and fleshy, whitish-pruinose above, green or grey-green with brownish-green markings; petiole broad, amplexicaul, 3.5–6.5 cm long; blade ovate-lanceolate, 13–50 × 4.5–10 cm, folded lengthwise, apex acute with bulbils producing roots while still attached, margins sinuate to coarsely crenate, glaucous or not. **Inflorescence** a lax cyme, corymbiform, 20–30 cm in diameter; peduncle up to 50 cm long; pedicels 5–15 mm long. **Flowers** pendulous or somewhat spreading. **Calyx** inflated, 1.8–2.5 cm long, pale green, with red or violet lines, glabrous; tube cylindrical, 1.3–1.6 cm long; lobes deltoid, acute, contracted basally, 5–6 × 4.2–5.3 mm. **Corolla** 4–5 cm long, yellow-green marked with violet or red lines, sparsely glandular-pubescent; tube cylindrical c. 3 cm long, contracted basally; lobes triangular-ovate, apex acuminate, 9–11 × 5.5–7.5 mm. **Stamens** inserted below the middle of corolla-tube, upper parts slightly exserted; anthers reniform, c. 3 mm long. **Carpels** 9–11 mm long; style 1.6–2.4 cm. Nectary scales square, emarginate, 1.2–2 mm long. **Seed** obovate, c. 0.8 mm long.

References: Descoings (2003), Moran (2009).

Bryophyllum gastonis-bonnieri (Fig. 291, 292, 293) is grown as an ornamental in southern Africa and it is apparently naturalised in Florida, USA (PIER, 2010).

Fig. 291. *Bryophyllum gastonis-bonnieri* (Raym.-Hamet & H.Perrier) Lauz.-March.
(Picture by Neil R. Crouch)

Fig. 292. Base of a plant of *Bryophyllum gastonis-bonnieri* (Raym.-Hamet & H.Perrier) Lauz.-March. (Picture by Neil R. Crouch)

Fig. 293. Flowers of *Bryophyllum gastonis-bonnieri* (Raym.-Hamet & H.Perrier) Lauz.-March. (Picture by Neil R. Crouch)

Kalanchoe Adans.

Biennial or perennial or sometimes annual succulent herbs, sometimes undershrubs, shrubs or small trees, with branches spreading, fleshy but somewhat tough and woody towards base. **Leaves** usually opposite and decussate, connate at the base, sessile or petiolate; blade undivided or rarely pinnatifid, entire, crenate or serrate, usually flat, sometimes semi-terete, fleshy-succulent, persistent or deciduous. **Inflorescence** a terminal thyrse, panicle or corymb, consisting of several dichasia usually ending in monochasia with few to many flowers; peduncle present or absent with gradual transition from leaves to shorter bracts below flowers. **Flowers** spreading or stiffly erect, 4-merous, ± pedicellate, medium-sized or ± large. **Calyx** shorter than or sometimes equalling the corolla tube, completely green or with purple or red lines; sepals almost free or connate, rarely up to or beyond the middle. **Corolla** gamopetalous, along at least the lower ⅔; tube ± distinctly 4-angled, rounded and swollen near the base, usually constricted upwards; lobes four, shorter than the fused part, spreading or reflexed or erect and sometimes connivent, ± stiff, sometimes minutely papillate above, usually apiculate. **Stamens** 8, in two whorls; filaments glabrous and fused to corolla tube at about the middle; anthers included, ovate or oblong, with ± spherical terminal appendage. **Carpels** 4, free, with ovary gradually constricted into styles; stigma terminal. Nectary glands 4, free, semi-orbicular to linear, entire, crenulate or ± emarginate at the top. **Fruit** consisting of erect follicles. **Seeds** numerous, ellipsoid, covered with longitudinal ridges and dense horizontal striations in grooves between them.

References: Fernandes (1983); Tölken (1985); Dreyer & Makwarela (2000).

Members of the genus are found in tropical Africa, Madagascar, southern and southeastern Asia, and number c. 200 (Dreyer & Makwarela, 2000). In southern Africa there are 14 indigenous species, mainly restricted to the summer-rainfall areas excluding most parts of southern Namibia and the Great Karoo (Tölken, 1985).

Kalanchoe beharensis Drake

In: *Bulletin du Muséum d'Histoire Naturelle* 9: 41 (1903).

=*Kalanchoe van-tieghemii* Raym.-Hamet

Common names: elephant's ear kalanchoe, felt bush/feltbush, felt plant; velvet bush, velvet elephant ear, velvet leaf, velvet leaf kalanchoe (English); donkie-oor (Afrikaans).

Shrubs or small trees up to 3 m tall; stems simple below and branched above, erect, 2–12 cm diameter, pubescent, with conspicuous leaf scars with sharp projections on either side, toughly woody when old. **Leaves** crowded towards branch tips, petiolate; petiole terete and fleshy, up to 10 cm long; blade deltoid to peltate, sometimes lobate, 7–40 × 8–30 cm, base emarginate, apex acute, glabrous and pruinose to ± densely white to brownish pubescent. **Inflorescence** axillary, many-flowered panicles, 20–30 cm tall; peduncle 40–50 cm long; pedicel 4–13 mm long.

Flowers placed in all directions, pubescent. **Calyx** yellow-green with reddish lines; tube 1–3 mm long; lobes deltoid, 5–13 mm long, apex acute. **Corolla** urceolate, tube 6–10 mm; lobes ovate, 5–13 × 3–6 mm acute, pink-greenish to green-yellow. **Stamens** inserted near the top of the corolla tube, exserted. **Carpels** 5–12 mm long; style 5–10 mm long. Nectary glands rectangular, basally connate, c. 1 × 1.5–3 mm. **Seed** obovate, c. 0.7 mm long.

Reference: Descoings (2003).

Kalanchoe beharensis (Fig. 294, 295) is native to Madagascar where it occurs in the south and southwestern parts of the country in xerophytic forests (Descoings, 2003).

It is a popular garden plant and mature leaves are often silvery in colour (Fig. 296) or a brownish colour above and silvery below. The fine hairs covering the leaves of plants can, however, vary in colour and density even within populations, and some forms with leaf surface outgrowths are being marketed as cultivars in the horticultural trade (Descoings, 2003).

Kalanchoe beharensis grows in four camps within the Kruger National Park in South Africa, where it has shown signs of naturalisation (Foxcroft *et al*., 2008). It has potential as a garden escape, especially in subtropical parts of South Africa, due to its hardiness and prolific production of seedlings. Plants are frost-sensitive and will not easily survive the winter climates of South Africa above the Great Escarpment.

Fig. 294. *Kalanchoe beharensis* Drake. (Picture by Geoff R. Nichols)

Fig. 295. Flowers of *Kalanchoe beharensis* Drake. (Picture by Geoff R. Nichols)

Fig. 296. Leaves of *Kalanchoe beharensis* Drake. (Picture by Geoff R. Nichols)

DRACAENACEAE Salisb.

(Dragon-tree family; *Skoonma-se-tong-familie*)

by

M. Walters

Shrubs to large trees or rhizomatous xerophytic perennials; stems fibrous and partly or wholly subterranean and rhizomatous, or more rarely pachycaul and enormous or occasionally absent. **Leaves** often in rosettes crowded at branch tips or tips of subterranean rhizomes, spirally arranged or occasionally distichous, entire, stiff, simple, narrowly linear to ovate and sessile, sometimes conspicuously succulent and terete, usually fibrous, venation parallel. **Inflorescence** a raceme or panicle, axillary and pedunculate, emerging either from rosette near the ground or on branch ends. **Flowers** small but numerous, bisexual, hypogynous, 3-merous, pedicellate, generally very fragrant; pedicels with an often discoid articulation. **Tepals** 6, in two whorls, petaloid, elongate, all equal, usually basally connate into a short to very long tube with free tips, brownish, purple-violet or white. **Stamens** 6, in two whorls, arising at the base of the lobes, exserted; filaments filiform to inflated; anthers versatile, introrse. **Ovary** superior, 3-carpellate, 3-locular; ovule 1 per locule, anatropous; style often long and simple; stigma 3-lobed or capitate. **Fruit** a globose berry, red or orange. **Seeds** 1–3, globose or elongate, dirty white.

References: Archer (2000), Walker (2001), Heywood *et al*. (2007).

The Dracenaceae is sometimes included in a broadly circumscribed Asparagaceae but is here treated as a separate family. It consists of two genera i.e. *Dracaena* L. and *Sansevieria* Thunb. (Archer, 2000) (though the inclusion of *Sansevieria* in *Dracaena* which has been discussed by various authors, would make the family monogeneric), with c. 100 species (Heywood *et al*., 2007).

The family is mostly tropical, occurring worldwide in rainforests or arid areas (Heywood *et al*., 2007). It is distributed throughout subtropical and tropical Africa, Asia and Australasia, with one species of *Dracaena* from Mesoamerica (Walker, 2001; Heywood *et al*., 2007). Species in this family have a centre of distribution in Africa (Walker, 2001).

Certain species of Dracaenaceae are cultivated as garden or house plants e.g. *Dracaena draco* (L.) L. (the dragon tree) (Heywood *et al*., 2007) and *Sansevieria trifasciata* Prain (mother-in-law's tongue), of which variegated cultivars are usually grown (Walker, 2001).

Only one succulent species from one genus is naturalised in southern Africa.

Sansevieria Thunb*.*

Caulescent or acaulescent, very drought-hardy perennials, sometimes branching near base with subterranean rhizomes or runners above ground, forming colonies; rhizome thick, fibrous, bearing early deciduous cataphylls. **Leaves** solitary, few or many, distichous or rosulate, succulent or leathery, lanceolate, linear or lorate and flat, or cylindrical or semi-cylindrical and usually with a groove on adaxial side, sessile, sometimes narrowed at the base resembling petiole, plain green or often with irregular lighter and darker green transverse bands. **Inflorescence** a terminal, paniculate or simple spike-like raceme, sometimes capitate, dense or lax, with extrafloral nectary glands associated with the bracts. **Flowers** numerous, subsessile, solitary or in irregular clusters along scape, bracteate, pedicellate, actinomorphic, often nocturnal and opening for one night only, sweetly scented; pedicel articulated. **Tepals** united at the base to form a tube with 6 free lobes curling back at anthesis, mostly whitish. **Stamens** 6, erect, much exserted, exposed at anthesis by curling back of tepals, fused to tube below; filaments filiform. **Ovary** 3-locular, ovoid; style simple, filiform and as long as stamens or slightly longer, exserted early from closed perianth at anthesis. **Fruit** a berry, smooth or tuberculate. **Seeds** 1–3, with thick softly verrucose epidermis, dirty white.

References: Obermeyer (1992), Archer (2000), Newton (2001).

The genus consists of c. 60 species from Africa, southern Asia (India, Sri-Lanka, Myanmar), Madagascar, Comoro Islands and the Arabian Peninsula (Yemen) (Newton, 2001; Mabberley, 2008). Only seven species in the genus are native to southern Africa (Klopper *et al*., 2006). A number of *Sansevieria* species are naturalised in other regions of the world (PIER, 2010).

Members of the genus *Sansevieria* are used as medicine or protective charms and the fibres are used for making nets, string, sails and paper in various African countries (Watt & Breyer-Brandwijk, 1962; Mabberley, 2008).

Sansevieria trifasciata **Prain**

In: *Bengal Plants* 2: 1054 (1903).

Common names: bowstring hemp, mother-in-law's tongue, snake plant (English); skoonma-se-tong (Afrikaans); isikuha, isikusha, sikuha, sikusha (Ndebele).

Acaulescent, rhizomatous herb; rhizome 1.3–2.5 cm in diameter. **Leaves** 1–2 (–6) per branch, erect, linear-lanceolate, 30–122 × 2.5–7 cm, narrowed gradually from the middle or somewhat above to a channeled petiole, with 3–4 mm green subulate tip, with alternating transverse bands of light green or whitish green and deep green to almost blackish green with slight glaucous bloom, margin green, surface smooth. **Inflorescence** a simple, spike-like raceme, 30–76 cm long, lax, with 3–8 flowers per cluster; peduncle green with pale-green dots; bracts ovate, acute or acuminate, 1–4 mm long; pedicel 2–4 mm long. **Flowers** whitish or greenish-white sometimes slightly red-tinged outside. **Tepals** united at the base; tube c. 1 cm long; lobes 1.2–1.5 cm long. **Stamens** exserted. **Ovary** 3-locular, ovoid. **Fruit** a berry. **Seeds** 1–3. **Distribution**: SA. (Fig. 297).

Reference: Walker (2001).

Two varieties of *Sansevieria trifasciata* are recognised and the plant occurring in southern Africa can be ascribed to the typical variety (Fig. 298). The var. *laurentii* differs from var. *trifasciata* in having yellow leaf margins up to 1 cm wide (Walker, 2001).

Fig. 297. Distribution map of *Sansevieria trifasciata* Prain.

Fig. 298. *Sansevieria trifasciata* Prain in a healer garden. (Picture by Neil R. Crouch)

This species hails from Nigeria and the Democratic Republic of the Congo (Walker, 2001). In southern Africa it has been found growing in natural vegetation in the Westville area of the KwaZulu-Natal Province of South Africa (Fig. 299). This species should be monitored for further spread and escape from gardens elsewhere. It has also become naturalised or invasive in other countries, for example, Australia, Ecuador, Samoa and the USA (PIER, 2010).

Sansevieria trifasciata is widely cultivated as both an indoor and outdoor plant, with numerous cultivars in existence. These may differ in their leaf sizes, degrees of variegation and shades of green (Walker, 2001). The leaves are known to contain haemolytic compounds and organic acids (Watt & Breyer-Brandwijk, 1962).

Fig. 299. *Sansevieria trifasciata* Prain invasion. (Picture by Neil R. Crouch)

EUPHORBIACEAE Juss.

(Spurge or Milkweed Family; *Noors-* or *Melkbosfamilie*)

by

E. Figueiredo

Dioecious or monoecious herbs, shrubs or trees, with or without a milky latex or coloured sap. **Leaves** usually alternate, sometimes opposite or whorled, mostly petiolate, simple or compound, entire lobed or toothed, sometimes with a gland at the base of the petiole; stipules present or absent. **Inflorescence** terminal, axillary, lateral or leaf-opposed, cymose, paniculate, racemose, spicate or cyathial, or with the flowers fasciculate or solitary. **Flowers** unisexual, usually actinomorphic and small. **Calyx** usually with 3–6 lobes or sepals. **Corolla** with 3–6 free (rarely united) petals or absent. Disc of free or united glands, or lobed, annular, cupular or absent. **Stamens** 1–many. Pistillode sometimes present. **Ovary** superior, usually sessile, usually 3-locular; styles usually 3; staminodes sometimes present. **Fruit** usually schizocarpic, often dehiscing into 3 bivalved cocci leaving a persistent columella, or fruit drupaceous indehiscent. **Seeds** 1–2 per locule, or by abortion 1 per fruit, carunculate or not.

Reference: Carter (2002).

