CLIVIA

THREE

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CLIVIA

THREE

*Clivia miniata mu*ltipetal. Breeder: Y. Nakamura Grower: Ian Brown

EDITORS

John Winter Mick Dower Claude Felbert

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EDITORIAL

What is most striking in every new publication on *Clivia* is the extraordinary versatility of the genetic make-up of this genus. As John van der Linde points out in his article on plant related manias, this genetic richness has ensured that there have always been, and always will be, plant enthusiasts who are infatuated with the prospect of breeding new *Clivia* cultivars.

It is a richness which has enabled those enthusiasts to breed *Clivia* which satisfy the aesthetic needs of many very different cultures. In Japan it has been a preference for unique shapes and variegations in the leaves; in China it has been for well emphasised and prominent patterns of leaf veins and unique rounded leaf shapes; in Europe naturally miniature forms and plants which flower within two years have been selected; in temperate climates in the Western world the emphasis has been on unique flowers. Twenty years ago it was the yellow flower which was rare. Today it is not, but a range of different yellows and brilliant red, pink, pastel and bi-coloured flower colours has been developed and is continually being improved with broader, narrower, straight, rolled or recurved petals and more prominent umbels well proportioned to the size of the plant.

Yoshikazu Nakamura is unique in that he has developed this richness of the *Clivia* genes not only to satisfy the preference of Japanese culture for variegated and dwarf leaf forms, but he has also taken the lead in the development of flowers with new colours and shapes, and in exploring the potential of hybridising the different *Clivia* species. His article reminds us that the potential for further improvement is far from being exhausted.

This is all the more remarkable when one remembers that *Clivia* are endemic to South Africa and the material which has been used in developing those cultivars has been confined, in the case of *Clivia miniata,* to those few plants which found their way in the 19th Century only from Kwa Zulu-Natal to Europe, where they were improved before going also to Australia, Japan, China and California. In the 20th Century yellow forms in particular were exported from South Africa by breeders such as the late Gordon McNeil and Cynthia Giddy, mostly to Japan and California, adding to the genetic material used to produce new cultivars. But those plants also originated from the KwaZulu-Natal gene pool.

In the past six years John Winter has led explorations in the area south west of KwaZulu-Natal between Port Edward and East London, known as the Transkei, where different forms of *Clivia miniata* have been found in the habitat. These include two mutating populations. The one has normal florets which are 7.5 cm. in diameter but with colours ranging from orange to yellow to pink and pink suffused with yellow. In the other population the florets are much larger (10 to 12 cm. in diameter) with wider petals and a whole range of pastel colours. These explorations have also found different forms of swamp C. *gardenii* in the eastern Transkei and widely different forms of C. *gardenii* (including a robust yellow form) in KwaZulu-Natal. Some of these have been illustrated in this publication.

They are an important extension of the *Clivia* gene pool, adding to its versatility and the potential for even more exciting cultivars, emphasizing Craig Honiball's conclusion that 'rich, diverse and underutilised variation exists' in this genus.

The South African National Botanical Institute has recently acquired state-of-the-

art equipment at Kirstenbosch to map the DNA of plants. The Cape Province Clivia Club has helped sponsor financially the use of this facility to establish the DNA and inter-relationships of the *Clivia* species. This will reveal whether the swamp C. *gardenii* is indeed a different species, as Keith Hammet suspects, or whether the many different forms of C. *gardenii* found and collected in the habitat (including the robust yellow form) are in fact all one species. All members and Clubs of the Clivia Society are encouraged to *add* their financial support to this project.

The Yearbooks are entirely dependent on contributions by *Clivia* enthusiasts. The Editorial Committee invites each and all to submit their contributions for publication of their best *Clivia* and of new cultivars, including good quality photographs with true colours.

While this publication has been delayed because two of the editors have undergone heart surgery, the planning for Clivia Four is already far advanced. It will bring you the results of the investigation into the DN A of the species, and also details of new discoveries, one quite miraculous, which can be made public only then.

Cape Town, November 2001.

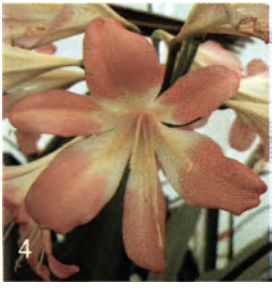
Clivia names

The use ofgrex names by Harold Koopozvitz in his article on Clivia Names *in Clivia Yearbook 2 has been criticized on the grounds that the International Code stipulates that grex names be used only for orchids.*

Professor Koopozvitz has agreed therefore that the word 'group' should be substituted for 'grex' wherever it is used in his article. Eds.

Northern Club Best on Show 2000.
Anna Mever

C. *miniata* - Special Merit Award. Northern Club Show 2000. Anna Mever



PHOTOGRAPHING CLIVIA - DIGITALLY

Mike Jeans

Digital photography, which is developing at an ever increasing pace, has now reached the point where it is a viable alternative to conventional film photography in nearly all respects. This article is intended to set out in simple terms the case for and against using a digital camera to photograph your *Clivia.* To add some *Clivia* interest to the article, I have illustrated it with some of my digital photographs of what I hope are my more interesting *Clivia.*

The digital camera can only work efficiently when used with other equipment:

A **PC** or **laptop computer** through which the camera is downloaded. The computer needs to have a spare port compatible with the needs of the camera - usually a USB port. The photos can be stored on the computer hard disc drive, but scope is greatly extended if the computer has a **CD writer,** or a **ZIP drive.** Many hundreds of photos can be stored on a single CD, but it should be noted that you can only record once on a normal CD. If the CD is a re-writable one, then it is possible to record over the top of what is already on it, but not to add to it.

A reasonably good quality **monitor.** This will let you view your photos, choose those that are to be kept and make any alterations required.

An **inkjet printer,** preferably of photo quality so that you can make high quality prints of up to A4 size of any of the photos.

