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Plectranthus: A plant for the future?

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Abstract

The genus *Plectranthus* (Lamiaceae) is a significant, prolific and extensively used genus in southern Africa. It plays a dominant role in both horticulture and traditional medicine. Some 12 species are documented for their use in treating ailments by various indigenous peoples of southern Africa. It is a firm favourite in gardens and *Plectranthus* has been bred to further utilise the remarkable diversity of indigenous South African wildflowers with amenity horticultural potential. Although previously subjected to both horticultural (Van Jaarsveld, 2006) and ethnobotanical (Lukhoba et al., 2006) review, *Plectranthus* is a genus with economic potential in various sectors, and this article aims to review this potential of southern African species.

Keywords: Ethnobotany; Flow cytometry; Flowering pot plants; Genetic resources; Plant Breeders' Rights; *Plectranthus*; Triploid breeding; Wildflowers

1. Introduction

The genus *Plectranthus* L'Hér. (Lamiaceae), also known as spurflowers, belongs to the subfamily Nepetoideae, tribe Ocimeae, subtribe Plectranthinae, comprising of ca. 300 species distributed through the tropical and warm regions of the Old World (Retief, 2000) including Africa, India and Australia. The generic boundary is in flux and Paton et al. (2004) showed that the current circumscription is paraphyletic and may require future expansion to include allied genera such as *Pycnostachys* Hook., *Solenostemon* Thonn., *Aeollanthus* Mart. ex K.Spreng., *Thorncroftia* N.E.Br. and *Tetradenia* Benth.

The diversity of *Plectranthus* is an important element of the biodiversity of Africa (Bhatt et al., 2010). In southern Africa the genus exhibits its highest level of diversity on the sandstone derived island substrates of southern KwaZulu-Natal (KZN) and the northern parts of the Eastern Cape (EC), i.e. the Pondoland Centre of Endemism sensu Van Wyk and Smith (2001), where 29 described species of *Plectranthus* occur. Eleven of these species (or sub-species) are endemic or near-endemic to the region. These two provinces (EC and KZN) are home to the species with most promise for horticulture (Van Jaarsveld, 2006). Other prominent areas of diversity are Mpumalanga Province, with 15 species occurring in the area around Barberton, and the KZN Midlands, where 13 species occur near the Karkloof (Potgieter, 2009).

Species of *Plectranthus* have been grown in hanging baskets in Europe for decades and one such species, *Plectranthus oertendahlii* T.C.E.Fr. ('Swedish Ivy'), was named from a cultivated plant in 1924 despite having an unknown wild origin, it has been in cultivation in Sweden for over 100 years. A specimen collected from Oribi Gorge, on the KZN South coast of South Africa, by L. Britten in 1936, remained unidentified until 1974. Material collected from Oribi Gorge by H. Nicholson in 1971/72 was identified in 1973 and finally the mystery was solved (Codd, 1977). It is thought that plants made their way to Scandinavia via the Hermannsburg Mission Society in southern KZN, or via a Swedish surveyor working at Uvongo (Van Jaarsveld, 2006).

Plectranthus is a horticulturally important genus of predominantly herbaceous plants that is becoming increasingly popular in indigenous landscaping in South Africa. Some species are suitable as shrubs or may be pruned into hedges; some make good groundcovers; there are good species for rockeries and succulent gardens; and a number of species thrive in large

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containers, pots and hanging baskets. Most species are easily grown from cuttings or seed and require little maintenance other than a need for pruning at the end of the flowering season, making them a welcome addition to any garden.

A continuous demand for novelty has become axiomatic in the field of flower market development. In Europe the cooler climate favours mostly new kinds of potted plants whilst elsewhere new types of both garden and potted subjects are sought. The contribution of South Africa's spectacular wildflowers to world floriculture spans several centuries and has yielded major new flower crops to world floriculture — e.g. *Gerbera* L., *Gladiolus* L., *Pelargonium* L'Her. ex Aiton. The herbaceous *Plectranthus* species form a fairly new resource in the continued exploitation of wildflower diversity.

A large number of *Plectranthus* species are used in traditional medicine in southern Africa, and have potential for development towards their use in the primary health care system (Gaspar-Marques et al., 2006). In fact, *Plectranthus* is most commonly cited in the literature for its medicinal properties and uses (Lukhoba et al., 2006). Although used for horticulture and other aspects of daily life (Tables 1 and 2), 85% of the documented uses of *Plectranthus* are medicinal (Table 2) (Lukhoba et al., 2006).

The Lamiaceae are a group of plants which hold valuable biologically active compounds (Dellar et al., 1996) and *Plectranthus* is no exception. The aromatic nature of the genus is attributed to essential oil production (Alasbahi and Melzig, 2010; Grayer et al., 2010). Isolated diterpenoids exhibit anti-bacterial (Stavri et al., 2009; Grayer et al., 2010; Simões et al., 2010) and anti-fungal (Simões et al., 2010) activities and may offer resistance to insects (Grayer et al., 2010). In particular abietane diterpenes are responsible for antiplasmodial (Van Zyl et al., 2008), anti-bacterial (Dellar et al., 1996; Gaspar-Marques et al., 2006; Van Zyl et al., 2008), anti-fungal (Dellar et al., 1996) and antitumoral (Gaspar-Marques et al., 2006; Van Zyl et al., 2008) activities. The pharmacological activities of these compounds make *Plectranthus* an important genus to search for drug development (Gaspar-Marques et al., 2006).

Lukhoba et al. (2006) reviewed the genus *Plectranthus* and its ethnobotanical uses extensively, providing a comprehensive understanding of the global ethnobotany of *Plectranthus*. Their review touches on the horticultural uses of the genus but, since their review was of an ethnobotanical nature, this subject was not fully explored. Van Jaarsveld (2006) provides a comprehensive horticultural review of South African species providing valuable information on cultivation. Here we offer an updated horticultural and ethnobotanical review of the southern African species. Focusing on the economic potential of *Plectranthus* and incorporating the history of the genus, its breeding and development.

2. Horticultural use of *Plectranthus*

Plectranthus is considered the largest genus of Lamiaceae in southern Africa, with ca. 53 southern African species described to date (Codd, 1975, 1985; Van Jaarsveld and Edwards, 1991, 1997; Van Jaarsveld and Hankey, 1997; Edwards et al., 2000; Van Jaarsveld and Van Wyk, 2004; Edwards, 2005; Winter and Van Jaarsveld, 2005). Despite this large number of species, relatively few are popular as ornamental plants in South Africa, but the number of species that are being introduced into gardens is steadily increasing.