The Euphorbiaceae is a large family with c. 300 genera and 5 000 species (Carter, 2002). It is subcosmopolitan but mostly occurs in the humid tropics and subtropics of both hemispheres (Carter, 2002). It includes groups of genera that are sometimes segregated into other families by some authors (Androstachydaceae, Antidesmataceae, Bischofiaceae, Hymenocardiaceae, Phyllanthaceae, Pedilanthaceae, Picrodendraceae, Porantheraceae, Putranjivaceae, Ricinocarpaceae, Scepaceae, Stilaginaceae, Trewiaceae and Uapacaceae). However, some parts of the Euphorbiaceae that were separated from it (such as the Phyllanthaceae and Picrodendraceae) may be combined again (Stevens, 2008). For that reason the family is accepted here in a broadly defined sense (Carter, 2002).

Many species of Euphorbiaceae have economic importance. The family is well-known as the main source of rubber (*Hevea* Aubl.) but also as the source of widely consumed edible products such as cassava and tapioca (*Manihot* Mill.) (Heywood *et al*., 2007). Other products include oils such as tung oil (*Aleurites* J.R.Forst. & G.Forst.) and castor oil (*Ricinus* L.), medicines and insecticides (Burkill, 1994; Carter, 2002; Smith & Crouch, 2002). Several species are ornamental, particularly in the genera *Euphorbia* L. (e.g. poinsettia) and *Codiaeum* Rumph. ex A.Juss. (garden croton) (Heywood *et al*., 2007)

Only four succulent species from two genera of the Euphorbiaceae are naturalised in southern Africa.

These two genera can be distinguished on the inflorescence being composed of cyathia in *Pedilanthus*, while *Jatropha* has inflorescences with lateral male flowers and terminal female flowers (Carter, 2002).

Jatropha L.

Monoecious or rarely dioecious trees, shrubs or herbs, with clear, whitish or reddish latex. Indumentum simple, sometimes glandular or absent. **Leaves** alternate, sometimes crowded, petiolate or sessile; blade usually lobed, usually with glands at petiole apex; stipules multifid and glandular or spiny, usually palmatilobed. **Inflorescence** terminal or subterminal, cymose, usually with a solitary female flower terminating each primary axis and lateral cymules of male flowers. **Male flowers:** sepals 4–6, imbricate and slightly connate at the base; petals 5, imbricate, disc entire or of 5 free glands; stamens 6–10, often in 2 whorls, outer whorl opposite petals; pistillode filamentous or absent. **Female flowers:** sepals and petals as in male flower but larger; sepals usually persistent in fruit; staminodes sometimes present; disc entire, 5-lobed or of 5 free glands; ovary 1–5-locular; style entire or bifid. **Fruit** schizocarpic, dehiscing septicidally or loculicidally, rarely subdrupaceous and ± indehiscent. **Seed** with caruncle.

References: Radcliffe-Smith (1986, 1987, 1996), Gilbert *et al*. (1993), Carter (2002), Li & Gilbert (2008a), Mabberley (2008).

Jatropha is a pantropical genus extending to North America and South Africa. It includes c. 175 species of which 70 are native to Africa (Gilbert *et al*., 1993). Several *Jatropha* species are known for their ornamental value in domestic horticulture, the most commonly cultivated species being *Jatropha podagrica* Hook. (Mabberley, 2008). This bottle-trunked species carries small, but magnificent, crimson red inflorescences in summer. It grows well in mild areas in open ground or in containers as a stoep plant. Extracts of two species (*Jatropha curcas* and *J. multifida* L.) are used locally as a purgative (Van Wyk & Gericke, 2000; Van Wyk *et al*., 2002). *Jatropha* is also used to produce fuel from seed oil.

Key to the three succulent species of *Jatropha* naturalised in southern Africa [adapted from Li & Gilbert (2008a); note that succulence is little developed in *J. gossypiifolia* and *J. curcas*]:

1. Petioles with gland-tipped hairs along their length, 8–12 cm long, sticky; leaf blade reddish-brown to bronze coloured at least in young leaves . . . . **2. *Jatropha gossypiifolia***

1'. Petioles without gland-tipped hairs, 10–20 cm long, not sticky; leaf blade green to grey-green **2**

2. Stipules scalelike, minute, caducous; petals fused in lower half, greenish-yellow; leaves unlobed or shortly 3–5-lobed . . . . **1. *Jatropha curcas***

2'. Stipules divided, spinose or setose, persistent; petals free or almost so, red; leaves shortly lobed . . . . **3. *Jatropha podagrica***

1. *Jatropha curcas* L.

In: *Species Plantarum* 2: 1006 (1753b).

Common names: Barbados nut, fig nut, pig nut, purging nut (tree), physic nut (English); purgeerboontjie (Afrikaans); mathlapametse (Tswana); inhlakuva (Zulu).

Shrubs or small trees up to 7 m tall with olive grey-green, peeling bark; branchlets semisucculent. Latex watery. **Leaves** alternate; petiole 3–20 cm long, glabrous; blade broadly ovate in outline, pentagonal or shallowly 5-lobed, 5–15 × 5–15 cm, cordate, margins usually entire, glabrous, 7–9-nerved from the base; stipules subulate, 0.5 mm long, caducous. **Inflorescence** subterminal or supra-axillary, subcorymbiform, up to 12 cm long; peduncle up to 6 cm long; bracts up to 8 mm long, acute. **Male flowers:** pedicels up to 4 mm long; sepals c. 2 mm long united at base; petals c. 7 × 3 mm, united to middle, oblong, greenish-yellow, pilose within; disk glands 5; stamens 8, in two whorls, 5 outer and 3 inner, 5–6 mm long; filaments glabrous; anthers c. 2 mm long. **Female flowers:** pedicels up to 3 mm long, extending in fruit; calyx lobes obtuse, entire, 5–7 mm long, puberulous; petals elliptic-oblong, c. 6.5 × 3 mm, greenish-yellow, pilose within; disk glands 5, free; staminodes 10, up to 1 mm long; ovary ovoid-ellipsoid, somewhat 3-lobed, c. 2.5 × 2 mm; style c. 2.5 mm long; stigma bifid. **Fruit** a ellipsoid, slightly 3-lobed capsule, 2.5–3 × 2–2.5 cm, loculicidally dehiscent, green. **Seed** ellipsoid to subcylindric, up to 2 × 1 cm, blackish; caruncle depressed-conic. **Distribution**: S, SA. (Fig. 300).

References: Radcliffe-Smith (1986, 1996), Gilbert *et al*. (1993), Carter (2002), Henning (2007), Li & Gilbert (2008a).

Jatropha curcas (Fig. 301, 302, 303, 304) is a small to medium-sized leafy tree with pale yellowish pealing bark. As indicated by its common names, the seeds (Fig. 305) of *Jatropha curcas* contain a strong purgative oil (curcas oil), which is used medicinally. In West Africa, for instance, it is part of a local remedy for paralysis, leprosy and skin diseases (Burkill, 1994; Oliver-Bever, 1986). It is also used to anoint the body, as a lubricant and in the manufacturing of soap, paint, candles, and for lighting (Burkill, 1994; Henning, 2007; Li & Gilbert, 2008a). Seeds have also been shown to have anti-tumour activity (Mabberley, 2008). Leaves, bark, roots and latex are also used medicinally in various ways (Burkill, 1994). Although roasted seeds are used as a purgative (Hutchings *et al*., 1996) seeds are poisonous when chewed and a common cause of human poisoning in South Africa (Van Wyk *et al*., 2002). Given the plant's toxic properties it has also been used as a vermifuge, insecticide, fish, bird or mammal poison, and arrow-poison (Burkill, 1994). The sap is used as a black dye.

Fig. 300. Distribution map of *Jatropha curcas* L.

Jatropha curcas is also widely cultivated in the tropics as a living fence, for erosion control, demarcation of boundaries and for protection (Henning, 2007; Burkill, 1994), which contributed to it becoming naturalised. It has been increasingly used for bio-fuel (Henning, 2007). It is thought that it will become a major source of renewable energy in the drier rural areas of tropical and subtropical Asia, Africa and America and much research is being done to improve its viability in cultivation (Henning, 2007).

The origin of *Jatropha curcas* is somewhat uncertain but it is thought to be native to Mexico or the neighbouring regions of central America. Portuguese seafarers took it to Cape Verde, where it became an export crop. It was distributed all over the world long ago and is now naturalised throughout the tropics and subtropics (Henning, 2007). It is commonly cultivated in the Old World tropics and Australia which has contributed to its widespread naturalisation in these regions (Radcliffe-Smith, 1996).

In Africa it is widely cultivated for the oil-producing seeds and also as living hedges and stockades, which contributed to it becoming naturalised. In South Africa, it is said to have been introduced by Sekukuni's [Sekhukhune] ancestors when the tribe invaded the north of the country (Smith, 1966).

Jatropha curcas occurs in semi-arid tropical and warm subtropical frost-free climates, on degraded, sandy or gravelly and even saline but not waterlogged soils (Henning, 2007).

Fig. 301. *Jatropha curcas* L.
(Picture by Neil R. Crouch)

Fig. 302. Leaves of *Jatropha curcas* L. (Picture by PPRI)

Fig. 303. Inflorescence of *Jatropha curcas* L. (Picture by Geoff R. Nichols)

Fig. 304. Fruits of *Jatropha curcas* L. (Picture by Geoff R. Nichols)

Fig. 305. Seeds of *Jatropha curcas* L. (Picture by Geoff R. Nichols)

2. *Jatropha gossypiifolia* L. var. *elegans* (Pohl) Müll.Arg.

In: De Candolle, *Prodromus Systematis Naturalis Regni Vegetabilis* 15(2): 1087 (1866).

Common names: bellyache bush, cotton-leaved physic nut, red fig-nut, red fig-nut flower, red physic nut, wild cassada, wild cassava (English).

Erect shrubs up to 2–3 m tall. Young shoots exuding brownish latex. **Leaves** alternate; petiole 3–13 cm long, with stipitate glands adaxially; blade broadly ovate in outline, 6–10 × 8–14 cm, 3(5)-lobed, cordate, reddish-brown to dark bronze-coloured, glabrous, 3–5-nerved from the base; lobes obovate to oblanceolate, middle lobe 4–10 × 2–5 cm, margins glandular and minutely toothed; stipules multifid, 4–8 mm long. **Inflorescence** leaf-opposed, paniculate, up to 8–18 cm long; peduncle 6–8 cm long. **Male flowers:** sepals c. 2.5 mm long; petals obovate, c. 3.5 mm long, dark red; disk glands 5; stamens 8, in two whorls, 2–3 mm long. **Female flowers:** calyx and petals as in the male flowers but twice larger; disk 5-lobed; ovary 3-lobed to subglobose, c. 2 × 2 mm; style c. 1.5 mm long, stigma bifid. Fruit a 3-lobed to subglobose capsule, c. 1 × 1 cm, septicidally and loculicidally dehiscent. **Seed** compressed ellipsoid-ovoid, 7 × 4 mm, light brown; caruncle multifid. **Distribution**: SA. (Fig. 306).

References: Radcliffe-Smith (1986, 1996), Carter (2002).

Jatropha gossypiifolia (Fig. 307) is native to the West Indies, and Central and South America (Radcliffe-Smith, 1986). It was introduced into the Old World tropics where it was planted as a quick-growing hedge and boundary plant. It is also grown ornamentally for its striking dark red young foliage (Fig. 308). It is widely planted as an ornamental and medicinal plant in villages of the tropics (Kawanga, 2007). It escaped and became naturalised throughout tropical Africa, but only sporadically in northern South Africa.

Fig. 306. Distribution map of *Jatropha gossypiifolia* L. var. *elegans* (Pohl) Müll.Arg.

The plant is used medicinally in tropical Africa mostly as a purgative and to expel internal parasites (seed oil). The oil is also applied internally as an abortifacient (Kawanga, 2007). Leaves, bark and sap are used for a variety of diseases and conditions. In the West Indies, for instance, it is used to treat, amongst others, diarrhoea, colds, asthma and diabetes (Ayensu, 1981). The seed oil can also be used as lamp oil and fuel (Kawanga, 2007).

Jatropha gossypiifolia var. *elegans* is an opportunistic invader of disturbed sites where it can become weedy. In southern Africa it has only been recorded as naturalised in South Africa (Limpopo). It is a short-lived plant, often only annual in cultivation and became naturalised in regions with a pronounced dry season, occurring along roads, on waste areas, in grassland and shrub vegetation (Kawanga, 2007).

Fig. 307. Flowers and fruit of *Jatropha gossypiifolia* L. var. *elegans* (Pohl) Müll.Arg. (Picture by Geoff R. Nichols)

Fig. 308. Leaves of *Jatropha gossypiifolia* L. var. *elegans* (Pohl) Müll.Arg.
(Picture by Geoff R. Nichols)

3. *Jatropha podagrica* Hook.
In: *Botanical Magazine* 74: pl. 4376 (1848).

Common names: gouty-stalked jatropha (English); bottelplant, vetvoet (Afrikaans).

Erect shrubs up to 2 m tall, with woody stem swollen at base or lower part, completely glabrous with short fleshy branches. **Leaves** with petiole 8–20 cm long, glabrous; blade peltate, entire or shallowly 3–5-lobed, round to elliptic, 8–18(–25) × 6–16 cm, base truncate or obtuse, apex obtuse, shiny green on upper surface, grey-green on lower surface, glabrous; stipules spiniform, divided to c. 5 mm, glandular, becoming hardened, leaf scars persistent, prominent. **Inflorescence** a terminal corymb up to 26 cm long; peduncle up to 20 cm long; branches short, red. **Male flowers:** calyx c. 2 mm long; sepals round, c. 0.6 mm long, erose or emarginate at apex; petals obovate-oblong, c. 6 mm long, scarlet; nectary glands urceolate; stamens 6–8, basally connate, 5 mm long; anthers c. 2 mm long, orange. **Female flower:** sepals ovate-lanceolate, c. 2 mm long, apex obtuse, entire; petals 6–7 mm long; nectary glands free; ovary ellipsoid, 3–4 × 2.5 mm, glabrous; styles 3, bifid. **Fruit** a capsule, ellipsoid, c. 1.5 × 1.3 cm, septicidally and loculicidally dehiscent. **Seed** ellipsoid, c. 12 × 6 mm, smooth, brown; fluted caruncle. **Distribution**: SA. (Fig. 309).

References: Radcliffe-Smith (1987), Carter (2002), Li & Gilbert (2008a).

Fig. 309. Distribution map of *Jatropha podagrica* Hook.

Jatropha podagrica is native to central America but has been dispersed to many tropical countries as a garden-plant (Burkill, 1994). It has beautiful showy red inflorescences and a bottle-shaped trunk (Fig. 310, 311, 312) making it a striking garden subject and popular among succulent enthusiasts. In southern Africa it has been recorded as naturalised on the south coast of KwaZulu-Natal in South Africa. It is frost-sensitive and does not easily survive in South Africa's climatically severe interior.

Apart from its use as an ornamental it is also cultivated for medicinal purposes. In Africa it is used for treating wounds, skin ailments and as an antipyretic, diuretic, choleretic and purgative (Burkill, 1994; Neuwinger, 2000) and has been shown to have anti-bacterial activity (Oliver-Bever, 1983).