The above equipment constitutes a 'digital darkroom' where you can manipulate and alter your photographs with a flexability that cannot be approached in a conventional darkroom. It is likely that both the camera and the inkjet printer will come with software that is more than adequate to do all the editing, re-sizing, colour adjustments and a mass of special effects that you did not know even existed - that is if you are so inclined!

Digital Cameras

The main section of the market is that of the 'consumer' camera which is intended for the mass market. The camera is a sealed (but not waterproof!) unit with a fixed lens, usually a zoom lens equivalent to about 35-105 mm focal length in a conventional 35 mm camera. The only moving parts are those associated with the operation of the lens.

The light from the object to be photographed is focused by the lens onto a CCD (Charge-coupled device), which is a light sensitive chip that converts the beams of light into electrical signals. These signals are stored in the camera's memory which is usually in the form of a removable card. This card can be removed and read in a card reader, or, in most cases, be downloaded directly into the computer whilst still in the camera.

Most digital cameras are designed to give the operator whatever degree of control is required. They work very well as 'point and shoot' cameras, but also have sufficient overriding controls to let the operator have what is virtually a manual control camera. The photograph is previewed on a LCD screen usually built into the back of the camera - this tends to drain the power so an optical viewfinder is a worthwhile

additional feature. This is also a great help in bright light when it is difficult to see the image on the LCD. The LCD screen can be used to view the photos that have been taken and those that are unsatisfactory can be deleted from the camera's memory.

Clivia gardenii with flowers darker coloured and longer than usual. From a clone that came to England about 150 years ago. File size 883 KB.

Cameras can be set to give a range of image sizes; the image size is measured in pixels (Picture ELements), which are the minute elements that make up the picture. A given picture can be enlarged or reduced physically without altering the image size - it is also possible to reduce the image size in the computer by compressing it into an image with less pixels which will reduce its resolution (or detail). At present consumer cameras have a maximum image size of 5.2 Mpixel. There are many qualities needed to produce good image quality in a digital camera; for instance the lens is critical as it has to focus the object onto the CCD which is very small in area compared to a 35mm negative. Merely increasing the number of pixels that the CCD will resolve does not necessarily mean that the picture quality will improve accordingly as light may spill over from one pixel into its neighbour. A good 3.1 Mpixel camera is capable of producing a high quality A4 size print.

Clivia nobilis of good form and colour. File size 140 KB.

The maximum image size of the illustrations is 2 Mpixel about 850 Kb file size in JPEG format. Photo 11 was photographed in highly compressed form (640x480 pixels - file size 60 Kb), and is the size that I use for e-mail as it takes about 30 sec to transmit or download. For website use the photos have to be compressed quite a lot more to stop browsers becoming bored while downloading. Much of the detail of the illustrations will be lost in the printing process and it may be difficult to see the extra detail in the larger files.

The memory card bundled with the camera is often of insufficient capacity for practical purposes, and additional capacity in the form of another card may need to be bought.

For the best pictures, such as would be required for submission for publication or printing at A3 size, the photo is downloaded uncompressed from the camera, usually in TIFF or RAW format. This will result in a very large file size, typically a 5 Mpixel photo will produce a file of 14 Mb. Most of the photos in this article were compressed to 2 Mpixel in JPEG format in the camera which enabled a 32 Mb memory card to store about 40 photos. In attempting to assess the quality of a digital photo, the easiest route is to print it onto photo glossy paper using a good photo quality inkjet printer, correctly set. Even a good monitor screen will miss much of the detail.

PROS. AND CONS. OF DIGITAL

The main advantages are :

The ability to examine a photo as soon as it has been taken, and if below expectation, corrections can be made to achieve the desired result.

Operational flexibility is far greater, and photographs are easier in dull conditions. Whereas with a conventional camera, photos taken earlv or late in the dav, indoors, in glare and sundry adverse conditions all require a suitable filter to be attached to the front of the lens, the electronics (white balance) of a digital camera can do it automatically, or if the user prefers, let him set it manually.

Named C. *miniata* clone, probably 50 years or more old. Colour of flowers (RHS colour chart 37B/38B) corrected on computer. File size 210 KB

Photos for e-mails and web sites can not only be produced direct from the camera, but also in a much more efficient form than by scanning a conventional print or negative. Like for like quality, the file size is a fraction of that produced by a scanner. Consequently the transmission and downloading times are greatly reduced.

Once the camera has been bought, the only running costs are for the purchase of photographic paper and ink for the printer.

Not only is the cost of, say, an A4 size photo a fraction of that charged by a laboratory, but you have a preview on your computer screen to enable you to make any improvements that are required.

China miniata 'Red Starburst' (RMS colour chart 41 A), large flowers; petals up to 8,75cm long. File size 807 KB.

Although a digital camera cannot produce slides, you can view your photos on your television set subject to the television using the same colour system as your camera. This offers tremendous scope for parties to view your holiday photos if you feel the need to return the favour to any of your friends! Also useful for business presentations.

Many cameras have the facility of movie clips or sound recording. The resolution of the movie clips, typically 30 sec total, is not great, but adequate to analyse a golf swing or record an embarrassing party moment.

The main disadvantages are :

The cost of a 4 or 5.2 Mpixel 'consumer' digital camera is 50 to 100% more than a middle range 35mm SLR such as a Nikon 80 complete with a zoom lens, which in turn is slightly more than a 3.1 Mpixel camera.

If the cameras are used extensively, the reduced costs associated with the digital would cancel out the extra initial cost within a year or two. However digital cameras prices are dropping week by week whereas conventional camera prices are steady.

Many digital cameras are unable to take a sequence of action photos as several seconds preparation is often required. An increasing proportion of digital cameras are offering the facility of taking a few photographs at high shutter speeds to capture fast moving action. These photos are put in a buffer memory within the camera and then transferred to its memory card at a more leisurely pace later.