Plectranthus is attractive and floriferous and its salient cultural advantages include its low light requirement (shade tolerant), adaptability to semi-dry conditions and tolerance to a warm and dry atmosphere. Furthermore it is robust and easy-to-grow.

Many *Plectranthus* species are tall plants (1–2 m) with small blue-to-purple flowers (*Plectranthus ecklonii*, *Plectranthus saccatus*, *Plectranthus zuluensis*) and this group is popularly used in landscape gardening (Hitchcock, 1990). Another, smaller, group consists of compact plants, some with decorative leaves and large flowers, which lend themselves to pot plant development (Brits et al., 2001) and also to smaller bedding plants or groundcover use — e.g. *Plectranthus hilliardiae*, *P. oertendahlii*, *Plectranthus praetermissus*, *Plectranthus purpuratus*, *Plectranthus verticillatus*.

It is a useful genus for developing new gardens that may need large areas covered in a short space of time as this can be achieved using cuttings. Shrubby and groundcover species assist with a build-up of leaf mulch that fertilises the soil, traps moisture and out competes weeds. Plants produce spectacular autumn displays of flowers, especially when planted en-masse, but a use that is seldom considered is the ability of species of Lamiaceae in general, and *Plectranthus* in particular, to attract pollinating insects to a garden. A number of solitary bee species, long-proboscid flies, generalist butterflies and day-flying hawkmoths visit *Plectranthus* flowers for nectar. A pollination study of twenty species of South African *Plectranthus* and relatives showed that bees (Apidae), and various families of flies (Nemestrinidae, Tabanidae and Acroceridae) are important pollinating agents (Potgieter et al., 1999, 2009) and revealed the existence of a unique guild of long-proboscid fly-pollinated plants that included long-tubed species of *Plectranthus* (Potgieter and Edwards, 2001, 2005).

The growing popularity of *Plectranthus* is not limited to its floral diversity but also extends to foliage. A few species show varying degrees of natural leaf patterning (e.g. heritable silver venation of the upper surface of *P. oertendahlii* leaves, and variegated leaf margins of certain clones of *Plectranthus madagascariensis* (Pers.) Benth.) whilst others have striking, characteristic, red leaf under-surfaces (e.g. *Plectranthus reflexus* Van Jaarsv. & T.J.Edwards, *P. oertendahlii*). This opens a potential for extensive breeding and new cultivars to be developed on the basis of both genetic and vegetative features.

A useful key to identifying South African *Plectranthus* was published by Hankey (1999) in the popular journal Plantlife. Another useful source of information is the popular PlantZafrica web site of the South African National Biodiversity Institute (www.plantzafrica.com) where eleven horticultural entries were made for various *Plectranthus* species between 2001 and 2010.

Authors of popular general guides on indigenous gardening in South Africa have given some attention to the genus, but mostly recommended the same few species since the 1980s: *P. ecklonii* Benth., *Plectranthus fruticosus* L'Hér., *P. madagascariensis* and *P. saccatus* Benth., with occasional mention made of *Plectranthus ambiguus* (Bolus) Codd, *P. verticillatus* (L.f.)

Druce, *P. zuluensis* T.Cooke, *P. hilliardiae* Codd and *P. praetermissus* Codd (Pienaar, 1984, 1985, 1991; Joffe, 2001).

The situation changed when Van Jaarsveld (1987) published a small handbook on *Plectranthus* that focused solely on this genus and its horticultural potential. He included accounts of eight more species and mentioned another five of interest to gardeners. Van Jaarsveld's (2000) publication on water-wise gardening listed an additional fourteen species of *Plectranthus* for use in various bioclimatic zones in southern Africa, although this publication did not give accounts for the species. The most comprehensive treatment thus far is a book published by Van Jaarsveld (2006) which covers all the species in southern Africa. This publication is a culmination of Van Jaarsveld's interest in *Plectranthus* since the mid-1970s; he spent most of his career as a horticulturist at Kirstenbosch National Botanical Garden promoting *Plectranthus* to gardeners and horticulturists.

Van Jaarsveld (2006) gives a full history of the horticultural use of *Plectranthus* in South Africa. His book covers a number of topics: history of the genus and its discovery, accounts of the searches for plants to cultivate, chapters on the use of *Plectranthus* in the garden, and full descriptions of 57 species with cultivation notes for each. The cultivation chapters lists shade-loving shrubs and perennials, groundcovers for the shade, sun-loving shrubs and perennials, groundcovers for sun/partial shade, recommendations for rock gardens and containers, advice on propagation, pruning, pests and diseases, and a key for identifying the southern African species of *Plectranthus*.

Of the 57 species covered in Van Jaarsveld (2006), four species do not occur in southern Africa, and five species are considered not very attractive (or are difficult to grow), which presents at least 48 species with horticultural potential. Ten species are recommended as container plants (Van Jaarsveld, 2006), but a further ten of the southern African species are deemed suitable for cultivation in containers. These figures show the enormous potential locked up in the individual species of this genus, before hybridization and selection are considered. *Plectranthus* has been investigated over the past 30 years, mainly as half-shade garden plants and flowering pot plants (Van Jaarsveld, 1987; Brits et al., 2001).

Internet searches reveal that the popularity of *Plectranthus* goes far beyond southern Africa. Many searches lead to the use of the popular cultivar, Mona Lavender, but other species are also popular garden plants across the world. The web site for Kambroo Succulent Plant Nursery (http://www.kambroo.com/succulent_plant_nursery/) lists 76 available species and/or subspecies of *Plectranthus*, of which 54 taxa originate from southern Africa, ten from East/Tropical Africa and beyond, and twelve taxa from Australia.