Fig. 310. *Jatropha podagrica* Hook. (Picture by Gideon F. Smith)

Fig. 311. Flower of *Jatropha podagrica* Hook. (Picture by Neil R. Crouch)

Fig. 312. Fruit of *Jatropha podagrica* Hook. (Picture by Neil R. Crouch)

Pedilanthus Neck. ex Poit.

Shrubs or small trees with woody or fleshy branches. Latex white. **Leaves** alternate, distichous, entire, shortly petiolate, or absent; stipules small. **Inflorescence** with cyathia in dichotomous axillary or terminal bracteate cymes; bracts persistent. **Cyathia** pedunculate, involucre with 5 bracts, obliquely shoe- or boat-shaped, with 2–6 glands at the base, often brightly coloured. **Male flowers:** many, each reduced to 1 stamen, in 5 groups. **Female flower:** solitary at center of involucre, pedicellate, with the perianth reduced to a rim below the ovary; ovary 3-locular, with 1 ovule per locule; styles 3, united; stigmas bifid. **Fruit** a capsule, 3-lobed, usually dehiscent. **Seeds** smooth or tuberculate, without a caruncle.

References: Carter & Leach (2001), Carter (2002), Li & Gilbert (2008b).

Pedilanthus is a genus with c. 15 species from Central America, northern South America and the West Indies (Carter & Leach, 2001; Li & Gilbert, 2008b), sometimes included in *Euphorbia*. It includes a few species cultivated in tropical regions. In the whole of Africa only *Pedilanthus tithymaloides* subsp. *smallii* has been recorded as naturalised, in South Africa.

Pedilanthus tithymaloides (L.) A.Poit. subsp. *smallii* (Millsp.) Dressler

In: *Contributions from the Gray Herbarium of Harvard University* 182: 152 (1957).

=*Pedilanthus smallii* Millsp.
=*Euphorbia tithymaloides* L. subsp. *smallii* (Millsp.) V.W.Steinm.

Common names: bird cactus, jacob's ladder, slipperplant (English); swaelblom (Afrikaans); ibunga labesutu (unrecorded language).

Shrubs up to 1–3 m tall with markedly zigzag stems. **Leaves** distichous; petiole 2–5 mm long; blade broadly ovate to lanceolate, 3.5–8 × 2.5–3.5 cm, base rounded or obtuse, apex ± acuminate, entire, fleshy, sometimes variegated with yellowish-green or pink, slightly glaucous, glabrescent, deciduous; stipules small, caducous. **Inflorescence** a cyme, in terminal and axillary clusters on leafless stems. **Cyathia** with many male flowers and 1 female flower; involucres slipper-shaped, deep-red or purple-red, glabrous, apex nearly labiate, bifid, 3-serrulate, other lobe boat-shaped, with 4 glands. **Male flowers:** pedicel slender, 2.5–4 mm long, similar to filaments; anther globose. **Female flower:** inserted at center of involucres, exserted; pedicel 6–8 mm long; ovary fusiform; styles usually united; stigmas 3, bifid. **Fruit** 5–6 mm in diameter. **Distribution**: SA. (Fig. 313).

References: Carter & Leach (2001), Carter (2002), Li & Gilbert (2008b).

This taxon originates from North America and Cuba (Carter, 2002). It is naturalised in many parts of the world such as Australia (Forster, 1996) and China (Li & Gilbert, 2008a). It is often grown for its showy inflorescence and ornamental foliage. The subsp. *smallii* (Millsp.) Dressler is particularly widespread due to the attractiveness of the accentuated zigzag stems and variegated foliage (Fig. 314, 315). The species is also grown as a hedge (Mabberley, 2008) and it is used medicinally locally (Von Ahlefeldt *et al*., 2003) and in other regions as an antidote to venomous bites or stings, as an emetic or for the treatment of fractures (Burkill, 1994; Li & Gilbert, 2008a).

Fig. 313. Distribution map of *Pedilanthus tithymaloides* (L.) A.Poit. subsp. *smallii* (Millsp.) Dressler.

Fig. 314. Zigzag stems of *Pedilanthus tithymaloides* (L.) A.Poit. subsp. *smallii* (Millsp.) Dressler. (Picture by Estrela Figueiredo)

Fig. 315. Variegated leaves of *Pedilanthus tithymaloides* (L.) A.Poit. subsp. *smallii* (Millsp.) Dressler. (Picture by Estrela Figueiredo)

LAMIACEAE Martinov.

(Mint family; *Saliefamilie*)

by

N.R. Crouch

Perennial or annual, aromatic, mesophytic to xerophytic herbs, shrubs or trees, rarely succulent; roots fibrous, occasionally succulent; stems usually 4-angled. **Leaves** decussate or whorled, simple, sometimes succulent, rarely pinnatifid or digitately compound, usually gland-dotted, without stipules. **Inflorescence** a terminal (rarely axillary) raceme or panicle (rarely spikes or corymbs). **Flowers** strongly zygomorphic (rarely actinomorphic), normally bisexual, rarely unisexual, usually 5-merous, bracts present, foliaceous, often caducous. **Calyx** of 5 fused sepals, tubular, campanulate to spreading, often persistent and enlarged in fruit; lobes often toothed. **Corolla** with 5 united petals, tubular (straight or geniculate), often 2-lipped at the throat or subregular and 4–5-lobed. **Stamens** 4 (rarely 2), subequal or didynamous, epipetalous at corolla mouth or in tube; filaments occasionally connate, sometimes with a crest or projection near base; anthers 1–2-locular. **Ovary** superior, often deeply 4-lobed, seated often on entire or lobed nectariferous disc, of 2 united carpels divided into 2–4 locules; ovule 1 per locule, erect, basal or sub-basal; style gynobasic. **Fruits** usually 4 (or by abortion fewer) 1-seeded nutlets, ± enveloped by the persistent calyx, usually smooth, rarely rugose or winged, dry at maturity, otherwise if ovary entire the fruit a drupe with 4 pyrenes.

References: Codd (1985), Retief (2000), Van Jaarsveld (2002), Heywood *et al*. (2007).

Lamiaceae is a well-known family of c. 230 genera and 4 000–7 000 species. It has a worldwide distribution, except in Antarctica and is best represented in the Mediterranean region. The majority of the genera belong to the subfamily Nepetioideae (Heywood *et al*., 2007). Succulence is scattered throughout seven genera, which (with the exception of *Tetradenia* Benth.) belong to subfamily *Ocimoideae. Plectranthus* is the largest of these genera. Leaf succulence is found in the family particularly in southern and tropical Africa, but caudiciform, swollen stems are also encountered in some representatives.

Many species of Lamiaceae are frequently cultivated both for medicinal, culinary or ornamental value. They include common kitchen herbs such as basil (*Ocimum* L.), rosemary (*Rosmarinus* L.), thyme (*Thymus* L.), mint (*Mentha* L.) and oregano (*Origanum* L.), used on account of their flavoursome essential oils. Many very attractive garden plants such as numerous species of *Salvia* L. and *Leonotis* (Pers.) R.Br. are frequently encountered in cultivation. Many taxa are grown commercially for their essential oils such as basil (*Ocimum*) and *Pogostemon* Desf. (product patchouli). Some species of *Plectranthus* L'Hér. and *Solenostemon* Thonn. are popular house plants. *Plectranthus esculentus* N.E.Br. and *Solenostemon rotundifolius* (Poir.) J.K.Morton have been cultivated in southern Africa for their edible potato-like root-tubers (Van Jaarsveld, 2002).

Two exotic species from the genus *Plectranthus* are naturalised in southern Africa.

Plectranthus L'Hér.

Annual, biennial or perennial herbs, subshrubs or shrubs up to 3.5 m tall, herbaceous, fleshy or sometimes succulent; roots fibrous or rarely fleshy or tuberous. **Leaves** decussate, simple, often succulent, usually crenate-dentate, petiolate. **Inflorescence** terminal or in the upper leaf axils, spike-like, often branched and paniculate. **Flowers** zygomorphic, arranged in verticils, few-flowered cymes or dichasia, occasionally solitary, bracts small. **Calyx** 2-lipped to sub-equally 5-toothed; when 2-lipped, upper lip consisting of a single broad lobe scarcely longer than the lower lip which comprises 4 lanceolate-deltoid to subulate teeth, tube glabrous or villous within, sometimes gibbous at base. **Corolla** 2-lipped, mauve, white, purple or yellow; tube longer than calyx, gibbous or produced into a spur on the upper side, usually bent and variously expanded near the base, occasionally expanding gradually, rarely straight; upper lip usually 4-lobed, shorter than the lower boat-shaped entire lip. **Stamens** 4, rarely 2 abortive; filaments free or variously fused near the base, arising at corolla mouth, declinate in lower lip; anthers circular to oblong, medifixed, 1-locular. **Ovary** deeply 4-lobed; style gynobasic, declinate with stamens in lower corolla lip; stigma shortly bifid. **Fruit** a nutlet, oblong to ovoid, smooth or slightly granular.

References: Codd (1985), Retief (2000), Forster & Van Jaarsveld (2002).

Plectranthus is an Old World genus of c. 350 species, c. 70 of which have succulent stems, leaves, roots or a combination thereof (Forster & Van Jaarsveld, 2002). Historically, the tuberous roots of some species have been cultivated and eaten as a starch staple: *Plectranthus esculentus* is the most prominent example (Crouch & Styles, 2010). Many non-succulent or fleshy species are commonly cultivated as garden subjects, and a few of the succulent species are in general cultivation. Various regional species are used in traditional medicine, and at times used as herbs to flavour foods [e.g. soup mint, *P. amboinicus* (Lour.) Spreng.] (Codd, 1985). One species, *P. unguentarius* Codd is even used by the Himba of Namibia as a deodorant in their red ochre body lotion (Van Jaarsveld, 2006).

Both succulent *Plectranthus* species naturalised in southern Africa belong to the subgenus *Calceolanthus*. Members of this subgenus are characterised by the pubescence of their inner calyx.

Key to all *Plectranthus* species of subgenus *Calceolanthus* native [*P. neochilus* Schltr., *P. caninus* Roth, *P. tetensis* (Bak.) Agnew, *P. pentheri* (Gürke) Van Jaarsv. & T.J.Edwards] or naturalised in southern Africa [from Van Jaarsveld (2006)]:

1. Bracts rounded; stems procumbent . . . .(***Plectranthus tetensis***)
1'. Bracts acute, forming imbricate coma; stems decumbent or erect **2**

2. Branches decumbent or erect to 50 cm high; leaves medium-sized **3**
2'. Branches erect, 0.9–4 m high; leaves large . . . .**1. *Plectranthus barbatus* var. *grandis***

3. Roots distinctly tuberous . . . .(***Plectranthus pentheri***)
3'. Roots not tuberous **4**

4. Plants annual; corolla less than 1 cm long . . . . .(***Plectranthus caninus***)
4'. Plants perennial; corolla longer than 1 cm **5**

5. Corolla 1–2 cm long . . . . (***Plectranthus neochilus***)
5'. Corolla 2–2.5 cm long . . . .**2. *Plectranthus ornatus***

1. *Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton

In: *Kew Bull*. 58: 915 (2003).

=*Coleus grandis* L.H.Cramer
=*Coleus kilimandschari* Gürke
=*Plectranthus grandis* (L.H.Cramer) R.H.Willemse

Common names: woolly plectranthus, bearded spurflower (English); baardspoorsalie (Afrikaans).

Aromatic, perennial sub-shrub or succulent shrub 0.9–4 m tall. **Stems** erect or ascending, fleshy, creeping at base, purplish above, pubescent to villous with glandular hairs, shiny glandular hairs and red sessile glands. **Leaves** spreading to ascending, succulent, soft, velvety, sometimes folded along midrib on drying; petiole 3–50 mm long; blade broadly ovate, widest near base, 1.5–20 × 0.8–11 cm, base subcordate to broadly cuneate, sharply cuneate at petiole, apex acute to rounded, margins serrate or crenate, densely hairy to woolly with reddish sessile glands. **Inflorescence** with glandular, sticky axis, lax with 10–14-flowered verticils; cymes sessile, 5(–7)-flowered; bracts ovate to lanceolate, apiculate, 2–20 mm long, cucullate, enclosing buds, falling as buds start to develop; pedicels 3–7 mm long. **Calyx** (at flowering) 3–4 mm long, sparsely pubescent to villous with red and yellowish sessile glands, purplish; at fruiting 6–10 mm long, shortly tubular, slightly curved, densely hairy in throat. **Corolla** (7–)12–26 mm long, pale blue, blue or purple, with scattered red glands or hairs on lobes; tube sigmoid, dorsally gibbous to saccate at second bend, 5–12 mm long; upper lip 4-lobed, reflexed against tube, much shorter than lower lip; lower lip ascending to horizontal, deeply cucullate, enclosing stamens, 8–10 mm long. **Stamens** fused. **Nutlets** broadly ovate, slightly flattened, 1.5–2 mm long, pale or dark brown to black, smooth, with dark gland dots, producing copious speckled mucilage when wet. **Distribution**: S, SA. (Fig. 316).

In southern Africa, plants flower (Fig. 317) during summer but peak in autumn (Van Jaarsveld, 2006).

Given the wide variety of names that have been applied to the two varieties of *Plectranthus barbatus*, and the relatively recent resolution of its taxonomy, it is difficult to unequivocally attribute historical traditional usage accounts to particular varieties. Accordingly, in reviewing the ethnobotany of the *Plectranthus* species of East Africa, Lukhoba *et al*. (2006) reported on the collective literature that has referred to *P. barbatus*, under all synonyms. The species in its broadest sense is evidently extremely well utilised medicinally across its range by a variety of ethnic groups; readers are referred to the review of Lukhoba *et al*. (2006) and references cited within for further information. Given the range of medicinal applications it is likely that dispersal of this species is in part synanthropic, evidenced by its current anthropogenic tendency (Fig. 318).

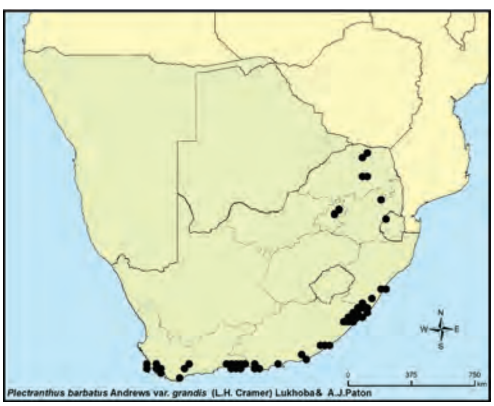

Fig. 316. Distribution map of *Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton.

Fig. 317. Flowers of *Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton. (Picture by Neil R. Crouch)

Plectranthus barbatus var. *grandis* (Fig. 319) has for long been historically confused both with the typical variety (also present in East Africa), which is an altogether smaller plant with elliptic leaves, and with *P. comosus* Sims from Asia. This is reflected in the literature, particularly that pertaining to horticulture (e.g. Forster, 1997), fieldguides (Agnew, 1974) and even accounts of the taxon as an alien invader (Wells *et al*., 1986; Henderson, 2001). However, this taxonomic issue has been resolved by Lukhoba and Paton (2003) following the earlier research of Cramer (1978) and Ryding (1999). The native range of *P. barbatus* var. *grandis* is imprecisely known as it has been widely disseminated by humans. Its origin appears to be East Africa, but it is cultivated elsewhere in Africa as well as in India and Sri Lanka. It is, however, a common garden subject and is widely cultivated in rural areas as a fast-growing but drought-tolerant hedging plant, which is the reason for its spread in South Africa.