C. miniata var. *citrina*, 'Dr. Hirao x Y. Nakamura'. (RHS colour chart 12D). Flowers 10cm across with obvious 'Vico Yellow' influence. File size 846 Kb.

Digital cameras cannot produce slides. For a lecture, digital photos can be projected using a digital projector. It is a very neat and effective system, but has the twin drawbacks of needing to download the

photos from a laptop and, even worse ,the extremely high cost of the digital projector. Alternatively, digital photos can be printed onto transparent film, and light passed through will give a satisfactory image.

No camera, digital or conventional, thrives in extreme heat such as that in a glove box in a car with its windows shut on a sunny day. The electronics in the digital camera will produce electrical noise (equivalent to grain on film) and degrade the image. The latest digital cameras have seen much development in reducing noise almost totally. Even so, the camera is far better kept in a well padded case secured against movement in the boot of the car.

CHOOSING A DIGITAL CAMERA

For general photography such as views and social gatherings any camera, be it conventional or digital will give good results as this is the work that it was primarily designed for. For plant photography I have found the following features to be of assistance or to have suffered because my camera lacked them:

A range of programs. I have found 'Shutter Priority' particularly useful as it gives the minimum aperture required to maintain the minimum shutter speed to avoid camera shake. This in turn gives maximum depth of field.

A range of operating speeds equivalent to 100 - 400 ASA in conventional photography. In low light the higher speed allows the use of a smaller aperture and consequently gives a greater depth of field.

Spot exposure metering in addition to the normal centre weighted average metering. This is useful if there is backlight, as the exposure will be determined by the actual colours of the flowers and will result in more realistic flower colours.

In addition to auto focus, manual and spot focus are two extremely valuable, if not essential features.

Much can be done at a later stage to correct errors in exposure and white balance. Little can be done to correct out of focus photos !

Exposure compensation. Many cameras have the ability to vary the exposure by up to 2 stops (+2 EV to -2 EV), usually in steps of .3 or .5 of a stop. To me it is important to record the colours of a flower correctly and I play around with under/over exposing the image to get the correct colour. The colour can also be corrected on the computer at a later stage.

Very dark red (RHS colourt chart 44A/45A) C. *miniata*, small flowers. Colour absolutely constant from opening until the flower is over. Recently bought from a garden centre to add to my gene pool. File size 847Kb.

Macro facility. This is useful when photographing *Clivia* but a really powerful macro is not required as nearly all photographs are of the full head of flowers which is quite a large object.

Most digital cameras combine a wide range of controls and features with ease of use. They come with easy to follow instructions and within a matter of half an hour of unpacking the box you should be taking some simple photos; always assuming that the rechargeable battery pack has been fully charged as a first step in your introduction to digital photography !

As a starting point to choosing a digital camera, those listed below have been particularly well received for build quality, operational capability and image quality as well as representing performance equivalent to a reasonable SLR:

Canon G2: 4.1 Mpixel, 3x zoom lens. Recent addition to the digital scene, hence mass of features. Very solidly built. Excellent quality images.

Fujifilm Fine Pix 6900 Zoom: 6x zoom lens, SLR design and handling , unusual CCD arrangement gives performance at least equivalent to 4 Mpixel cameras.

Minolta Dimage 7: 5.2 Mpixel, 7x zoom lens. Amazing list of features including spot focussing on moveable cross hairs. Highly detailed image and excellent colour reproduction.

Olympus Camedia C2040 ZOOM : 2.1 Mpixel, easy controls, 3x zoom lens. Probably the best 2.1 Mpixel camera, producing superb results despite budget price.

Olympus Camedia C4040 ZOOM : 4.1 Mpixel, gives outstanding results, 3x zoom lens.

Nikon Coolpix 995: 3.3 Mpixel, 4x zoom lens, a wealth of features and a true enthusiast's camera, superb macro performance. Outstanding build quality.

New 5.2 Mpixel Nikon Coolpix 5000 due in January 2002.

None of the above are likely to disappoint and all of them are capable of producing very high quality images. Choosing a digital camera is like buying a computer, you need to select on the basis of build quality, back-up service and the capability of offering all the features that you are likely to require. If you buy the very latest model, you may pay an unnecessary premium for a camera that will be anything but 'cutting edge' in a year's time. Digital cameras are developing even faster than PCs.

If you are able to get hold of the current issue of any specialist digital photography magazine, you will realise just how heavily the prices of cameras and consumables are discounted if ordered through the Internet or mail order. However this has to be balanced against the advantage in buying from a source with a good help line if you do not have access to knowledgeable help.

Initially the problems I came up against were related to computer software rather than the operation of the camera, and resulted from trying to do far more with the system than I had ever attempted with my conventional photography.

Very vigorous, large flowered *Clivia caulescens* with heads of up to 35 flowers. Possibly some *C. miniata* blood. File size 60Kb.

C. miniata - Bill Morris

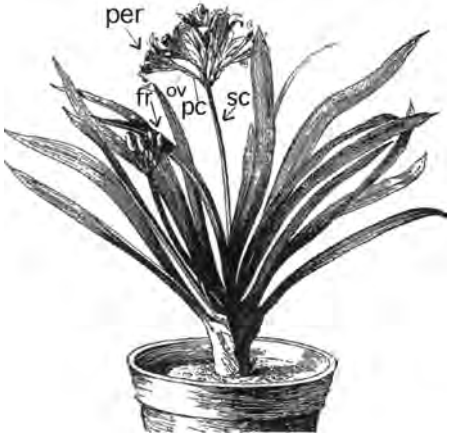
CLIVIA TERMINOLOGY

Terminology of Reproductive Parts

Prof. H. Robbertse

Hannes Robbertse spent the greater part of his career in the Department of Botany, University of Pretoria, but joined the Department of Plant Production and Soil Science in 1994. His main interests are the relation between plant structure and function, especially in the field of flowering and fruit development. He is a former Director of the Margaretha Mes Institute for Seed Research, University of Pretoria.