Caution needs to be applied with international trade since New Zealand has already listed one of the South African species, *Plectranthus ciliatus* E.Mey. ex Benth., as a 'Regional Surveillance Plant Pest' within Auckland (http://www.rnzih.org.nz/pages/f80910_2.pdf). Similarly, *Plectranthus comosus* Sims, with origins in Ethiopia, is listed as a declared Category 3 invader and may not be sold in South Africa (Henderson, 2001). It is also currently listed on the 'Invasive Species in South Africa' web site (http://invasives.org.za/flora-listed-invasives/plectranthus-comosus.html). According to Henderson (2001), the name *Plectranthus barbatus* Andrews was misapplied to this taxon in the past, but at present it appears that the name *P. comosus* was erroneously applied to *P. barbatus* in South Africa. Currently, the name *P. barbatus* var. *grandis* (L.H. Cramer) Lukhoba & A.J.Paton is considered applicable to the South African taxon (A. Paton, pers. com. 2011), following Lukhoba and Paton (2003) and Lukhoba et al. (2006). The name *P. comosus* is a synonym of *P. barbatus* var. *barbatus*, which does not appear to occur in South Africa (Suddee et al., 2004).

A particularly decorative group of *Plectranthus*, mostly from the section *Plectranthus* (subgenus *Plectranthus*) and endemic to forests of the warm eastern coastline of South Africa (Codd, 1985), are annuals and perennials that thrive on semi-dry forest floors and are therefore well tailored to the main requirements of both potted plants for indoor usage (Van Jaarsveld, 1987) and for 'waterwise' gardening. The following are good examples: *P. praetermissus*, *P. oertendahlii*, *Plectranthus lucidus*, *P. hilliardiae*, *P. ambiguus* and *Plectranthus strigosus*.

Hybrids form the basis of artificial breeding and horticultural developments in *Plectranthus*, but natural hybrids are also widespread. Natural areas where more than one species co-occur and share a pollinator often produce extensive stands of hybrids and hybrid swarms. Such hybrids are seldom fertile and multiply through vegetative means. Hybrids share the characteristics of parent species, but may also produce novelties, such as the novel terpenoids recorded by Viljoen et al. (2006) in a natural hybrid of *P. zuluensis* and *P. ciliatus*.

3. Floricultural use of *Plectranthus*

The horticultural potential of *Plectranthus* continually impressed South African botanical investigators of the genus. Alongside with taxonomic work, living collections were established at botanical gardens and were invariably studied horticulturally as well, albeit on an unofficial basis. The aesthetic appeal of the 'spurflower' eventually inspired dedicated floricultural work.

Between the 1970s and the 1990s, Ernst Van Jaarsveld, of the Kirstenbosch National Botanical Garden (now SANBI), complemented the botanical collection of *Plectranthus* with systematic observations of cultural requirements, with a view to promoting its popular use. Appealing botanical varieties and ecotypes were also established and prominently displayed, and colourful mass plantings of *Plectranthus* soon became public favourites at Kirstenbosch. Van Jaarsveld maintained the botanical identity of promising ecotypes and subsequently began releasing selected forms of these, often under their botanical variety names (or otherwise under commercially more acceptable popular names) as new horticultural varieties to the gardening industry. Examples are the white and the hooded, dark-striped varieties of *P. saccatus* (released as 'King Goodwill' and 'Nkandla', respectively) and *P. hilliardiae* Codd subsp. *australis* Van Jaarsv. & A.E.Van Wyk (released as cv. Magwa) (Van Jaarsveld, 1994, 2006).

This foundational horticultural development programme was further supported by publication of horticultural guidelines and

regular promotional articles to the public (e.g. Van Jaarsveld, 1987, 1994), which culminated in the definitive taxonomic revision-cum-horticultural guide *The Southern African Plectranthus* (Van Jaarsveld, 2006).

Van Jaarsveld also experimented with hybridising, producing the forerunner of the commercial *Plectranthus* flagship cultivar Mona Lavender (Fig. 4, a cross between *P. hilliardiae* 'Magwa' and *P. saccatus*, which was subsequently improved by Mr. Roger Jacques (also at Kirstenbosch)).

Involvement with the creation of potted plants from Proteaceae led Brits to recognise a similar potential in *Plectranthus*. At Kirstenbosch the pot plant qualities of several species had been touted for a long time and attractive species such as *P. hilliardiae* drew him to this idea.

In 1991 Brits surveyed *Plectranthus* species and varieties (ecotypes) with favourable characters for pot plant breeding. During a study sabbatical he investigated these in the extensive *Plectranthus* collection at the Kirstenbosch NBG, Cape Town (described in Van Jaarsveld, 1987). Good candidates were later obtained and grown in 15 cm pots for evaluation as pot plants.

The following *Plectranthus* types were chosen in accordance with pot and garden plant industry standards, for further work: *P. ambiguus*, *P. hilliardiae*, *P. reflexus* and *P. saccatus* were selected for their larger flowers; *P. ciliatus*, *P. ecklonii* 'Tommy', *P. saccatus* Benth. var. *longitubus* Codd 'King Goodwill' (Van Jaarsveld, 1994) and *P. verticillatus* were selected for their white flower colour; *P. ecklonii* 'Erma', *P. fruticosus* and *P. verticillatus* 'Pink Surprise' were selected as pink flower varieties; *P. ambiguus*, *P. ecklonii* 'Medley Wood', *P. hilliardiae*, *P. praetermissus*, *P. saccatus* and *P. zuluensis* were the selected blue flower varieties; *P. hilliardiae*, *P. oertendahlii*, *P. praetermissus* and *P. verticillatus* were selected for their compact growth habit; *P. hilliardiae*, *P. oertendahlii* and *P. praetermissus* were selected for their decorative leaves (Miller and Morgan, 2000); *Plectranthus ernstii* Codd, *Plectranthus neochilus* Schltr., *P. purpuratus* Harv. and *P. verticillatus* were selected for their tolerance to full sunlight.

The existence of several attractive chance hybrids, both at Kirstenbosch and in private collections, was clear evidence of the hybridization potential amongst *Plectranthus* species. Varied colours, larger flowers and compact growth habit from different species were combined in new crosses. Hybrids with seed sterility were particularly valued, assuming they would be non-invasive in new habitats.

A number of vigorous, sterile F1 hybrids were selected, tested and later released as flowering pot plant cultivars (c 1999). Plant Breeders' Rights for these non-invasive plants were obtained in six countries (including the EU zone) under the registered Trademark of 'Cape Angels'® (Table 4; Fig. 1). Recently some diploid cultivars (including garden plants and hanging basket varieties) were introduced to China for testing, and further research and development, by the South China Normal University (SCNU) in Guangdong Province (Table 2; Hu et al., 2008).

