CHAPTER 4: MORPHOLOGY

4.1 Introduction

The Nyctaginaceae, a family which is commonly known as the Four-O'Clocks, comprises about 30 genera and 400 species (Mabberley, 1990; Zomlefer, 1994). It is mainly distributed throughout the tropical and subtropical regions of the New World (Bittrich & Kühn, 1993; Jordaan, 2000), with some genera extending into temperate parts such as southern Africa (Thulin, 1994).

4.1.1 Morphology of the Nyctaginaceae

The morphology of the family has been described by numerous authors (Standley, 1909; Standley, 1918; Riley, 1963; Bogle, 1974; Cronquist, 1981; Stannard, 1988; Bittrich & Kühn, 1993; Zomlefer, 1994; Whitehouse, 1996; Spellenberg, 2004). The family consists of annual or perennial herbs (that are often scandent), shrubs or trees. The stems are procumbent or erect, sometimes swollen at the nodes or with axillary spines. The leaves are opposite, alternate or whorled, sessile or petiolate, and linear to ovate or rounded with the margins entire to sinuate or repand. The blade is thin or slightly fleshy. The inflorescence is terminal or axillary, in panicles, cymes or umbels. The flowers are perfect or imperfect and apetalous. The calyx varies from small and inconspicuous to large and colorful. The stamens vary from 1–10 (–40) and are connate at the base forming a cup. The anthers are either included or exerted. The ovary is monocarpellate, unilocular and superior. The fruit is an achene or nutlet enclosed by the persistent perianth base, called an anthocarp.

The anthocarp morphology of the Nyctaginaceae is considered to be a particularly important taxonomic character to distinguish between taxa (Standley, 1918; Heimerl, 1934; Willson & Spellenberg, 1977). Smith (1976) used the presence and absence of wings on the anthocarp to distinguish between *Selinocarpus* A.Gray and *Acleisanthes* A.Gray. Codd (1966) stated that the anthocarps of the *Boerhavia* L. species which occur in southern Africa provide diagnostic features and Bohlin (1988) divided *Colignonia* Endl. into two sections based on the morphology of the perianth and anthocarp. Standley (1909; 1911; 1918) recognized *Alliona* L, *Allioniella* Rydb.,

Quamoclidion Choisy, *Hesperonia* Standl. and *Mirabilis* L. as genera in his 1909, 1911 and 1918 treatments of the North American Nyctaginaceae based on characters of the anthocarp, involucres and flowers.

4.1.2 Nyctaginaceae in southern Africa

In southern Africa, south of the Zambezi River, that is Botswana, Lesotho, southern Mozambique, Namibia, South Africa, Swaziland and Zimbabwe, five genera occur, namely *Boerhavia*, *Commicarpus* Standl., *Mirabilis* L., *Phaeoptilum* and *Pisonia* L. (Germishuizen & Meyer, 2003; Leistner, 2005). *Boerhavia* and *Commicarpus* are the most species-rich genera of this region, totaling 16 species (seven and nine respectively) of which six are endemic (Table 1.3).

4.1.3 Morphology of *Boerhavia* and *Commicarpus*

Boerhavia (Plate 1) and *Commicarpus* (Plate 2) are often confused with each other, but can be distinguished morphologically by their growth habit, shape of the flower and anthocarp structure (Meikle, 1978). *Boerhavia* has a diffuse habit, the flowers have a bell-shaped perianth, the anthocarp has either five ribs (a protruding enlargement of the anthocarp wall) or 3–5 wings (an enlarged proximal part of the rib), and the surface is either smooth or covered in multicellular trichomes (Stannard, 1988). *Commicarpus* has a scrambling or climbing habit, the flowers have a funnel-shaped perianth and the anthocarp has ten ribs covered in large, viscid and mucilaginous glands (Stannard, 1988).

Our existing knowledge of the taxonomy of these two genera in southern Africa is based on the descriptions and an identification key for *Boerhavia* by Codd (1966), and floras from elsewhere in Africa for *Commicarpus* (Baker & Wright, 1909; Hutchinson & Dalziel, 1927; Meikle, 1954; Stannard, 1988; Whitehouse, 1996). A few species of *Boerhavia* (*B. coccinea* var. *coccinea*, *B. cordobensis*, *B. diffusa*, *B. erecta* and *B. repens* subsp. *repens*) and *Commicarpus* (*C. chinensis* subsp. *natalensis*, *C. pentandrus*, *C. plumbagineus*) have featured in field guides (Table 4.1), but a lack of a complete treatment of species descriptions and regional identification keys for

Boerhavia and *Commicarpus* species in southern Africa have led to numerous misidentifications. This was especially evident when herbarium specimens from different herbaria were studied.

4.2 Aim

The aim of this chapter is to identify morphological characters that will allow for easy delineation of the southern African *Boerhavia* and *Commicarpus* genera and species. The growth form and leaf, inflorescence, flower and anthocarp morphology of the species will be described and compared to report on the taxonomic significance of these characters.

4.3 Materials and Methods

4.3.1 Collecting of plant material

Fresh plant material was collected *in situ* during 2009 and 2010 in Namibia and South Africa, and used for morphological investigations (Table 4.2). Voucher specimens were deposited in the A.P. Goossens Herbarium (PUC), Potchefstroom, South Africa, and duplicates of specimens collected in South Africa in the National Herbarium, Pretoria (PRE), South Africa and duplicates collected in Namibia in the National Herbarium (WIND) Windhoek, Namibia (Table 4.2). Photographs of plant growth forms, flowers and fruits were taken with a Canon EOS 350D and a 100 mm Sigma macrolens.

4.3.2 Leaves

Micrographs of the leaves were taken with a Canon 450D fitted with a 100 mm Sigma macro lens. Ten herbarium specimens per species were subjected to measurements (the length and breadth of the leaves as well as the length of the petioles). Three leaves and petioles of medium size were measured per specimen. Terminology describing the shape of the leaves follows Hickey & King (2000).

4.3.3 Flowers

Micrographs of the flowers were taken at 30x, 40x and 50x magnification with a Nikon Digital Camera DXM 1200 F fitted on a Nikon SMZ 1500 stereomicroscope. Flowers collected in 4% paraformaldehyde as well as flowers from herbarium specimens were dissected. Flowers from herbarium specimens were rehydrated for 10 min in boiling water. Three flowers per species were dissected and the length of the following parts measured: peduncle, pedicle, flower, upper and lower portions of the flower, stamens and ovary. The type of inflorescence and the terminology for the shape of the upper and the lower part of the flower follows Hickey & King (2000).

4.3.4 Anthocarp

Micrographs of the anthocarps were taken at 10x, 20x and 30x magnification with a Nikon Digital Camera DXM 1200 F fitted on a Nikon SMZ 1500 stereomicroscope. The length and width of three anthocarps each of ten herbarium specimens per species were measured. Terminology describing the anthocarp follows Hickey & King (2000).

4.4 Results

4.4.1 Growth form

4.4.1.1 *Boerhavia*

Boerhavia species are either annual or perennial and there are two types of growth forms (Table 4.3). *B. deserticola* and *B. hereroensis* are perennial, upright herbs. *B. deserticola* has numerous 1 m long stems from a basal rosette while those of *B. hereroensis* are diffuse and the branches ca. 40 cm long (Fig. 4.1A). The second growth form includes four species which are either annuals or perennials (*B. coccinea* var. *coccinea, B. cordobensis, B. diffusa* var. *diffusa, B. erecta*) and the annual *B. repens* subsp. *repens*. They are prostrate, procumbent or decumbent herbs (Fig. 4.1B).

4.4.1.2 *Commicarpus*

The *Commicarpus* species are all perennial and three growth forms are found (Table 4.3). *C. chinensis* subsp. *natalensis*, *C. decipiens*, *C. helenae* var. *helenae*, *C. pentandrus* and *C. plumbagineus* are herbaceous forbs with stems procumbent, decumbent or scrambling, sometimes upright (Fig. 4.2A). The second group includes *C. fruticosus* and *C. squarrosus*, which are semi-woody sub-shrubs of 0.6–1 m high (Fig. 4.2B). *C. fallacissimus* and *C. pilosus* make up the third group, with younger plants being herbaceous forbs and older plants tending towards a semi-woody sub-shrub growth form (Fig. 4.2C, D).

4.4.2 Leaf

4.2.2.1 *Boerhavia*

The shape of the leaves is variable (Table 4.4) and can be roughly divided into two groups. The leaves of *B. coccinea* var. *coccinea*, *B. cordobensis, B. diffusa* var. *diffusa* and *B. erecta* are roundish (ovate, oblong, orbicular, oval and obovate), while those of *B. deserticola, B. hereroensis* and *B. repens* subsp. *repens* are elongated (elliptic, linear and lanceolate). The leaf pairs at the nodes of *B. repens* subsp. *repens* differ in size with one leaf bigger than the other. The leaves of *B. diffusa* var. *diffusa* [(18–) 35 (–61) x (11–) 25 (–46) mm] are the largest in the group and those of *B. repens* subsp. *repens* [(10–) 19 (–30) x (6–) 10 (–16) mm] the smallest (Fig. 4.3).

4.2.2.2 *Commicarpus*

The shape of the leaves is variable (Table 4.4) and can be roughly divided into three groups. The leaves of *C. chinensis* subsp. *natalensis*, *C. helenae* var. *helenae, C. pentandrus* and *C. plumbagineus* are triangular (cordate, ovate and deltoid), those of *C. fruticosus, C. pilosus* and *C. squarrosus* are roundish (orbicular and ovate) and the those of *C. fallacissimus* and *C. decipiens* are elongated with a roundish base (lanceolate-ovate). The leaves of *C. chinensis* subsp. *natalensis* [(22–) 40 (–65) x (10–) 35 (–58) mm], *C. decipiens* [(20–) 32 (–57) x (10–) 18 (–37) mm] and *C. plumbagineus* [(26–) 49 (–87) x (16–) 35 (–68) mm] are the largest and those of *C.*

fruticosus [(15–) 22 (–33) x (10–) 17 (–31) mm], *C. pilosus* [(12–) 23 (–49) x (10–) 21 (–39) mm] and *C. squarrosus* [(10–) 17 (–30) x (8–) 13 (–27) mm]) the smallest (Fig. 4.4).

4.4.3 Inflorescence

4.4.3.1 *Boerhavia*

The inflorescence of the *Boerhavia* species is a much branched, compound cyme, consisting of a primary peduncle and anthoclinium with secondary peduncles and anthocliniums (Fig. 4.5). The primary peduncles are on average (20–) 87 (–150) mm long and the secondary peduncles (5–) 34 (–45) mm long (Table 4.5). The inflorescence of *B. diffusa* var. *diffusa* is the longest [primary peduncle (60–) 105 (–150) mm long; secondary peduncle (25–) 42 (–60) mm long], and the inflorescence of *B. repens* subsp. *repens* the shortest [primary peduncle (20–) 22 (–24) mm long, secondary peduncle (5–) 10 (–20) mm long[.

4.4.3.2 *Commicarpus*

The inflorescence of the *Commicarpus* species is an umbel, sometimes with up to four whorls of umbels together (Fig 4.6). The peduncles are on average (20–) 57 (–150) mm long, with the inflorescence of *C. fruticosus* the shortest [peduncle (25–) 30 (–32) mm long] and the inflorescence of *C. pentandrus* the longest [peduncle (30–) 79 (–150) mm long] (Table 4.5).

4.4.4 Flower

The flowers of both *Boerhavia* and *Commicarpus* can be divided into two parts, an upper petaloid part and a distinct lower, coriaceous part (Fig. 4.7). The lower part of the flower has five ribs (Fig. 4.7A), 3–5 wings or ten narrow, longitudinal grooves (Fig. 4.7B). It is either glabrous or covered in sessile or stalked glands or trichomes (Fig. 4.7B). The indumentum of the lower part of the flower is species specific, especially for the *Commicarpus* species. Indumentum refers to the covering of trichomes and/or glands on the base of the flower or the anthocarp.

4.4.4.1 *Boerhavia*

The flowers of the *Boerhavia* species are campanulate. They are (2–) 3 (–5) mm long, with the lower part (1–) 1.2 (–2) mm long and the upper part (1–) 1.4 (–4) mm long (Table 4.6). The flower of *B. deserticola* is the largest [(4–) 4.5 (–5)mm] and those of *B. erecta* [(2–) 2.1 (–3) mm], *B. diffusa* var. *diffusa* [(2–) 2.1 (–3) mm], and *B. repens* subsp. *repens* are the smallest [(2–) 2.3 (–3) mm]. The lower, coriaceous part is either elliptic (*B. coccinea* var. *coccinea* and *B. repens* subsp. *repens*), clavate (*B. cordobensis* and *B. erecta*), elliptic-clavate (*B. diffusa* var. *diffusa*) or oval (*B. deserticola* and *B. hereroensis*). The lower, coriaceous part has either five ribs (*B coccinea* var. *coccinea, B. deserticola*, *B. diffusa* var. *diffusa*, *B. hereroensis*, *B. repens* subsp. *repens*) or 3–5 wings (*B. cordobensis*, *B. erecta*) and can either be glabrous (*B. cordobensis*, *B. deserticola* and *B. erecta*) or covered with multicellular, glandular trichomes (*B. coccinea* var. *coccinea*, *B. diffusa* var. *diffusa*, *B. hereroensis*, *B. repens* subsp. *repens*) (Fig. 4.8). The upper petaloid part can be pink, purple or white (Table 4.6).

4.4.4.2 *Commicarpus*

The flowers of the *Commicarpus* species are infundibiliform. They are (5–) 11 (–14) mm long, with the lower part (2–) 3.1 (–7) mm long and the upper part (2–) 7.8 (–17) mm long (Table 4.6). The flowers of *C. chinensis* subsp. *natalensis* [(12–) 15 (–20) mm], *C. decipiens* [(11–) 15 (–20) mm], *C. pentandrus* [(12–) 15 (–23) mm] and *C. plumbagineus* [(10–) 10.4 (–20) mm] are the largest while the flowers of *C. helenae* var. *helenae* [(4–) 6 (–7) mm] are the smallest. The lower, coriaceous part is cylindrical (*C. chinensis* subsp. *natalensis*, *C. fallacissimus* and *C. plumbagineus*), clavate (*C. decipiens*, and *C. pentandrus*) or elliptic (*C. fruticosus, C. helenae* var. *helenae, C. pilosus* and *C. squarrosus*). The coriaceous part has ten narrow, longitudinal grooves with either five (*C. fruticosus, C. helenae* var. *helenae, C. pentandrus*, *C. pilosus* and *C. squarrosus*) or ten (*C. fallacissimus* and *C. plumbagineus*) prominent glands around the apex and less prominent glands scattered over the surface further below. In *C. chinensis* subsp. *natalensis* and *C. decipiens* the prominent glands around the apex are the least conspicuous (Fig. 4.9). The upper petaloid part can be coloured in white, pink or purple (Table 4.6).

