

## CHAPTER 1: INTRODUCTION

The Nyctaginaceae Jussieu is a relatively small family of about 30 genera and 400 species (Douglas & Manos, 2007). It is commonly known as the Four-O'Clock family, because most species have flowers that open in the late afternoon to early evening (Levin *et al.*, 2001).

### 1.1 Phylogeny of Nyctaginaceae

The Nyctaginaceae is one of the core groups of families in the Caryophyllales due to the presence of betalain pigments, rather than anthocyanins, a free, central placentation, p-type plastids in sieve tubes, the presence of a perisperm and molecular evidence (Douglas & Manos, 2007).

The family is monophyletic due to two synapomorphies; the absence of a corolla and the specialized anthocarp (Levin, 2000). Levin (2000) states that the taxonomy within the family is difficult, because similar morphologies have evolved multiple times.

The family is closely related to, and thought to have been derived from the Phytolaccaceae (Bogle, 1974, Cronquist, 1981, Douglas & Manos, 2007). Both families share a monocarpellate gynoecium, uniseriate perianth, raphides and styloids (Bittrich & Kühn, 1993).

### 1.2 Nyctaginaceae systematics

The family name, Nyctaginaceae, is conserved and based on the illegitimate generic name *Nyctago* Juss. (Jussieu, 1789), which is a later synonym of *Mirabilis* (Linnaeus, 1753). *Mirabilis* is the type genus of the family (Bohlin, 1988; Nowicke, 1970). The older family name is Allioniaceae (Riley, 1963), based on the genus *Allionia* L. (Reichenbach, 1828).

The first treatment of the family as a whole was done by Choisy in De Candolle's Prodrômus (1828), but it was Dr. Anton Heimerl (1934) who synthesized the family

as it is circumscribed today. Bittrich & Kühn (1993) revised the family, but it was based on Hiemerl's treatment of 1934.

Hiemerl (1934) divided the family into five tribes, namely Nyctagineae, Pisonieae, Colignonieae, Boldoeae and Leucastereae, but Bittrich and Kühn (1993) recognized two more tribes, namely the Abronieae and the Bougainvilleae, and reduced the tribe Colignonieae to a subtribe of tribe Nyctagineae. The classification of the tribes was mainly based on habit type, flower gender (that is, perfect or imperfect flowers), fruit morphology and embryo characters (Zomlefer, 1994).

Recently, molecular studies led to a reclassification of the family into seven monophyletic tribes (Douglas & Spellenberg, 2010) (Table 1.1). Subtribe Colignoniinae is once again reinstated as a tribe and the genus *Caribea* is placed into its own tribe Caribeaeae. *Phaeoptilum* is transferred from tribe Nyctagineae to tribe Bougainvilleae and tribe Abronieae is no longer recognized. Its taxa have been incorporated under the tribe Nyctagineae. No subtribes are recognized within tribe Nyctagineae (Douglas & Spellenberg, 2010).

The taxonomy within the family is both interesting and problematic, as half the genera in the family are monotypic and the circumscription of several of the larger genera (e.g. *Boerhavia*, *Mirabilis* and *Pisonia*) is problematic (Zomlefer, 1994). Woodson (1961) speculated that interspecific hybridization may be responsible for obscuring the lines of the species.

### **1.3 Family characters**

The family consists of annual and perennial herbs, shrubs and trees (Zomlefer, 1994). The flowers do not have a corolla. In some genera the calyx is small and inconspicuous and sometimes it is surrounded by large, brightly coloured, petaloid, involucre bracts (such as the *Bougainvillea* Comm. ex Juss.). In other genera the calyx is large and colourful, simulating a corolla with involucre bracts forming an apparent calyx (e.g. *Mirabilis* L.) (Bogle, 1974). The family is characterized by an anthocarp (Sharma, 1963a). The anthocarp can differ in structure, as the side walls of some taxa bear sticky glands, others have warts, that produce mucilage, and some

have wings that can be expanded into winglike folds (Spellenberg, 2004). Pollen morphology varies between genera, especially in the size of the pollen grains, their shape, aperture form and exine sculpture (Bogle, 1974). Anatomically, raphides are common in the family and the roots and stems show anomalous secondary growth (Metcalf & Chalk, 1950; Mabberley, 1990). The family is also unusual in that it has the ability to grow on soil with a high concentration of gypsum (Douglas & Manos, 2007).