This article deals briefly with the terminology of the *Clivia* reproductive system. It is essential that we all use the same terminology especially when it comes to plant descriptions for registration or at shows when plants and plant parts are compared.



The branch system bearing the flowers in *Clivia*, is called an **inflorescence.** In *Clivia* the type of inflorescence is classified as an **umbel.** It consists of an elongated, leafless branch, called the **scape** (Fig. 1, sc), which comes from one of the leaf axils and reaches up to the point where the flowers are borne, all more or less at the same level on an extremely condensed axis.. Each flower is attached to the inflorescence axis by means of a flower stalk, called the **pedicel** (Fig. 1, pc). Then follows the **ovary** of the flower (Fig. 1, ov), situated below the **perianth** (Fig. 1, per). The perianth consists of three outer and three inner perianth members, called **tepals. i**nside the perianth, are the six **stamens,** each consisting of an **anther,** containing the pollen and a **filament,** which is the stalk of the anther. The **stigma** and **style** are situated in the flower centre. The style is attached to the **ovary** and together the three parts form the **pistil.** The ovary in *Clivia* has three cavities or **locules,** each containing about eight to ten **ovules.** After pollination and fertilization, each fertilized ovule will form a **seed,** and the developing seeds will stimulate the ovary wall to grow and become the succulent part of the **fruit** (F^{io-} 1 fr)

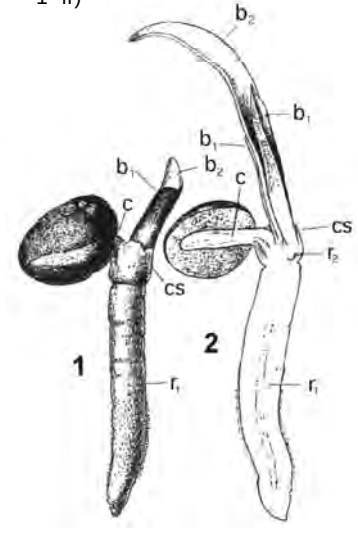


Figure 2 This figure shows a young seedling (kiemplant) of *Clivia miniata* (1) as well as a longitudinal section of a slightly older seedling (2). The figure was copied from R Wettstein (1935). Handbuch der Systamatischen Botanik.

The *Clivia* fruit is called a **berry,** containing 1 to 15 **seeds** depending on how many of the ovules inside the ovary were fertilized. Some of the fertilized ovules (now called young seeds) may abort at an early stage, thus reducing the number of seeds per berry. The membranous layer covering each seed is part of the inner layer of the fruit wall or endocarp. The fruit wall (derived from the ovary wall), consists of three layers, namely the outer, pigmented **exocarp,** the fleshy **mesocarp** and the inner, membranous **endocarp.** The suffix **-carp** refers to fruit.

Please note that the *Clivia* fruit is not a ***pod*** or ***seed pod*** as so often referred to in the literature. Pods are the fruit of peas, beans and other leguminous plants and the *Clivia* is surely not a legume. The *Clivia* fruit is also not a *seed,* since the seeds are contained inside the ***fruit*** which is classified as a ***berry***. In future, please use the names given in bold in the previous paragraph.

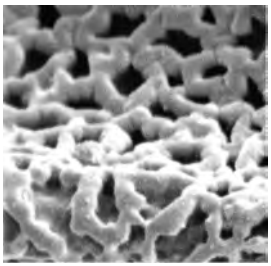
Terminology of Vegetative Parts

(Afrikaans terminology is given in brackets.)

The vegetative plant starts with the germinating seed. *Clivia* seeds are naked since they do not have a seed coat. They are also recalcitrant (onortodoks), which means that they can germinate spontaneously, even in the ripe fruit; they can only be stored for a limited period of time and will die if desiccated beyond a certain point. The seed consists of the endosperm (kiemwit) enclosing the embryo (embrio) consisting of one cotyledon (c in the figure), a plumule (pluimpie) and a radicle (kiemwortel of radikula). Being a Monocotyledonous plant (eensaadlobbige plant), the embryo (embrio) contains one cotyledon (saadlob). The whole embryo is embedded in the endosperm (kiemwit of endosperm). The tip of the radicle can be observed as a small round spot opposite the larger brown spot (hypostase) on the side of the seed where it was connected to the placenta. During germination the cotyledon elongates to about 0,5 to 1 cm, thus pushing the plumule (plumula) and radicle out of the seed, whilst the radicle (kiemwortel) starts to elongate to become the primary root (primere wortel). The primary root immediately produces a collar of root hairs (wortelhare) behind the root tip, and continues to do so as the root grows. The primary root (r^1 in Figure 2) normally does not form secondary roots (sy wortels). It has a limited life span and is soon followed by adventitious roots (bywortels) originating from the first and later nodes (r^2 in Figure 2) of the stem.

The junction of the plumule or apical bud (apikale groeiknop) and the primary root forms the first node (knoop) of the stem where the cotyledon with its cotyledonary sheath (saadlobskede) (cs in Figure 2) is attached. The cotyledon acts as a haustorium, (suigorgaan) responsible for absorbing nutrients from the endosperm. The first vegetative leaf (b^1 Figure 2), produced by the apical meristem (apiekale meristeem) of the plumule, consists of a sheath (blaarskede) with a very small lamina (blaarskyf). In orange and red *Clivia* the sheath of the first leaf is pigmented.