4.4.5 Anthocarp

The anthocarp of *Boerhavia* has five conspicuous ribs and the anthocarp is either glabrous or it can be covered with trichomes (Fig. 4.10A). The anthocarp of *Commicarpus* has stalked and sessile glands around the apex with sessile glands scattered over the surface below (Fig. 4.10B).

4.4.5.1 *Boerhavia*

The anthocarps are (3–) 4 (–5) x 1–2 mm and are either clavate (*B. cordobensis* and *B. erecta*) or elliptic-clavate (*B. coccinea* var. *coccinea, B. deserticola*, *B. diffusa* var. *diffusa, B. hereroensis, B. repens* subsp. *repens*) (Table 4.7). The anthocarps have five ribs except for *B. cordobensis* which has 3–4 wings and *B. erecta* which has 5 wings. The anthocarps are either glabrous (*B. cordobensis*, *B. deserticola*, *B. erecta*) or covered with glandular trichomes (*B. coccinea* var. *coccinea*, *B. diffusa* var. *diffusa*, *B. hereroensis*, *B. repens* subsp. *repens*). The anthocarp of *B. diffusa* var. *diffusa* has a characteristic indentation near the apex (indicated with a white arrow on Fig. 4.11G). The anthocarp of *B. coccinea* var. *coccinea* is the longest [(3–) 4.1 (–5) mm long] and that of *B. cordobensis* the broadest [(2–) 2.3 (–3) mm broad] (Fig. 4.11).

4.4.5.2 *Commicarpus*

The anthocarps are (5–) 7(–10) x 2–3 mm and the shape varies from cylindrical (*C. chinensis* subsp. *natalensis*), to fusiform (*C. fallacissimus, C. fruticosus, C. plumbagineus, C. squarrosus*), to clavate (*C. decipiens, C. helenae* var. *helenae*, *C. pentandrus*) and elliptic clavate (*C. pilosus*) (Table 4.7). The apex is surrounded by ten stalked glands (*C. fallacissimus, C. plumbagineus)* or five stalked glands alternating with five sessile glands (*C. fruticosus, C. helenae* var. *helenae, C. pentandrus, C. squarrosus*), five stalked glands (*C. pilosus)* or five sessile glands (*C. chinensis* subsp. *natalensis*, *C. decipiens*). *C. decipiens* has shortly stalked glands around the apex that appear sessile. The stalked glands around the apex of *C. helenae* var. *helenae* can be either short (1 mm) or long (2 mm). Below the apex sessile wart-like glands are scattered over the surface. The anthocarp of *C. chinensis* subsp.

natalensis is the longest [(8–) 8.7 (–10) mm long] and that of *C. decipiens* the broadest [(2–) 2.8 (–7) mm broad] (Fig. 4.12).

4.6 Discussion

Leaf shape is of taxonomic significance within *Mirabilis* section *Mirabilis* (Le Duc, 1995) and Fowler & Turner (1977) distinguished the different *Selinocarpus* species by, among other characters, the leaf shape. Meikle (1978), however, stated that all the *Commicarpus* species are superficially similar in growth form and foliage, and various authors (Stannard, 1988; Whitehouse, 1996; Spellenberg, 2004; Chen & Wu 2007) report that the *Boerhavia* species are extremely polymorphic. Likewise, the *Boerhavia* and *Commicarpus* species studied in this chapter are very similar in growth form and foliage, both within and between genera, and cannot be easily identified based on these two characters alone.

Growth form and foliage are, however, useful to divide the species into small groups, which can make for easier identification. On the basis of growth form and foliage the *Boerhavia* species can be divided into two groups. *B. deserticola* and *B. hereroensis* can be distinguished from the other *Boerhavia* species by their upright growth form and elongated, elliptic-lanceolate leaves. *B. coccinea* var. *coccinea*, *B. cordobensis*, *B. diffusa* var. *diffusa*, *B. erecta* and *B. repens* subsp. *repens* has a prostrate, decumbent or procumbent growth form with roundish leaves (ovate, oblong, orbicular, oval or obovate). *B. repens* subsp. *repens* can however, be easily distinguished from the other *Boerhavia* species by its small (less than 30 mm) leaves of variable sizes at the nodes.

Growth form allows for the *Commicarpus* species to be divided into two groups. *C. fallacissimus*, *C. fruticosus*, *C. pilosus* and *C. squarrosus* have a similar subshrub growth form, while *C. chinensis* subsp. *natalensis*, *C. decipiens*, *C. helenae* var. *helenae*, *C. pentandrus* and *C. plumbagineus* are herbaceous. The shape and size of the foliage divide *Commicarpus* into three groups. *C. fruticosus, C. pilosus* and *C. squarrosus* have small, roundish leaves (orbicular and ovate), *C. chinensis* subsp. *natalensis*, *C. helenae* var. *helenae*, *C. pentandrus* and *C. plumbagineus* have larger, triangular leaves (cordate, ovate, deltoid) and *C. fallacissimus* and *C. decipiens* have elongated leaves with a roundish base.

Boerhavia and *Commicarpus* can easily be distinguished from one another by their inflorescences and flowers. The inflorescences of the *Boerhavia* species are compound cymes while those of the *Commicarpus* species are umbels. The flowers are campanulate with five ribs or 3–5 wings on the lower, coriaceous part in *Boerhavia* and infundibiliform with ten, narrow longitudinal grooves on the lower, coriaceous part in *Commicarpus*. The indumentum of the lower, coriaceous part of the flower proved to be species specific, especially so for *Commicarpus* species (Struwig *et al*., in press). However, this character was not helpful for distinguishing between *C. fruticosus* and *C. squarrosus* which are similar. In *Boerhavia*, groups of species could be distinguished based on the coriaceous part of the flowers, but it did not prove conclusive up to species level. For instance, three species of one group had very similar flowers (*B. coccinea* var. *coccinea, B. diffusa* var. *diffusa* and *B. repens* subsp. *repens*). The presence of glandular hairs in the area between the ribs in *B. coccinea* var. *coccinea* and *B. repens* subsp. *repens* separated these species from *B. diffusa* var. *diffusa* where these hairs are present on the ribs. It is therefore necessary to use additional characters, such as the anthocarp, when distinguishing between these species. Flower morphology, on its own, is therefore not conclusive.

After pollination and fertilization, the upper part of the flower falls off and the lower, coriaceous part enlarges and develops into the protective structure around the fruit, called the anthocarp (Joshi & Rao, 1934; Vanvinckenroye *et al*., 1993; Hickey & King, 2000). The size, shape and indumentum of the anthocarp are distinctive for most taxa and are not only used to distinguish between different genera [e.g. *Tripterocalyx* (Torr.) Hook. and *Abronia* Juss. (Galloway, 1975)], but also between different species [e.g. the different species of *Abronia* (Wilson, 1974), *Allionia* L. (Tuner, 1994), *Anulocaulis* Standl. (Spellenberg, 1993) and *Colignonia* Endl. (Bohlin, 1988)]. The anthocarp morphology of the southern African *Boerhavia* and *Commicarpus* species is distinct, regarding the two genera and the different species.

The anthocarps of *Boerhavia* are clavate or elliptic-clavate with five conspicuous ribs or 3–5 wings, while the anthocarps of *Commicarpus* are cylindrical, fusiform, clavate or elliptic-clavate with stalked and sessile glands around the apex and sessile glands over the surface below. The shape of the anthocarp and the arrangement of the glands are species specific for *Commicarpus* (Struwig *et al.*, 2011), except for the anthocarps

of *C. fruticosus* and *C. squarrosus,* which are similar, therefore making them indistinguishable. *B. deserticola* and *B. hereroensis* are endemic to southern Africa (Germishuizen & Meyer, 2003; Klopper *et al*., 2006), and the ribs on their anthocarps are broader than the ribs on the anthocarps of the other *Boerhavia* species occurring in southern Africa. The anthocarps of *B. diffusa* var. *diffusa* have a characteristic indentation at the apex and the apexes of *B. cordobensis*, *B. diffusa* var. *diffusa* and *B. erecta* end in a pointed tip, whereas the apexes of the other *Boerhavia* species (*B. coccinea* var. *coccinea*, *B. deserticola*, *B. hereroensis* and *B. repens* subsp. *repens*) are rounded. *B. cordobensis*, *B. diffusa* var. *diffusa* and *B. erecta* are aliens from America (Codd, 1966; Bromilow, 2010) and, based on anthocarp structure, form a morphological group distinguishable from the southern African Boerhavias.

Phylogenetic studies (Levin, 2000; Douglas and Manos, 2007) showed that flower and anthocarp characters are homoplasious in the Nyctaginaceae, which led to artificial groupings such as *Acleisanthes*, *Ammocodon* Standl. and *Selinocarpus* as separate genera (Levin, 2000). *Boerhavia* and *Commicarpus* are however, monophyletic groups (Douglas & Manos, 2007; Hernández-Ledesma *et al*., 2010) and the ten-ribbed anthocarps evolved from an ancestral five-ribbed anthocarp (Hernández-Ledesma *et al*., 2010). The lower, coriaceous part of the flower of the non-southern Africa species of *Boerhavia* and *Commicarpus* should also be investigated to test the validity of this character as distinctive for the classification of species. Anthocarp morphology of these species should also be thoroughly documented.

Commicarpus fruticosus and *C. squarrosus* are both sub-shrubs with similar morphologies. The leaves, flowers and anthocarps are similar in shape, size range and indumentum (refer to tables 4.3–4.5). The only difference between the two species is the dark purple colour of the flowers of *C. fruticosus* while those of *C. squarrosus* are of a lighter purple. The morphological similarities call into question the validity of recognizing two different species. Merxmuller (1969) sunk *C. fruticosus* into *C. squarrosus*, but this change is not recognized (Nowicke, 1970; Germishuizen & Meyer, 2003; Klopper *et al*., 2006; African Plant Database, 2011). Molecular studies (Chapter 7) should give an indication as to the genetic similarity between the two species and the need for a change in specific rank.

4.7 Identification keys

The following keys, based on morphological characters, especially the anthocarp, are therefore proposed to distinguish between the genera and species:

4.7.1 Key to distinguish between *Boerhavia* and *Commicarpus*

1a Inflorescence a compound cyme; flowers (2–) 3 (–5) mm long, campanulate; flower base with five ribs or 3or 4 wings, without wart-like glands; anthocarp elliptic-clavate or clavate, (3–) 4 (–5) mm long, five-ribbed or 3–5 winged, without wart-like glands … *Boerhavia*

1b Inflorescence an umbel; flowers (5–) 11 (–14) mm long, infundibiliform; flower base with ten ribs and wart-like glands scattered over the surface (especially around the apex); anthocarp cylindrical, fusiform, clavate, elliptic-clavate, (5–) 7 (–10) mm long, 10-ribbed with wart-like glands around the apex and the surface below…*Commicarpus*

4.7.2 Key to the species of *Boerhavia*

1a Growth form erect; leaves elongated, elliptic-lanceolate …2

1b Growth form prostrate, decumbent or procumbent; leaves roundish (oblong, obovate, orbicular, ovate, oval) …3

2a Lower, coriaceous part of the flower and the anthocarp covered by long, glandular hairs; growth form diffuse, branches ± 40 cm long … *B*. *hereroensis*

2b Lower, coriaceous part of the flower and the anthocarp glabrous; long stems (± 1 m) from basal rosette … *B*. *deserticola*

3a Anthocarp and lower, coriaceous part of the flower clavate and glabrous …4

3b Anthocarp and lower, coriaceous part of the flower elliptic-clavate and covered with glandular hairs …5

4a Lower coriaceous part of the flower 3 or 4-ribbed with the apexes of the ribs expanded; anthocarps 3 or 4-winged, apex broadly truncate … *B*. *cordobensis*
4b Lower coriaceous part of the flower 5-ribbed; anthocarps 5-winged, wings undulate, apex truncate … *B*. *erecta*

5a Anthocarp 5-ribbed, with an indentation near the apex, apex ends in a pointed tip; lower part of the flower 5-ribbed, glandular hairs on the ribs … *B*. *diffusa* var. *diffusa*
5b. Anthocarp 5-ribbed, with rounded apex; lower part of the flower 5-ribbed, glandular hairs in the area between the ribs … 6

6a Growth form decumbent or prostrate, leaves more than 30 mm long; anthocarps narrowly elliptic-clavate, 3–5 mm long … *B*. *coccinea* var. *coccinea*
6b Growth form prostrate, leaves less than 30 mm long; anthocarps elliptic-clavate, 3–4 mm long … *B*. *repens* subsp. *repens*

4.7.3 Key to the species of *Commicarpus* (adapted from Struwig *et al*., 2011):

1a Growth form subshrub …2
1b Growth form herbaceous …4

2a Flower base elliptic, five prominent sessile glands around the apex; anthocarp elliptic-clavate tapering to both ends, five shortly stalked glands around the apex …*C*. *pilosus*
2b Flower base cylindrical or ellitic-clavate, ten shortly stalked glands or 5 shortly stalked glands alternating with 5 sessile glands around the apex; anthocarp fusiform, ten shortly stalked glands or 5 shortly stalked glands alternating with 5 sessile glands around the apex ...3

3a Apex of the anthocarp surrounded by ten stalked glands; base of the flower cylindrical with ten shortly stalked, prominent glands around the apex … *C. fallacissimus*

3b Apex of the anthocarp surrounded by five stalked glands alternating with five sessile glands; base of the flower broadly elliptic with five shortly stalked, prominent glands alternating with five sessile, less prominent glands around the apex …*C. squarrosus*