#### 1.4 Distribution

The Nyctaginaceae is mainly concentrated in the tropical and subtropical areas of the New World (Bittrich & Kühn, 1993; Jordaan, 2000), especially the Americas (Stannard, 1988), with some genera extending into the temperate regions (Thulin, 1994). In the Americas the family has two centres of distribution, namely, tropical and subtropical South America and the Antilles, and the southwestern United States of America (USA) and northern Mexico in North America (Bittrich & Kühn, 1993). The South African genera, *Boerhavia* L., *Commicarpus* Standl., *Pisonia* L. and *Mirabilis* L. occur in the Old World (Bittrich & Kühn, 1993), with *Phaeoptilum* Radlk. restricted to Africa (Douglas & Manos, 2007).

Six genera and 49 species occur in Africa with *Commicarpus* the dominant genus (Table 1.2) (Meikle, 1978; Stannard, 1988; Thulin, 1993; Whitehouse, 1996; Germishuizen & Meyer, 2003; Klopper *et al.*, 2006; African Plant Database, 2010). It is distributed throughout the continent, except for the extreme north and south and the wet forested areas of the west (Meikle, 1978) (Fig. 1.1).

In southern Africa, south of the Zambezi River, that is, Botswana, Lesotho, southern Mozambique, Namibia, South Africa, Swaziland and Zimbabwe, the Nyctaginaceae are distributed throughout the region except for the most southern parts (Fig. 1.2). *Phaeoptilum* is considered by some authors to be endemic to southern Africa (Bittrich & Kühn, 1993; Jordaan, 2000), while others state that it also occurs in tropical Africa (Riley, 1963; Leistner, 2005). *Pisonia* is restricted to KwaZulu-Natal and the extreme south of Mozambique (Coates Palgrave, 2002), while *Mirabilis jalapa* L. is partly naturalized over a fairly wide area with *M. viscosa* Cav. occurring only in Namibia

(Jordaan, 2000). *Boerhavia* is distributed throughout the region except in Lesotho. It has erroneously been omitted from Northwest by Germishuizen & Meyer (2003). *Commicarpus* is distributed throughout the region (Germishuizen & Meyer, 2003).

## 1.5 Nyctaginaceae in southern Africa

In southern Africa, five genera occur of which one is monotypic and one alien. There are 20 species of which six are endemic (Table 1.3) (Germishuizen & Meyer, 2003). The five genera are morphologically variable and each genus will be described briefly to highlight the differences (based on Struwig & Siebert, 2010).

### 1.5.1 *Boerhavia*

*Boerhavia* species are annual or perennial herbs with slender stems (Fig. 1.3). The leaves are opposite, petiolate, and vary from ovate to lanceolate to elliptic. The margins are entire or sinuate. The flowers are small and arranged in a cyme, the perianth is brightly coloured in white, pink and purple, and campanulate in shape. The anthocarp has 3–5 ribs or wings, and is glabrous or glandular pubescent (Jordaan, 2000).

### 1.5.2 *Commicarpus*

*Commicarpus* species (Fig. 1.4) look very similar to *Boerhavia* species, but are distinguished by their more scrambling or climbing habit, flowers with a funnel-shape perianth and an anthocarp that has 10 ribs with large viscid and mucilaginous glands (Stannard, 1988).

*Commicarpus* was originally regarded as a section of *Boerhavia* (*Boerhavia* sect. *Adenophorae* Heimerl.) (Heimerl, 1889a), but was segregated in 1909 by Standley. Fosberg (1978) reduced it to a subgenus of *Boerhavia*, but this combination was never formally made and therefore invalid (Harriman, 1999). Authors differ in opinion as to whether *Commicarpus* should be kept separate as a genus (Dyer, 1975; Stannard, 1988; Thulin, 1993; Whitehouse, 1996) or be included in *Boerhavia* (Stemmerik, 1964; Bogle, 1974).

### 1.5.3 *Mirabilis*

Species of the introduced *Mirabilis* (Fig. 1.5) are erect, perennial herbs. The leaves are thin, opposite, ovate to ovate-cordate and the lower leaves have petioles while the upper leaves are sessile. Flowers are subtended by a calyx-like involucre. The flowers are purple, red, yellow or white, and open in the late afternoon and are fragrant at night. The anthocarp is black, hard and ribbed (Jordaan, 2000).

### 1.5.4 *Phaeoptilum*

Only one species of *Phaeoptilum* (Fig. 1.6) occurs in southern Africa. It is a shrub up to 3 m high with branch tips modified into spines. The bark is greyish-yellow or brown. The leaves are opposite or fascicled, sessile or subsessile, linear and nearly fleshy. Leaf margins are entire. The flowers are creamy yellow, scented, solitary or in fascicles, and usually on leafless branches. The anthocarp is yellowish-green turning pink, red or purple with age and the wings are more or less semi-circular, broad and parchment-like with the central portion fusiform (Coates Palgrave, 2002).