Plectranthus barbatus var. *grandis can* be distinguished from other South African species by its size, large leaves and sticky inflorescencse. The indigenous *P. ecklonii* Benth. attains a similar height but is a smaller-leaved and shade-loving species that has flowers with straight rather than sigmoid tubes.

The species was first identified as a local problem plant by Wells *et al*. (1986) who described it as a competitive species of moist terrestrial zones. Henderson (2001) further noted its invasion of roadsides, rocky sites and forest margins (Fig. 320). As *Plectranthus barbatus* var. *grandis* has in the past mistakenly been referred to as *P. comosus*, it is the latter taxon that has accordingly been declared a category 3 invader. Trade in this species, including the variegated cultivar 'Vicki', is not permitted.

Fig. 318. *Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton near a village. (Picture by Geoff R. Nichols)

Fig. 319. *Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton. (Picture by Geoff R. Nichols)

Fig. 320. *Plectranthus barbatus* Andrews var. *grandis* (L.H.Cramer) Lukhoba & A.J.Paton invasion. (Picture by Neil R. Crouch)

2. *Plectranthus ornatus* Codd

In: *Bothalia* 11: 393 (1975).

=*Coleus comosus* Hochst. ex Gürke

Common names: ornamental spurflower (English); skutblaarsalie, tuinspoorsalie (Afrikaans).

Perennial, decumbent, succulent herb, branching freely at base, up to 30 cm tall. **Leaves** succulent; petiole 2–10 mm long; blade broadly obovate, 20–30 × 15–25 mm, base wedge-shaped, apex obtuse, margin finely crenate-dentate in the upper half, finely to densely downy, lower surface with orange gland-dots, strongly veined below. **Inflorescence** a terminal dense spike-like raceme, 4–9 cm long; bracts large, forming a 4-angled apical cap, greenish white to purple, tipped with dark purple, soon deciduous. **Flowers** in 3-flowered sessile cymes, forming 6-flowered verticils; verticils crowded; pedicels erect. **Calyx** 2-lipped, 6 mm long in fruit, red gland-dotted, densely villous inside. **Corolla** 2–2.5 cm long, bluish mauve, with purple mottling on the upper lip; tube slightly deflexed and expanding towards the throat; upper lip c. 6 mm long, lower lip boat-shaped, 1.2–1.5 cm long, sometimes bifurcate at the apex. **Stamens** 1.2–1.4 cm long, united at the base for 3–4 mm. **Nutlets** 2 mm long, dark brown. **Distribution**: SA. (Fig. 321).

Reference: Van Jaarsveld (2000).

Fig. 321. Distribution map of *Plectranthus ornatus* Codd.

Plectranthus ornatus (Fig. 322) is often confused with the indigenous *Plectranthus neochilus* but may be distinguished on account of its shorter, more compact inflorescence (Fig. 323) and its longer corolla (those of *P. neochilus* attain lengths of only 1.2–2 cm), especially the longer upper lip; the lower lip is additionally often split longitudinally at the apex (Codd, 1975). Both species possess leaves that are unpleasantly scented. *P. caninus* is also closely related to *P. comosus* but has much shorter and less showy corollas (8–10 mm long), and is an annual rather than a perennial (Codd, 1975).

Plectranthus ornatus is native to East Africa including Tanzania and Ethiopia (Codd, 1975), and was introduced for its showy flowers as a horticultural subject to South Africa, where it subsequently naturalised. It may often be found growing in sites where garden refuse has been dumped, usually close to habitation. It has been encountered fully naturalised away from habitation in remote rural regions such as the lower Thugela Valley.

Fig. 322. *Plectranthus ornatus* Codd. (Picture by Neil R. Crouch)

Fig. 323. Inflorescences of *Plectranthus ornatus* Codd. (Picture by Neil R. Crouch)

MONTIACEAE Raf.

(Rock purslane family; *Klip-porseleinfamilie*)

by

M. Walters and E. Figueiredo

Annual to perennial herbs, rarely subshrubs or semi-aquatic, with or without stems, with or without thickened roots or stems. **Leaves** spiral, frequently rosulate, often succulent, sometimes amplexicaul, usually glabrous with naked leaf axils. **Inflorescence** terminal or lateral, often a cyme, frequently scorpioid or with solitary, axillary flowers. **Flowers** sessile or pedicellate, usually bisexual (both bisexual and unisexual in *Hectorella*), actinomorphic. **Sepals** 2–9, often dry and persistent in fruit. **Petals** 4–5 or up to 19 (*Lewisia*), usually free but sometimes basally connate. **Stamens** as many as petals or numerous (to 100). **Ovary** superior, 1-locular with 2–8 united carpels. **Fruits** 2–3-valved capsules, valves persistent (rarely deciduous) or basally circumscissile, or 1-seeded utricles, dehiscent or not, or 1–2-seeded indehiscent capsules disintegrating with time, sometimes with deciduous calyptra. **Seed** often minutely papillate, with strophiole or elaiosome or not, rarely with thin, fleshy chartaceous aril.

References: Nyffeler & Eggli (2010).

This family (excluding the genera *Hectorella* Hook.f. and *Lyallia* Hook.f.) was until recently considered part of the Portulacaceae, which has been split into four families namely the Portulacaceae, Anacampserotaceae (a newly created family), Montiaceae and Talinaceae (both family names long disused) (Nyffeler & Eggli, 2010; Ocampo & Columbus, 2010). The Montiaceae now includes 15 genera and c. 225 species (Nyffeler & Eggli, 2010). In southern Africa it is represented by a single exotic genus (*Calandrinia* Kunth) and one species (Germishuizen *et al*., 2006; Klopper *et al*., 2006).

The Montiaceae is distributed worldwide but most notably in North and South America (mainly in the west) northern Asia to northern Europe, Australia and New Zealand (Nyffeler & Eggli, 2010) with some species naturalised elsewhere.

Many of the species in this family are used by humans, for both medicinal purposes and as a source of food. The Native Americans for instance use species of *Lewisia* Pursh to treat pleurisy and diabetes while some species of *Claytonia* L. are used as an anti-convulsive and to treat rheumatic pains (Moerman, 2009). In southern Africa no local usage, medicinal or otherwise, has been recorded.

Only one species of Montiaceae is reported as naturalised in southern Africa.

Calandrinia Kunth

Annual or perennial herbs with prostrate to erect stems, simple to branched from the base with glabrous nodes, rarely with tuberous taproots, with unicellular trichomes. **Leaves** alternate, often with the appearance of rosettes, slightly to markedly amplexicaul; blade linear to oblanceolate, or ovate to spathulate, flattened, glabrous or sparsely covered with unicellular hairs, without stipules. **Inflorescence** with solitary flowers in basal leaf axils or an elongate raceme, bracteate; bracts leaflike, narrowing towards the base of the flowers. **Flowers** bisexual, long pedicellate. **Sepals** 2, often unequal, ovate, distinctly angled or keeled, green, persistent in fruit, glabrous or with unicellular hairs. **Petals** 5–7, usually deep red-purple or rarely white. **Stamens** 3–15, usually opposite petals, free, inserted. **Ovary** with 6–many ovules; style 1; stigmas 3. **Fruit** a 3-valved capsule longitudinally dehiscent from the top, valves persistent and reflexed after dehiscence, margins involute. **Seeds** 10–20, ellipsoid, reticulate or tuberculate, shiny black.

References: Jordaan (2000a), Kelley (2003).

Calandrinia has 14 species native to Australia and North and South America (Jordaan, 2000a) with most of the diversity found in western South America (Kelley, 2003). Several species are cultivated elsewhere as ornamental plants and some of them are edible (Mabberley, 2008).

Calandrinia ciliata (Ruiz & Pav.) DC.

In: *Prodromus Systematis Naturalis Regni Vegetabilis* 3: 359 (1828c).

=*Calandrinia ciliata* (Ruiz & Pav.) DC. var. *menziesii* (Hook.) J.F.Macbr.
=*Talinum ciliatum* Ruiz & Pav.

Common names: desert rock purslane, fringed redmaids, red maids/redmaids (English).

Annual herb up to 3–40 cm high, with prostrate to ascending stems, nearly glabrous to somewhat ciliate. **Leaves** linear to narrowly oblanceolate, up to 1–10 cm long, fleshy, glabrous or with elongate, unicellular hairs. **Inflorescence** racemose with leafy bracts. **Flowers** pedicellate; pedicel 0.4–2.5 cm long. **Sepals** keeled, 2.5–8 mm long, often ciliate on midrib and margins. **Petals** 5, 4–15 mm long, white, pink, red or purple. **Stamens** 3–15, c. ⅔ the length of the petals. **Fruit** a capsule ovoid, 4–5 mm long, slightly larger than the calyx. **Seeds** 10–20, 1–2.5 mm wide, finely reticulate. **Distribution**: SA. (Fig. 324)

Fig. 324. Distribution map of *Calandrinia ciliata* (Ruiz & Pav.) DC.

References: Shreve & Wiggins (1964), Kelley (2003).

This is an ornamental species much cultivated for the solitary, attractive flowers, which can be pink, red, purple or white (Fig. 325). It shows great variation in vegetative characters, especially in size.

Calandrinia ciliata was introduced to southern Africa as an ornamental plant and it has become naturalised in the Western Cape, South Africa (Germishuizen *et al*., 2006). In its native habitat it prefers open grassy areas and meadows at lower elevations, often occurring in cultivated fields or orchards (Thomas, 1991; Vizgirdas & Rey-Vizgirdas, 2009).

Native Americans prized the seed of this plant which they dried over coals, ground and pressed into cakes for eating. They also ate the roots and young stems and leaves (Vizgirdas & Rey-Vizgirdas, 2009). While the leaves and young shoots can be eaten, it should be done in moderation because of their high oxalic acid content (Cribb & Cribb, 1981). No use has been reported from southern Africa.

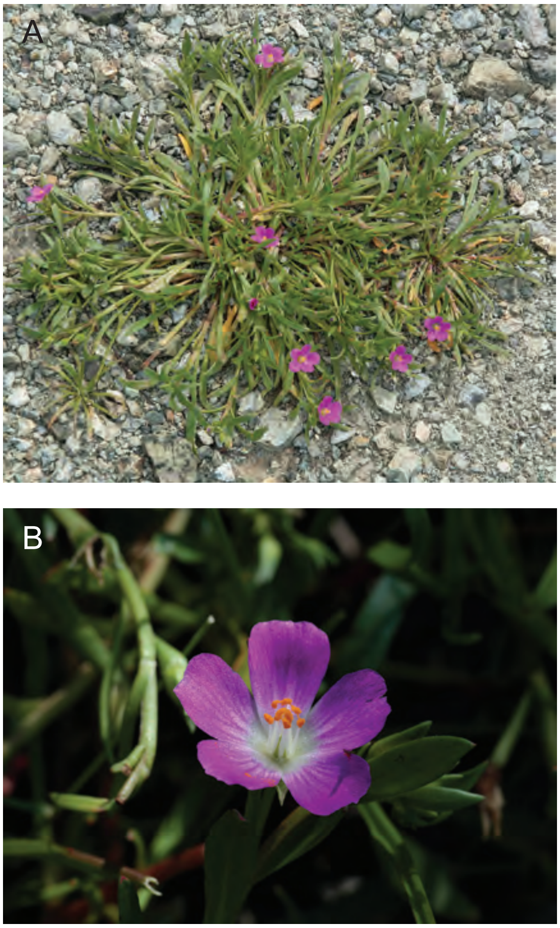

Fig. 325. *Calandrinia ciliata* (Ruiz & Pav.) DC. A. Habit; B. Flower. (Pictures by Lynn Watson)

PHYTOLACCACEAE R.Br.

(Pokeweed family; *Bobbejaandruif-familie*)

by

E. Figueiredo

Herbs, shrubs, lianas, rarely trees, annual or perennial, mostly glabrous. **Leaves** alternate, simple, entire, often undulate, usually petiolate; stipules absent or very small. **Inflorescence** an axillary, terminal or leaf-opposed raceme, spike, panicle or dichasium. **Flowers** small, usually bisexual, when unisexual then plants dioecious, sometimes dimorphic, actinomorphic, rarely zygomorphic. **Sepals** 4–5(–8), free or united at base, imbricate, usually persistent, often unequal, greenish to whitish. **Petals** absent. **Stamens** 4–many, inserted on a hypogynous fleshy disk, free, in 1–2 whorls; filaments usually persistent, free or united at base; anther 2-loculed, dorsifixed, dehiscent longitudinally. **Ovary** superior, globose, consisting of 1–18 carpels, free or more or less united; styles as many as the carpels, usually free; stigma linear or capitate; ovule solitary in each carpel, campylotropous. **Fruit** mostly a lobed berry or drupe, carpels often separating, rarely a capsule, depressed-globose, fleshy. **Seed** lenticular or subreniform, sometimes arillate, testa thick or thin, perisperm abundant to absent.

References: Polhill (1971), Stannard (1988), Eggli (2002c), Mabberley (2008).

The Phytolaccaceae consists of 18 genera and c. 70 species that occur widespread in tropical and temperate regions, especially in the neotropics (Eggli, 2002c). The delimitation of the family is a matter of debate with different concepts being presently followed (Nienaber & Thieret, 2004). The family includes a few widespread species that are planted as ornamentals (such as *Phytolacca dioica* L.) or for their medicinal use (such as *P. americana* L.). Some species are dye-producing, others are used as pot-herbs (Mabberley, 2008). The genera *Hilleria* Vell., *Phytolacca* L. and *Rivina* L. have been recorded in southern Africa; of these only *Rivina* does not have indigenous representatives (Germishuizen *et al*., 2006). The genus *Lophiocarpus* Turcz., also recorded in southern Africa (Germishuizen *et al*., 2006), is often placed in its own family, Lophiocarpaceae.

Only one species from the genus *Phytolacca* is considered succulent (Eggli, 2002c).

Phytolacca L.

Herbs, shrubs or rarely trees (sometimes with fat-trunk), erect, rarely scandent; stems and branches terete, sulcate or angular, glabrous or pubescent when young. **Leaves** alternate, petiolate, rarely sessile; blade ovate, elliptic, or lanceolate, apex acute or obtuse. **Inflorescence** mostly a spike or raceme, terminal or leaf-opposed. **Flowers** pedicellate or sessile, uni- or bisexual. **Sepals** 5–8, oblong to ovate, subequal, apex obtuse, free, persistent, spreading or reflexed. **Stamens** 5–30, inserted at the base of the sepals, included or exserted, sometimes in 1–2 whorls;

filaments sometimes united at base. **Ovary** subglobose, with 5–16 carpels, distinct or united proximally; styles as many as carpels, free or united at base; stigma 1 per carpel. **Fruit** a fleshy berry, oblate, with the stigma persistent at apex, or a group of achenes. **Seeds** 6–16 per berry or 1 per achene, reniform, compressed, black.