4a Flower base cylindrical; anthocarp cylindirical or fusiform …5

4a Flower base elliptic or clavate; anthocarp clavate …6

5a Anthocarp cylindrical with sessile glands around the apex and prominent sessile glands scattered over the surface below the apex; sessile glands scattered over the surface of the flower base, flowers pink …*C. chinensis* subsp. *natalensis*

5b Anthocarp fusiform with a ring of ten stalked glands around the apex and a few shortly stalked glands below the apex grouped together; ten prominent, sessile glands around the apex of the flower base with a few glands scattered on the surface below, flowers white ...*C. plumbagineus*

6a Flower base elliptic with five shortly stalked, prominent glands around the apex; anthocarp clavate, tapering noticeably from apex to base, apex surrounded by five thin, long stalked (1–2 mm long) glands alternating with five sessile glands, 1 or 2 rings of sessile glands on the surface below the apex …*C. helenae* var. *helenae*

6b Flower base clavate, one or two rows of prominent sessile glands around the apex, or the surface covered sessile glands; anthocarp clavate, five shortly stalked glands around the apex, or five thickly stalked glands alternating with five smaller, less prominent glands ...7

7a Anthocarp broadly clavate with five shortly stalked glands around the apex, surface covered with prominent glandular hairs; surface of flower base covered with glandular hairs and glands, flowers white …*C. decipiens*

7b Anthocarp clavate with five thickly stalked glands alternating with five smaller, less prominent glands around the apex; one or two rows of five prominent sessile glands around the apex of the flower base, flowers purple or pink …*C. pentandrus*

4.8 Summary

In southern Africa, *Boerhavia* and *Commicarpus* are two distinct genera which differ morphologically from each other on the basis of:

- growth form: *Boerhavia* species are upright or spreading herbs while *Commicarpus* species are subshrubs, speading or scrambling herbs.
- inflorescence type: a compound cyme in *Boerhavia* and an umbel in *Commicarpus*.
- shape of the upper part of the flower: campanulate in *Boerhavia* and infundibiliform in *Commicarpus.*
- shape and indumentum of the lower part of the flowers: in *Boerhavia* it is 5-ribbed or 3–5-winged, glabrous or covered with multicellular, glandular trichomes while in *Commicarpus* it is ten-ribbed with 5–10 prominent glands around the apex and less prominent glands below the apex.
- shape and indumentum of the anthocarp: in *Boerhavia* it is clavate or elliptic-clavate, five ribbed or 3–5-winged, glabrous or covered in trichomes. In *Commicarpus* it is cylindrical, fusiform, clavate or elliptic-clavate, 10-ribbed with sessile or stalked glands.

Morphologically, seven species of *Boerhavia* and eight species of *Commicarpus* can be distinguished. This study reports for the first time that *Boerhavia* and *Commicarpus* species can be distinguished from one another based on the lower, coriaceous part of the flower, as the arrangement of the glands, ribs and trichomes is species specific. It is also an indication of the later arrangement of the glands, ribs and trichomes of the mature anthocarp and is therefore a taxonomic character which can be used to distinguish between non-fruiting specimens in flower. The anthocarp provides the most valuable taxonomic character by which to distinguish the different species. The shape of the anthocarp, the ribs and the presence of the trichomes are species specific for *Boerhavia* and the shape of the anthocarp and the arrangement of the stalked glands around the apex, together with the arrangement of the wart-like glands below the apex, are species specific for *Commicarpus*. Growth form and foliage are very similar within the genera, but classifies the various *Boerhavia* and *Commicarpus* species into smaller groups, which can make identification easier.

Table 4.1. *Boerhavia* and *Commicarpus* species featured in field guides.

Taxon	Field Guide
Boerhavia coccinea var. *coccinea*	Van der Walt (2009), pp. 76.
Boerhavia cordobensis	Van der Walt (2009), pp. 238.
Boerhavia diffusa	Bromilow (2010), pp. 200; Botha (2001), pp 284; Van Wyk & Wink (2004), pp. 401; Pooley (1998), pp. 378.
Boerhavia erecta	Bromilow (2010), pp. 200; Botha (2001), pp 284.
Boerhavia repens subsp. *repens*	Van der Walt (2009), pp. 238; Van Rooyen (2001), pp. 126.
Commicarpus chinensis subsp. *natalensis*	Bandeira *et al*. (2007), pp. 78; Pooley (1998), pp. 378.
Commicarpus pentandrus	Germishuizen & Clarke (2003), pp. 159; Van der Walt (2009); pp. 239; Pooley (1998), pp. 378; Van Wyk (2000), pp. 106; Letty (1962), pp. 128.
Commicarpus pilosus	Van der Walt (2009), pp. 239. (Erroneously named *C. pentandrus*)
Commicarpus plumbagineus	Van der Walt (2009), pp. 77; Pooley (1998), pp. 378.

Table 4.2. Specimens of *Boerhavia* and *Commicarpus* examined for the morphology and measurements of the leaves, flowers and anthocarps.

Taxon	Specimens examined	Herbarium
Boerhavia coccinea var. *coccinea*	Acocks, J.P.H. 1985	KMG
	Burgoyne, P.M. 3499	PRE, WIND
	Roodt, V. 313	PRE
	Struwig , M. 55	PUC, WIND
	Struwig, M. 67	PUC, WIND
	Struwig, M. 68	PUC, WIND
	Struwig, M. 75	PUC, WIND
	Struwig, M. 77	PUC, WIND
	Struwig, M. 81	PUC, WIND
	Theron, G.K. 2795	PRE
Boerhavia cordobensis	Bosch, M. 61	KMG
	Gotze, A. 146	PUC
	Leistner, O.A. 938	KMG, PRE
	Meyer, J.J. 3420	PRE
	Retief, E. & Germishuizen, G. 27	PRE
	Siebert, S.J. 3962	PUC
	Straub C.C. 499	PRE
	Straub, C.C. 808	PRE
	Struwig, M. 82	PUC, WIND
	Struwig, M. 132	PUC, PRE
	Zietsman, P.C. 4105	PRE
Boerhavia deserticola	Baker, L. 29	PRE, WIND
	Gindrig, T. & Henning, Z. 60	PRE, WIND
	Muller, M.A.N. & Giess, J.W.H. 357	PRE
	Muller, M.A.N. & Giess, J.W.H.387	PRE
	Merxmüller, H. & Giess, J.W.H. 30622	PRE
	Struwig, M. 38	PUC, WIND
	Struwig, M. 42	PUC, WIND
	Struwig, M. 43	PUC, WIND
	Urschler, I s.n.	PRE
	Van Wyk, A. E. 692	PUC
Boerhavia diffusa var. *diffusa*	Acocks, J.P.H. 8578	BOL
	Germishuizen, G. 7575	PRE, WIND
	Lessing, P. 58	PRE
	Roodt, V. 228	PRE
	Siebert, S.J. 3490	PUC
	Siebert, S.J. 3965	PUC
	Struwig, M. 66	PUC, WIND
	Struwig, M. 70	PUC, WIND
	Struwig, M. 74	PUC, WIND
	Struwig, M. 85	PUC, PRE
	Struwig, M. 88	PUC, PRE
	Struwig, M. 89	PUC, PRE
	Struwig, M. 90	PUC, PRE
	Struwig, M. 91	PUC, PRE
	Struwig, M. 174	PUC, WIND
	Struwig, M. 178	PUC, WIND
Boerhavia erecta	Balkwill, K., McCallum, D.A. & Campbell-Young, C.G. 10840	J
	Du Preez, P. 125	PRE
	La Grange, M. & Lubbe, R. 11	PUC
	Motsami, J. 4958	PRE
	Retief, I.M. 567	PRE
	Siebert, S.J. 3964	PUC
	Struwig, M. 23	PUC, PRE
	Struwig, M. 133	PUC, PRE
	Struwig, M. 135	PUC, KSAN
	Cilliers, S.S. s.n.	PUC
	Van Wyk, A.E. & Siebert, S.J. 1341	J

Table 4.2. Specimens of *Boerhavia* and *Commicarpus* examined for the morphology and measurements of the leaves, flowers and anthocarps.

Taxon	Specimens examined	Herbarium
Boerhavia hereroensis	Craven, P. 718	PUC
	Germishuizen, G. 2527	PRE
	Hanekom, W.J. 354	PRE, WIND
	Hardy, D.S.2025	PRE
	Marloth, R. 1403	BOL
	Pearson, H.H.W. 8474	BOL
	Seydel, R. 1436	PRE
	Struwig, M. 34	PUC, WIND
	Struwig, M. 35	PUC, WING
	Struwig, M. 40	PUC, WIND
	Wilman, M. s.n.	KMG
Boerhavia repens var. *repens*	Acocks, J.P.H. 1978	KMG
	Acocks, J.P.H. 21788	PRE
	Immelman, K.L. 588	PRE
	Kolberg, H.H. HK1006	PRE, WIND
	Leistner, O.A. 1783	KMG, PRE
	Merxmüller, H. & Giess, W. 30306	PRE
	Mucina, L. s.n.	PRE
	Straub, C.C. 833	PRE
	Struwig, M. 69	PUC, WIND
	Theron, G.C. 772	PRE
	Theron, G.K. 2797	PRE
Commicarpus chinensis subsp. *natalensis*	Abbott, A. 6966	KZN
	Buthelezi, C.N. 443	KZN
	Lubbe, R.A. 368	KZN
	MacDevette, K. 162	KZN
	Pentz & Acocks. 10444	PRE
	Steyn, E. 38	KZN
	Struwig, M. 60	PUC, KZN
	Struwig, M. 61	PUC, KZN
	Struwig, M. 62	PUC, KZN
	Struwig, M. 63	PUC, KZN
	Struwig, M. 86	PUC, KZN
	Struwig, M. 87	PUC, KZN
	Weisser, P.J. 7956	KZN
	Moll E.J. 2913	NU, PRE
Commicarpus decipiens	Hanekom, W.J. 351	PRE
	Immelman, K.L. 453	PRE
	Struwig, M. 47	PUC, WIND
	Struwig, M. 51	PUC, WIND
	Wanntorp, H. & H.E. 605	PRE
Commicarpus fallacissimus	Germishuizen, G. 9553	PRE
	Kerfoot, O. 7748	J
	Struwig, M. 33	PUC, WIND
	Struwig, M. 46	PUC, WIND
	Struwig, M. 58	PUC, WIND
	Struwig, M. 165	PUC, WIND
Commicarpus fruticosus	Struwig, M. 59	PUC, WIND
	Struwig, M. 160	PUC, WIND
	Struwig, M. 163	PUC, WIND
	Struwig, M. 164	PUC, WIND
Commicarpus helenae var. *helenae*	Biol Afd. 4592	KNP
	Maurin, O. & Van der Bank, M. OM 348	KNP
	Straub, A. 831	PRE
	Drummond, R.B. & Seagrief, S.C. 5247	PRE
	Struwig, M. 44	PUC, WIND
	Struwig, M. 183	PUC, WIND
	Zambatis, N. 1954	KNP
Commicarpus pentandrus	Bredenkamp, G. & Van Vuuren, D.R.J. 9	PRE
	De Winter, B. 2527	PRE
	Dyer, R.A. & Verdoorn, I.C. 3422	PRE
	Germishuizen, G. 7431	PRE

Table 4.2. Specimens of *Boerhavia* and *Commicarpus* examined for the morphology and measurements of the leaves, flowers and anthocarps.

Taxon	Specimens examined	Herbarium
Commicarpus pentandrus	Giess, W. 12612	PRE
	Götze, A.R. 247	PUC
	Hansen, O.J. 3555	PRE
	Louw, W.J. 1279	PRE, PUC
	Louw, W.J. 2008	PUC
	Wedermann, E. & Oberdieck, H.D. 2318	PRE
	Klein, R.G. 91	PRE
	Lewis, G.J. 363	PRE
	Moraile, J. 4879	BLFU
	Raal, P. 664	PRE
	Reid, C. 108	PRE
	Struwig, M. 48	PUC, WIND
	Struwig, M. 57	PUC, WIND
	Struwig M. 131	PUC, PRE
	Tinley, K.L. 1286	PRE
Commicarpus pilosus	Allen, A X349	J
	Kerfoot & Falconer. 72	J
	Kluge, J.P. 2481	PRE
	Kruger, P.R. 311	PRE
	Leach, L.C. 10664	PRE
	Obermeyer, A.A., Schweickerd, H.G.W.J. & Verdoorn, I.C. 103	PRE
	Raal, P. & Raal, G. 676	PRE
	Seydel, R.H.W. 4344	PRE
	Seydel, R.H.W. 4488	PRE
	Straub, C.C.609	PRE
	Struwig, M. 111	PUC, PRE
Commicarpus plumbagineus	Alward, R.D. 37	PRE
	Compton, R.H. 31467	PRE
	Croeser, P.M. 52	PRE
	Edwards, D. 4367	PRE
	Galpin, E,E, 13690	PRE
	Herman, P.P.J. 753	PRE
	Hines, C.J.H. 953	PRE
	Pope, G.V. 327	PRE
	Siebert, S.J. 3969	PUC
	Siebert, S.J. 3970	PUC
	Straub, C.C.611	PRE
	Straub, C.C. 679	PRE
	Strey, R.G. & Moll, E.J. 3705	PRE
	Struwig, M. 113	PUC, PRE
	Struwig, M. 126	PUC, PRE
Commicarpus squarrosus	Barnard, S.A. 85	PRE
	Craven, P. 490	PUC
	Hardy, D.S. 7017	PRE, WIND
	Müller, M.A.N & Tilson 894	PRE
	Müller, M.A.N 1362	PRE
	Rodin, R.J. 2833 & Stray, R. 2132	BOL
	Range, P. 1283	BOL
	Struwig, M. 39	PUC, WIND
	Struwig, M. 41	PUC, WIND
	Struwig, M. 45	PUC, WIND

Table 4.3. Growth forms of the southern African *Boerhavia* and *Commicarpus* species.