### 1.5.5 *Pisonia*

*Pisonia* (Fig. 1.7) is also represented by only one species in southern Africa. It is a climbing shrub with paired, axillary, recurved thorns. The bark is whitish to pale brown. The leaves are petiolate, alternate to subopposite, oblong and the margins are entire or slightly wavy. The flowers are arranged in a cyme, cream to yellow and sweetly scented. The anthocarps are ribbed and the ribs have soft, viscid, prickle-like glandular hairs (Coates Palgrave, 2002).

## 1.6 Medicinal and cultural uses

The family is used medicinally especially in Asia, Brazil and Mexico to treat dysentery, diarrhoea, muscular pain, abdominal colic, and as poultices for boils, abscesses and scabies (Hiruma-Lima *et al.*, 2000; Aoki *et al.*, 2008). Apart from its medicinal use, the flowers of *Mirabilis jalapa* are steeped in water to provide a crimson dye used in China for tinting cakes and also jellies prepared from seaweed. A

cosmetic powder is made in Japan from the powdered seeds (Bogle, 1974). In southern Africa, roots of some species (e.g. *Boerhavia coccinea* Mill. var. *coccinea*) are eaten as a vegetable (Von Koenen, 2001) and others are herbage plants (called cerise stars) that are excellent for stock (Riley, 1963; Pooley, 1998). Poisoning of children has been reported after consumption of roots, seeds or fruits of *M. jalapa* (Munday, 1988). The medicinal and traditional uses of the Nyctaginaceae in southern Africa, however, are very poorly documented.

### 1.7 Objectives

The overall objective of the study was to give a full systematic and phylogenetic treatment of the genera *Boerhavia* and *Commicarpus* occurring in southern Africa (defined as Botswana, Lesotho, Namibia, South Africa and Swaziland).

### 1.8 Aims

The aims of this systematic study of *Boerhavia* and *Commicarpus* were to:

- investigate various morphological and anatomical characters, as well as genetic markers.
- understand the natural affinities and phylogenetic relationships and to produce a predictable classification system.
- solve their nomenclatural problems in southern Africa.
- improve the floristic inventory of *Boerhavia* and *Commicarpus* through field work in under-collected areas.
- develop, maintain and share a collection of specimens to archive the diversity of *Boerhavia* and *Commicarpus* in southern Africa.
- describe and document southern Africa's diversity of the *Boerhavia* and *Commicarpus* for use in floras and other inventories.
- contribute to the ethnobotanical knowledge base of *Boerhavia* and *Commicarpus* in southern Africa if appropriate.
- document their biogeographical patterns in southern Africa.

## 1.9 Hypotheses

In southern Africa, *Boerhavia* and *Commicarpus* are two distinct genera with morphological, anatomical and molecular characters which distinguish them. The various species can be distinguished by means of their reproductive structures (flowers and anthocarps) and molecular analysis supports their separate identities.

## 1.10 Layout of thesis

This study is a descriptive account of the southern African *Boerhavia* and *Commicarpus* species. Chapters 4–7 are written in a format derived from the scientific approach. Each chapter has an introduction, aim, materials and methods, results, discussion and summary. The thesis is divided into the following chapters:

Chapter 2 gives a brief overview of the different species concepts used to define a species, as well as data that can be used in systematic analyses. A broad understanding of these topics is essential to interpret taxonomic results and phylogenies meaningfully.

Chapter 3 summarizes the materials and methods used throughout the study.

Chapter 4 investigates the morphological characters and identifies those characters that separate the genera and allow for species identifications. Parts of this chapter were published in *Bothalia* 41(2):289–326 (2011) and other parts have been submitted for possible publication.

Chapter 5 describes the anatomy of the two genera and investigates the anatomical adaptations of these species to arid environments in which they survive. The results have been published in *Acta Biologica Cracoviensia Series Botanica* and *Bangladesh Journal of Plant Taxonomy*.

Chapter 6 describes the pollen morphology. Results will be incorporated with the taxonomic synopsis (Chapter 8) and submitted for possible publication in the *South African Journal of Botany*.

Chapter 7 investigates the phylogenetic relationships of the *Boerhavia* and *Commicarpus* species in relation to each other and other related taxa. These results are preliminary and require additional analysis before being submitted for publication.

Chapter 8 is a contribution to the *Flora of Southern Africa* and provides a comprehensive taxonomic synopsis of the *Boerhavia* and *Commicarpus* species of southern Africa. This treatment will be submitted to the *South African Journal of Botany* for publication.

Chapter 9 discusses molecular research that still needs to be done and the need to combine the morphological, anatomical, palynological, molecular and biogeographical data to produce a workable classification and evolutionary history of the group in southern Africa.

Chapter 10 is the general conclusion to the thesis.