C. *miniata* - Best Orange. Cape Club Show 2000. Ben Marais



CLIVIA POLLEN: Function & Structure

Prof. H. Robbertse & Z.H. Swanevelder

Z.H. (Dirk) Swanevelder is an MSc student in the Department of Botany /FABI, University of Pretoria, South Africa. The aim of his Masters Degree project is to investigate the genetic diversity of wild *Clivia* populations. Dirk is an enthusiastic member of the Clivia Society and is busy building up his own collection.

Most people know pollen as the yellow powdery "stuff found on the anthers of flowers or carried on the hind legs of honeybees (as feed for their young). The high nutrient content of the pollen plays an important role in attracting insects, birds and other small animals to the flowers.

Their role as pollinators, is to transfer the pollen from the anthers of one flower to a compatible stigma of another flower of the same species. The transfer of pollen is critical, since pollen grains contain the precursor of the sperm cell (as in *Clivia),* or the actual sperm cells required for fertilization. In animals and even primitive plants like mosses, ferns and cycads, the sperm cells are mobile and when deposited in the female organ, they can actively swim to the egg cell for fertilization. In flowering plants like *Clivia,* the sperm cells are immobile and first have to be transported from the anther, through the atmosphere, to the stigma where they will arrive in a fairly dehydrated condition. On the stigma, the pollen grain has to be recognized by the stigma before the stigma will supply it with water for rehydration and germination. During germination a pollen tube is produced which grows through the stigma, style and ovary, thus transporting the two sperm cells to the embryo sac where the egg cell and the central cells are waiting to be fertilized.

How and where is pollen produced?

Clivia pollen is produced inside the young anthers, at a stage where the flower buds are still very small and the inflorescence still embedded in the leaf bases of the plant.

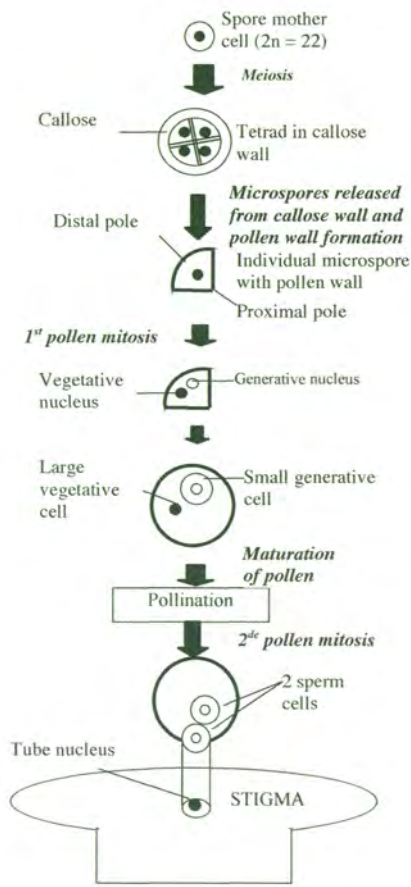


Figure 1. Schematic representation of general pollen formation.

All vegetative cells of the plant (leaves, roots and stem), as well as the young flower parts, contain diploid nuclei (2n) with 22 chromosomes (each nucleus with two sets of 11 chromosomes). Inside the young anther the **spore mother cells** *(Figure 1*) are located.

Each spore mother cell becomes encapsulated in a layer of isolating material, called **callose,** before undergoing two cell divisions, known as **meiosis or reduction division.** This gives rise to a **tetrad** of four daughter ceils, each containing half the number of chromosomes (11) of the spore mother cell (see *Figure* 2). At this stage, the inner cell layer of the anther wall has become a specialized nutritious layer known as the **tapetum.**

The single cells of the tetrad, now pollen grains, become separated and released from the callose wall through the action of a tapetal-derived enzyme, callase. Their cell walls become thicker, impregnated with substances from the disintegrating tapetal cells and develop its characteristic ornamentation as shown in *Figure* 2.

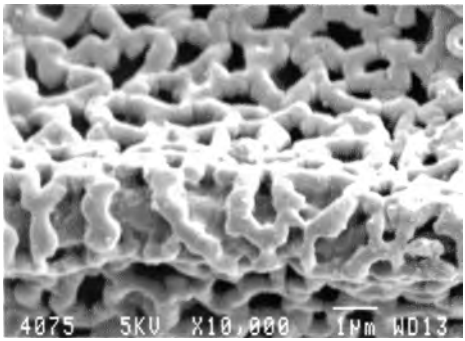


Figure 2. A SEM photo showing the exine of the *Clivia* pollen.

The first mitotic cell division in the pollen grain is asymmetrical, resulting in a larger **vegetative cell** and a smaller **generative cell.** The latter is engulfed by the vegetative cell and will give rise to the two **sperm cells,** only after pollination and the formation of a pollen tube formed by the vegetative cell *(Figure 1).*

Pollen shedding and structure

The mature anther consists of two lobes, each containing two pollen sacs filled with pollen. The partitioning between adjacent pollen sacks in each lobe breaks down prior to dehiscence of the anther and pollen shedding. At this stage the pollen is covered with another tapetal-derived, sticky substance, called the **pollenkit.** The latter allows the pollen to stick to pollinators, e.g. insect, bird or brush in the case of hand pollination. *Figure* 3 shows the pollen grain as seen under the light microscope at the stage of pollination with the curved generative cell embedded in the cytoplasm of the vegetative cell, also called the tube cell.

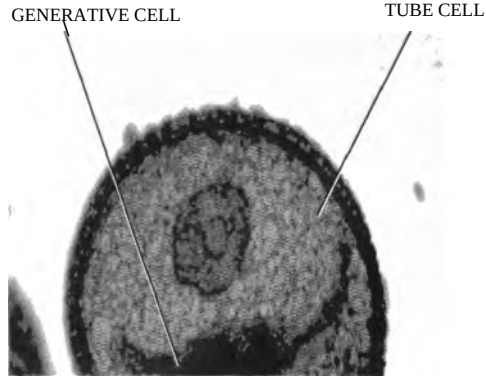


Figure 3. A mature pollen grain of the genus *Lilium*, containing a generative (giving rise to two sperm cells) and a larger tube cell (forming the pollen tube).