Species of *Plectranthus* proved relatively incompatible in crosses (Brits et al., 2001). The segregation and recombination of favourable characters were not easily achieved, on account of infertility in F1 hybrids (Tables 4 and 5).

In order to overcome general sterility in F1 plants, Brits et al. (2001) created allotetraploids of the best crosses. Growing shoot tips of infertile diploid (2n=28) hybrid selections were treated with 0.2% colchicine. Successful tetraploid treatment was investigated using flow cytometry to measure relative nuclear DNA content (Doležel and Bartoš, 2005). Generally fertility was restored in successful allotetraploids and these were crossed to combine and segregate for combinations of good characters, e.g. compact size, large flowers and attractive leaves (Brits and Li, 2008).

Allotetraploids were successfully created in c. 40 infertile F1 diploid (2n=28) hybrids, in 1996, 2002 and 2004 (Fig. 2). The 4n status of some of these was verified (Fig. 5 -21a). The most important group, for flowering pot plants, was (*P. hilliardiae* x *P. saccatus*) hybrids (Table 4; Fig. 2). Tetraploids had enlarged leaves and flowers (Fig. 2) and showed restored seed fertility and slight loss of vigour. These plants were judged unsuitable for commercial release on account of their high fertility and consequently the risk of escape and possible invasion in new environments.

Tetraploid and diploid parents were crossed to create 3n plants (3n=42) using reciprocal crosses. The objective was to regain sterility whilst retaining some of the polyploid advantages of large flowers, hybrid vigour, etc. The triploid status of some plants was verified using flow cytometry.

Triploids were, typically, sterile with enlarged plant organs in which hybrid vigour appeared higher (Table 6; Figs. 1, 3 and 4). Triploid status was successfully verified (Fig. 5). For example, triploid Cape Angels® 'Purple' [2n *P. hilliardiae* x 4n (*P. hilliardiae* x *P. saccatus*) — Fig. 3] gave a mean fluorescence (channel no.) of 75, as opposed to 98 for its allotetraploid parent, and this means a basic 3:4 ratio for relative DNA content (Fig. 5-2s, -2a).

Various colours were selected, e.g. rose-white, purple and pink (Figs. 1, 3 and 4). These 3n plants performed well in trials and could be the basis for an improved generation of *Plectranthus* cultivars compared with the original 2n generation. A new series of these (including some low-fertility tetraploids) are currently under testing in South Africa, Europe and the U.S.A.

The Cape Angels® varieties are being used as 'model' plants for the investigation of flower abscission during pot plant transportation (Ascough et al., 2005, 2006, 2008).

4. Ethnobotanical use of *Plectranthus*

A wide variety of *Plectranthus* species are used in the traditional medicine of southern Africa. The potential medicinal and economic uses of *Plectranthus* are of great interest (Gaspar-Marques et al., 2006) as there are potentially treatments for many conditions hidden in this genus. Stems, leaves, roots and tubers of different *Plectranthus* species are used to treat all thirteen categories of ailments as described in Economic Botany Data Collection Standard (Cook, 1995), with southern African species covering ten categories (Table 2). Other uses include charms (Hutchings et al., 1996), insect repellants (Pooley, 1998) and culinary herbs (Lukhoba et al., 2006). The essential oils

Fig. 1. Triploid '7s' compared with diploid Cape Angels® Pink (left) and White.

which grant this genus its aromatic nature are thought to hold a number of potential treatments (Rabe and Van Staden, 1998).

P. ambiguus is used to treat respiratory ailments (Hulme, 1954). The leaves are crushed and mixed with hot water to make a treatment for colds (Hutchings et al., 1996; Rabe and Van Staden, 1998).

An infusion or syrup made from the aromatic leaves of *Plectranthus amboinicus* (Lour.) Spreng. is prescribed to treat coughs (Rabe and Van Staden, 1998; Albuquerque, 2001). This species is reported to be used in Zulu medicine, the details of which are not described (Hutchings et al., 1996). The leaves may also be used to flavour food (Hutchings et al., 1996; Pooley, 1998; Van Jaarsveld, 2006). In addition, this species is used in the treatment of cattle (Hutchings et al., 1996; Pooley, 1998).

P. barbatus does not originate from southern Africa, rather from north-eastern Africa (Codd, 1985), however it is found in South Africa as an invasive species (Van Jaarsveld, 2006). This species is one of the most widely used *Plectranthus* species (Alasbahi and Melzig, 2010). It is mentioned here as it is used to treat all 13 categories of ailments (Lukhoba et al., 2006). The species has low toxicity (Figueiredo et al., 2010) and is the subject of ethnobotanical research (Falé et al., 2009; Figueiredo et al., 2010; Porfírio et al., 2010). It is thought that a tea made from its leaves could be useful in the treatment of dental infections (Figueiredo et al., 2010). Infusions and syrups made from the leaves are used to treat digestive and liver complaints by people of African descent living in South America (Albuquerque, 2001).

Fig. 2. Blue fertile allotetraploid (*P. hilliardiae x P. saccatus*) '14s' vs. 2n 'Mona Lavender'.

Fig. 3. Triploid '2s' Cape Angels® Purple.

Fig. 4. Pink, suspected triploid '11s'.

Hay fever and headaches are often treated with *P. ecklonii* (Pooley, 1998).The essential oils from this species show both anti-bacterial and anti-fungal activity useful in the treatment of skin infections (Nyanyiwa and Gundidza, 1999).

Plectranthus elegans Britten has anti-bacterial, anti-fungal (Dellar et al., 1996) and anti-helmintic activity (Lukhoba et al., 2006), providing this species as a treatment for digestive complaints (Neuwinger, 2000). *P. elegans* is also used for relief from sore throats (Lukhoba et al., 2006).

Perhaps the most familiar species, *Plectranthus esculentus* N.E.Br. or Livingstone potato is grown and stored as a food crop in rural areas of southern Africa. The tubers provide an important source of starch and are highly nutritional (Van Wyk and Gericke, 2000). Tubers are boiled before they are eaten and are said to taste similar to turnips, parsnips (Van Wyk and Gericke, 2000) or sweet potato (Pooley, 1998). This species is very adaptable and so is a desirable food crop for almost any climatic region (Van Wyk and Gericke, 2000). Yield is high and tubers can be dried and stored for winter (Pooley, 1998; Van Wyk and Gericke, 2000). This species is also used to treat digestive complaints and topically to treat skin conditions (Lukhoba et al., 2006).