**Table 1.1. The seven tribes recognized by Douglas & Spellenberg (2010) in the Nyctaginaceae.**

|                                 | Tribe Boldoeae<br>Heimerl (1889)  | Tribe<br>Leucastereae<br>Benth. & Hook.<br>(1880)                               | Tribe Nyctagineae<br>Horan (1847)<br>(Including tribe<br>Abronieae (Benth.<br>& Hook.) Heimerl.<br>(1897) | Tribe Colignonieae<br>Standl. (1918)            | Tribe<br>Bougainvilleae<br>Choisy (1849)                              | Tribe Pisonieae<br>Meisner (1841)  | Tribe Caribeeae<br>Douglas &<br>Spellenb. (2010) |
|---------------------------------|---|---|---|---|---|--|--|
| <b>Habit</b>                    | Woody or herbaceous   | Woody   | Herbs, subshrubs, shrubs or lianas  | Woody or lianas                                 | Woody   | Woody  | Herbaceous                                       |
| <b>Indumentum</b>               | Hooked or straight  | Stellate  | —   | 3–4-stellate                                    | —   | —  | —  |
| <b>Leaves</b>                   | Alternate   | Alternate   | Opposite or whorled   | Opposite or whorled                             | Alternate   | Opposite, sometimes apparently whorled or rarely alternate   | Opposite   |
| <b>Involucre and bracteoles</b> | Absent  | Involucre absent, bracteoles present or absent                                  | Absent or present   | Involucre absent; bracts present                | Involucre ± striking coloured bracts, enclosing 1–3 flowers or absent | Involucre absent   | Involucre present, 3–5 bracts                    |
| <b>Flowers</b>                  | Bisexual; stamens opposite the perianth lobes; style filiform; stigma fimbriate | Bisexual; hypogynous or perigynous; style thickish or absent; stigma crest-like | Bisexual; styles filiform or clavate; stigma capitate, papillose, fimbriate or penicillate                | Bisexual; style filiform; stigma pencillate     | Bisexual; style filiform; stigma crest-like or laciniate              | Unisexual with rudimentary organs of the other sex or rarely bisexual; perianth inconspicuous; stigma pulvinate, lobed, fimbriate or penicillate | Bisexual; style filiform; stigma capitate        |
| <b>Fruit</b>                    | Enclosed in persistent but not enlarged perianth                                | Not enclosed in anthocarp   | Enclosed in anthocarp   | Enclosed in anthocarp which is angled or winged | Enclosed in anthocarp   | Enclosed in anthocarp  | Enclosed in anthocarp                            |
| <b>Embryo</b>                   | Circular or horseshoe-shaped  | Hooked  | Hooked or horseshoe-shaped, or rarely straight  | Hooked  | Hooked  | Straight   | —  |
| <b>Cotyledons</b>               | 2   | 2   | 2   | —   | 2   | 2  | —  |
| <b>Pollen</b>                   | Tricolpate; 24–46 x 20–35 µm  | Tricolpate; 20–25 µm Ø  | Pantoporate; 25–35 µm Ø or (65)100–200µm Ø  | 12-pantoporate; 17–30 µm Ø                      | 3–4 - or pantocolpate or 6-porate; 26–43 µm Ø                         | Tricolpate to pantocolpate; 20–40µm Ø  | —  |

**Table 1.2. Genera and species of the Nyctaginaceae occurring in Africa, north and tropical Africa, the *Flora Zambesiaca (FZ)* and *Flora of southern African (FSA)* regions and the surrounding islands (northern and southern islands).**

