Anthurium 'Montana', an *A. amnicola* hybrid

Anthurium *aristocracy*

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The anthurium is a unique ornamental plant that has been dubbed the aristocrat of the plant world, commanding attention and generating considerable interest wherever it is displayed. Its estimated world trade exceeds US$20 million. This places it second in trade and economic value only to spray orchids, and makes it a thriving lucrative industry in many parts of the world, including several Caribbean countries, Taiwan, Singapore, Thailand, Japan, and the Philippines. However, Holland remains the world's largest grower, and by virtue of its extensive breeding programme, this country is the primary source of new colours and cultivars to the international market. While Holland supplies mainly the European market, Hawaii remains the chief supplier to the United States, and over the years has developed as the epicentre for published research on various aspects of anthurium genetics, propagation and improvement. Recently, the anthurium has been a popular feature in the ornamental arena of New Zealand and Australia. There is a uniquely strong market for the anthurium as a pot plant in both these countries, whereas in many other countries the predominant economic focus is the cut flower industry.

The genus *Anthurium* belongs to the family Araceae, which includes other well known ornamental genera, such as *Spathiphyllum, Zantedeschia, Philodendron,* and *Monstera*. While the taxonomic literature describes as many as 1,000 *Anthurium* species, *A. andraeanum* Linden is widely accepted as the progenitor of the anthurium cut flower cultivars commercially propagated today, and is the highlight of this article. Since its discovery in Colombia it has been bred and cultivated extensively for its brilliantly coloured and patterned flowers. However, *A. andraeanum* itself represents a hybrid population, and the wide variation in size, colour, and growth form of anthuriums in cultivation is a consequence of extensive interspecific hybridisation.

Anthurium flowers

The term "flower" is used to refer to the commercial product, made up of the spathe, spadix and peduncle (flower stalk). The anthurium spathe is actually a modified bract that subtends the protruding cylindrical inflorescence rachis, called the spadix (Higaki *et al*., 1984). The surface of the spadix is made up of fused segments, each being the point from which the true flower emerges. The true flowers are minute, hermaphroditic and protogynous (the female parts of the flower develop first) in development, making anthurium highly outcrossing (Campbell, 1900). The flowers are invisible to the naked eye and are insect pollinated. Once fertilised the ovary enlarges and forms a single berry with one or two seeds inside, in a process that completely disfigures the spadix. Once mature, these detach from the spadix.

The growth of the anthurium plant is divided into a juvenile phase, followed by a generative or reproductive phase. In the juvenile phase, vegetative buds emerge in the axils of the leaves, while in the generative phase, inflorescence buds can be found in the leaf axils (Christensen, 1971). Once the juvenile phase has passed, flowers are produced in an alternating cycle with leaves throughout the year (Kamemoto and Nakasone, 1963). When the flower emerges in the leaf axil, the spathe may or may not be highly coloured, but it is tightly curled around the immature spadix. It takes an average of 6-9 weeks from the time of its emergence, for the peduncle to be fully extended and the spathe fully expanded, exposing a mature spadix. For *A. andraeanum,* the spathe is cordate and simple, with very prominent veins that originate at the spadix-spathe junction. These run in arcs along the surface of the spathe, and converge at its apex (Higaki *et al*., 1984). The spathe is also characterised by a thick cuticle on the upper and lower epidermis. The epidermis (both upper and lower) is one cell layer thick, and beneath this is a single or double layer of similar sized, hypodermal cells. In anthurium, flower colour pigment generally accumulates only in the hypodermal cells of both the upper and lower epidermis.

Flower colour

The main colours in anthurium spathes are red/pink, orange/coral, and white. A few cases of green, and even brown, coloured spathes are also known. Some white lines can

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develop a pink blush as the flower matures giving a patterned arrangement to the spathe. Blues and yellows are notably absent, and while varied shades of red and orange are present, these are not always in a desirable genetic background. Cultivars with a red spathe usually have a bright yellow spadix, while the colour of the spadix varies from orange to red in cultivars with a pink spathe. In the orange spathe group, spadices are either orange or yellow, whereas in cultivars with a white spathe, there can be attractive matches with pink to bright red spadices. Other colours such as purple, bronze and green are also found in the spadix (Kamemoto and Kuehnle, 1996).

In *Anthurium* (and in the family Araceae in general), the major colour pigments in the spathe are anthocyanin derivatives. Carotenoid pigments are also present, but only in spadix tissue where they are responsible for the bright yellow colour of this organ. All other spadix colours are flavonoid-based. Chlorophyll also contributes to spathe colour, either alone, giving a completely green spathe, or in combination with other anthocyanin pigments to give a brown spathe (Kamemoto and Kuehnle, 1996).