Plectranthus fruticosus has long been noted for its healing properties (Lukhoba et al., 2006). It falls into the 'skin' category as it is used in the treatment of burns (Pages et al., 1998). Interestingly, the stems act as a fly repellent (Roberts, 1990; Pooley, 1998), and are rubbed on window sills (Pooley, 1998).

It is not specified what exactly *Plectranthus grallatus* Briq. is used for, but it is reported that the roots are used in Zulu medicine (Hutchings et al., 1996), and that the tubers of this species are traded on the eastern seaboard of South Africa (Von Ahlefeldt et al., 2003).

Infusions from *Plectranthus hadiensis* (Forssk.) Schweinf. ex Spreng. are administered as an enema to treat coughs (Hutchings et al., 1996; Pooley, 1998). Infusions are also used as a charm to ward off evil spirits (Hutchings et al., 1996).

Plectranthus hereroensis Engl. has shown both anti-bacterial and anti-viral activity, particularly against *Herpes simplex* (Batista et al., 1995) and activity against certain anti-biotic resistant bacterial strains (Gaspar-Marques et al., 2006). An infusion from the roots is used to treat liver complaints (Ferreira et al., 1997).

Plectranthus laxiflorus Benth. is used in the treatment of a variety of illnesses. The literature reports its use in nine categories (Table 4). Crushed leaves and stems are used to keep away mosquitoes and also to treat eye complaints (Hutchings et al., 1996). Enemas made from this species are given for fevers and abdominal conditions (Roberts, 1990; Hutchings et al., 1996; Pooley, 1998; Rabe and Van Staden, 1998; Neuwinger, 2000) and influenza (Watt and Breyer-Brandwijk, 1962). Coughs and colds are treated with a tea (Hutchings et al., 1996; Pooley, 1998; Rabe and Van Staden, 1998), and a mouthwash is made from root infusions and used for loose and bleeding teeth (Hulme, 1954; Hutchings et al., 1996; Pooley, 1998).

P. laxiflorus is also used to treat livestock. Roots are crushed and boiled to treat gallsickness. Roots and bark are used in combination against redwater, and crushed and boiled bark is used when the placenta is retained (Masika and Afolayan, 2003).

P. madagascariensis is used to treat ailments in the respiratory and skin categories (Lukhoba et al., 2006). Coughs are treated with an enema (Hutchings et al., 1996) or

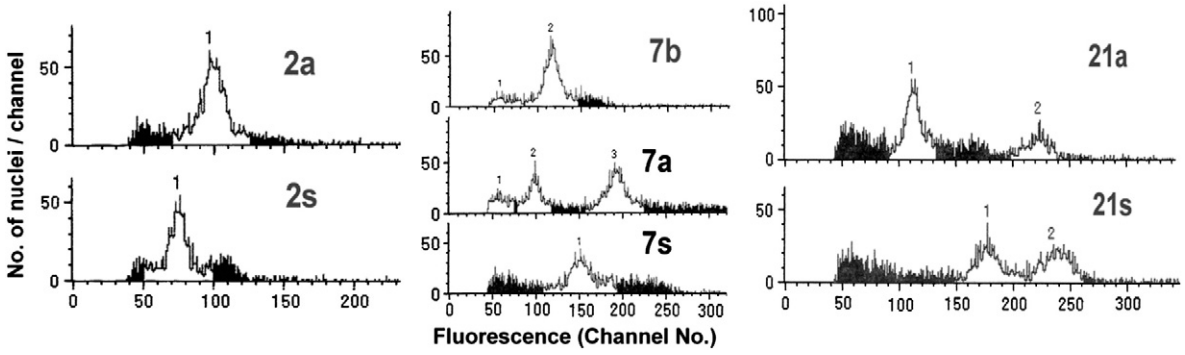

Fig. 5. Flow cytometry histograms of three triploid *Plectranthus* hybrids, their triploid status indicated by their relative position to known diploid and tetraploid parents on the X-axis. No. 2s (left bottom) — Cape Angels® Purple, compared with known allotetraploid ♂ parent 2a (*P. hilliardiae* x *P. saccatus*); No. 7 — 7s triploid hybridised from putative mixoploid (2n+4n) ♀ (*P. hilliardiae* x *P. saccatus*) (7a) and 2n ♂*P. saccatus* (7b); No. 21s peak 1 — triploid hybridised from allotetraploid ♀ (*P. hilliardiae* x *P. saccatus* — 21a, 21s peaks 2) and 2n ♂ *P. hilliardiae* (21a peak 1).

alternatively with root decoctions and infusions (Hutchings et al., 1996; Rabe and Van Staden, 1998). Crushed leaves are massaged into the skin to treat scabies (Hutchings et al., 1996).

Although not originally from southern Africa, *Plectranthus rotundifolius* Spreng. is a popular food in South Africa. Native to West Africa, the tubers of this plant (Hausa potato) are eaten as a vegetable and show potential for development as a domestic crop (Rivera Nunez and Obon de Castro, 1992; Venter et al., 2000).

The wide variety of ailments that may be treated with *Plectranthus* is an indication of the medicinal value of the genus. A number of species are not toxic and so may be taken orally, whilst others are used topically on the skin or as enemas. The scope for drug development from these plants is endless and there is undoubtedly a call for further research into this area.

5. Conclusions

Plectranthus is attracting growing attention in the horticultural sector, largely due to its marked breeding improvements in recent years. In addition there is a wealth of ethnobotanical species. The potential for research around the horticulture and ethnobotany of the genus imply that this may truly be 'a plant for the future'.

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Appendix 1

Table 1
Horticulutral uses of southern African *Plectranthus* species. Number indicates the conservation status of species.