| Taxon  | Africa              |      | Tropical Africa  |               | FZ | FSA | Northern islands |            | Southern islands |   |
|--|---------------------|------|------------------|---------------|----|-----|------------------|------------|------------------|---|
|  | 1, 2, 3, 4, 6, 7, 8 | 1, 4 | 1, 3, 4, 6, 7, 8 | 1, 3, 4, 6, 7 |    |     | 2, 3, 4, 5, 8    | 1, 2, 3, 4 | 4                | 4 |
| <i>Boerhavia coccinea</i> Mill. var. <i>coccinea</i>                           | X                   | -    | X                | X             | X  | X   | -                | -          | X                |   |
| <i>Boerhavia coccinea</i> Mill. var. <i>pubescens</i> (Choisy) Cufod.          | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia cordobensis</i> Kuntze  | X                   | -    | X                | X             | -  | X   | -                | -          | -                |   |
| <i>Boerhavia crispifolia</i> Fosberg   | X                   | -    | -                | -             | -  | -   | -                | -          | X                |   |
| <i>Boerhavia deserticola</i> Codd  | X                   | -    | X                | X             | -  | X   | -                | -          | -                |   |
| <i>Boerhavia diffusa</i> L. var. <i>acuta</i> Balle                            | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia diffusa</i> L. var. <i>diffusa</i>                                | X                   | -    | X                | X             | X  | X   | -                | -          | X                |   |
| <i>Boerhavia diffusa</i> L. var. <i>ehrenbergerii</i> (Asch. & Graebn.) Cufod. | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia diffusa</i> L. var. <i>hirta</i> Balle                            | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia diffusa</i> L. var. <i>undulate</i> (Asch. & Graebn.) Cufod.      | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia elegans</i> Choisy  | X                   | X    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia erecta</i> L.   | X                   | -    | X                | X             | X  | X   | -                | -          | -                |   |
| <i>Boerhavia graminicola</i> Berhaut   | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |
| <i>Boerhavia hereroensis</i> Heimerl   | X                   | -    | -                | -             | -  | X   | -                | -          | -                |   |
| <i>Boerhavia repens</i> L. subsp. <i>diandra</i> (L.) Maire & Weiller          | X                   | -    | X                | X             | -  | -   | -                | -          | -                |   |

**Table 1.2. Genera and species of the Nyctaginaceae occurring in Africa, north and tropical Africa, the Flora Zambesiaca (FZ) and Flora of southern African (FSA) regions and the surrounding islands (northern and southern islands).**

| Taxon  | Africa              |      | Tropical Africa |               | FZ | FSA | Northern islands |   | Southern islands |   |
|--|---------------------|------|-----------------|---------------|----|-----|------------------|---|------------------|---|
|  | 1, 2, 3, 4, 6, 7, 8 | 1, 4 | 1, 3, 4, 6, 7   | 1, 3, 4, 6, 7 |    |     | 1, 2, 3, 4       | 4 | 4                |   |
| <i>Boerhavia repens</i> L. subsp. <i>repens</i>                                    | X                   | -    | X               | X             | X  | X   | -                | - | X                | X |
| <i>Commicarpus ambiguus</i> Meikle   | X                   | -    | X               | -             | -  | -   | -                | - | -                | - |
| <i>Commicarpus chinensis</i> (L.) Heimerl subsp. <i>chinensis</i>                  | X                   | X    | X               | -             | -  | -   | -                | - | -                | - |
| <i>Commicarpus chinensis</i> (L.) Heimerl subsp. <i>natalensis</i> Meikle          | X                   | -    | X               | X             | X  | X   | -                | - | -                | - |
| <i>Commicarpus decipiens</i> Meikle  | X                   | -    | -               | -             | -  | X   | -                | - | -                | - |
| <i>Commicarpus fallacissimus</i> (Heimerl) Heimerl ex Oberm., Schweick. & I. Verd. | X                   | -    | -               | -             | -  | X   | -                | - | -                | - |
| <i>Commicarpus fruticosus</i> Pohnert  | X                   | -    | -               | -             | -  | X   | -                | - | -                | - |
| <i>Commicarpus grandiflorus</i> (A. Rich.) Standl.                                 | X                   | -    | X               | X             | X  | -   | -                | - | -                | - |
| <i>Commicarpus greenwayi</i> Meikle  | X                   | -    | X               | -             | -  | -   | -                | - | -                | - |
| <i>Commicarpus helenae</i> (Roem. & Schult.) Meikle var. <i>barbatus</i> Meikle    | X                   | -    | X               | X             | -  | -   | -                | - | -                | - |
| <i>Commicarpus helenae</i> (Roem. & Schult.) Meikle var. <i>helenae</i>            | X                   | -    | X               | X             | X  | X   | X                | X | X                | X |
| <i>Commicarpus hiranensis</i> Thulin   | X                   | -    | X               | -             | -  | -   | -                | - | -                | - |

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| Taxon  | Africa              | North          | Tropical                | FZ            | FSA        | Northern     | Southern     |
|--|---------------------|----------------|-------------------------|---------------|------------|--------------|--------------|
|  | 1, 2, 3, 4, 6, 7, 8 | Africa<br>1, 4 | Africa<br>1, 3, 4, 6, 7 | 2, 3, 4, 5, 8 | 1, 2, 3, 4 | islands<br>4 | islands<br>4 |
| <i>Commnicarpus mistus</i> Thulin                      | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus montanus</i> Mirè & H. Gillet & Quézel | X                   | X              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus parviflorus</i> Thulin                 | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus pedunculatus</i> (A.Rich.) Cufod.      | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus pentandrus</i> (Burch.) Heimerl        | X                   | -              | X                       | X             | X          | -            | -            |
| <i>Commnicarpus pilosus</i> (Heimerl) Meikle           | X                   | -              | X                       | X             | X          | -            | X            |
| <i>Commnicarpus plumbagineus</i> (Cav.) Standl.        | X                   | -              | X                       | X             | X          | -            | -            |
| <i>Commnicarpus ramosissimus</i> Thulin                | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus raynaltii</i> J.-P. Lebrun & Meikle    | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus reniformis</i> (Chiov.) Cufod.         | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus sinuatus</i> Meikle                    | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Commnicarpus squarrosus</i> (Heimerl) Standl.       | X                   | -              | -                       | -             | X          | -            | -            |
| <i>Commnicarpus stenocarpus</i> (Choiv.) Cufod.        | X                   | -              | X                       | -             | -          | -            | -            |
| <i>Mirabilis jalapa</i> L.                             | X                   | X              | -                       | X             | X          | -            | X            |