Taxon	Growth form
Boerhavia coccinea var. *coccinea*	Annual or perennial, herb, decumbent, prostrate
Boerhavia cordobensis	Annual or perennial, herb, decumbent, prostrate
Boerhavia deserticola	Perennial, herb, upright, numerous 1 m long stems from a basal rosette
Boerhavia diffusa var. *diffusa*	Annual or perennial, herb, decumbent, diffuse, prostrate
Boerhavia erecta	Annual or perennial, herb, decumbent, prostrate
Boerhavia hereroensis	Perennial, herb, branches upright, diffuse
Boerhavia. repens subsp. *repens*	Annual, herb, prostrate
Commicarpus chinensis subsp. *natalensis*	Perennial, herb, procumbent or scrambling
Commicarpus decipiens	Perennial, herb, branches upright, decumbent or scrambling
Commicarpus fallacissimus	Perennial, herb to sub-shrub, branches upright, decumbent
Commicarpus fruticosus	Perennial, sub-shrub
Commicarpus helenae var. *helenae*	Perennial, herb, branches upright, procumbent
Commicarpus pentandrus	Perennial, herb, prostrate, procumbent
Commicarpus pilosus	Perennial, herb to sub-shrub, decumbent
Commicarpus plumbagineus	Perennial, herb, procumbent, prostrate, scrambler
Commicarpus squarrosus	Perennial, sub-shrub

Table 4.4. Leaf measurements, shape and petiole length of the southern African *Boerhavia* and *Commicarpus* species.

Taxon	Measurement (mm)	Shape	Apex	Base	Margin	Petiole (mm)
Boerhavia coccinea var. *coccinea*	(11–) 27 (–42) x (9–) 18 (–33)	Elliptic, oblong, ovate, lanceolate, oval	Rounded, acute, apiculate	Rounded, shortly attenuate	Entire	(3–) 9 (–25)
Boerhavia cordobensis	(14–) 25 (–47) x (8–) 16 (–34)	Deltoid, oblong, lanceolate, elliptic, ovate	Obtuse, acute, acuminate, apiculate	Obtuse, truncate	Entire, undulate	(3–) 10 (–25)
Boerhavia deserticola	(15–) 31 (–55) x (5–) 15 (–34)	Elliptic, lanceolate, ovate	Apiculate, rounded, acute	Shortly attenuate	Undulate	(6–) 17 (–41)
Boerhavia diffusa var. *diffusa*	(18–) 35 (–61) x (11–) 25 (–46)	Ovate, elliptic, oblong, orbicular, lanceolate, obovate	Apiculate, acuminate, rounded, obtuse	Shortly attenuate, obtuse	Entire, undulate	(8–) 17 (–33)
Boerhavia erecta	(15–) 32 (–51) x (10–) 20 (–29)	Oblong, lanceolate, elliptic, deltoid, ovate	Apiculate, acuminate, acute, obtuse	Shortly attenuate, obtuse, truncate	Entire, undulate	(5–) 15 (–35)
Boerhavia hereroensis	(18–) 31 (–41) x (5–) 12 (–34)	Elliptic, lanceolate, ovate, linear	Apiculate	Shortly attenuate, rounded	Entire, undulate	(7–) 16 (–38)
Boerhavia repens subsp. repens	(10–) 20 (–30) x (6–) 11 (–16)	Lanceolate, elliptic, ovate, oblong	Apiculate, acuminate, rounded	Obtuse	Entire, undulate	(3–) 9 (–20)
Commicarpus chinensis subsp. *natalensis*	(22–) 40 (–65) x (19–) 35 (–58)	Deltoid, ovate, cordate	Acute, apiculate	Cordate	Entire, repand	(8–) 19 (–38)
Commicarpus decipiens	(20–) 32 (–57) x (10–) 18 (–37)	Ovate, elliptic	Acute, acuminate, apiculate	Rounded to shortly attenuate	Entire	(5–) 8 (–14)
Commicarpus fallacissimus	(24–) 36 (–48) x (8–) 20 (–28)	Ovate, elliptic, cordate	Apiculate, acute	Shortly attenuate, obtuse, cordate, almost truncate	Entire, repand	(5–) 10 (–20)
Commicarpus fruticosus	(15–) 22 (–33) x (10–) 18 (–31)	Ovate, orbicular, lanceolate, trullate, elliptic, spathulate,	Apiculate, acuminate, rounded	Shortly attenuate, obtuse	Entire	(10–) 17 (–28)
Commicarpus helenae var. *helenae*	(18–) 28 (–58) x (13–) 22 (–38)	Deltoid, ovate	Apiculate, rounded to acute, acuminate	Shortly attenuate, cordate, subcordate, obtuse, truncate	Entire, repand	(4–) 10 (–22)
Commicarpus pentandrus	(13–) 27 (–39) x (13–) 20 (–29)	Ovate, elliptic, orbicular, deltoid	Acute, apiculate, rounded	Cordate, truncate, cuneate, rounded, obtuse, subcordate, shortly attenuate	Entire	(4–) 8 (–12)
Commicarpus pilosus	(12–) 23 (–49) x (10–) 21 (–39)	Cordate, ovate, oval, orbicular, oblong	Apiculate, rounded, acute	Shortly attenuate to rounded, truncate, cuneate	Entire, repand	(7–) 10 (–20)
Commicarpus plumbagineus	(26–) 49 (–87) x (16–) 35 (–68)	Cordate, elliptic, orbicular, ovate, lanceolate,	Apiculate, acute, rounded	Obtuse, almost truncate, subcordate, shortly attenuate, cuneate	Entire, repand	(7–) 15 (–31)
Commicarpus squarrosus	(10–) 17 (–30) x (8–) 13 (–27)	Elliptic, ovate, orbicular, trullate, oval, lanceolate	Apiculate, rounded, retuse, emarginate	Attenuate	Entire	(8–) 12 (–23)

Table 4.5. Inflorescence type of the *Boerhavia* and *Commicarpus* species, as well as the length of the primary and secondary peduncles and the number of umbels.

Taxon	Type of inflorescence	Number of umbels	Length of primary peduncle (mm)	Length of secondary peduncle (mm)
Boerhavia coccinea var. *coccinea*	Compound cyme	–	(54–) 91 (–118)	(32–) 38 (–43)
Boerhavia cordobensis	Compound cyme	–	(60–) 105 (–130)	(20–) 27 (–35)
Boerhavia deserticola	Compound cyme	–	95–120	34–40
Boerhavia diffusa var. *diffusa*	Compound cyme	–	(60–) 105 (–150)	(25–) 42 (–60)
Boerhavia erecta	Compound cyme	–	115	(55–) 60 (–65)
Boerhavia hereroensis	Compound cyme	–	65	27
Boerhavia repens subsp. *repens*	Compound cyme	–	(20–) 22 (–24)	(5–) 10 (–20)
Commicarpus chinensis subsp. *natalensis*	Umbel	1 OR 2	(38–) 55 (–75)	–
Commicarpus decipiens	Umbel	–	(23–) 38 (–70)	–
Commicarpus fallacissimus	Umbel	1–3	(28–) 46 (–70)	–
Commicarpus fruticosus	Umbel	1 OR 2	(25–) 30 (–32)	–
Commicarpus helenae var. *helenae*	Umbel	1–4	(35–) 69 (–120)	–
Commicarpus pentandrus	Umbel	1–3	(30–) 79 (–150)	–
Commicarpus pilosus	Umbel	1–3	(20–) 60 (–105)	–
Commicarpus plumbagineus	Umbel	1 OR 2	(38–) 53 (–85)	–
Commicarpus squarrosus	Umbel	1 OR 2	(30–) 48 (–90)	–

Table 4.6. Flower length and colour, and lower floral indumentum of the southern African *Boerhavia* and *Commicarpus* species.

Taxon	Flower length (mm)	Length upper floral part (mm)	Length lower floral part (mm)	Flower colour	Shape and indumentum of lower floral part
Boerhavia coccinea var. *coccinea*	(1–) 2.5 (–4)	(1–) 1.6 (–3)	(1–)1.3 (–1.5)	Pink, white, purple	Elliptic, 5- ribbed, glandular hairs present
Boerhavia cordobensis	3	(1.5–) 1.6 (–2)	(1–) 1.4 (–1.5)	Dark purple, purple, pink	Clavate, 3 or 4-ribbed with apexes of ribs expanded, glabrous
Boerhavia deserticola	(4–) 4.5 (–5)	(3–) 3.2 (–4)	(1–) 1.3 (–2)	White, purple	Oval, 5-ribbed, glabrous
Boerhavia diffusa var. *diffusa*	(2–) 2.1 (–3)	(1–) 1.1 (–2)	1	White, pink, purple, red-purple	Elliptic-clavate, 5-ribbed, glandular hairs present
Boerhavia erecta	(2–) 2.1 (–3)	1	(1–) 1.1 (–2)	White, pink, purple, reddish	Clavate, 5-ribbed, glabrous
Boerhavia hereroensis	(2–) 3.2 (–4)	(1–) 2.2 (–3)	1	Purple, pink	Oval, 5-ribbed, long glandular hairs present
Boerhavia repens subsp. *repens*	(2–)2.3(–3)	1	(1–) 1.3 (–2)	White, pink, purplish	Elliptic, 5-ribbed, glandular hairs present in the grooves between the ribs
Commicarpus chinensis subsp. *natalensis*	(12–) 16.8 (–22)	(10–) 13 (–17)	(2–) 2.7 (–6)	Pink	Cylindrical, sessile glands scattered over surface
Commicarpus decipiens	(11–) 14.8 (–21)	(8–) 11 (–16)	(2–) 3.8 (–6)	White	Clavate, prominent, sessile glands and glandular trichomes scattered over surface
Commicarpus fallacissimus	(8–) 9.5 (–11)	(5–) 5.5 (–6)	(3–) 4 (–5)	Pink/purple	Cylindrical, 10 shortly stalked, prominent glands around the apex; sessile, less prominent glands scattered on the surface below
Commicarpus fruticosus	(5–) 7.1 (–10)	(3–) 4.6 (–6)	(2–) 2.5 (–4)	Dark purple	Broadly elliptic, 5 shortly stalked, prominent glands alternating with 5 sessile, less prominent glands around the apex. Smaller, less prominent glands scattered over the surface below
Commicarpus helenae var. *helenae*	(4–) 5.5 (–7)	(2–) 2.5 (–4)	(2–) 2.5 (–4)	Light pink almost white	Elliptic, 5 shortly stalked, prominent glands around the apex. Smaller, less prominent glands scattered over the surface below
Commicarpus pentandrus	(12–) 14.9 (–23)	(9–) 11.2 (–17)	(2–) 4.1 (–6)	Purple/pink	Clavate, one or two rows of five prominent sessile glands around the apex with smaller, less prominent glands scattered over the surface below
Commicarpus pilosus	(5–) 6.6 (–12)	(3–) 4.2 (–9)	(2–) 2.6 (–3)	Pink/purple	Elliptic, 5 prominent sessile glands around apex with smaller, less prominent glands scattered over the surface below
Commicarpus plumbagineus	(10–) 12.9 (–20)	(7–) 9.5 (–14)	(2–) 3.4 (–7)	White	Cylindrical, 10 prominent, sessile glands around the apex with a few glands scattered on the surface below. Glandular trichomes present
Commicarpus squarrosus	(5–) 6.3 (–8)	(3–) 4.3 (–6)	2	Purple	Broadly elliptic, 5 shortly stalked, prominent glands alternating with 5 sessile, less prominent glands around the apex. Smaller, less prominent glands scattered over the surface below

Table 4.7. Measurements, shape and indumentum of the anthocarps of the southern African *Boerhavia* and *Commicarpus* species.

Taxon	Measurement (mm)	Shape	Indumentum
Boerhavia coccinea var. *coccinea*	(3–) 4.1 (–5) x (1–) 1.4 (–2)	Narrowly elliptic-clavate	5-ribbed, rounded at the apex, glandular hairs present
Boerhavia cordobensis	(3–) 3.5 (–4) x (2–) 2.3 (–3)	Clavate	3 or 4 winged, broadly truncate at the apex, apex ends in a pointed tip, glabrous
Boerhavia deserticola	(3–) 3.9 (–5) x (1–) 1.8 (–2)	Elliptic-clavate	5-ribbed, rounded at the apex, glabrous
Boerhavia diffusa var. *diffusa*	(3–) 3.4 (–4) x (1–) 1.4 (–2)	Elliptic-clavate	5-ribbed, with a slight indentation near the apex, apex ends in a pointed tip, glandular hairs present
Boerhavia erecta	(3–) 3.2 (–4) x (1–) 1.5 (–2)	Clavate	5-winged, wings slightly undulate along the margins, apex truncate, apex ends in a pointed tip, glabrous
Boerhavia hereroensis	(3–) 3.5 (–4) x (1–) 1.7 (–2)	Elliptic-clavate	5-ribbed, rounded at the apex, long glandular hairs present
Boerhavia repens subsp. *repens*	(3–) 3.3 (–4) x (1–) 1.2 (–2)	Elliptic-clavate	5-ribbed, rounded at the apex, glandular hairs present
Commicarpus chinensis subsp. *natalensis*	(8–) 8.7 (–10) x (1–) 1.8 (–3)	Cylindrical	Sessile glands around the apex. Prominent glands scattered over the surface below the apex
Commicarpus decipiens	(5–) 6.8 (–8) x (2–) 2.8(–7)	Broadly clavate	5 Shortly stalked glands around the apex. Prominent sessile glands scattered over the surface below the apex. Surface covered with prominent glandular hairs
Commicarpus fallacissimus	(8–) 8.6 (–9) x (1–) 2.3 (–3)	Fusiform	10 stalked glands around the apex. Sessile glands scattered over the surface below the apex
Commicarpus fruticosus	(5–) 5.3 (–6) x (1–) 1.8 (–2)	Fusiform	Apex surrounded by 5 stalked glands alternating with 5 sessile glands. Sessile glands scattered over the surface below the apex
Commicarpus helenae var. *helenae*	(5–) 5.3 (–6) x 2	Clavate, tapering noticeably from apex to base	Apex surrounded by 5 thin, long stalked (1–2 mm long) glands alternating with 5 sessile glands. 1 or 2 rings of sessile glands on the surface below the apex
Commicarpus pentandrus	(7–) 8.4 (–9) x (2–) 2.1 (–3)	Clavate	5 thickly stalked glands alternating with 5 smaller, less prominent glands around the apex. Sessile glands scattered over the surface below the apex
Commicarpus pilosus	(5–) 6 (–7) x (1–) 1.5 (–2)	Elliptic clavate tapering to both ends	5 shortly stalked glands around apex, sessile glands scattered over the surface below the apex
Commicarpus plumbagineus	(8–) 8.5 (–9) x (1–) 1.8 (–2)	Fusiform	Ring of 10 stalked glands around the apex. Few shortly stalked glands below the apex grouped together
Commicarpus squarrosus	(3–) 5 (–7) x (1–) 1.7 (–2)	Fusiform	Apex surrounded by 5 stalked glands alternating with 5 sessile glands. Sessile glands scattered the over surface below the apex

Plate 1: *Boerhavia deserticola* (C. Mannheimer).