References: Polhill (1971), Stannard (1988), Eggli (2002c), Dequan & Larsen (2003), Nienaber & Thieret (2004).

Phytolacca is a genus with c. 25 species (Mabberley, 2008) mostly native to South America, with several species naturalised elsewhere. Some species are cultivated for the attractiveness of their red to black berries in elongated racemes, while others are used as vegetables or medicinally. Some species are poisonous. Five species have been recorded in southern Africa with three of them being introduced (Germishuizen *et al*., 2006).

Phytolacca dioica L.

In: *Species Plantarum* (ed. 2) 1: 632 (1762).

Common names: belhambra, ombu, pokeberry tree (English); belambra(-boom), belombra(-), belhambra(-), belhamel(-), bobbejaandruifboom (Afrikaans); belle ombre (French); bella sombra (Spanish); ombú, umbú (Spanish, South America); bella umbra, mzimuka, mzimuka-omhlophe (unrecorded language).

Fast growing, soft-wooded, deciduous, unisexual trees up to 25 m high, with a massive trunk, erect, stout, swollen at the base, up to 4 m in diameter and spreading above ground, bark grey to pale-brown, and rounded crown. **Leaves** alternate, spirally arranged, simple, crowded in terminal whorls; petiole up to 7 cm long, pinkish; blade ovate, up to c. 15 × 6 cm, acute, bright green, margin appearing white, glabrous. **Inflorescence** a raceme up to 15 cm long, semi-erect to drooping. **Flowers** small, with sepals 2–3 mm long, white to creamy-yellow, male and female flowers occurring in separate trees. **Male flowers:** stamens 20–30; aborted carpels 2–4. **Female flowers:** carpels 10–12; staminodes 10. **Fruit** consisting of fused berries, up to 1 cm in diameter, yellowish-white to green, turning black. **Seed** small, shiny, grey-black. **Distribution**: B, N, S, SA. (Fig. 326)

Fig. 326. Distribution map of *Phytolacca dioica* L.

References: Jacobsen (1986), Eggli (2002c).

Phytolacca dioica (Fig. 327, 328, 329) is native to South America and introduced elsewhere as an ornamental tree. It is also much used as a shade tree, hence its common names. The Afrikaans names are a corruption of 'belle ombre' (French) or 'bella sombra' (Spanish), meaning beautiful shade. It is widely cultivated in eastern South Africa around homesteads and trading stores (Von Ahlefeldt *et al*., 2003). The plant is also visited by honeybees and provides fodder and fruits (Fig. 330) which are locally eaten or made into jams but they have also been reported in the literature as being poisonous (Orwa *et al*., 2009). Seeds, leaves and roots contain saponins (Van Wyk *et al*., 2002). The leaves and fruits have been used as a purgative.

Phytolacca dioica is aggressive in gardens, with root suckers appearing above the soil and the thick fleshy roots growing to a great size, often damaging walls and pavements. Its appearance gave rise to the name 'elephant tree' by which the tree is also known (Jacobsen, 1986). In South Africa this species was classified in Category 3: a declared invader (ornamentals) and no new planting, trade or propagation is permitted (AGIS, 2006).

Phytolacca dioica was reputedly introduced into South Africa by Baron von Ludwig of Cape Town around 1845 (Smith, 1966). It is now found growing wild in savanna, fynbos, coastal bush and riverbanks where it competes with indigenous species. It is naturalised in Botswana, Namibia, Swaziland and South Africa.

Fig. 327. *Phytolacca dioica* L.
(Picture by Neil R. Crouch)

Fig. 328. Female flowers of *Phytolacca dioica* L. (Picture by Geoff R. Nichols)

Fig. 329. Male flowers of *Phytolacca dioica* L. (Picture by Geoff R. Nichols)

Fig. 330. Fruits of *Phytolacca dioica* L. (Picture by Neil R. Crouch)

PORTULACACEAE Juss.

(Purslane family; *Porseleinfamilie*)

by

M. Walters and E. Figueiredo

Annual or perennial herbs, usually succulent and mucilaginous, with fibrous to tuberous roots, sometimes minute and ephemeral; stems herbaceous to somewhat succulent, rarely woody, or very succulent, sometimes articulated; nodes sometimes with scales and/or hairs in complete whorls around the nodes. **Leaves** alternate (sometimes opposite), linear to obovate, flat to terete, sessile, succulent, glabrous (rarely tomentose); axils appearing naked or often with scales or short to long hairs sometimes almost completely enveloping the leaves. **Inflorescence** terminal, much congested and head-like, surrounded by 2–several involucral leaves, rarely an open cyme. **Flowers** sessile or pedicellate, fugaceous, developing in succession and open only for a short time in sunny or inclement weather. **Sepals** 2, ovate-triangular, united at base. **Petals** (4–)5(–8), very shortly connate, united basally to the sepals, delicate and usually showy with bright colours, white, yellow, red, pink to violet, orange and usually somewhat glossy. **Stamens** 4–ca. 100; filaments glabrous or hairy; anthers dorsifixed. **Ovary** semi-inferior with (4–)5–8 carpels, 1-locular, at least in the upper part, with many ovules; style simple, long filiform; stigma with 2–many lobes, often brightly coloured. **Fruit** a circumscissile capsule with a persistent basal part, the brittle top forming an operculum often covered with the collapsed dry perianth. **Seeds** usually numerous, reniform to rounded, 0.3–3 mm long, smooth or with intricate stellate pattern, sometimes with tubercles or short to long spines, yellow, brown to black or grey, often iridescent.

The Portulacaceae is a family containing only the genus *Portulaca* L. (incl. *Lamia* Endl., *Lemia* Vand., *Merida* Neck. and *Sedopsis* Exell & Mendonça) consisting of c. 100 species that are distributed throughout the tropics and subtropics but very rare in temperate regions (Nyffeler & Eggli, 2010). This family was until recently considered to be much larger with 20–30 genera and around 500 species (depending on family circumscription) (Packer, 2004), but has since been split into four families of which the Talinaceae and Montiaceae (long disused families), and Anacampserotaceae (a newly created family) are the others (Nyffeler & Eggli, 2010; Ocampo & Columbus, 2010). Members of this family can easily be distinguished from other members of the Portulacineae by the contracted head-like inflorescences and the operculate capsules (pyxidia) (Nyffeler & Eggli, 2010).

The family has some economic importance with certain species popular as garden ornamentals due to their bright flowers (particularly *Portulaca grandiflora* Hook. and cultivars selected from it) that may even be variously coloured within the same species (Eggli, 2002d). *P. oleracea* L. is an edible plant that has, as a result of its past popularity, become a weed throughout the tropics and sub-tropics (Eggli, 2002d; Smith & Figueiredo, 2010).

Only two species in the Portulacaceae are naturalised in southern Africa.

Portulaca L.

Genus description as for the family.

Portulaca is a cosmopolitan genus that includes several species that have become cosmopolitan weeds. The total number of species in the genus is a matter of controversy due to the existence of different genus treatments. Estimates range between c. 40–100 species (Eggli, 2002d; Mabberley, 2008). Almost all species are very variable and many are self-pollinating, resulting in a variety of different forms, which make classification rather difficult (Eggli, 2002d).

The genus includes some ornamental species such as *Portulaca grandiflora* (see under family description) and potherbs or salad greens such as purslane (*P. oleracea*), which also has medicinal uses and is a common weed throughout the tropics and subtropics (Eggli, 2002d; Mabberley, 2008).

In southern Africa the genus is represented by c. 10 species (Klopper *et al*., 2006). Two of these species are confirmed to be introduced and can be easily distinguished from the others.

Key to the two species of *Portulaca* naturalised in southern Africa:

1. Very large, variously coloured flowers (petals 1.5–3 cm long, sometimes double). Stamens 40–80. Leaves linear-terete ..... **1. *Portulaca grandiflora***

1'. Much smaller, yellow flowers (petals up to 8 mm long). Stamens up to 12. Leaves obovate-spathulate . . . .**2. *Portulaca oleracea***

1. *Portulaca grandiflora* Hook.

In: *Botanical Magazine* 56: pl. 2885 (1829).

Common names: eleven-o'clock, moss-rose, moss-rose purslane, portulaca, rose moss, sun plant (English); potjielekkers (Afrikaans).

Annual or short-lived perennial herbs with procumbent or ascending stems up to 30 cm long, mostly branching from near the base. **Leaves** alternate, spreading, blade linear to lanceolate, terete to semi-circular in cross section, 10–30 × 2–3 mm, acute or subacute; axillary hairs few to abundant, whitish-woolly, in shaggy tufts up to c. 7 mm long. **Flowers** in terminal clusters of 3–5, surrounded by 8–10 involucral leaves larger than the stem leaves, enclosing woolly hairs. **Flowers** very large, 2.5–4 cm wide. **Sepals** 6–8 mm long. **Petals** 5 or more, obovate, rounded, 15–30 mm long, mostly bright magenta-pink in the original form or pink, red, purple, white, orange or yellow in the horticultural form. **Stamens** 40–80. **Stigma** 5–9-branched, whitish. **Fruit** a capsule 4–6.5 mm long, transversely dehiscent near the middle. **Seed** reniform, orbicular or elongate, 0.75–1 mm long, iridescent grey-black to black, mostly with stellate testa cells. **Distribution**: SA. (Fig. 331).

Reference: Eggli (2002d), Matthews (2004).

This is a species from South America (Uruguay and Argentina) where it prefers

Fig. 331. Distribution map of *Portulaca grandiflora* Hook.

sandy soils and shows uniform pink-magenta flowers across most of its range in Argentina, with only a few plants displaying irregular flower colour. The plant commonly grown in gardens for its colourful flowers [sometimes double-flowered (Fig. 332) or multicoloured (Fig. 333)], was selected from this taxon (Eggli, 2002d; Rowley, 2010) and is now widespread in warmer parts of the world as a garden subject.

Fig. 332. *Portulaca grandiflora* Hook. with double flowers. (Picture by Gideon F. Smith)

Fig. 333. *Portulaca grandiflora* Hook. with single flowers. (Picture by Geoff R. Nichols)

Portulaca grandiflora has escaped from gardens and is recorded as naturalised in South Africa (Klopper *et al*., 2006).

No uses, beyond its horticultural value, are recorded for this species in southern Africa. Elsewhere it is used medicinally for, amongst others, hepatitis, pharyngeal pain, burns and snake bites (Plants for a Future, 2008). The leaves were used as salad greens by the Native Americans and the seeds were ground up and made into bread (Yanovsky, 1936).

2. *Portulaca oleracea* L.

In: *Species Plantarum* 1: 445 (1753a).

=*Portulaca oleracea* L. subsp. *sylvestris* (DC.) Thell.
=*Portulaca oleracea* L. var. *opposita* Poelln.

Common names: common purslane, pigweed, purslain, purslane, pusky, wild purslane (English); beesporselein, bobbejaandraad, misbredie, porselein, porslein, postelein, rooipootjiepors(e)lein, snotterbel, varkbossie, varkkos (Afrikaans); Rapunzelsalat [German, Namibia; note that in Germany this name refers to species of *Valerianella* and *P. oleracea* is there called ‘Sommerportulak’ or ‘Gemüse-Portulak’ (U.Eggli, *pers. comm*.)]; ojitandavare (Herero); bobo (Kung San); oshimhelewene (Kwanyama); solele (Sotho); silele (Swati); makhulu-wa-luvhisi (Venda); ingwanitsha (Xhosa); amadilika, ilenjane, isilate, isilele (Zulu).

Annual herbs with spreading or prostrate stems up to 40 cm long, up to 5 mm in diameter, thickly succulent, sometimes with purplish tinge; taproot 2–10 cm. **Leaves** alternate (subopposite on branchlets), succulent, sessile or with petiole 1–3 mm long, obovate-spathulate, flattened, up to 4(–6) × 2(–2.5) cm, apex rounded to truncate, green sometimes tinged purplish; axillary hairs inconspicuous, up to 1 mm long, caducous. **Flowers** terminal, 1–5(–30), surrounded by c. 4 involucral leaves and an inner whorl of triangular scales, opening in the morning, self-pollinating in bud. **Sepals** broadly ovate, keeled or slightly winged, 8 × 8 mm. **Petals** (4–) 5, obovate-oblong to obovate, emarginate to bilobed, 3–8 mm long, yellow. **Stamens** 7–12 (–15). **Ovary** ovoid; style short; stigma 3–6-branched. **Fruit** a capsule, obovoid to ovoid, c. 4 × 3 mm in diameter, enveloped in the marcescent corolla, transversely dehiscent across the middle or higher, operculum conical, the apical portion retaining 1–more seeds. **Seeds** many, orbicular-reniform, 0.5–1 mm in diameter, verrucose-granulate, usually glossy, black. **Distribution**: L, N, S, SA. (Fig. 334)

References: Eggli (2002d), Phillips (2002), Matthews (2004).

Portulaca oleracea (Fig. 335, 336, 337) is a highly variable species, a polyploid complex, that has been divided into several subspecies on the basis of seed size and ornamentation (see for example Von Poellnitz, 1934). The cultivated form, sometimes called subsp. *sativa* (Haw.) Celak, but better referred to as a cultivar, is distinguished by its larger seeds (more than 1 mm long) (Phillips, 2002).

The Afrikaans common name 'porselein' (and its derivations) is a corruption of the Dutch 'purslaan' (Rood, 1994a). Interestingly, 'porselein' is the Afrikaans word for 'ceramic' and refers to the shiny leaf surfaces of the plants. Other Afrikaans names refer to properties of the plant, for example 'varkkos' [fodder, feed (kos) for pigs (varke)], 'snotterbel' [hanging (bel of) nose mucus, because of the slimy consistency of the plant when boiled] and 'rooipootjiepors(e)lein' [for the red (rooi) stems (pootjie=little leg)] (Smith, 1966; Smith & Figueiredo, 2010).

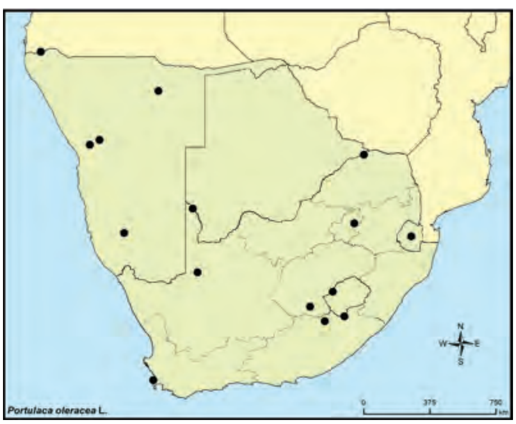

Fig. 334. Distribution map of *Portulaca oleracea* L.

Purslane is eaten as a vegetable throughout southern Africa (Rood, 1994a; Von Koenen, 2001), the leaves of the young plants are usually cooked or used as an ingredient in salad. The seed is also edible and can be made into flour and porridge (Yanovsky, 1936). The plant is one of the most widely used medicinal plants, and has been used in folk medicine since ancient times (Rood, 1994b; Smith & Figueiredo, 2010). It is also used as livestock fodder.