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| Taxon   | Africa              | North  | Tropical      | FZ            | FSA        | Northern | Southern |
|---|---------------------|--------|---------------|---------------|------------|----------|----------|
|   | Africa              | Africa | Africa        |               |            | islands  | islands  |
| <i>Mirabilis viscosa</i> Cav.                             | 1, 2, 3, 4, 6, 7, 8 | 1, 4   | 1, 3, 4, 6, 7 | 2, 3, 4, 5, 8 | 1, 2, 3, 4 | 4        | 4        |
| <i>Phaeoptilum spinosum</i> Radlk.                        | X                   | -      | -             | -             | X          | -        | -        |
| <i>Pisonia aculeata</i> L.                                | X                   | -      | X             | X             | X          | -        | X        |
| <i>Pisonia costata</i> (Bojer ex Bouton) Choisy           | X                   | -      | -             | -             | -          | -        | X        |
| <i>Pisonia grandis</i> R. Br.                             | X                   | -      | X             | -             | -          | -        | X        |
| <i>Pisonia lanceolata</i> (Poiret) Choisy                 | X                   | -      | -             | -             | -          | -        | X        |
| <i>Pisonia umbellifera</i> (J.R. Forst. & G. Forst.) Seem | X                   | -      | -             | -             | -          | -        | X        |
| <i>Selinocarpus somalensis</i> Chiov.                     | X                   | -      | X             | -             | -          | -        | -        |

<sup>1</sup>African Plant Database (2011); <sup>2</sup>Germishuizen & Meyer (2003); <sup>3</sup>Klopper *et al.* (2006); <sup>4</sup>Meikle (1978); <sup>5</sup>Stannard (1988); <sup>6</sup>Thulin (1993); <sup>7</sup>Whitehouse (1996); <sup>8</sup>Mapaura & Timerlake (2004)

**North Africa:** Algeria, Canary islands, Egypt, Libya, Madeira, Mauritania, Morocco, Tunisia (African Plant Database, 2010); **Tropical Africa:** Angola, Benin, Burkina Faso, Burundi, Cabinda, Cameroon, Central African Republic, Chad, Cote D' Ivoire, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gabon, Gambia, Ghana, Guinea-Bissau, Guinea, Kenya, Liberia, Malawi, Mali, Mauritania, Mozambique, Niger, Nigeria, Senegal, Sierra Leone, Republic of the Congo, Rwanda, Somalia, Sudan, Tanzania, Togo, Uganda, Western Sahara, Zambia (Klopper *et al.*, 2006); **Flora Zambesiaca:** Botswana, Caprivi Strip, Malawi, Mozambique, Zambia, Zimbabwe (Anon, 2010); **Flora of southern Africa:** Botswana, Lesotho, Namibia, South Africa, Swaziland, Zimbabwe (Klopper *et al.*, 2006); **Northern Islands:** Islands occurring north of the equator. Canary islands, Cape Verde, Madeira, São Tome and Principe; **Southern Island:** Islands occurring south of the equator. Aldabra, Ascension, Comoros, Madagascar, Mauritius, Pemba, Seychelles, St. Helena, Réunion, Zanzibar