Plate 2*: Commicarpus pentandrus* (M.F. Smit).

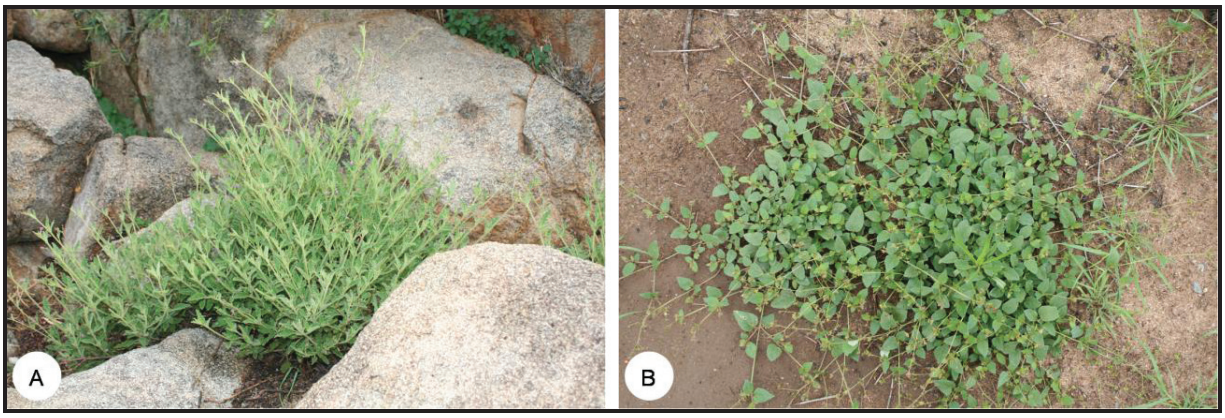

Figure 4.1: Growth form of the southern African *Boerhavia* species: A: upright growth form of *B. hereroensis*; B: decumbent growth form of *B. cordobensis*. (Photo: S.J. Siebert).

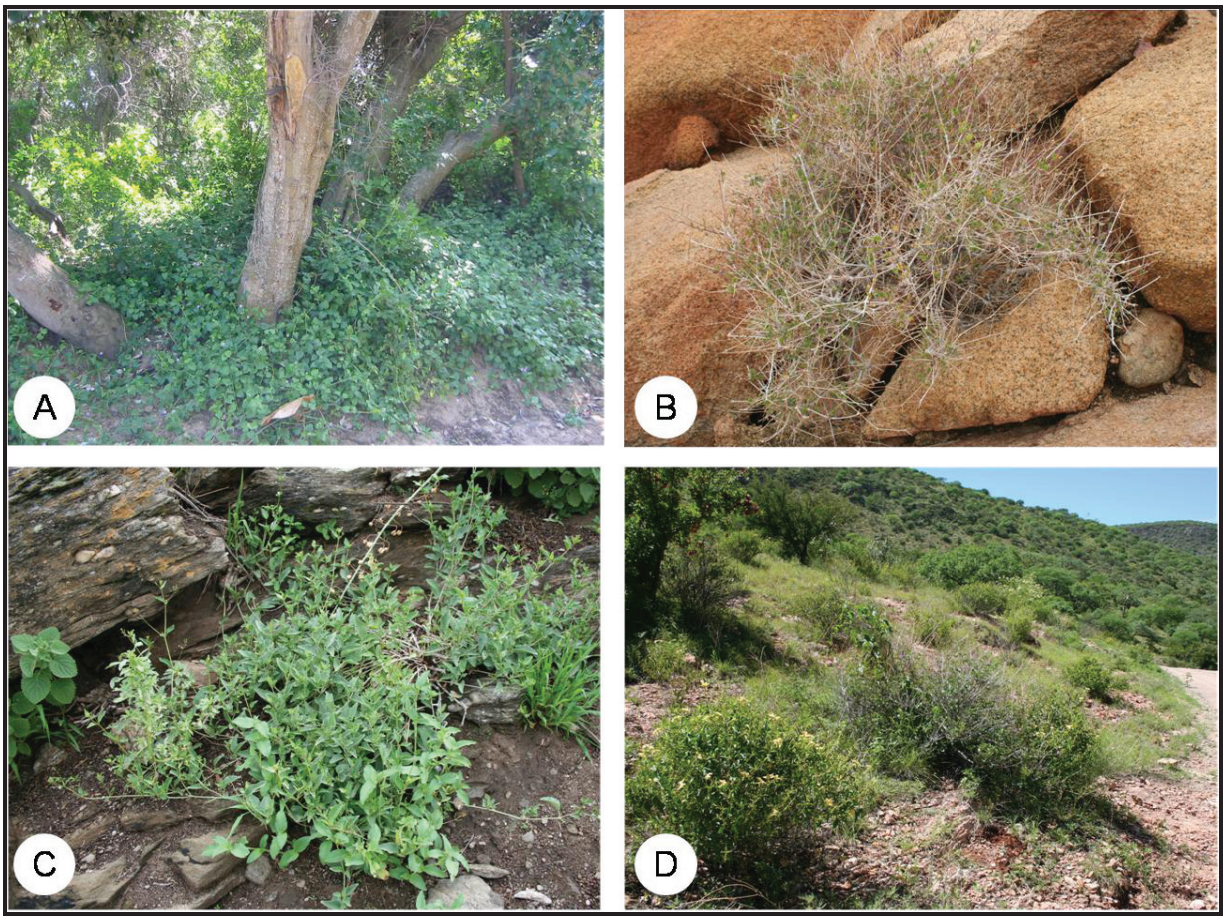

Figure 4.2: Growth forms of the southern African *Commicarpus* species: A: herbaceous, procumbent growth form of *C. chinensis* subsp. *natalensis*; B: semi-woody, sub-shrub growth form of *C. squarrosus*; C: herbaceous growth form of *C. fallacissimus*; and D: sub-shrub growth form of *C. fallacissimus*. (Photos: S.J. Siebert and S. Kurzweg).

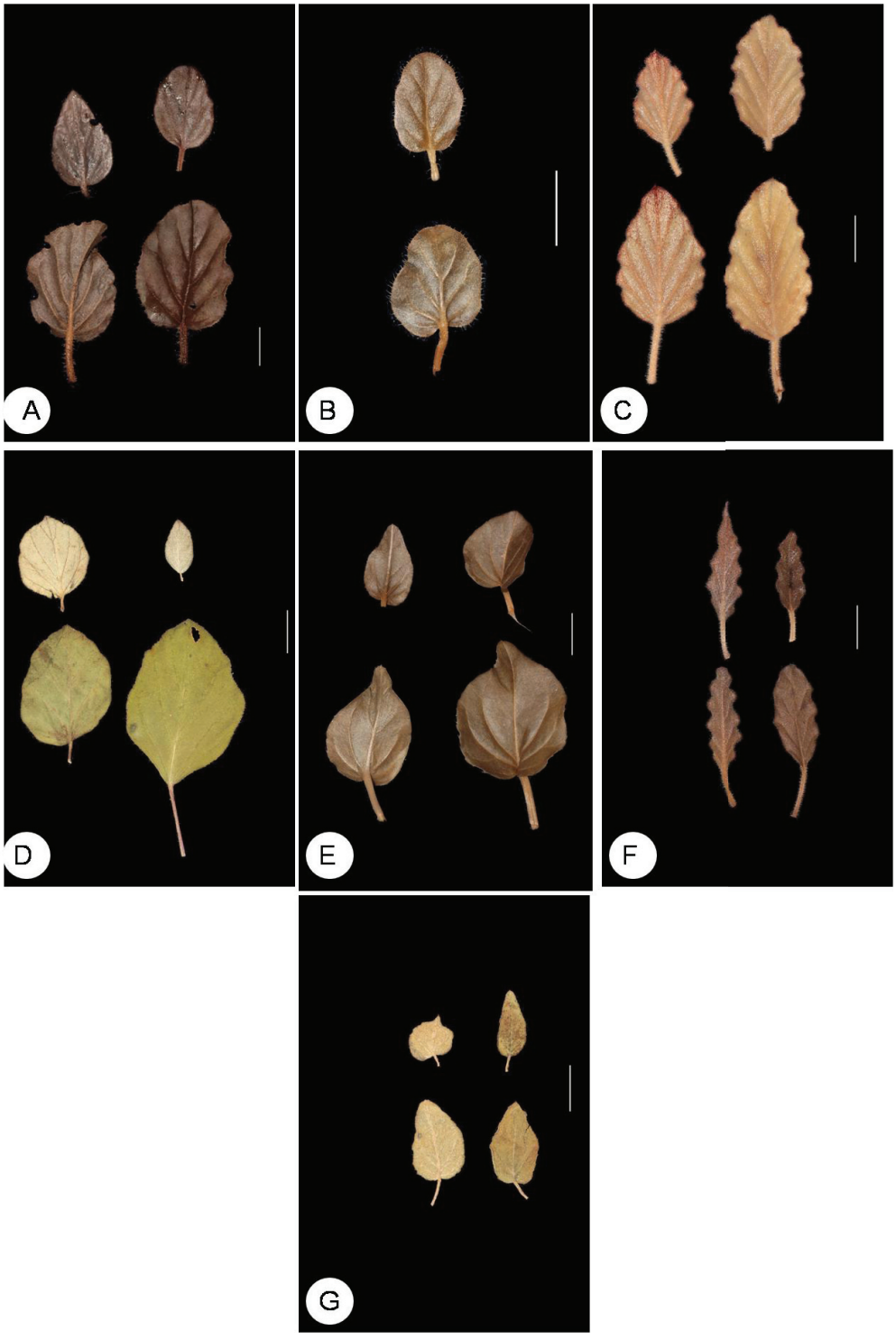

Figure 4.3: Micrographs showing the leaf shape of the *Boerhavia* species: A: *B. coccinea* var. *coccinea*; B: *B. cordobensis*; C: *B. deserticola*; D: *B. diffusa* var. *diffusa*; E: *B. erecta*; F: *B. hereroensis*; and G: *B. repens* subsp. *repens*. Scale bars 10 mm.

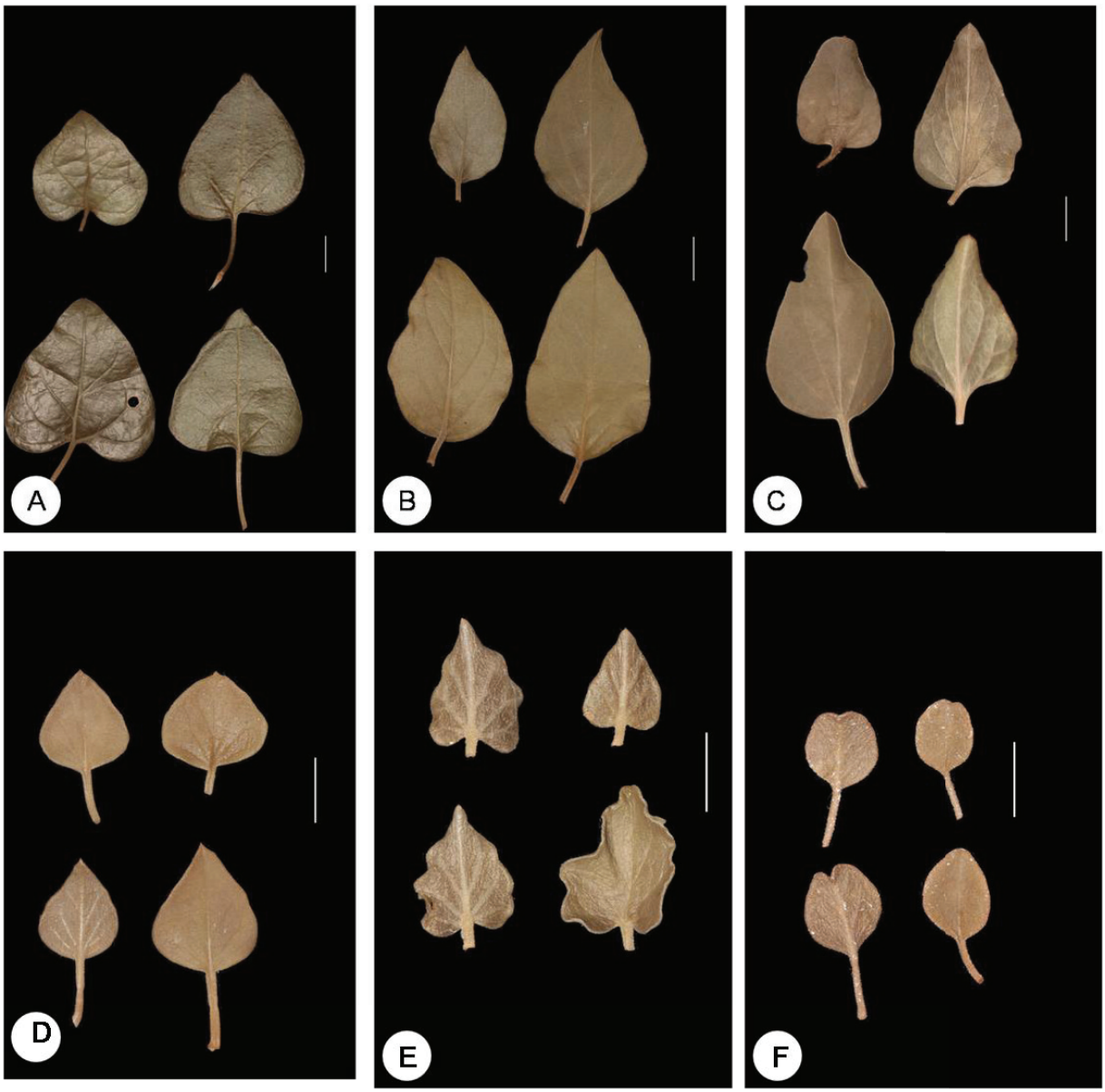

Figure 4.4: Micrographs showing the leaf shape of the *Commicarpus* species: A: *C. chinensis* subsp. *natalensis*; B: *C. decipiens*; C: C. *fallacissimus*; D: *C. fruticosus*; E: *C. helenae* var. *helenae*; and F: *C. squarrosus*. Scale bars 10 mm.