Portulaca oleracea was introduced from Europe to South Africa for its value as an antiscorbutic (against scurvy). Scurvy is a consequence of lack of vitamin C, which affected many sailors after spending months at sea with an inadequate diet (Smith & Figueiredo, 2010). *P. oleracea* was planted in ports of call for vessels sailing east around the Cape to supply them with this supplement. In 1811 it was recorded as occurring wild at Asbestos Mountains (Afrikaans: Asbesberge) in the Northern Cape Province, by the early traveling explorer, William Burchell (Rood, 1994b). It is thought that it was spread to the interior by cattle. It is a weed of fields and disturbed localities, and also occurs in open grassland and bushveld, from sea-level up to an altitude of 2 400 m (Smith & Figueiredo, 2010).

It generally perpetuates itself by reseeding. The seed is easily dispersed by water and wind. Stem fragments also root easily after being cut. Uprooted plants left on the ground will also re-root (Smith & Figueiredo, 2010).

Although purslane is often listed as one of the world's worst weeds it is considered by some as innocuous because of its shallow rooting and because it is a nutritious leafy vegetable that can be easily collected and used (Smith & Figueiredo, 2010; Matthews, 2004). It rarely becomes established in heavily mulched beds, and mulch placed over it will smother plants and prevent seed from germinating (Smith & Figueiredo, 2010).

Fig. 335. *Portulaca oleracea* L. (Picture by Neil R. Crouch)

Fig. 336. Flower of *Portulaca oleracea* L. (Picture by Neil R. Crouch)

Fig. 337. Fruit of *Portulaca oleracea* L. (Picture by Neil R. Crouch)

TALINACEAE Doweld

(Flameflower family; *Vlamblomfamilie*)

by

M. Walters and E. Figueiredo

Dwarf shrubs, rarely small caudiciform trees, often with tuberous roots or rootstock. **Leaves** alternate, sometimes clustered on short shoots, flat, sometimes assymetrical, mucilaginous, slightly succulent, apex variable, entire (rarely papillate or ciliate), sometimes deeply revolute, glabrous or tomentose. Axils usually with rudimentary axillary short shoot (though appearing naked). **Inflorescence** a terminal or lateral panicle or flowers solitary from leaf axils, open to compact. **Flowers** small to medium sized, bisexual, sometimes dioecious (rarely gynodioecious), actinomorphic. **Sepals** 2, deciduous or persistent when fruiting. **Petals** usually 2–5 but if fewer than 5 then not clearly separated from sepals. **Stamens** 15–35, sometimes attached to a nectar disc. **Ovary** superior, 1-locular, with 3–5 carpels. **Fruits** a mucilaginous berry or many-seeded loculicidal capsule with persistent perianth, dehiscent from the top and/or bottom with valves deciduous. **Seed** mostly black (rarely dark grey), glossy with a strophiola.

References: Nyffeler & Eggli (2010).

As with the Montiaceae, this family was until recently considered part of the Portulacaceae, which has since been split into four families of which the Talinaceae (a long disused family) is one. The others are Portulacaceae (now only containing *Portulaca*), Anacampserotaceae (a newly created family), and Montiaceae (a long disused family) (Nyffeler & Eggli, 2010; Ocampo & Columbus, 2010). The Talinaceae now includes 3 genera (*Amphipetalum* Bacigalupo, *Talinella* Baill. and *Talinum* Adans.) and c. 28 species (Nyffeler & Eggli, 2010).

The Talinaceae is found in Madagascar (the genus *Talinella* being endemic), America and Africa, with two species [*Talinum paniculatum* (Jacq.) Gaertn. and *T. triangulare* (Jacq.) Willd.] being pantropical weeds (Applequist, 2005; Nyffeler & Eggli, 2010).

Only one exotic species from the family Talinaceae is naturalised in southern Africa.

Talinum Adans.

Perennial herbs or subshrubs with tuberous, fleshy to woody roots. Stems simple or branched, sometimes shrubby. **Leaves** alternate, rarely subopposite or in basal rosette, succulent or semi-succulent, broadly planate, entire, articulate at the base, petiole short or leaf subsessile, not clasping with attachment points round. Axils naked or with scale-like prophylls, often in pairs. **Inflorescence** a terminal or axillary cyme, panicle or raceme, sometimes a panicle that can be reduced to axillary flowers, peduncle short to elongate, few–many flowered. **Flowers** pedicellate. **Sepals** 2, deciduous or persistent, distinct. **Petals** mostly 5 (rarely more), free or united at the base, distinct, fugaceous. **Stamens** 15–35, anthers 2-locular, oblong. **Ovary** with many ovules; stigma 1–3-lobed. **Fruit** a capsule, 3-valved (rarely 5), with the valves wholly or partly deciduous, tardily dehiscent from the apex, erect. **Seeds** many, circular-reniform, ± compressed, minutely tuberculate or striolate, black.

References: Gilbert (1993), Kiger (2003), Nyffeler & Eggli (2010)

Talinum is a genus with c. 15 species (in this treatment excluding the genus *Phemeranthus* Raf. which has been transferred to Montiaceae) (Nyffeler & Eggli, 2010). It is distributed mostly in the Old World, with few species in North and South America (Eggli, 2002e) and five species indigenous to southern Africa (Jordaan, 2000a). The genus includes some species cultivated as ornamentals. *T. triangulare* is also cultivated as a pot-herb and used medicinally for illnesses ranging from stomach trouble and oedema to kidney problems (Burkill, 1985b). It is naturalised in other parts of Africa but it has not been recorded in southern Africa.

Six species of *Talinum* occur in southern Africa, of which one is introduced (Germishuizen *et al*., 2006). Several indigenous species are eaten or used medicinally in South Africa, Botswana, Swaziland and Namibia (Fox & Norwood Young, 1982; Von Koenen, 2001; Arnold *et al*., 2002) while the introduced one is used medicinally in South Africa and Swaziland (Arnold *et al*., 2002).

***Talinum paniculatum* (Jacq.) Gaertn.**

In: *De Fructibus et Seminibus Plantarum* 2: 219 (1791).

=*Portulaca paniculata* Jacq.

Common names: flameflower, jewels of Opar, pink baby-breath (English).

Annual or perennial herbs 0.3–1.5 m high, glabrous, with fleshy, elongate, tuberous, branched roots and succulent stem; stems simple or sparsely branched basally, semi-woody, sometimes reddish, thin. **Leaves** alternate, simple, sessile or with a petiole up to 15 mm; blade elliptic to obovate or obovate-lanceolate, up to 3–12 × 1.5–5 cm, basally cuneate, apex acute, margins rarely revolute. **Inflorescence** terminal, paniculate, up to 60 cm long, sometimes nodding, with many small flowers maturing at different times, so that at one time the plant has both flowers and fruits. **Flowers** bisexual, actinomorphic, c. 1 cm in diameter, probably self-pollinating, opening towards evening. **Sepals** ovate to suborbicular, deeply concave, 1–2 mm long, deciduous. **Petals** 5, obovate to suborbicular, apex rounded (rarely obtuse), 3–6 mm long, usually pink or reddish-purple, sometimes yellow or white. **Stamens** 15–20. **Ovary** ovoid, 1-locular, green; stigmas 3. **Fruit** a capsule, subglobose, 3–5 mm long, 3-valved, papery, many-seeded. **Seed** lenticular to reniform, c. 1 mm in diameter, smooth or tuberculate, shining black. **Distribution**: S, SA. (Fig. 338)

References: Steyn & Smith (2001), Eggli (2002e), Phillips (2002), Dequan & Gilbert (2003), Kiger (2003).

In the checklist of South African Plants (Germishuizen *et al*., 2006) this species is mistakenly listed as indigenous while *Talinum portulacifolium* (Forssk.) Asch. ex Schweinf. is listed as naturalised in South Africa. It is, of course, the other way round. The two species are distinguished by the 1–few-flowered lateral cymes of *T. portulacifolium*, as opposed to the many-flowered *T. paniculatum* (Fig. 339, 340, 341), as well as the larger flowers (2–2.5 cm wide) and capsules (6–7 mm long) of *T. portulacifolium* (Eggli, 2002e) and smaller size of flowers (1 cm across) and capsules (3–5 mm long) of *T. paniculatum.* The other *Talinum* species in the region have yellow flowers.

Talinum paniculatum is a native of tropical America, now a pantropical weed and probably the most widespread taxon in the genus (Eggli, 2002e). In southern Africa it is naturalised in Swaziland and South Africa (Germishuizen *et al*., 2006). It is cultivated as a vegetable in West Africa (Burkill, 1985b) and used medicinally in South Africa (Arnold *et al*., 2002).

Fig. 338. Distribution map of *Talinum paniculatum* (Jacq.) Gaertn.

Fig. 339. Inflorescence of *Talinum paniculatum* (Jacq.) Gaertn. (Picture by Neil R. Crouch)

Fig. 340. Flowers of *Talinum paniculatum* (Jacq.) Gaertn.
(Picture by Neil R. Crouch)

Fig. 341. Fruits of *Talinum paniculatum* (Jacq.) Gaertn
(Picture by Neil R. Crouch)

The flameflower is a highly variable species and sometimes plants with different flower colour can be found close together (Eggli, 2002e). It grows easily from pieces of root (Fig. 342) in disturbed areas such as roadsides and cultivated lands (Fig. 343, 344) (Burkill, 1985b) as well as escaping from gardens to shaded and wet areas (Dequan & Gilbert, 2003).

Fig. 342. Root of *Talinum paniculatum* (Jacq.) Gaertn. (Picture by Neil R. Crouch)

Fig. 343. *Talinum paniculatum* (Jacq.) Gaertn. invasion. (Picture by Pieter J.D. Winter)

Fig. 344. *Talinum paniculatum* (Jacq.) Gaertn. invasion. (Picture by Geoff R. Nichols)

URTICACEAE Juss.

(Nettle family; *Brandnetelfamilie*)

by

N.R. Crouch

Herbs, shrubs, or rarely lianas or trees, without latex; stems often fibrous, sometimes succulent and/or armed with stinging hairs, often with cystoliths. **Leaves** simple, opposite or alternate; stipules present, sometimes conspicuous. **Inflorescence** a panicle, spike, raceme or cymose cluster. **Flowers** unisexual (plants dioecious or monoecious), small to minute, actinomorphic, usually wind pollinated. **Perianth** segments rarely absent, normally (1–)4–5-merous, free or united. **Male flowers:** stamens as many as perianth segments and opposite to them, incurved in bud, straightening to an exserted position; anthers 2-locular, dehiscing explosively when mature. **Female flowers:** perianth lobes free or connate; ovary superior, 1-locular; ovule 1, basal; style simple or absent; stigma diverse. **Fruit** an achene or sometimes a fleshy drupe, sometimes enclosed in the persistent perianth.

References: Walker (2002), Chen *et al*. (2003).

A family of c. 47 genera and 1 300 species, mostly numerous in wet tropical regions, extending into temperate regions (Chen *et al*., 2003). Only four genera in the family are considered (borderline) succulent: *Obetia* Gaudich., *Laportea* Gaudich., *Sarcopilea* Urban and *Pilea* Lindl. (Walker, 2002).

Plants in this family have numerous uses, with the stem fibers of some genera and species being of high quality and used to make cloth, ropes and fishing nets. In central and southern China, *Boehmeria nivea* (L.) Gaudich. is widely cultivated for ramie fiber (Chen *et al*., 2003). Elsewhere a few species of *Urtica* L. and *Laportea* are similarly sourced for their fibres (Walker, 2002). At least historically in South Africa, *Obetia tenax* (N.E.Br.) Friis has been harvested for its high quality bark fibres (Crouch & Smith, 2000). The leaves of this species are also cooked as a vegetable by the Zulu, much as the young shoots of *Girardinia* Gaudich., *Laportea*, *Urtica* and *Pilea* are boiled and eaten as vegetables (pot herbs) (Boufford, 1997; Chen *et al*., 2003). Various species of *Pellionia* Gaudich. and especially *Pilea* are widely cultivated as ornamentals.

The cystoliths characteristic of this family produce distinctive patterns on epidermal surfaces that are highly diagnostic (Boufford, 1997).

A single species of Urticaceae is naturalised in southern Africa, arguably the most succulent family member.

Pilea Lindl.

Annual or perennial herbs without stinging hairs, monoecious, or dioecious by abortion; stems simple or branched, often succulent. **Leaves** opposite, equal or unequal in pairs, petiolate or subsessile; blade herbaceous or succulent, entire or dentate, 1 or 3-veined, cystoliths linear; stipules intrapetiolar, completely connate. **Inflorescence** unisexual or bisexual, solitary or in pairs, axillary, dense subsessile cyme; bracts small. **Male flowers**: perianth lobes 3, equal, with dorsal horn-like appendage; stamens 3, filaments inflexed in bud; rudimentary ovary sometimes present. **Female flowers**: perianth lobes 3, unequal, in fruit enlarged, often boat-shaped with a horn-like corniculate appendix near apex; staminodes 3, opposite perianth lobes, scale-like, minute or inconspicuous, in fruit enlarged and under tension, reflexing to eject the mature achene; ovary straight, ovule orthotropous, stigma sessile, shortly penicillate. **Fruit** a sessile achene, laterally compressed, ovate to orbicular, smooth, not or only partly enclosed by persistent perianth. **Seed** thin coated, cotyledons large, scarcely any endosperm.

References: Jordaan (2000b), Friis & Immelman (2001), Chen *et al*. (2003).

Pilea is a member of the tribe Lecantheae (=Procrideae) which characteristically does not possess stinging hairs, and has female flowers with 3-merous perianths and paintbrush-like stigmas (Walker, 2002). The genus has not attracted monographic attention since Weddell (1869), with the result that conservative estimates for the number of valid species range widely, from 250 to 400 (Jordaan, 2000b; Chen *et al*., 2003; Monro, 2006). Accordingly, it is the largest genus in the family Urticaceae and one of the larger genera in the Urticales and eudicot rosids. *Pilea* is widespread in the tropics and subtropics, and some warm temperate regions, although not naturally in Australia or New Zealand. Many of the taxa are highly localised, with a centre of diversity in the American tropics (West Indies) hosting c. 180 species (Walker, 2002). The seeds of several species are ejected forcefully through the catapult-like action of the enlarged inflexed staminodes (Walker, 2002).

Most genus members are semi-succulent, shade-loving herbs or shrubs, which are easily distinguished from other Urticaceae by the combination of opposite leaves (with rare exceptions) with a single ligulate intrapetiolar stipule in each leaf axil and cymose or paniculate inflorescences (again with rare exceptions). *Pilea* is of little economic importance, with only a few of its species of minor horticultural importance.

The genus name is derived from Latin *pileus*, “felt cap”, referring to the calyx covering the achene of the type species.Its common names derive from the fact that the anthers explosively discharge, releasing a cloud of pollen.

Key to indigenous (*Pilea rivularis* Wedd.) and naturalised species of *Pilea* occurring in southern Africa:

1. Margin of blade entire; leaves, including petiole, less than 1 cm long, succulent . . . . ***Pilea microphylla***

1’. Margin of lamina with 10–11 pairs of teeth; leaves, including petiole, greater than 7.5 cm long, herbaceous . . . .**(*Pilea rivularis*)**

Pilea microphylla (L.) Liebm.