**Table 1.3. List of Nyctaginaceae genera and species occurring in southern Africa and their African distribution. (\* = alien, <sup>E</sup> = endemic) (Meikle, 1978; Stannard, 1988; Thulin, 1993; Whitehouse, 1996; Germishuizen & Meyer, 2003; Mapaura & Timerlake, 2004; Leistner, 2005; Klopper *et al.*, 2006; African Plant Database, 2011).**

| <b>Taxon</b>  | <b>Distribution</b>   |
|---|---|
| <i>Boerhavia coccinea</i> Mill. var. <i>coccinea</i>  | Botswana, Namibia, Mozambique, South Africa, Swaziland, Zimbabwe (and Tropical Africa)          |
| * <i>Boerhavia cordobensis</i> Kuntze   | Namibia, South Africa (and Tropical Africa)   |
| <sup>E</sup> <i>Boerhavia deserticola</i> Codd  | Namibia   |
| * <i>Boerhavia diffusa</i> L. var. <i>diffusa</i>   | Botswana, Namibia, Mozambique, South Africa, Swaziland, Zimbabwe (and Tropical Africa)          |
| * <i>Boerhavia erecta</i> L.  | Botswana, Namibia, Mozambique, South Africa, Swaziland, Zimbabwe (and Tropical Africa)          |
| <sup>E</sup> <i>Boerhavia hereroensis</i> Heimerl   | Namibia, South Africa (and Tropical Africa)   |
| <i>Boerhavia repens</i> L. var. <i>repens</i>   | Botswana, Namibia, South Africa, Zimbabwe (and Tropical Africa)                                 |
| <i>Commicarpus chinensis</i> (L.) Heimerl subsp. <i>natalensis</i> Meikle                       | Mozambique, South Africa (and Tropical Africa)  |
| <sup>E</sup> <i>Commicarpus decipiens</i> Meikle  | Botswana, Namibia, South Africa   |
| <sup>E</sup> <i>Commicarpus fallacissimus</i> (Heimerl) Heimerl ex Oberm., Schweick. & I. Verd. | Botswana, Namibia   |
| <sup>E</sup> <i>Commicarpus fruticosus</i> Pohnert  | Namibia   |
| <i>Commicarpus helenae</i> (Roem. & Schult.) Meikle var. <i>helenae</i>                         | Botswana, South Africa (and Tropical Africa)  |
| <i>Commicarpus pentandrus</i> (Burch.) Heimerl  | Botswana, Lesotho, Namibia, Mozambique, South Africa, Swaziland, Zimbabwe (and Tropical Africa) |
| <i>Commicarpus pilosus</i> (Heimerl) Meikle   | Botswana, Namibia, South Africa, Zimbabwe (and Tropical Africa)                                 |
| <i>Commicarpus plumbagineus</i> (Cav.) Standl.  | Botswana, Namibia, Mozambique, South Africa, Swaziland, Zimbabwe (and Tropical Africa)          |
| <sup>E</sup> <i>Commicarpus squarrosus</i> (Heimerl) Standl.                                    | Botswana, Namibia   |
| * <i>Mirabilis jalapa</i> L.  | Botswana, Namibia, Mozambique, South Africa, Zimbabwe (and Tropical Africa)                     |
| * <i>Mirabilis viscosa</i> Cav.   | Namibia   |
| <i>Phaeoptilum spinosum</i> Radlk.  | Botswana, Namibia, South Africa (and Tropical Africa)   |
| <i>Pisonia aculeate</i> L.  | Mozambique, South Africa (and Tropical Africa)  |

Tropical Africa as defined by Klopper *et al.* (2006) comprises countries south of the Sahara but excludes the following southern African countries: Botswana, Lesotho, Namibia, Mozambique, South Africa, Swaziland, Zimbabwe,