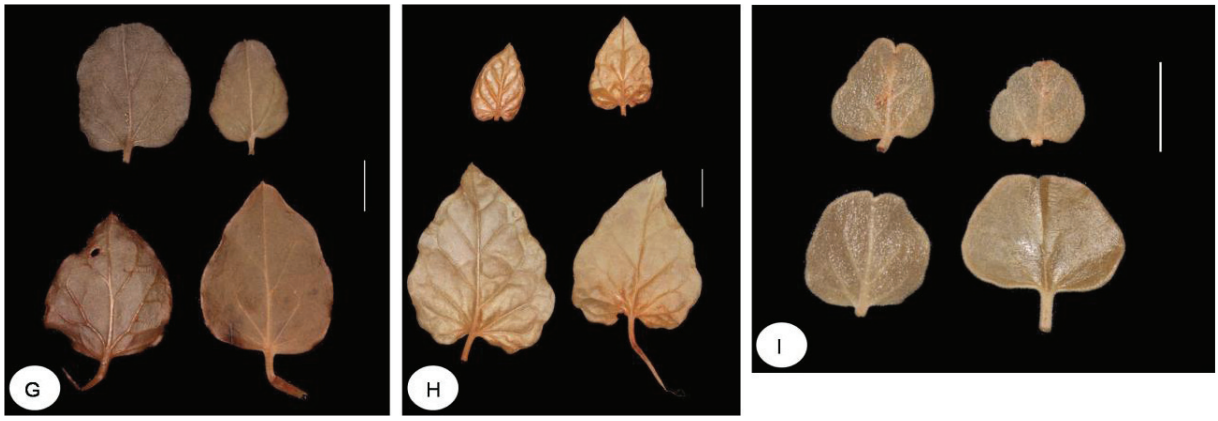

Figure 4.4: Micrographs showing the leaf shape of the *Commicarpus* species: G: *C. pentandrus*; H: *C. plumbagineus*; and I: *C. pilosus*. Scale bars 10 mm.

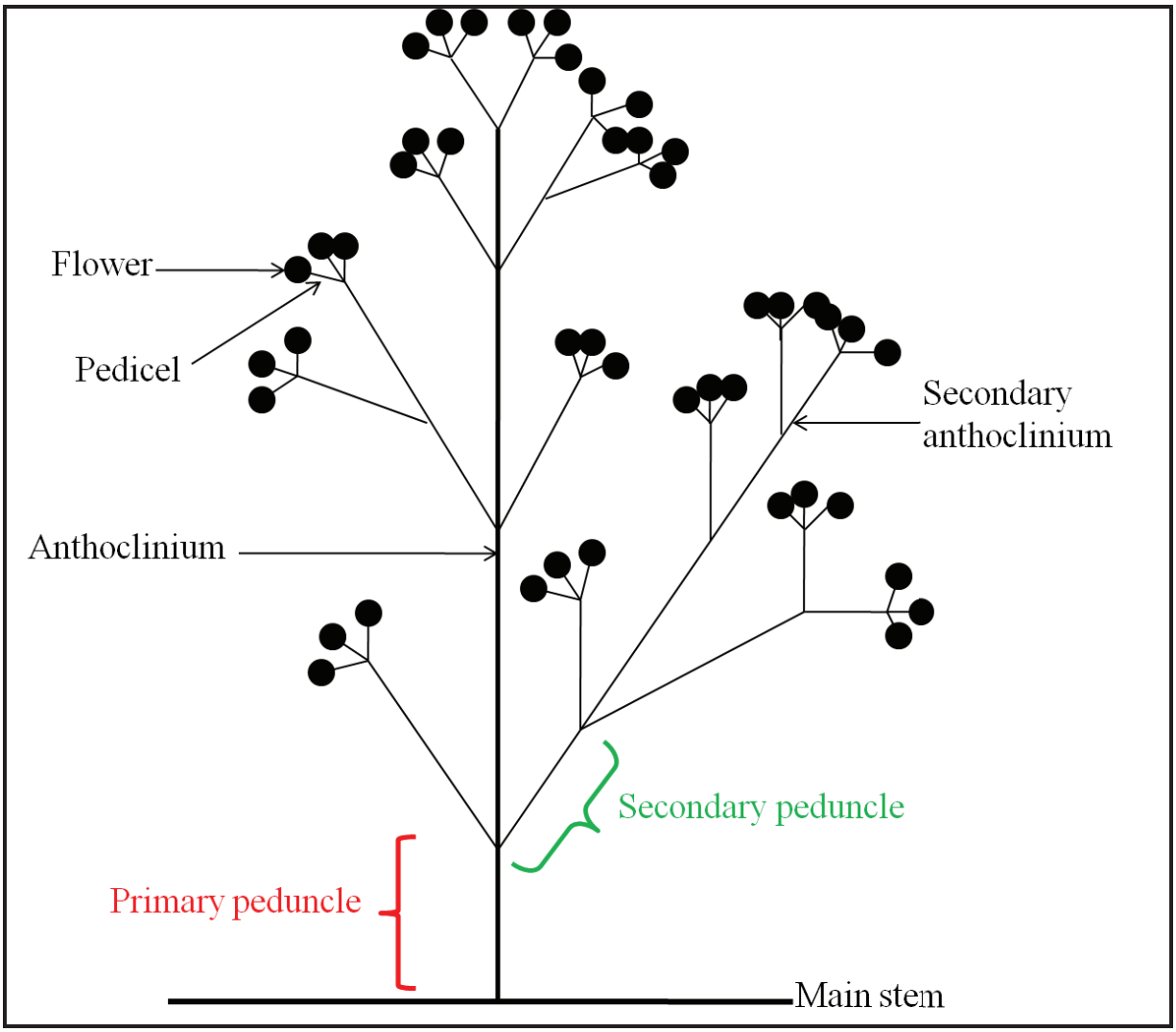

Figure 4.5: Diagrammatic representation of the inflorescence of the southern African *Boerhavia* species.

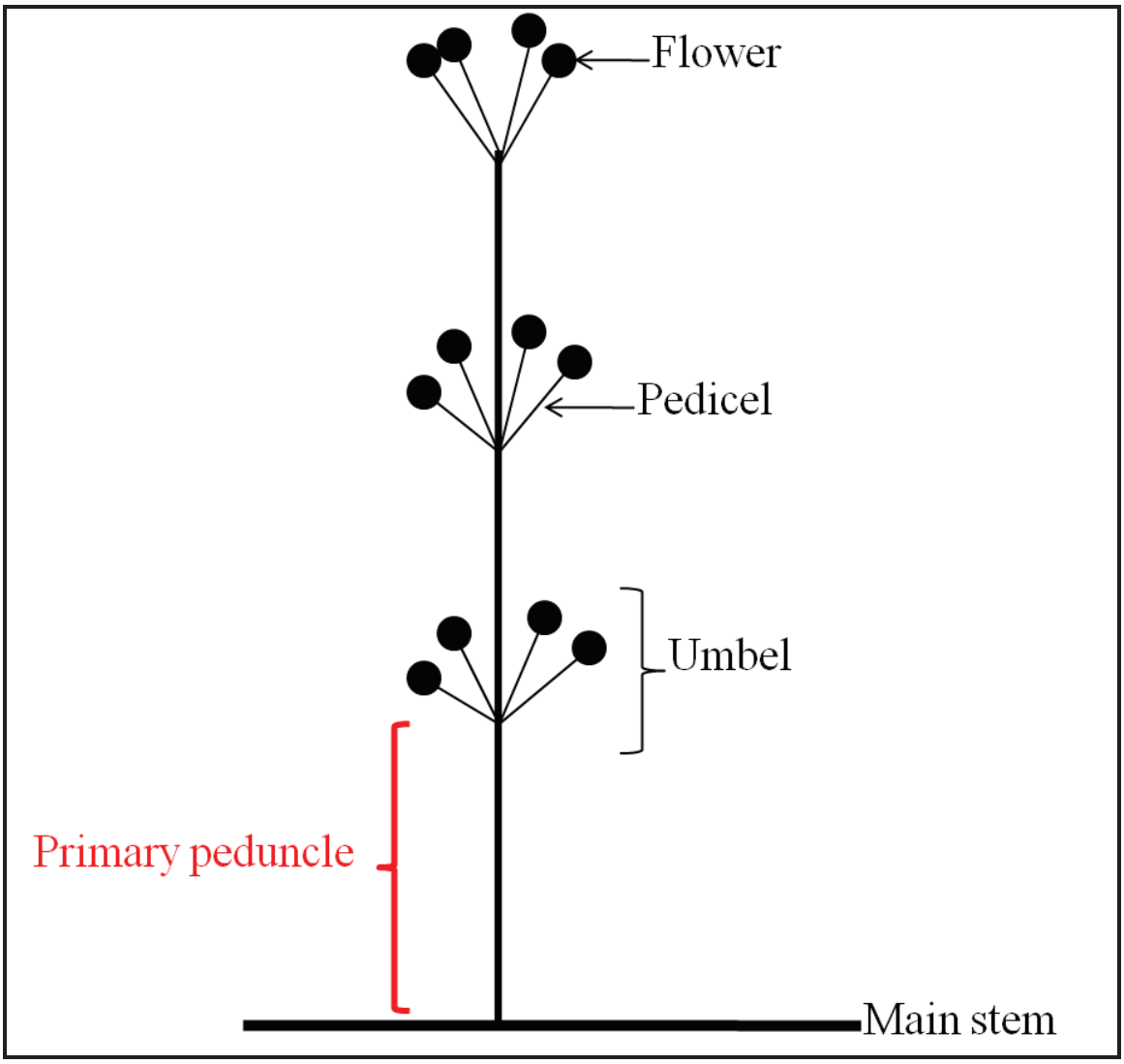

Figure 4.6: Diagrammatic representation of the inflorescence of the southern African *Commicarpus* species.

Figure 4.7: Flowers of *Boerhavia* and *Commmicarpus* species showing the upper, petaloid part (a) and the lower, coriaceous part of the flower (b): A: *B. deserticola*. Arrows indicate the ribs on the lower part of the flower. Scale bar 3 mm. B: *C. fallacissimus*. Black arrow indicates glands around the apex of the lower part of the flower and the white arrow the longitudinal grooves. Scale bar 1 mm. (Photo: S.J. Siebert).

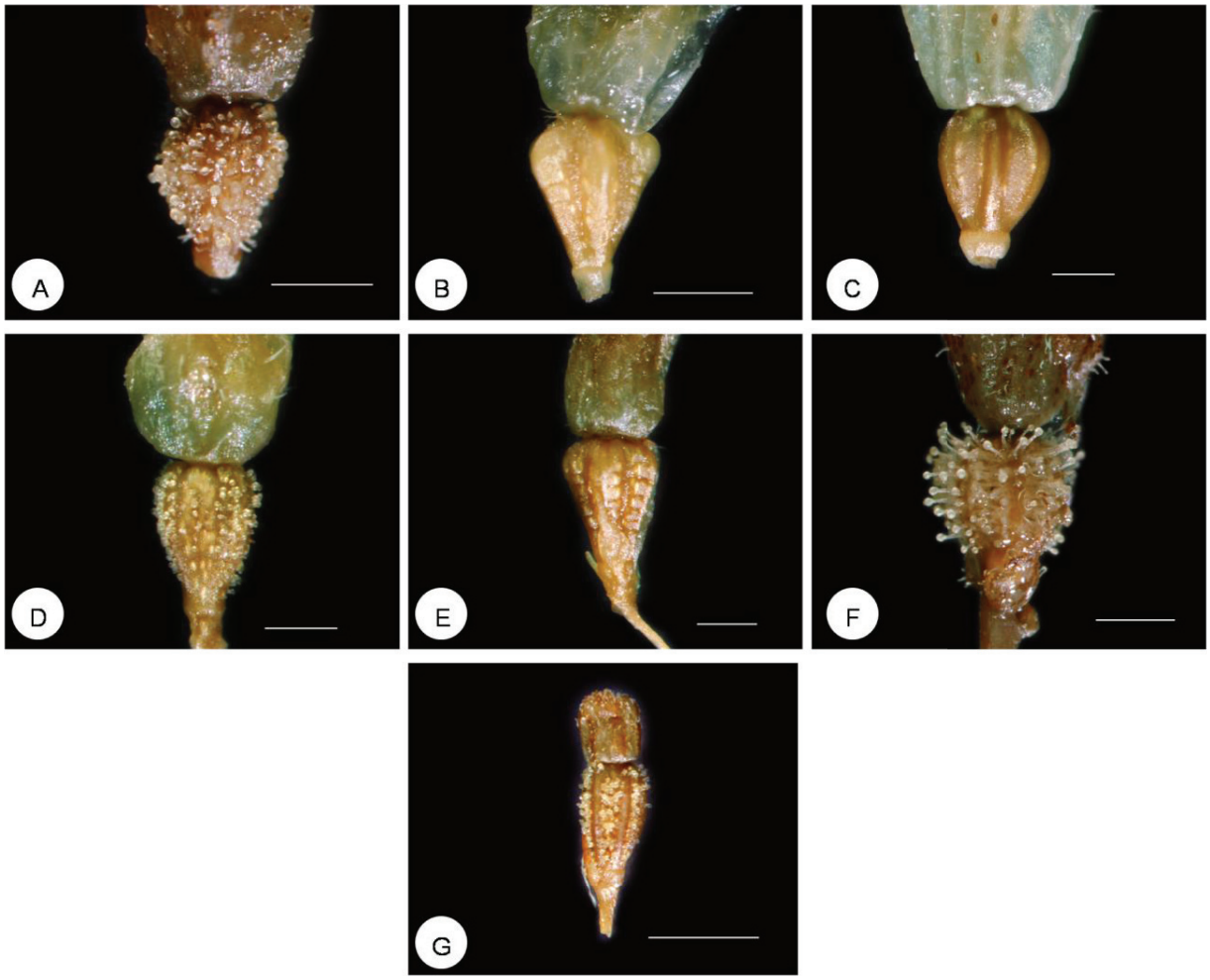

Figure 4.8: Micrographs showing the shape and indumentum of the lower part of the flower of the *Boerhavia* species: A: *B. coccinea* var. *coccinea.* Scale bar 0.8 mm; B: *B. cordobensis.* Scale bar 1 mm; C: *B. deserticola*; D: *B. diffusa* var. *diffusa.* Scale bar 0.5 mm; E: *B. erecta.* Scale bar 1 mm; F: *B. hereroensis.* Scale bar 0.5 mm; and G: *B. repens* subsp. *repens*. Scale bar 2 mm.