Pelargonidin and cyanidin derived anthocyanins are the main colour pigments in the anthurium spathe. These are usually glycosylated with glucose and rhamnose, forming pelargonidin and cyanidin 3-rutinoside (Iwata *et al*., 1979; 1985). The presence of one or both pigments, as well as their different concentrations, determines the spathe colour (Iwata *et al*., 1985). Flavones are the other main flavonoid pigments in the anthurium spathe. In a leaf survey of 142 species from 58 genera of the family Araceae, Williams *et al*. (1981) found that flavone *C*-glycosides comprised 82% of the major flavonoids. Flavone mono-*C* and di-*C*-glycosides along with *O*-glycosyl derivatives were all represented.

Anthocyanin pigments have also been found in the leaves, peduncle, stipules, roots, and stems of anthurium. In petals of other flowers, anthocyanins are nearly always found in epidermal cells, while in vegetative tissue they tend to be located sub-epidermally (Kay *et al*., 1981; Hrazdina, 1982). However, Wannakrairoj and Kamemoto (1990) found that in the anthurium spathe, the location of anthocyanin differed from species to species and could be located in the epidermis, hypodermis and/or mesophyll. In anthurium cultivars, anthocyanins were found exclusively in the hypodermal layers on both the upper and lower surfaces of the spathe (Higaki *et al*., 1984).

In *A. amnicola* Dressler, peonidin 3-rutinoside was reported in addition to pelargonidin and cyanidin glycosides. In combination with cyanidin 3-rutinoside, this compound accounts for the lavender spathe and purple spadix of this species (Marutani *et al.*, 1987). The distribution of anthocyanins, however, in *A. amnicola* is restricted to the lower and upper epidermis.

Breeding new anthuriums

Plant breeding has provided significant information concerning the inheritance of flower colour in anthurium (Kamemoto *et al*., 1988). The current hypothesis is that two genes, *M* and *O*, are responsible for anthocyanin production in anthurium, and that there is recessive epistasis of the *O* locus over the *M* locus. These authors proposed that gene *M* controls the production of cyanidin 3-rutinoside, and that gene *O* controls the production of pelargonidin 3-rutinoside. Although *M* and *O* may be the two major genes affecting spathe colour in anthurium, Kamemoto *et al*. (1988) suggested several other genes operate to provide the diversity of flower colours. However, these have not yet been identified and further experiments are being conducted to identify all the genetic factors controlling pigment production in the anthurium spathe.

Anthurium amnicola, one of the more recent additions to the anthurium genus, was discovered in Panama in 1972. Its most beneficial feature is the ease with which it can be crossed with other species, and it has been used in numerous interspecific crosses with *A. andraeanum* to produce slight variations in flower colour. While conventional plant breeding has been the standard approach for developing new colours in anthurium, it is limited in scope. A molecular approach to modifying anthurium flower colour has been initiated in response to the increasing demand for novel spathe colours. Several genes involved in the flower colour pathway in anthurium have been isolated, and studies of their expression over time in various tissues have revealed a unique expression pattern. Results also suggest that there is diurnal rhythm to the expression of one of these genes (Collette, 2002). The isolated genes are currently being used to design genetic constructs for various experiments to modify colour. New paths are being explored to discover the possibility of producing yellow and even the elusive blue anthurium.

Growing anthuriums

Anthurium andraeanum is a slow growing perennial requiring shady, humid conditions, such as might be found in a tropical rainforest. In addition to *A. andraeanum*, other species are commonly grown in New Zealand and Australia. *Anthurium scherzerianum* Schott is a flamboyant anthurium species noted for its coiled spadix and oval, orange coloured spathe. Its foliage, being lanceolate and linear, is another feature that distinguishes it from *A. andraeanum*. Another interesting species is *A. bakeri* Hook f., which has all colour and attractiveness uniquely invested in brightly coloured berries. The spathe is green, miniature and nondescript.

Anthuriums are not difficult to grow and are ideal as indoor plants once positioned away from direct sunlight. Once successfully established, they are quite productive generating new leaves and flowers all year round. They also tiller profusely. These side shoots can be broken off and potted up for multiplication. Should established plants become root bound, active regrowth can be initiated by severing the lower half of the root system, separating the plant clump into tillers, and repotting.

Vern Collette, originally from the Caribbean (Trinidad and Tobago), conducted research on flower colour development at Crop and Food Research, following his doctoral studies on Anthurium *at Massey University, Palmerston North. He has a strong interest in anthurium flowers because of their interesting and diverse morphology. In Trinidad, he worked extensively with farmers involved in the international market to develop new cultivars for export.*

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Two examples of the flamboyant *Anthurium scherzerianum*, noted for its coiled spadix and oval, orange coloured spathe