As viewed with the scanning electron microscope (SEM), the three dimensional structure of the *Clivia* pollen grain reminds one of a quarter segment cut from an orange with the peel side as the distal pole and the other end as the proximal pole *(Figure 1 &*

Figure 4). The wall of the pollen grain consists of a thick outer layer **(exine)** and an inner membranous layer **(intine).** The exine is reticulate (net-like, see *Figure 2)* and is composed of a very resistant substance known as **sporopollenin,** which apparently is derived from the tapetum and partly from the callose-derived substances during the breakdown of the callose wall.

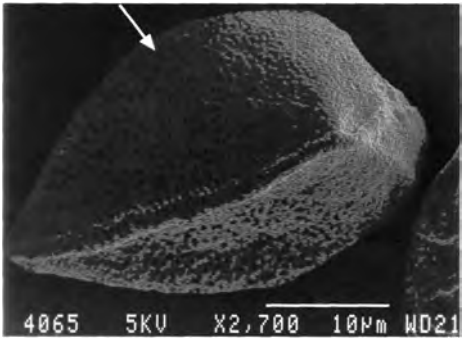


Figure 4. SEM photo of *China* pollen. Proximal pole indicated by arrow.

Due to the highly resistant nature of sporopollenin, the exine of pollen grains is preserved during fossilization, with the result that fossilized pollen can be identified in the same way as fresh pollen.

The open spaces in the reticulate exine contain tapetum-derived, easily leaching proteins that play a role during the recognition of the pollen by the stigma. These proteins ensure that the pollen grain will germinate only on a compatible stigma.

At the distal pole, a section of the exine is much thinner than the rest and this part is called the **sulcus** *{Figure* 5). The sulcus is the site where the pollen tube will emerge during germination.

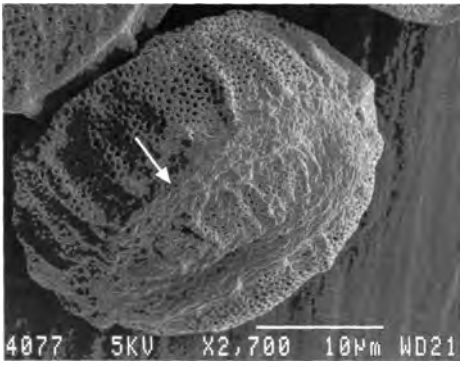


Figure 5. An equatorial view of the distal pole of a *Clivia* pollen grain showing the partly closed sulcus, (arrow).

Dehydration will cause a fold in the sulcus resulting in a change in the shape of the pollen grain as seen in *Figure* 6.

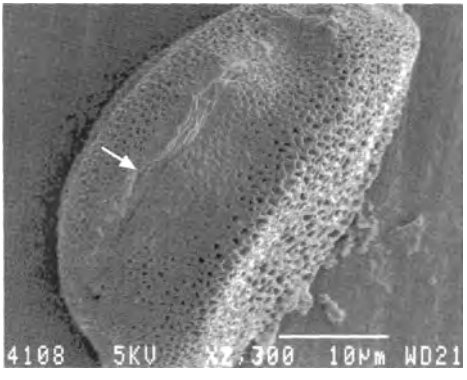


Figure 6. A SEM shoto showing a dehydrated pollen grain of *China* with closed sulcus (arrow).

In the next article we will discuss the process of fertilization, embryo and seed development.

THE CLIVIA PISTIL: STRUCTURE AND FUNCTION

Hannes Robbertse

Clivia seeds can only be formed after the **ovules,** from which they develop, are fertilized. As in all flowering plants, fertilization in *Clivia* is a **double fertilization** process where **two sperm cells** are required for the fertilization of each ovule, one for fertilizing the **egg cell** and the other for fertilizing the **central cell** in the embryo sac contained in the ovule. In the previous paper we explained the origin and development of pollen grains which are the 'carriers' of the precursor of the sperm cells from the anther to the stigma. In this paper the development of the stigma with all its sub-parts will be discussed. To really understand the structure and functioning of the pistil, it is necessary to look at the whole developmental process.

Origin of the flower

Each flower develops from a dome of cells (apical meristem) at the stage when the young inflorescence is still concealed in the leaf sheath, long before actual flowering. Being a monocotyledonous plant, the *Clivia* flower consists of whorls of three units each: one outer and one inner whorl of tepals, outer and inner whorls of stamens and one whorl of carpels. The three **carpel** primordia (initials) giving rise to the pistil, are the last whorl of flower parts formed by the apical meristem. During the development of the tepals and stamen initials (Figure 1), the apex becomes concave so that at the time the carpel initials appear, the young flower base is cup-shaped with the tepal and stamen initials situated at the rim of the 'cup' and the carpels developing inside the 'cup'.

The terminal ends of the folded carpel initials can be seen as three separate units (Figure 1B). They remain separate to form the three lobes of the stigma, while the fused middle parts elongate to form the style. The basal parts of the carpels give rise to the three-locular **ovary,** embedded in the flower base (receptacle). The carpels do not only fuse sideways with the adjacent carpels, but each carpel also fuses at its margins to form a closed ovary cavity (locule).

The **ovules** develop from the inner margins of each carpel and are therefore arranged back-to-back in two rows in each locule (Figure 2).