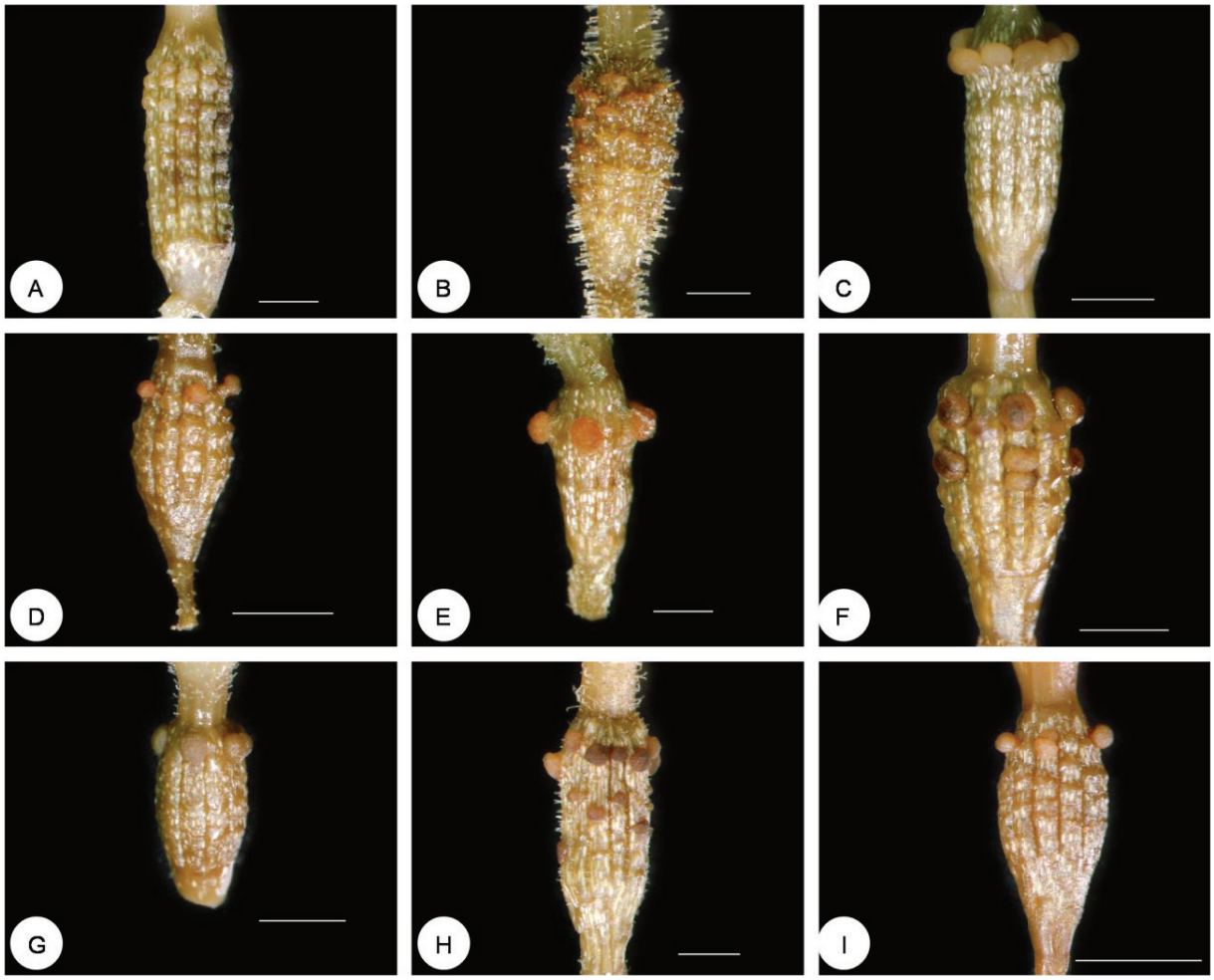

Figure 4.9: Micrographs showing the shape and indumentum of the lower part of the flower of the *Commicarpus* species: A: *C. chinensis* subsp. *natalensis.* Scale bar 1 mm; B: *C. decipiens.* Scale bar 2 mm; C: C. *fallacissimus*; D: *C. fruticosus.* Scale bar 1 mm; E: *C. helenae* var. *helenae*; F: *C. pentandrus.* Scale bar 2 mm; G: *C. pilosus*; H: *C. plumbagineus*; and I: *C. squarrosus*. Scale bar 1 mm.

Figure 4.10: Anthocarps of *Boerhavia* and *Commicarpus* showing the surface indumentum; A: anthocarp (a) of *B. hereroensis* showing the ribs (r) and the trichomes (t) which cover the surface. Scale bar 2 mm. B: anthocarp (a) of *C. fallacissimus* with the white arrow indicating the 10 stalked glands around the apex and the black arrow indicating the sessile glands scattered over the surface below the apex. Scale bar 3 mm. (Photo: S.J. Siebert).

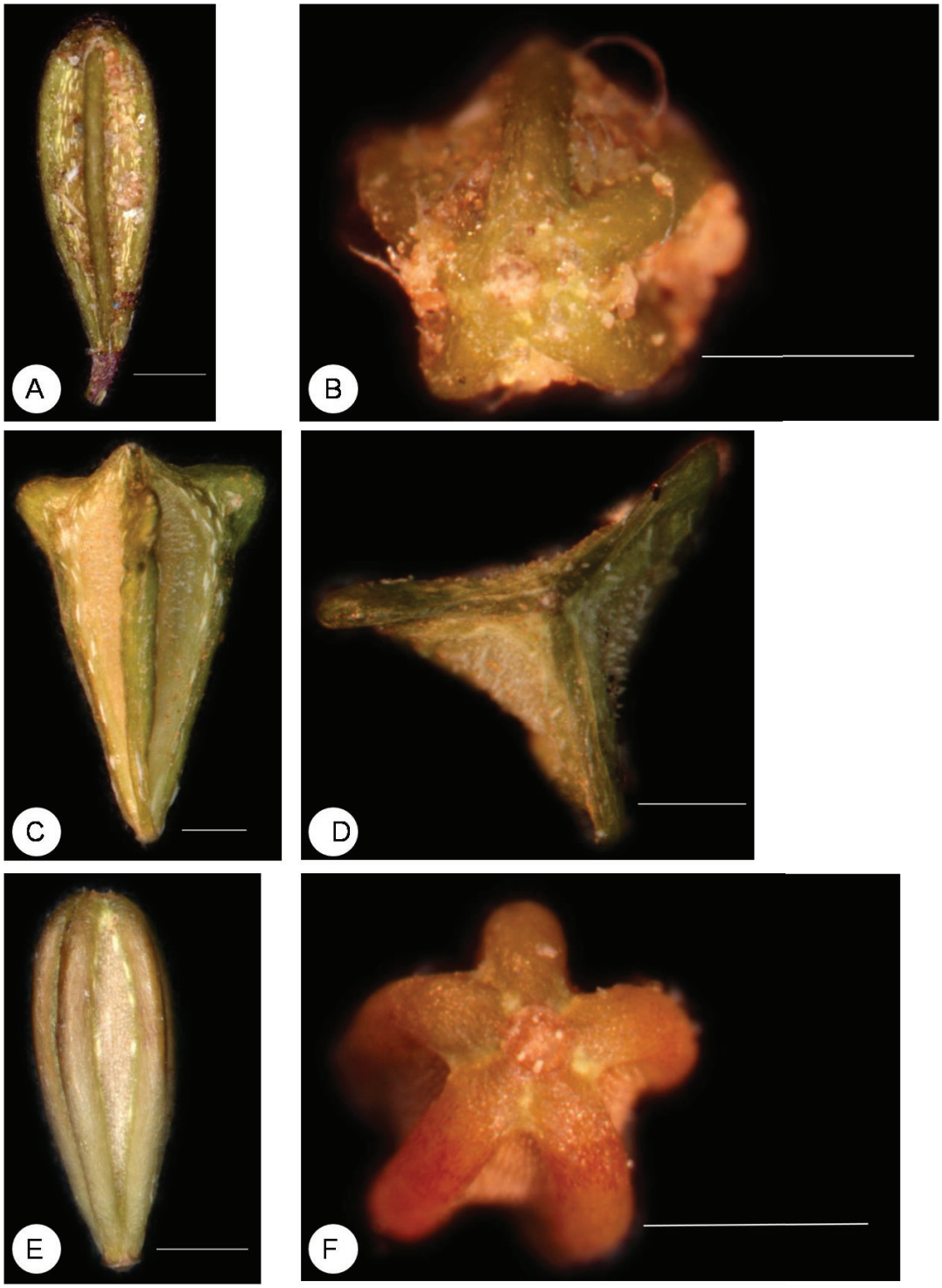

Figure 4.11: Micrographs of *Boerhavia* species showing the anthocarp in longitudinal (A, C, E) and apical views (B, D, F): A, B: *B. coccinea* var. *coccinea*; C, D: *B. cordobensis*; and E, F: *B. deserticola.* Scale bars 1 mm.

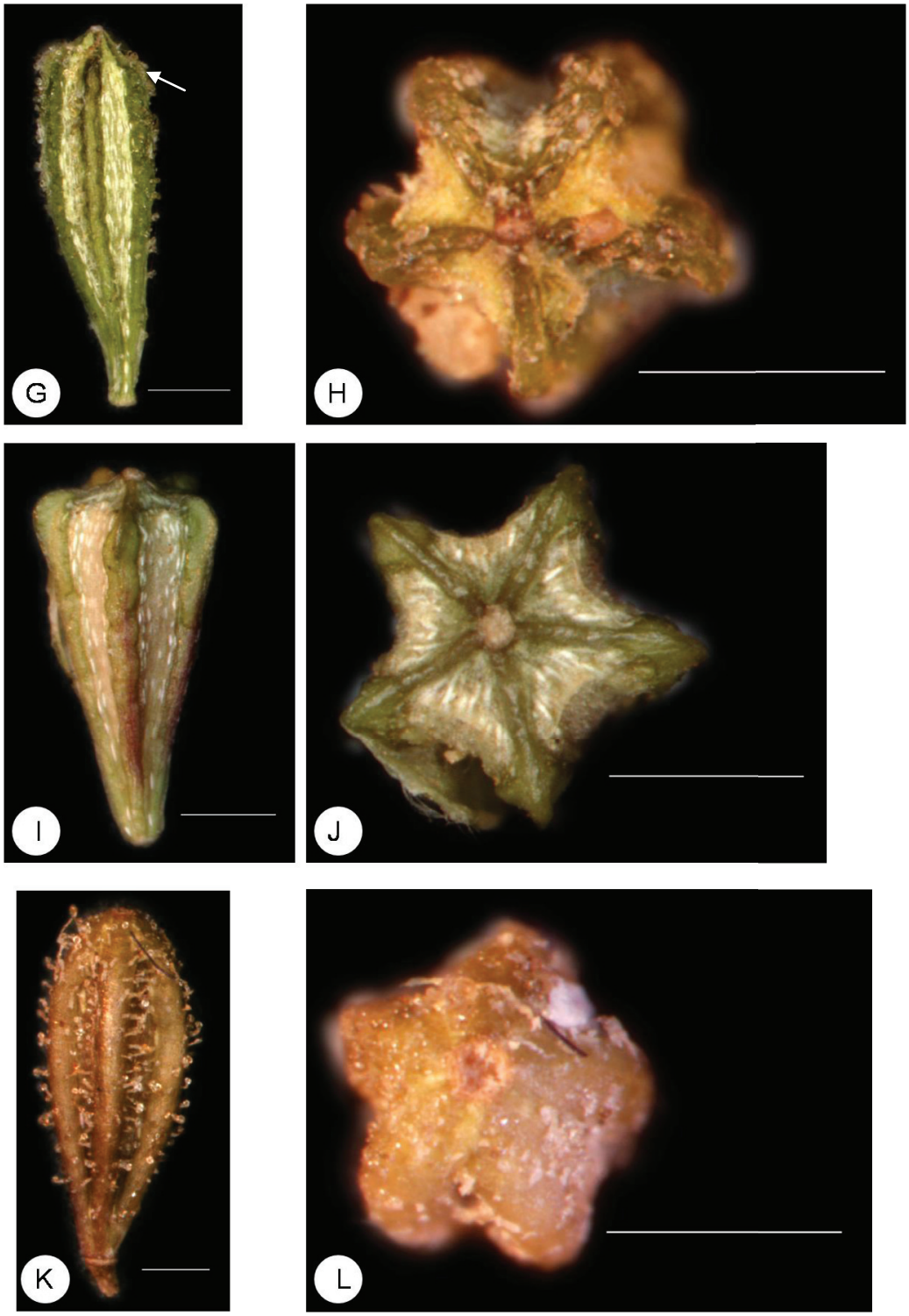

Figure 4.11: Micrographs of *Boerhavia* species showing the anthocarp in longitudinal (G, I, K) and apical views (H, J, L): G, H: *B. diffusa* var. *diffusa* (G, arrow indicates the indentation in the ribs); I, J: *B. erecta*; and K, L: *B. hereroensis*. Scale bars 1 mm.