Species	Species name with authority and recent synonym	Horticultural use	Reference
Plectranthus aliciae	*Plectranthus aliciae* (Codd) Van Jaarsv. & T.J.Edwards [=*Plectranthus madagascariensis* (Pers.) Benth. var. *aliciae* Codd]	Gardens	Joffe (2001)
		Groundcover	Joffe (2001)
		Hanging baskets	Joffe (2001)
		Potted plant	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus ambiguus	*Plectranthus ambiguus* (Bolus) Codd	Container	Pooley (1998) (Van Jaarsveld, 1987, 2006)
		Gardens	Van Jaarsveld (1987) (Pienaar, 1985, 1991)
		Groundcover	Pooley (1998) (Van Jaarsveld, 1987, 2006) Pienaar (1984)
		Hanging baskets	Van Jaarsveld (1987, 2006)
Plectranthus amboinicus	*Plectranthus amboinicus* (Lour.) Spreng.	Rockeries	Van Jaarsveld (2006)
Plectranthus barbatus[1]	*Plectranthus barbatus* Andrews	Gardens	Van Jaarsveld (2006) Pienaar (1984)
Plectranthus brevimentum[2]	*Plectranthus brevimentum* T.J.Edwards		
Plectranthus candelabriformis	*Plectranthus candelabriformis* Launert	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus caninus	*Plectranthus caninus* Roth	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus ciliatus	*Plectranthus ciliatus* E.Mey. ex Benth.	Container	Pooley (1998) (Van Jaarsveld, 1987, 2006)
		Garden	Van Jaarsveld (1987)
		Groundcover	Pooley (1998) (Van Jaarsveld, 1987, 2006)
		Hanging baskets	(Van Jaarsveld, 1987, 2006)
Plectranthus cylindraceus	*Plectranthus cylindraceus* Hochst. ex Benth.	Bushveld Gardens	Pooley (1998) Van Jaarsveld (2006)
		Pot plant	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus dinteri	*Plectranthus dinteri* Briq.	Bushveld gardens	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus dolichopodus	*Plectranthus dolichopodus* Briq.	Gardens	Van Jaarsveld (2006)
Plectranthus dolomiticus[2]	*Plectranthus dolomiticus* Codd	Bushveld gardens	Van Jaarsveld (2006)
		Potted plant	Van Jaarsveld (2006)

(*continued on next page*)

Table 1 (*continued*)

Species	Species name with authority and recent synonym	Horticultural use	Reference
Plectranthus ecklonii	*Plectranthus ecklonii* Benth.	Gardens	Pooley (1998)
			Lukhoba et al. (2006)
			(Van Jaarsveld, 1987, 2006)
			(Pienaar, 1984, 1985, 1991)
			Joffe (2001)
Plectranthus elegans	*Plectranthus elegans* Britten		
Plectranthus elegantulus	*Plectranthus elegantulus* Briq.	Garden	Lukhoba et al. (2006)
			Van Jaarsveld (1987)
		Groundcover	(Van Jaarsveld, 1987, 2006)
		Potted plant	(Van Jaarsveld, 1987, 2006)
		Hanging baskets	(Van Jaarsveld, 1987, 2006)
Plectranthus ernstii[3]	*Plectranthus ernstii* Codd	Bonsai	Pooley (1998)
			Van Jaarsveld (2006)
		Container	Pooley (1998)
		Hanging baskets	Van Jaarsveld (1987)
		Pot plant	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus esculentus[4]	*Plectranthus esculentus* N.E.Br.	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus fruticosus	*Plectranthus fruticosus* L'Hér.	Gardens	Pooley (1998)
			Lukhoba et al. (2006)
			(Van Jaarsveld, 1987, 2006)
			Pienaar (1984, 1985, 1991)
			Joffe (2001)
		Hanging baskets	Van Jaarsveld (1987)
Plectranthus grallatus	*Plectranthus grallatus* Briq.	Gardens	Van Jaarsveld (2006)
Plectranthus grandidentatus	*Plectranthus grandidentatus* Gürke	Gardens	Van Jaarsveld (1987)
		Groundcover	Pooley (1998)
			Van Jaarsveld (2006)
Plectranthus hadiensis	*Plectranthus hadiensis* (Forssk.) Schweinf. ex Spreng.	Bushveld gardens	Pooley (1998)
			(Van Jaarsveld, 1987, 2006)
Plectranthus hereroensis	*Plectranthus hereroensis* Engl.	Bushveld gardens	(Van Jaarsveld, 1987, 2006)
Plectranthus hilliardiae	*Plectranthus hilliardiae* Codd	Gardens	Pooley (1998)
		Groundcover	Van Jaarsveld (1987)
			Van Jaarsveld (2006)
		Potted plant	(Van Jaarsveld, 1987, 2006)
			Pienaar (1984)
Plectranthus laxiflorus	*Plectranthus laxiflorus* Benth.	Forest Gardens	Van Jaarsveld (2006)
Plectranthus lucidus	*Plectranthus lucidus* Van Jaarsv. & T.J.Edwards	Groundcover	Van Jaarsveld (2006)
Plectranthus madagascariensis	*Plectranthus madagascariensis* (Pers.) Benth.	Garden	Lukhoba et al. (2006)
			Van Jaarsveld (1987)
			Pienaar (1991)
		Groundcover	Pooley (1998)
			(Van Jaarsveld, 1987, 2006)
			Pienaar (1984)
Plectranthus malvinus[5]	*Plectranthus malvinus* Van Jaarsv. & T.J.Edwards	Forest Gardens	Van Jaarsveld (2006)
		Hanging baskets	Van Jaarsveld (2006)
Plectranthus mirabilis	*Plectranthus mirabilis* (Briq.) Launert	Bushveld gardens	Van Jaarsveld (2006)
			Van Jaarsveld (2006)
Plectranthus mutabilis	*Plectranthus mutabilis* Codd	Gardens	Van Jaarsveld (1987)
		Groundcover	Van Jaarsveld (2006)
		Bushveld gardens	Van Jaarsveld (2006)
Plectranthus mzimvubuensis[6]	*Plectranthus mzimvubuensis* Van Jaarsv.	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus neochilus	*Plectranthus neochilus* Schltr.	Groundcover	Pooley (1998)
			(Van Jaarsveld, 1987, 2006)
		Bushveld gardens	(Van Jaarsveld, 1987, 2006)
		Rockeries	Van Jaarsveld (1987)
Plectranthus oertendahlii[6]	*Plectranthus oertendahlii* T.C.E.Fr.	Bushveld gardens	(Van Jaarsveld, 1987, 2006)
		Container	Pooley (1998)
			(Van Jaarsveld, 1987, 2006)
		Groundcover	Van Jaarsveld (2006)
		Hanging baskets	Van Jaarsveld (2006)
			Van Jaarsveld (1987)
		Potted plants	Van Jaarsveld (2006)
Plectranthus oribiensis[6]	*Plectranthus oribiensis* Codd	Subtropical garden	Pooley (1998)
			Van Jaarsveld (2006)