In: *Kongel Danske Vidensk. Selsk. Naturvidensk. Math. Afh. Ser.* 5(2): 296 (1851).

=*Parietaria microphylla* L.
=*Pilea callitrichoides* (Kunth) Kunth
=*Pilea muscosa* Lindl.
=*Pilea muscosa* Lindl. var. *microphylla* (L.) Wedd.
=*Pilea trianthemoides* (Sw.) Lindl. var. *microphylla* (L.) Wedd.
=*Urtica callitrichoides* Kunth
=*Urtica microphylla* (L.) Sw.

Common names: artillery fern, artillery plant, gunpowder plant, lace-plant, pistol plant, rockweed (English).

Monoecious (sometimes dioecious) annual or short-lived perennial herb, 4–30(–50) cm high, usually much branched and forming mats, glabrous, pale green; stems succulent, sometimes slightly woody at base, freely branching, up to 2.5 mm diameter, usually ± erect, rarely prostrate or pendent. **Leaves** crowded, small, opposite, anisophyllous; petiole 0.5–6 mm long; blade broadly obovate to oblanceolate, elliptic or circular, 1–15 × 0.5–4 mm, base rounded to cuneate, apex rounded to bluntly obtuse, margin entire to slightly crenulate, lateral veins above obscure so leaves appear 1-veined, upper surface transversely striate with linear cystoliths, lower surface finely reticulate; stipules minute, up to 1 mm long, caducous. **Inflorescence** very small, subsessile, cymose-capitate, 1–2 clusters together in the leaf axils, usually androgynous with few male and 5–10 female flowers (or entirely with female flowers). **Flowers** subsessile, 0.5–0.8 mm long (male flowers usually longer). **Perianth** 3-merous; segments subequal in male flowers and with 1 long and 2 short lateral segments in female flowers, glabrous, with a blunt, dorsal, apiculate appendage. **Fruit** an achene, ovoid, 0.5–0.8 mm long, slightly exceeding the persistent perianth segments, smooth, brown. **Distribution**: SA. (Fig. 345)

References: Friis (1989), Walker (2002).

This species is native to southern Florida (USA), Mexico south to tropical South America, and various Caribbean islands, but widely naturalised in Asia, the Balkans, and on tropical Pacific Islands such as Hawaii. It is widely distributed as a garden weed in Africa in coastal zones and some localities inland (Friis, 1989, map 16; Friis, 1991; Burkill, 2000). Its dispersal has been through the agency of humans, who have cultivated plants of this species (Burkill, 2000). Forms of this species vary considerably in size, with the small form found particularly common on walls and along paved pathways.

This species has been recognised as a widespread complex in need of further study. Additionally, several horticultural variants have been developed (Walker, 2002). Different forms appear better adapted to becoming weeds, or occurring naturally in a wide range of habitats. In southern Africa it is one of the smallest forms (Fig. 346) that has become weedy in character. This entity is mat-forming,

Fig. 345. Distribution map of *Pilea microphylla* (L.) Liebm.

prostrate or creeping, with anisophyllous leaves c. 3 × 2 mm and 1.75 × 1.25 mm respectively (Friis & Immelman, 2001), and inconspicuous flowers (Fig. 347). Although larger forms (Fig. 348) are popular bedding plants—including red-foliaged and variegated forms (Nelson & Scannell, 1989)—these do not appear to have escaped.

This species is unlikely to be confused with the only other species of *Pilea* in our region, nor likely with any other succulent species for that matter. Only one other *Pilea* is native to southern Africa—*P. rivularis* from eastern South Africa—but this taxon is not succulent, and easily separated using the key above. Several other genus representatives have been introduced as horticultural subjects but these are very different in size and vegetative form. Amongst these are the aluminium plant from Vietnam (*P. cadierei* Gagnepain & Guillaumin) with its silvery striped leaves, *P. involucrata* (Sims) C.H.Wright & Dewar and *Pilea repens* (Sw.) Wedd., the blackleaf-panamigo (Glen, 2002).

Pilea microphylla is not listed in South African legislation as a declared weed and invader plant, but is present in the region as a weed as a result of historical human-assisted dispersal across the tropics.

It is possible that the small form of this species was introduced into South Africa as a miniature ornamental for co-planting with bonsai specimens. It was first regionally noted as a weed growing between bricks in a Durban (East coast) garden, and at that time considered to possibly have arrived from East Africa (Friis & Immelman, 2001). It may now frequently be found growing as a weed in moist rock wall cracks, and along the edge of steps and pavers in positions of shade or partial shade. It is particularly prevalent in greenhouses, often growing on the substrate below benches and appearing in pots.

Small pieces of stem, or individual leaves are able to take root if left in contact with soil. Manual removal of plants is near-impossible as the brittle stems break easily, resulting in fragments remaining behind.

Fig. 346. Small form of *Pilea microphylla* (L.) Liebm. (Picture by Neil R. Crouch)

Fig. 347. Flowers of *Pilea microphylla* (L.) Liebm. (Picture by Neil R. Crouch)

Fig. 348. Large leaf form of *Pilea microphylla* (L.) Liebm. (Picture by Geoff R. Nichols)

7. Glossary (from Lawrence, 1951; Beentje, 2010)

abaxial: applied to the side or surface facing away from the stem or axis (compare adaxial).

acaulescent: without an evident stem above ground level.

accrescent: increasing in size, e.g. the calyx of some plants in the fruiting stage.

achene: small dry fruit, not splitting when ripe, containing a single seed, with the seed coat free from the fruit wall.

acicular: needle-shaped, thin, cylindrical with a sharp point, meaning either a solid 3-dimensional shape, or a 2-dimensional shape.

actinomorphic: (of flowers) radially symmetrical, regular (compare zygomorphic).

acuminate: tapering gradually or abruptly from inwardly curved sides into a narrow point.

acute: pointed, the margins forming an angle of < 90º.

adaxial: applied to the side facing the stem or axis (compare abaxial).

adnate: fused with an organ of another kind.

adpressed: lying close to and flat along the surface.

alternate: applied to leaves and other organs inserted singly at different levels along the axis.

amplexicaul: stem-clasping, as when the base of the leaf is dilated and embraces the stem.

anatropous: (of ovule) reversed, bent so that the micropyle is close to the point of attachment of the funicle.

anisophyllous: with two opposite leaves very unequal in size.

annual: plant whose life span ends within one year after germination.

annular: arranged in a circle.

anther: the part of a stamen which contains the pollen.

antherode: remnant of anther, in a staminode.

anthesis: period during which the flower is open.

apical: at the apex.

apiculate: bearing a short point.

areole: (of Cactaceae) raised or sometimes sunken cushion that represents a condensed shoot system (brachyblast) of axillary origin, bearing modified leaves (bristles, spines and/or glochidia), flowers or shoots.

aril: appendage covering or partly enclosing the seed and arising from the funicle.

arillate: bearing an aril.

arista: long bristle-like point.

aristate: bearing an arista.

ascending: growing erect after an oblique or horizontal beginning.

asperous: rough, harsh to the touch.

attenuate: tapering gradually.

axil: the angle between a leaf or bract and the axis bearing it (usually the stem).

axile: (of placentation), with ovules attached to the axis of the ovary.

axillary: arising from the axil (e.g. branches).

baccate: berry-like.

basifixed: (of anthers) attached to the filament by the base (compare dorsifixed).

berry: indehiscent simple fruit with 1–many seeds immersed in a fleshy pulp.

biennial: taking two years from seedling stage to maturity, seed-set and death.

bifid: divided at the tip in two (usually equal) parts by a median cleft, for about half the length.

bifurcate: forked or divided into two sharp branches or prongs.

bisexual: having both sexes in the same flower or inflorescence.

bladder cells: (of Aizoaceae) cells for water-storage.

brachyblast: short shoot of limited growth usually borne on a main axis.

bract: leaf-like structure, different in form from the foliage leaves and without an axillary bud, associated with an inflorescence or a flower.

bracteate: possessing or bearing bracts.

bracteole: small bract borne on the pedicel or calyx of a flower.

bristle: stiff strong hair, slender and cylindrical.

bulbiferous: bearing or producing bulbils.

bulbil: small deciduous bulb (or tuber) usually axillary, formed around the mother bulb or in the axil of a leaf, and functioning to propagate the plant vegetatively.

caducous: non-persistent, falling off early.

calyptra: cap or lid-like covering of flowers or fruits.

calyx: outer envelope of the flower, consisting of free or united sepals.

campanulate: bell-shaped, with a tube about as long as wide.

campylotropous: (of an ovule) orientated transversely (i.e. with its axis at right angles to its stalk and with a curved embryo sac).

capitate: head-like; like the head of a pin (e.g. as for stigma).

capsule: dry fruit composed of two or more united carpels and either splitting when ripe into flaps called valves or opening by slits or pores.

carpel: the basic unit of the female sexual organ in a flower, comprising the ovary with its ovules, the style and the stigma.

caruncle: outgrowth of the outer seed integument, near the hilum; usually small and fleshy and associated with animal dispersal.

carunculate: with a caruncle.

cataphyll: small scale leaf, e.g. on rhizomes of flowering plants.

caudex (*pl.* caudices): enlarged storage organ at soil level, composed of the swollen stem or root, or both.

caudiciform: formed like a caudex, enlarged or swollen.

caulescent: with an evident stem above ground.

chartaceous: papery in texture, opaque and thin.

chasmogamous: pollinated when the flower is open (compare cleistogamous)

ciliate: with a fringe of hairs along the margin.

circumscissile: opening as if cut circularly around the upper part or equator, which then comes off like a lid.

cladode: segment of a jointed, flattened stem, with the function of a leaf.

clavate: club-shaped or thickened towards the end.

cleistogamous: (self) pollination occurring when the flower is closed (compare chasmogamous).

coccus (*pl.* cocci): one of the separate parts of a lobed capsule or of a schizocarp.

cochleate: spiral, like the shell of a snail.

columella: persistent central axis around which the fruit locules are arranged.

conical: cone-shaped.

connate: united, with structures or organs of the same kind (e.g. filaments) are joined margin to margin.

connective: the part of a stamen that connects the anther locules.

connivent: applied to parts converging so as to be nearer together above than below.

cordate: applied to the base of a leaf when it is more or less deeply notched.

corolla: the inner envelope of the flower, consisting of free or united petals. This whorl is inside or above the calyx and outside the stamens.

corymb: more or less flat-topped, racemose (indeterminate) inflorescence in which the branches or the pedicels start from different points but all reach to about the same level.

crenate: the margin notched with regular blunt or rounded teeth (crenations).

cuneate: wedge-shaped and attached at the point.

cupular: cup-shaped.

cuspidate: abruptly tipped with a sharp rigid point.

cyathium (*pl.* cyathia): (of Euphorbiaceae) inflorescence resembling a single flower but consisting of an involucre of modified leaves enclosing a female flower and several male flowers.

cymbiform: boat-shaped.

cyme: determinate inflorescence in which each flower, in turn, is formed at the tip of a growing axis, and further flowers are formed on branches arising below it.

cymose: with a cyme.

cymule: small cyme or portion of one, usually few-flowered.

cystolith: process from the cell wall impregnated with calcium carbonate.

deciduous: with leaves falling off at the end of the season of growth, not evergreen.

decumbent: lying prostrate but having the tip growing upwards.

decurrent: as when the edges of the leaf are continued down the stem or petiole as raised lines or narrow wings.

decussate: in opposite pairs, with each pair at right angles to the one above and below it.

deflexed: bent abruptly downwards or outwards (compare inflexed).

dehiscent: opening spontaneously when ripe as in capsules and anthers.

deltoid: shaped ± like an equal-sided triangle.

dentate: the margin prominently toothed, the teeth pointing outwards.

dichasia: determinate type of cymose inflorescence having a central, older flower which develops first and a pair of opposite lateral branches bearing younger flowers.

didynamous: (of stamens) in pairs of unequal length.

dimorphic: having two distinct forms or sizes.

dioecious: with unisexual flowers, the male and female flowers on separate plants.

discoid: like a plate or disc.

distal: farther from the point of attachment or origin (compare proximal).

distichous: regularly arranged one above the other in two opposite rows, one on each side of the stem.

diurnal: flowering during the day rather than at night.

divaricate: spreading wide.

dorsal: the back or outer surface, in this work referring to the upper surface of the lamina.

dorsifixed: attached at or by its back, said e.g. of an anther to the filament.

drupaceous: drupe-like, or producing fruit like a drupe.

drupe: indehiscent, fleshy fruit with the seed(s) enclosed in a stony endocarp (e.g. plum).

elaiosome: oily appendage on seeds, serving as a food-body for ants and other animals which then disperse the seed (see also strophiole).

ellipsoid: 3-dimensional shape that is elliptic in the vertical plane.

elliptic: broadest at the middle, with two equal rounded ends.

emarginate: with a distinct sharp notch at the apex.

embryotega: lid-like thickening in seed coat becoming detached on germination.

emetic: bringing on or causing the act of vomiting.

endemic: confined to a particular region or country and not native anywhere else.

endosperm: the nutritive material stored within the seed and often surrounding the embryo.

entire: with an even margin, without teeth or notches.

ephemeral: plant that completes its life cycle in less than one year, usually less than six months

epidermis: the outermost layer of cells of an organ, usually only one cell thick.

epidermal: having to do with the outermost layer of cells.

epigynous: (of flower) when sepals, petals and stamens are apparently borne above the ovary, the latter being enclosed in an adnate receptacle or calyx tube (compare hypogynous, perigynous).

epilithic: living on rocks.

epipetalous: borne on the petals.

epiphyte (*adj.* epiphytic): plant that grows on another plant but without deriving nourishment from it, i.e. not parasitic, as some ferns and orchids growing on trees.

erose: (of a margin) appearing to have been gnawed.

exserted: projecting beyond, as the stamens from the tube of the corolla (i.e.not included).

fascicle: tuft of leaves, branches, flowers etc. arising from about the same place.

fasciculate: bearing fascicles.

filament: the stalk of a stamen supporting the anther.

filiform: slender, thread-like.

fimbriate: with the margin bordered by long slender processes.

flexuose: zig-zag or bent alternately in opposite directions.

foliaceous: leaf-like.

foliolate: with leaflets, e.g. 3-foliolate with 3 leaflets, 5-foliolate with 5 leaflets etc.

follicle: fruit (pod) formed from a single carpel opening usually only along the inner (i.e. ventral) suture to which the seeds are attached.

funicular: deriving from the funicle (the stalk of the ovule or seed attaching it to the placenta).

fusiform: spindle-shaped, thick, but tapering towards each end.

gamopetalous: with the petals united, either entirely or at the base into a tube, cup or ring.

gamosepalous: with united sepals.

gibbous: with a pouch-like swelling or hump.

girdle: funicular girdle, the scar left on the seed at the point of attachment of the funicle.

glabrate: glabrous, but obviously having previously had an indumentum.

glabrescent: becoming glabrous or nearly so.