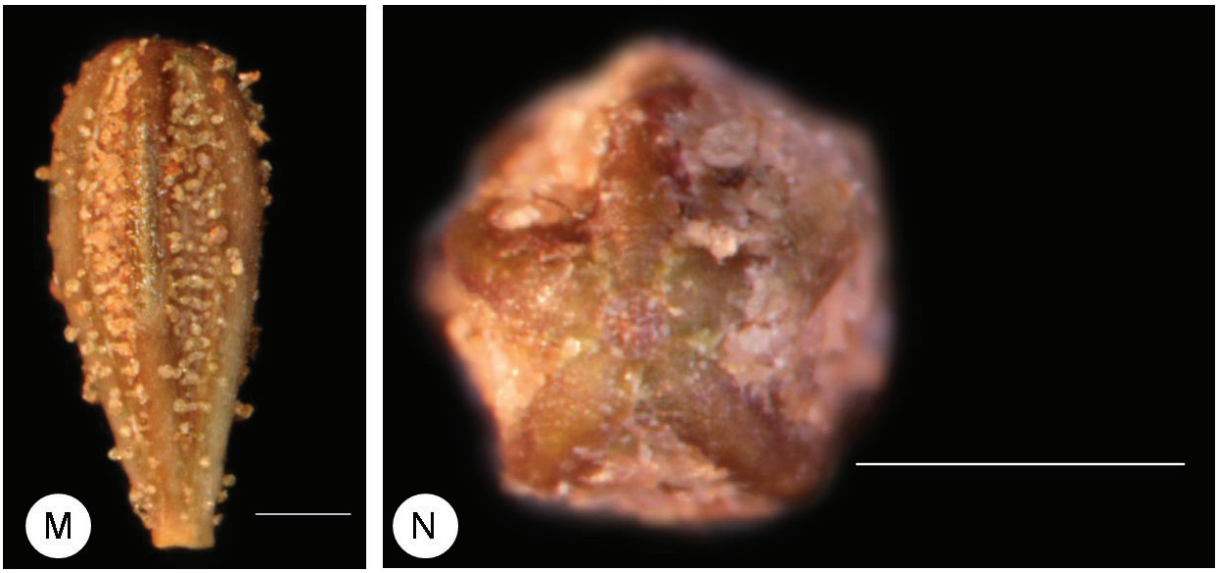

Figure 4.11: Micrographs of *Boerhavia* species showing the anthocarp in longitudinal (M) and apical views (N): M, N: *B. repens* subsp. *repens.* Scale bars 1 mm.

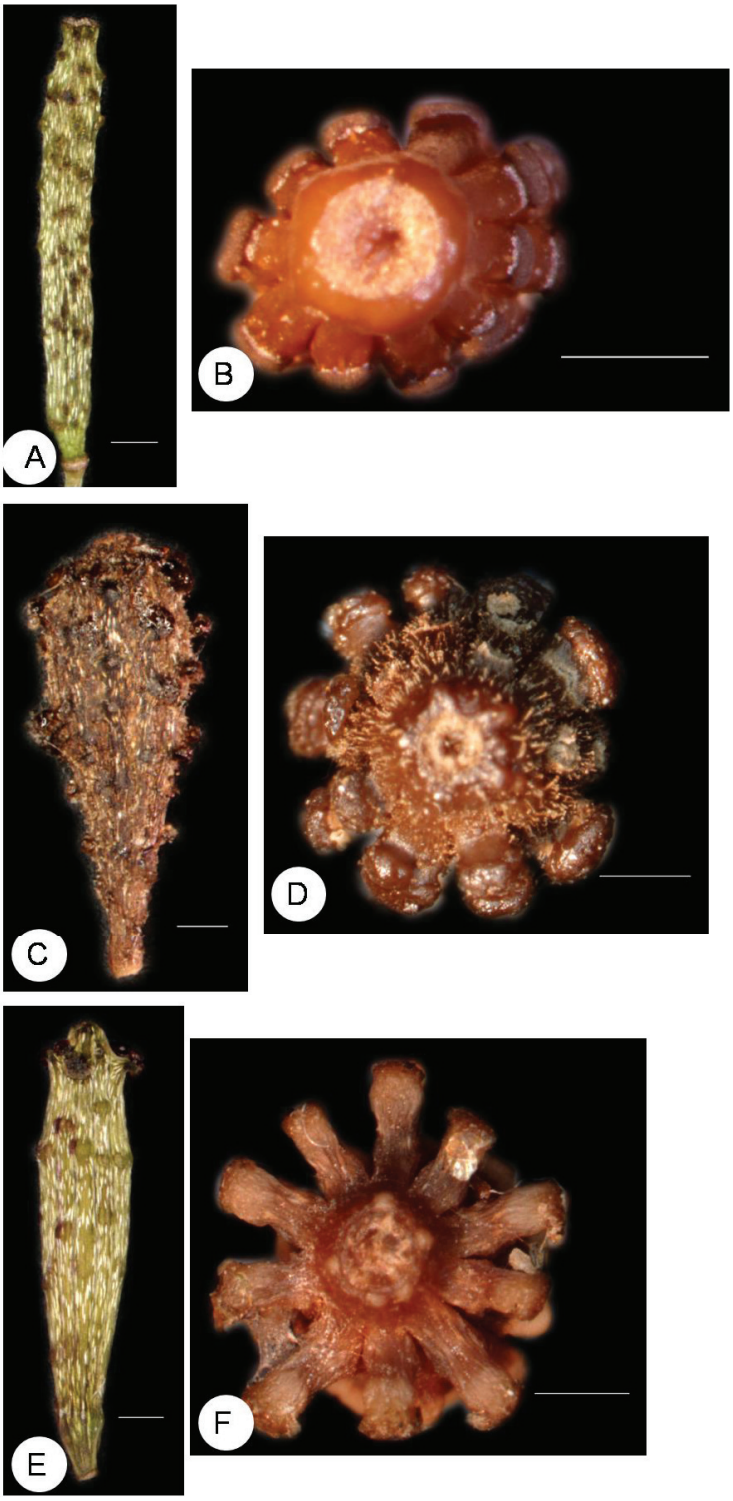

Figure 4.12: Micrographs of *Commicarpus* species showing the anthocarp in longitudinal (A, C, E) and apical views (B, D, F): A, B: *C. chinensis* subsp. *natalensis*; C, D: *C. decipiens*; and E, F: *C. fallacissimus.* Scale bars 1 mm.

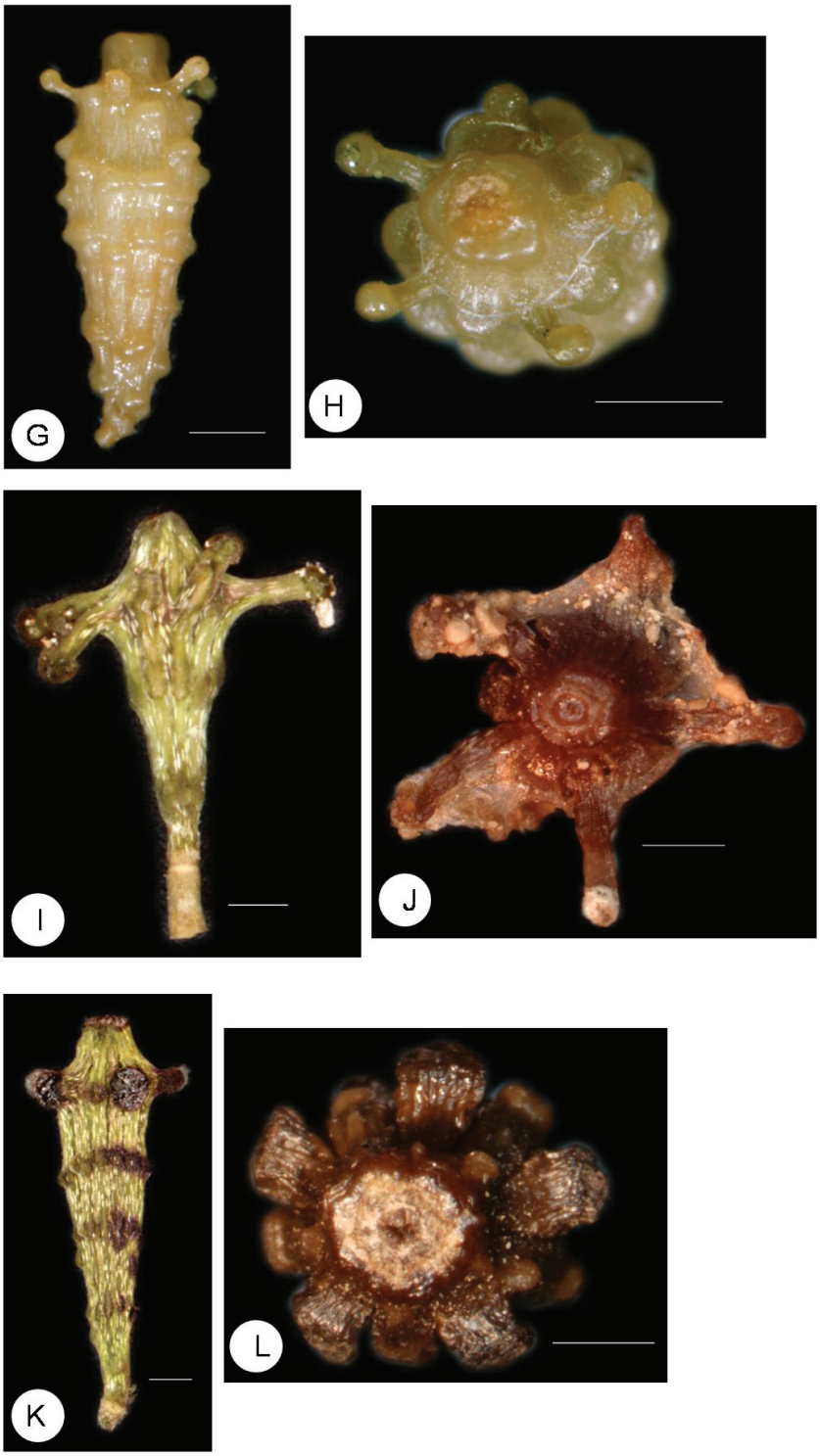

Figure 4.12: Micrographs of *Commicarpus* species showing the anthocarp in longitudinal (G, I, K) and apical views (H, J, L): G, H: *C. fruticosus*; I, J: *C. helenae* var. *helenae*; and K, L: *C. pentandrus*. Scale bars 1 mm.

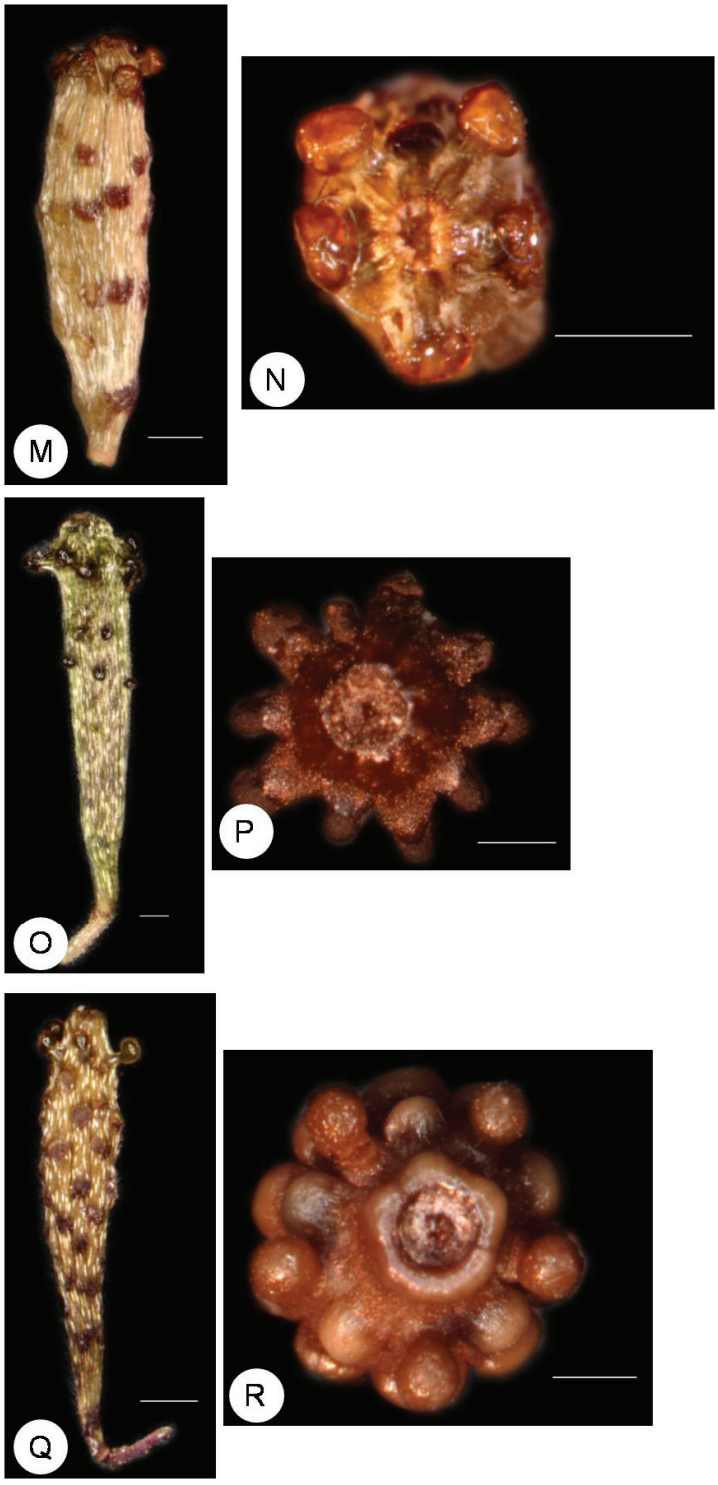

Figure 4.12: Micrographs of *Commicarpus* species showing the anthocarp in longitudinal (M, O, Q) and apical views (N, P, R): M, N: *C. pilosus*; O, P: *C. plumbagineus*; and Q, R: *C. squarrosus*. Scale bars 1 mm.