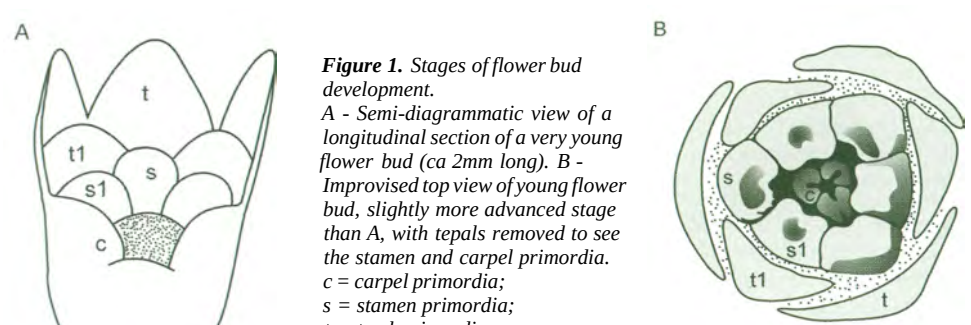
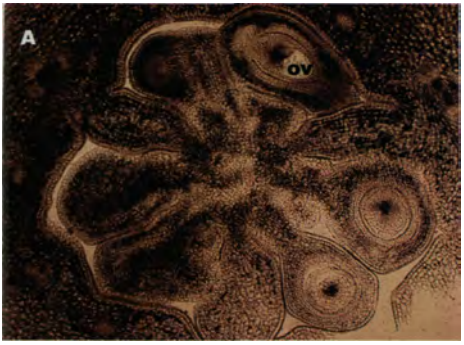


Figure 1. *Stages of flower bud development.*
A - Semi-diagrammatic view of a longitudinal section of a very young flower bud (ca 2mm long). B - Improvised top view of young flower bud, slightly more advanced stage than A, with tepals removed to see the stamen and carpel primordia.
c = carpel primordia;
s = stamen primordia;
t = tepel primordia



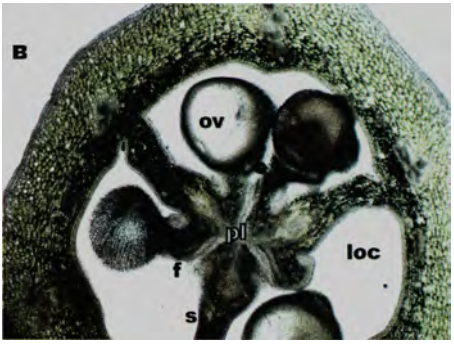


Figure 2. *Cross sections of* **Clivia miniata** *ovary at the stage of A - inflorescence just appearing from the leaf sheath and B - opening of the flower.*
f=funicle; loc = locule (ovary cavity); pi = placenta; s = septum (wall separating locules).

Each ovule is attached to the carpel margin (now the placenta), by means of a **funicle** containing the vascular elements which supply the ovule with water and nutrients.

Development of the ovule

Similar to the whole flower, the ovule develops from a globular cell mass.
The integuments start to develop as ring-shaped outgrowths (at A on Fig. 3) at the base of the globular ovule primordium and finally cover the whole central part now known as the **nucellus.** One of the sub-epidermal cells of the nucellus, close to the apex, start enlarging to form the **megaspore mother cell** containing a diploid nucleus (with two sets of chromosomes).
This cell (at C on Fig. 3) undergoes meiosis and produces four haploid cells (each with one set of chromosomes). Three of the haploid cells disintegrate (at D on Fig. 3) and the remaining one gives rise to the **embryo** sac. The embryo sac, ready for fertilization, consists of an egg cell accompanied by two synergid cells, one large central cell containing two nuclei, and three antipodal cells (at E on Fig. 3). The egg cell contains a fair amount of cytoplasm with plastids. These plastids also contain DNA which plays an important role in cytoplasmic heredity as in variegated *Clivia.*

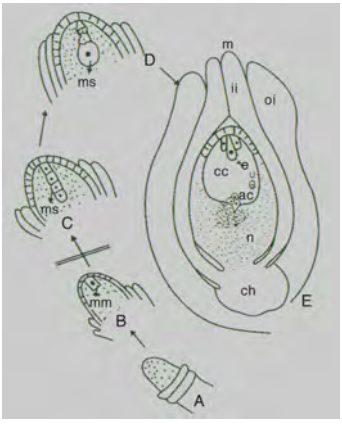


Figure 3. Diagrammatic illustrations of ovular development (A - D) and a line drawing of a young ovule shown in Figure 2A (ov).
a = antipodal cells; cc = central cell; ch = chalaza; e = egg cell; ii - inner integument; m = micropyle; mm = megaspore mother cell; ms = megaspores; n = nucellus; oi = outer integument

Stigma and pollination

The three lobes of the *Clivia* stigma are the unfused terminal parts of the three carpels. In the bud-stage of the flower, the three lobes are pressed together, but shortly after the flower has opened, they separate and unfold. Only the very tip of each stigma lobe becomes receptive to pollen (Figure 4). The receptive stage can be recognized by the appearance of papillae (short hairs) at the tip of each lobe and receptivity will only last as long as the papillae are turgid (swollen with water).

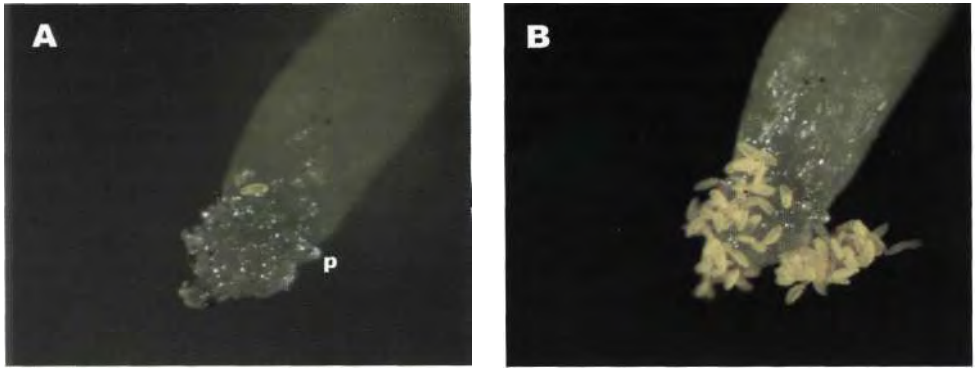


Figure 4. *One lobe of the three-lobed stigma (A) un-pollinated (except for one pollen grain), showing papillae on receptive part and (B) with pollen sticking onto the papillae. Note the mass of pollen on the right sticking together.*

When the stigma is receptive, pollination can be a once-off operation provided that an effective pollen load can be provided on each stigma lobe as demonstrated in Figure 4B. The fresh pollen as well as the stigma papillae are sticky, so that there should be no problem for the pollen to remain on the stigma long enough for gemination. If the pollen is recognized by the stigma papillae (see previous paper), the papillae will supply the pollen grains with water and they will start germinating within an hour.