glabrous: without hairs or scales.

glaucescent: becoming glaucous with age.

glaucous: covered with a waxy bloom, usually bluish grey or sea green, which rubs off easily.

globose: rounded, spherical.

glochid (*pl*. glochidia): (of Cactaceae) minutely barbed spinule (bristle) produced in the areole.

granulate: finely covered with very small granules.

gynodioecious: having bisexual flowers and female flowers on separate plants.

gynobasic: (of style) arising from the base of the ovary.

hemispheric: with the shape of half a sphere.

hilum: the scar left on the seed from its attachment point to the placenta.

hilum-micropylar region: (of Cactoideae) complex formed by hilum and micropyle on the seed surface.

hirsute: with rather coarse, stiff hairs.

hygrochastic: applied to plants in which opening of the fruit and dispersion of the spores or seeds are caused by absorption of water.

hypanthium: often cup-shaped extension of the receptacle formed by fusion with calyx, corolla and androecium, in some cases extended into a tube.

hypogynous: (of flower) with flower parts attached below the base of the ovary and free from it; flowers with this arrangement have a superior ovary (compare epigynous, perigynous).

imparipinnate: having an uneven number of pinnae, by virtue of having one terminal pinna.

included: (of stamens) not projecting beyond the tube of the corolla (compare exserted).

indehiscent: not opening when ripe.

indumentum: any covering to a surface, such as hairs, wool, scales, etc.

inferior: (of ovary) when calyx is inserted above ovary.

inflexed: bent sharply inwards, upwards or forwards (compare deflexed).

inflorescence: the part of the plant that bears the flowers.

infraspecific: (of taxa or variation) below the rank of species (e.g. subspecies, variety).

inserted: included.

internode: the portion of a stem between two nodes (compare node).

introrse: (of an anther) opening towards the centre of the flower.

involucral: having to do with the involucre.

involucre: a number of bracts surrounding the base of a head of flowers.

involute: having the edges of the leaves rolled towards the adaxial surface (compare revolute).

iridescent: many-coloured, with rainbow sheen.

keeled: ridged along the middle of a flat or convex surface.

lacrimiform: tear-shaped.

lamina: the expanded part of leaves or petals; same as blade.

lanceolate: lance-shaped, a lamina shape widest below the middle, tapering to the apex, with a length to width ratio of 3:1 or more.

latex: milky juice, often sticky.

leaflet: one expanded part of a compound leaf.

lenticular: shaped like a biconvex lens.

liana: woody climbing plant, mainly of tropical forests.

ligulate: strap-shaped, narrow and with parallel sides.

lithophytic: of a plant growing on rock.

lobate: with lobes.

locular: having chambers.

locule (*pl*. loculi): a chamber or compartment of an ovary or fruit or anther.

loculicidal: referring to the dehiscence of a fruit which splits down the middle of the cells or locules, along the midrib or dorsal suture.

lorate: strap-shaped; moderately long with parallel sides.

lunate: shaped like the waxing moon.

mamillate: having small nipple-like projections.

marcescent: withering without falling off.

-**merous**: referring to parts or their number (e.g. 3-merous).

mesophytic: adapted to normal conditions, avoiding very wet and arid conditions.

micropyle: opening in the teguments of the ovule, through which the pollen tube enters, and from which radicle emerges in seed.

midrib: the principal, usually central nerve of a leaf or leaf-like part.

moniliform: like a string of beads.

monocarpic: flowering (and possibly fruiting) only once, then dying.

monochasium (*pl.* monochasia): cyme reduced to single flowers on each axis (the laterals of the dichasium having been lost by reduction).

monoecious: with male and female flowers separate but borne on the same individual plant.

mucilage (*adj*. mucilaginous): gelatinous substance which absorbs water and increases in bulk.

multifid: divided into many lobes or segments.

nectary gland (nectary scale): gland-like organ, located outside or within a flower, that secretes nectar.

nocturnal: having flowers that open during the night.

node: the place on a stem at which a leaf or leaves and accompanying organs arise.

nut: one-seeded indehiscent fruit, with a hard dry shell (pericarp).

nutlet: little nut.

ob- (prefix): usuallly indicating the other way round from the usual (e.g. obconical being inversely conical, with the point of attachment at the small end).

oblate: transversely broadly elliptic.

oblong: 2-dimensional shape, much longer than broad, with nearly parallel sides.

obtuse: blunt or rounded at the end, the margins forming an angle of 90º–180º.

operculate: with a cap or lid.

operculum: lid, cap or cover.

opposite: pertaining to leaves or branches when two are borne at the same node on opposite sides of the stem.

orbicular: flat with a ± circular outline.

orthotropous: (of ovule) with a straight axis, the micropyle being distal.

ovary: that part of the pistil (the usually enlarged base) which contains the ovules and eventually becomes the fruit.

ovate: 2-dimensional shape with the outline of an egg, scarcely twice as long as broad, with the broader end below the middle.

ovoid: 3-dimensional shape that is ovate in the vertical plan.

ovule: the immature seed in the ovary before fertilisation.

pachycaul: plant with disproportionately thick stem for its length.

palmatilobed: (of a leaf) palmately divided to about halfway to the midrib.

panicle: compound raceme; an indeterminate inflorescence in which the flowers are borne on branches of the main axis or on further branches of these.

paniculate: with the inflorescence a panicle.

papilla (*pl*. papillae): soft, small, often nipple-shaped protuberance.

papillate: having papillae.

papillose: bearing many small, soft, nipple-like protuberances.

parietal: (of placentation) with the ovules borne on the inner surface of the wall of the ovary or on intrusions of the wall that form incomplete partitions.

partite: divided but not quite to the base.

pectinate: like a comb.

pedicel: the stalk of an individual flower.

pedicellate: (of flower) stalked, with a pedicel.

peduncle: the stalk of an inflorescence.

pedunculate: (of inflorescence) with a peduncle.

peltate: of a leaf or other plant organ of which the stalk is attached to its under surface instead of to its edge.

pendulous: hanging down from; (of ovules) arising on and hanging down from an apical placenta.

penicillate: brush or pencil-shaped, long and narrow with a tuft of hairs at the end.

pentagonal: 5-angled or 5-merous.

perennial: plant whose life span extends over more than two growing seasons.

perianth: the floral envelope, consisting of calyx or corolla or both.

pericarpel: the receptacle that encloses the ovary up to below a point (ovary apex) where it extends into an epigynous hypanthium; interpreted as a short shoot, of peduncular nature.

perigynous: (of flower) when the sepals, petals and stamens arise on an open receptacle surrounding the ovary but are not adnate to it (compare epigynous, hypogynous).

persistent: remaining attached to the plant beyond the expected time of falling.

petal: single, usually free, unit of a completely divided corolla or second floral whorl.

petaloid: formed or coloured like a petal.

petiolate: (of a leaf) having a petiole.

petiole: leaf stalk.

phloem pole: side of a vascular bundle closest to the phloem found in genera such as *Agave.*

pilose: hairy with rather long, soft, simple hairs.

pinnate: (of a leaf) divided into a central axis and lateral leaflets.

pinnatifid: (of a leaf) incompletely divided, not forming distinct leaflets but incised more than 1/2 way to the midrib.

pinnatisect: (of a leaf) pinnately divided down to the midrib.

pistil: the female organ of a flower, consisting when complete of ovary, style and stigma.

pistillode: rudimentary sterile pistil.

placenta: the part of the ovary where ovules are attached.

placentation: disposition of the placenta within the ovary.

planate: flat, uniform, level, horizontal.

plicate: folded or plaited; having parallel folds like a folding fan.

porrect: pointing upwards at a slight angle from the vertical.

procumbent: said of a stem or rhizome that lies on the ground for all or most of its length, without rooting at the nodes.

proliferous: with adventitious buds on the leaves or on the flowers, such buds being capable of rooting and forming separate plants.

prophyll: leaf formed at the base of a shoot, usually smaller than those formed subsequently.

prostrate: lying flat.

proximal: the closest to the point of attachment (compare distal).

pruinose: having a whitish, waxy, powdery bloom on the surface.

puberulent: minutely pubescent.

pubescent: covered with soft, short, erect hairs.

pyrene: (of fruit) stone; seed plus a hard layer of endocarp surrounding it.

pyriform: pear-shaped.

pyxidium (*pl*. pyxidia): capsular fruit with circumscissile dehiscence.

quadrate: almost square in form.

raceme: indeterminate inflorescence in which all the flowers are borne on pedicels along an unbranched axis or peduncle, the terminal flowers being the youngest and the last to open.

reflexed: bent downwards or backwards.

reniform: kidney-shaped.

reticulate: forming a network or lattice.

revolute: rolled back from the margin (compare with involute).

rhizomatous: possessing an underground stem.

rhizome: rootstock or root-like stem prostrate on or under the ground, sending rootlets downwards and leaves upwards; always distinguished from a true root by the presence of buds.

rhomboid: (of leaves) rhombic-like, ± diamond-shaped, having straight margins and being widest in the middle, with the petiole attached at one of the acute angles.

rosette: a circle of tightly packed leaves or other organs, if of leaves then usually at ground level (a basal rosette).

rosulate: with the leaves in a circle at the basis of the stem; with a rosette.

rugose: wrinkled; covered with coarse reticulate lines with the spaces in between convex.

rugulose: finely wrinkled.

runner: slender, prostrate or trailing stem which produces roots.

saccate: pouch-shaped.

scandent: climbing (usually without aid of tendrils).

scabrid: rough to the touch due to minute stiff hairs.

scape: naked flower stalk arising from the ground with radical or rosulate leaves.

scarious: thin and dry, not green.

schizocarp (*adj*. schizocarpic): dry dehiscent fruit which splits into its carpellary constituents at maturity.

scorpioid: (of a cymose inflorescence) with the main axis coiled in bud, the flowers being usually 2-ranked, i.e. with single flowers alternately right and left.

sepal: a single part of the outermost whorl of floral organs, the calyx; usually green, protecting the corolla in bud.

sepaloid: resembling a sepal, sometimes said of tepals.

septal nectaries: occurring in the partitions of the ovary where the carpel walls are incompletely fused, especially seen in monocotyledons.

septicidal: when a ripe capsule splits along the lines of junction of the carpels, i.e. along the septa, the fruit valves remaining attached and not falling off.

serrate: toothed like a saw, with regular acute and angled teeth pointing towards the apex.

sessile: of a leaf, without a petiole, the leaf being joined directly onto the stem.

sigmoid: S-shaped.

sinuate: with the margin uneven, with rather deep undulations (compare undulate).

spathaceous: resembling a spathe (a large bract surrounding the inflorescence).

spathulate: shaped like a small spatula or spoon, oblong, with an extended basal part.

spicate: arranged in a spike.

spike: racemose (unbranched) inflorescence with sessile flowers.

spinescence: spininess.

spiniform: shaped like a spine.

spreading: loose, not erect, said of petals and other plant organs.

stamen: the male organ of a flower, consisting of a filament, and the anthers that bear the pollen.

staminode: abortive or vestigial stamen without a perfect anther.

stellate: star-shaped, with numerous arms radiating outwards (as in the pattern on seeds, or a type of hair).

stigma: the pollen receptor on the gynoecium, which may be either sessile on the ovary or on top of the style or its arms.

stipule: leaf-like or scale-like appendages of a leaf, usually at the base of the petiole.

stipuliform: shaped like a stipule.

stolon: runner (vegetative shoot that spreads along the surface of the ground) which roots at the nodes.

striolate: marked with fine lines or ridges.

strophiolate: with strophioles.

strophiole: an aril or outgrowth of the outer seed integument near the hilum, serving as a food-body for animals which then disperse the seed (see also elaiosome).

style: narrow upper part of an ovary supporting the stigma; sometimes lacking when the stigma sits on the ovary.

sub- (prefix): nearly, almost.

subradical: (of leaves) appearing so close to the stem base that they appear to come from the root.

subtending: standing below and close to another organ.

subulate: awl-shaped.

sucker: shoot arising below ground from the roots some distance from the main stem.

suckering: producing suckers.

sulcate: grooved, furrowed.

superior: (of ovary) when sepals, petals and stamens are inserted below ovary.

surculose: producing suckers or runners from the base.

syncarpous: (of a flower) with two or more united carpels.

taproot: the main, descending root of a plant that has a single dominant root axis.

taxon (*pl.* taxa): a group or category, at any level, in a system for classifying organisms.

tepal: any of the members of a perianth that is not clearly differentiated into calyx and corolla.

terete: cylindrical, so circular in cross section and lacking grooves or ridges.

terminal: at apex of part under discussion.

ternate: arranged in a whorl or cluster of three.

testa: the outer coat of the seed (the inner coat is the tegument).

tetrasporangiate: (of anthers) four-locular.

thyrse: panicle with the secondary and ultimate axes cymose, i.e. the main axis is indeterminate and the lateral branches are determinate in their growth.

tomentose: densely covered in short, soft hairs.

trapeziform: having four edges, those which are opposite not being parallel.

trichome: epidermal outgrowth, such as a hair or scale.

trigonous: triangular in cross section and with obtuse angles (compare triquetrous).

triquetrous: triangular in cross section and with acute angles, therefore with three distinct longitudinal ridges (compare trigonous).

trullate: trowel-shaped; having its widest axis below the middle and with straight margins.

truncate: cut off ± squarely at the end.

tuber: thickened branch of an underground stem, serving as a storage organ (this bears leaf scars and axillary buds).

tuberous: swollen; (of roots) tuber-like.

tuberculate: with tubercules (rounded protuberances).

umbel: inflorescence (racemose or indefinite) with branches arising from the same point on a common peduncle.

undulate: said of a margin that is wavy.

urceolate: urn-shaped, with a short swollen tube contracted near the top and then slightly expanded in a narrow rim.

utricle: bladder-shaped fruit.

variegated: having streaks, marks, or patches of a different colour or colours; varicoloured.

vascular bundle: a strand of specialised tissue that conducts water or nutrients within the plant.

verrucose: warty.

versatile: (of an anther) swinging freely about the point of attachment to the filament which is in the middle of the back (compare basifixed, dorsifixed).

verticillate: (of leaves) in a whorl, i.e. several arising at the same node, arranged regularly around the stem.

villous: set with long weak hairs.

viviparous: bearing living young, when the seeds germinate on the parent plant, or where plantlets are produced from the edges of leaves.

whorled: the arrangement of similar parts (usually leaves) in a circle at the same level.

xeromorphic: having characteristics that serve as protection against excessive loss of moisture.

xerophytic: adapted to dry or arid habitats.

zoophilous: adapted for pollination by animals.

zygomorphic: with bilateral symmetry, i.e. either side of an imaginary line being a mirror image of the other (compare with actinomorphic).

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11. Index to the scientific names (accepted and synonyms) and common names of naturalised and invasive succulent taxa treated in this volume (accepted names in bold, synonyms or misapplied names in regular italics, and common names in non-italic regular font). Page numbers of main treatments are in bold. For scientific family and genus names only the page numbers of the main entries are provided.

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A resident from Nongoma district carrying a *Agave sisalana* Perrine leaf from which she was to manufacture a doormat. (Picture by Neil R. Crouch)

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