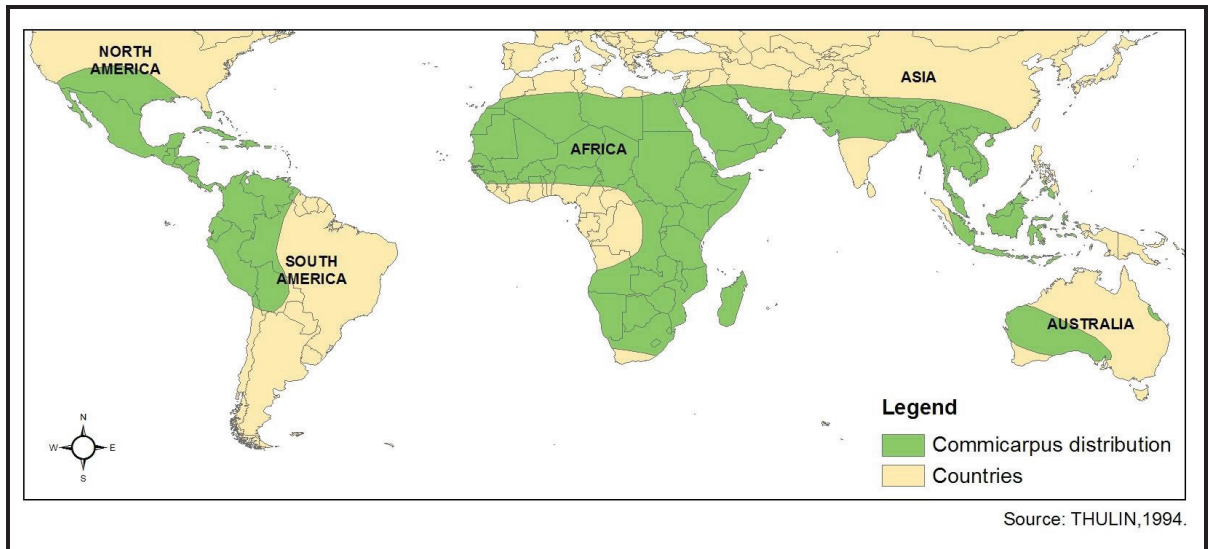


Figure 1.1: Map showing that *Commicarpus* is mainly distributed in Africa (Thulin, 1994).

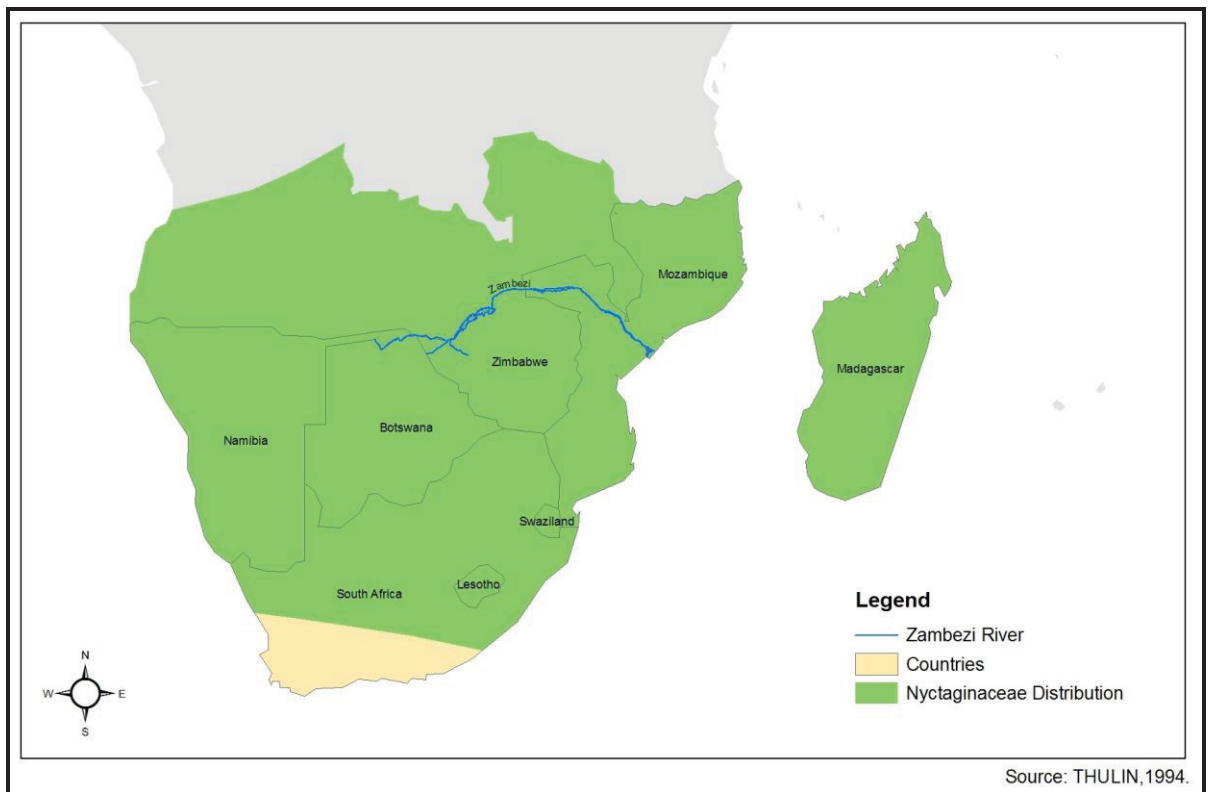


Figure 1.2: Map showing the distribution of the Nyctaginaceae in southern Africa and Madagascar (Thulin, 1994).





Figure 1.3: Typical growth form of *Boerhavia* (*B. diffusa* var. *diffusa*) (Photo: S.J. Siebert).



Figure 1.4: Typical growth form of *Commicarpus* (*C. pentandrus*) (Photo: S.J. Siebert).





Figure 1.5: Variation in the flower colour of *Mirabilis jalapa* (Photo: M. Struwig).



Figure 1.6: Winged fruit of *Phaeoptilum spinosum* (Photo: A.E. van Wyk ).



Figure 1.7: Branch of *Pisonia aculeata* (Photo: G. Nichols).