Table 1 (*continued*)

Species	Species name with authority and recent synonym	Horticultural use	Reference
Plectranthus ornatus[1]	*Plectranthus ornatus* Codd	Groundcover	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus pentheri[7]	*Plectranthus pentheri* (Gürke) Van Jaarsv. & T.J.Edwards	Bushveld gardens	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus petiolaris	*Plectranthus petiolaris* E.Mey. ex Benth.	Bushveld gardens	Van Jaarsveld (2006)
		Groundcover	Van Jaarsveld (2006)
Plectranthus porcatus[8]	*Plectranthus porcatus* Van Jaarsv. & P.J.D.Winter	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus praetermissus[8]	*Plectranthus praetermissus* Codd	Groundcover	Van Jaarsveld (2006)
		Hanging basket	(Van Jaarsveld, 1987, 2006)
		Potted plant	(Van Jaarsveld, 1987, 2006)
			Pienaar (1984)
Plectranthus psammophilus[5]	*Plectranthus psammophilus* Codd	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus purpuratus	*Plectranthus purpuratus* Harv.	Bushveld gardens	(Van Jaarsveld, 1987, 2006)
		Groundcover	Van Jaarsveld (2006)
		Hanging baskets	Van Jaarsveld (2006)
			Van Jaarsveld (1987)
		Rockeries	Van Jaarsveld (2006)
Plectranthus ramosior	*Plectranthus ramosior* (Benth.) Van Jaarsv. [=*Plectranthus madagascariensis* (Pers.) Benth. var. *ramosior* Benth.]	Rockeries	Van Jaarsveld (2006)
Plectranthus reflexus[5]	*Plectranthus reflexus* Van Jaarsv. & T.J.Edwards	Subtropical gardens	Van Jaarsveld (2006)
Plectranthus rehmannii	*Plectranthus rehmannii* Gürke	Subtropical gardens	Van Jaarsveld (2006)
Plectranthus rubropunctatus	*Plectranthus rubropunctatus* Codd	Forest gardens	Van Jaarsveld (2006)
		Groundcover	Van Jaarsveld (2006)
Plectranthus saccatus	*Plectranthus saccatus* Benth.	Container	Pooley (1998)
			Joffe (2001)
		Garden	Joffe (2001)
			Van Jaarsveld (1987)
			Pienaar (1985)
		Hanging baskets	Van Jaarsveld (1987)
		Groundcover	(Van Jaarsveld, 1987, 2006)
			Pienaar (1984)
			Joffe (2001)
		Potted plant	Van Jaarsveld (2006)
		Subtropical gardens	(Van Jaarsveld, 1987, 2006)
Plectranthus sanguineus	*Plectranthus sanguineus* Britten	Potted plant	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus spicatus	*Plectranthus spicatus* E.Mey. ex Benth.	Bushveld gardens	Pooley (1998)
			Van Jaarsveld (2006)
		Potted plants	Van Jaarsveld (2006)
Plectranthus strigosus	*Plectranthus strigosus* Benth.	Groundcover	Van Jaarsveld (1987)
		Hanging baskets	(Van Jaarsveld, 1987, 2006)
		Rockeries	(Van Jaarsveld, 1987, 2006)
		Subtropical gardens	(Van Jaarsveld, 1987, 2006)
Plectranthus stylesii[2]	*Plectranthus stylesii* T.J.Edwards	Rockeries	Van Jaarsveld (2006)
		Subtropical gardens	Van Jaarsveld (2006)
Plectranthus swynnertonii	*Plectranthus swynnertonii* S.Moore	Forest gardens	Van Jaarsveld (2006)
		Groundcover	Van Jaarsveld (2006)
Plectranthus tetensis	*Plectranthus tetensis* (Baker) Agnew	Bushveld gardens	Van Jaarsveld (2006)
		Groundcover	Pooley (1998)
		Rockeries	Van Jaarsveld (2006)
Plectranthus tetragonus	*Plectranthus tetragonus* Gürke	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus unguentarius	*Plectranthus unguentarius* Codd	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus venteri[6]	*Plectranthus venteri* Van Jaarsv. & Hankey	Bushveld gardens	Van Jaarsveld (2006)
		Rockeries	Van Jaarsveld (2006)
Plectranthus verticillatus	*Plectranthus verticillatus* (L.f.) Druce	Container	Van Jaarsveld (2006)
		Garden	Lukhoba et al. (2006)
			Van Jaarsveld (1987)
		Groundcover	Pooley (1998)
			(Van Jaarsveld, 1987, 2006)
			Joffe (2001)
		Hanging baskets	Pooley (1998)
			Van Jaarsveld (1987)
			Joffe (2001)

(*continued on next page*)

Table 1 (*continued*)

Species	Species name with authority and recent synonym	Horticultural use	Reference
Plectranthus woodii	*Plectranthus woodii* Gürke *Plectranthus hadiensis* (Forssk.) Schweinf. ex Spreng. var. *woodii* (Gürke) Codd	Rockery	Van Jaarsveld (2006)
Plectranthus xerophilus	*Plectranthus xerophilus* Codd	Bushveld gardens	Van Jaarsveld (2006)
Plectranthus zuluensis	*Plectranthus zuluensis* T.Cooke	Container	Pooley (1998) Van Jaarsveld (1987) Joffe (2001)
		Garden	Van Jaarsveld (1987) Joffe (2001)
		Groundcover	Van Jaarsveld (2006)
		Subtropical garden	Van Jaarsveld (2006)

[1] Not native to South Africa; [2] Critically rare; [3] Near Threatened; [4] Data deficient–insufficient information; [5]Possibly threatened; [6] Rare; [7] Data deficient-Taxonomically problematic; [8] Vulnerable.

Table 2
Ethnobotanical uses of southern African *Plectranthus* species.

Species	Species name with authority and recent synonym	Medicinal	Reference
Plectranthus ambiguus	*Plectranthus ambiguus* (Bolus) Codd	Respiratory	Hulme (1954) Hutchings et al. (1996) Pooley (1998) Rabe and Van Staden (1998) Neuwinger (2000)
Plectranthus amboinicus	*Plectranthus amboinicus* (Lour.) Spreng.	Respiratory	Albuquerque (2001)
		Veterinary (Cattle)	Pooley (1998) Hutchings et al. (1996)
Plectranthus barbatus	*Plectranthus barbatus* Andrews	Digestive	Albuquerque (2001)
		Liver complaints	Albuquerque (2001)
		Skin	Lukhoba et al. (2006)
		Respiratory	Lukhoba et al. (2006)
		Infections/fevers	Lukhoba et al. (2006)
		Genito-urinary	Lukhoba et al. (2006)
		Pain	Lukhoba et al. (2006)
		Muscular-Skeletal	Lukhoba et al. (2006)
		Circulation and Blood	Lukhoba et al. (2006)
		Nervous	Lukhoba et al. (2006)
		Sensory	Lukhoba et al. (2006)
		Poison treatment	Lukhoba et al. (2006)
		Inflammation	Lukhoba et al. (2006)
Plectranthus ecklonii	*Plectranthus ecklonii* Benth.	Headaches	Pooley (1998)
		Hayfever	Pooley (1998)
		Skin	Nyanyiwa and Gundidza (1999)
Plectranthus elegans	*Plectranthus elegans* Britten	Digestive	Neuwinger (2000)
		Respiratory	Neuwinger (2000)
Plectranthus esculentus	*Plectranthus esculentus* N.E.Br.	Digestive	Neuwinger (2000)
		Pain	Neuwinger (2000)
Plectranthus fruticosus	*Plectranthus fruticosus* L'Hér.	Skin	Pages et al. (1998)
Plectranthus grallatus	*Plectranthus grallatus* Briq.	Unspecified	Hutchings et al. (1996)
Plectranthus hadiensis	*Plectranthus hadiensis* (Forssk.) Schweinf. ex Spreng.	Respiratory	Pooley (1998) Hutchings et al. (1996)
Plectranthus hereroensis	*Plectranthus hereroensis* Engl.	Digestive	Batista et al. (1995) Ferreira et al. (1997)
Plectranthus laxiflorus	*Plectranthus laxiflorus* Benth.	Digestive	Pooley (1998) Roberts (1990) Hutchings et al. (1996) Rabe and Van Staden (1998) Neuwinger (2000)
		Skin	Neuwinger (2000)
		Respiratory	Hutchings et al. (1996) Pooley (1998) Rabe and Van Staden (1998) Neuwinger (2000)

Table 2 (*continued*)

Species	Species name with authority and recent synonym	Medicinal	Reference
		Infections/Fever	Watt and Breyer-Brandwijk (1962) Roberts (1990) Hutchings et al. (1996) Pooley (1998) Rabe and Van Staden (1998)
		Inflammation	Neuwinger (2000)
		Genito-urinary	Neuwinger (2000)
		Pain	Neuwinger (2000)
		Mouth wash	Pooley (1998)
		Muscular–skeletal	Neuwinger (2000)
		Nervous	Lukhoba et al. (2006)
		Sensory	Neuwinger (2000)
		Veterinary (Cattle)	Masika and Afolayan (2003)
Plectranthus madagascariensis	*Plectranthus madagascariensis* (Pers.) Benth.	Skin	Roberts (1990) Pooley (1998) Rabe and Van Staden (1998) Neuwinger (2000)
		Respiratory	Roberts (1990) Pooley (1998) Rabe and Van Staden (1998) Neuwinger (2000)

Table 3
Household uses of southern African *Plectranthus* species.

Species	Species name with authority and recent synonym	Use	Reference
Plectranthus amboinicus	*Plectranthus amboinicus* (Lour.) Spreng.	Culinary (herb)	Pooley (1998) Van Jaarsveld (2006) Hutchings et al. (1996)
Plectranthus ciliatus	*Plectranthus ciliatus* E.Mey. ex Benth.	Used to wash clothes	Watt and Breyer-Brandwijk (1962) Pooley (1998)
Plectranthus esculentus	*Plectranthus esculentus* N.E.Br.	Culinary (starch)	Pooley (1998) Van Wyk and Gericke (2000) Lukhoba et al. (2006) Van Jaarsveld (2006)
Plectranthus fruticosus	*Plectranthus fruticosus* L'Hér.	Fly repellent	Roberts (1990) Pooley (1998)
Plectranthus hadiensis	*Plectranthus hadiensis* (Forssk.) Schweinf. ex Spreng.	Fish poison Charm	Pooley (1998) Hutchings et al. (1996)
Plectranthus laxiflorus	*Plectranthus laxiflorus* Benth.	Culinary (vegetable) Mosquito repellent	Pooley (1998) Hutchings et al. (1996)
Plectranthus neochilus	*Plectranthus neochilus* Schltr.	Air purifier	Pooley (1998)
Plectranthus petiolaris	*Plectranthus petiolaris* E.Mey. ex Benth.	Aromatic	Pooley (1998)
Plectranthus rotundifolius	*Plectranthus rotundifolius* Spreng.	Culinary (vegetable) Culinary (starch)	Venter et al. (2000) Rivera Nunez and Obon de Castro (1992)
Plectranthus unguentarius	*Plectranthus unguentarius* Codd	Pomade	Lukhoba et al. (2006)

Table 4
Cape Angels® flowering pot plants — sterile *Plectranthus (hilliardiae* x *saccatus)*F1 hybrids.

Trade name	Ploidy	Originated
Blue Angel	2n	1994
Pink Angel	2n	1999
White Angel	2n	2002
Dark Pink Angel	2n	2002
Purple Angel	3n	1999

(Brits and Li, 2008).

Table 5
Cape Angels® *Plectranthus* evaluated by SCNU as pot and garden plants.

Cultivar	Hybrid type	Fertility (%)
Amanda	x *P. purpuratus*	0
Cloud Nine	x *P. hilliardiae*	0
Coral Cloud	x *P. fruticosus*	0
Edelblau	x *P. hilliardiae*	0
Frills	x *P. fruticosus*	2
Gurus Choice	x *P. saccatus*	?
Lilac Spur	x *P. oertendahlii*	3

(Brits and Li, 2008).

Table 6
Flower characters in triploids vs. typical diploid *Plectranthus*.

Cultivar (and ploidy)	Corolla (mm)		Flower dry wt (mg)
	Tube length	Tube width	
(3n:) '7s'	24.7±0.1	9.0±0.1	11.0±0.2
(3n:) '21a'	30.8±0.2	7.9±0.2	8.2±0.6
(2n:) Cape Angel® White	20.2±0.1	5.6±0.2	4.7±0.3

(Brits and Li, 2008).

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