Figure 5A shows fresh pollen germinated on an artificial medium at 23°C, two hours after the pollen was placed on the medium and Figure 5B shows the same medium with pollen 24 hours later. For good results stored pollen must be tested before being used for pollination.

The papillae on the receptive part of the stigma are actually outgrowths of the upper epidermal cells on the 'open' tips of the stigma lobes. This 'upper' epidermis also lines the inside of the stigma and the ovular

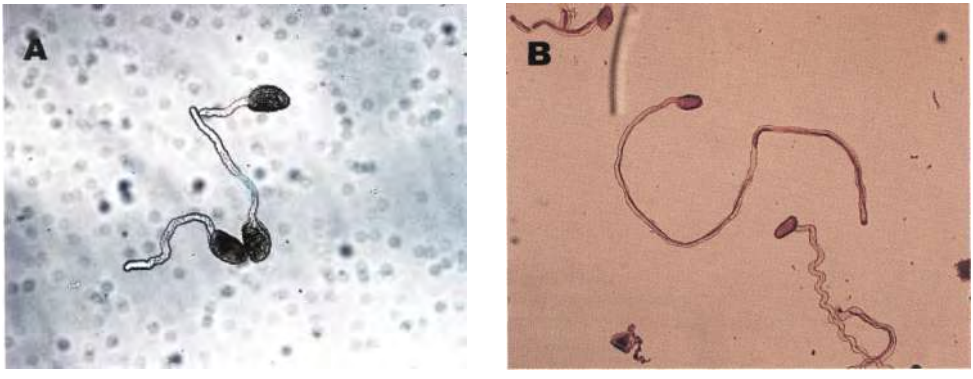


Figure 5. In vitro *germination of clivia pollen, two hours after the pollen was placed on the medium (A) and 24 hours later (B)*

cavities and forms the transmitting tract for the pollen tube from the stigma to the ovules in the ovary. Under favourable conditions pollen tubes can reach the ovules within 24 hours after pollination. One pollen grain is required for each ovule, since the pollen tube growing from the grain, carries only two sperm cells which are both needed for fertilizing one ovule. However, the more pollen tubes taking part in the'race' to the ovules, the better the chances for only the strongest to fertilize the ovule.

After reaching the ovule, the pollen tube enters the ovule through the micropyle (see E on Fig. 3) and the two sperm cells are deposited into one of the synergid cells. From there they move on their own - one fertilizes the egg cell and the other fertilizes the central cell.

Seed development

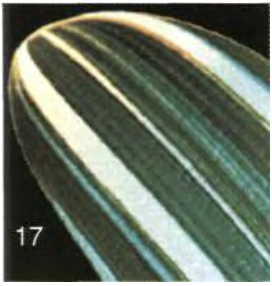
After fertilization, the zygote (product of fusion) resulting from the fertilized egg cell goes into a resting phase. The triploid nucleus of the fertilized central cell, however, divides rapidly to form a great number of free endosperm nuclei before cell formation will start from the outside, progressing towards the centre of the original embryo sac. The zygote of the fertilized egg cell starts dividing during the free nuclear stage of endosperm development and gives rise to the embryo of the seed.

In my first paper (see p. 11) I mentioned that *Clivia* has naked seeds (without a seed coat). However, as can be seen in Figure 3E, the young ovule does contain two integuments.

The ovule at E in Fig. 3 was taken from the ovary of a very young (Figure 2A) flower bud (at the stage when the inflorescence was just emerging from the leaf sheath). The two integuments are well developed and the embryo sac is complete. At a later stage (Figure 2B), when the flower has just opened, the embryo sac is occupying most of the volume of the ovule and the integuments have deteriorated to merely a few layers of epidermis cells. These cells deteriorate further during seed development so that in the mature seed, there is hardly anything left of the original integuments and no true seed coat can be distinguished except for the brown hypostaze remaining in the chalazal zone. The mature seed, therefore, consists of an embryo enveloped in a mass of endosperm. The tip of the radicle (embryonic root of the embryo) can be seen as a round spot opposite the brown spot (hypostase) on the mature seed.

Acknowledgments

The photographs used in this paper were taken by members of the Laboratory for Microscopy and Micro-analysis of the University of Pretoria.



THE GREAT CHINESE CLIVIA 'BUBBLE'

John van der Linde

The tulip 'bubble' in Holland in the 1630's is well known. The events are briefly summarized below, as an introduction to what happened in China around 350 years later.

Over a three-year period rare tulip bulbs changed hands in Holland for sums that would have bought a house in Amsterdam! Thousands of people, from the wealthiest of merchants to the lowliest of street traders, were caught in a frenzy of buying and selling.

The most valuable bulbs were rare, and the flowers they produced were extraordinarily beautiful (usually due to a mosaic virus, which caused an attractive streaking). However many bought, not because they wanted the plants, but to sell on at a profit. Prices had already risen rapidly for more than two years. Buyers believed that the huge sums the bulbs commanded were justified by the fact that they were in high demand and in short supply. Prices were confidently expected to go higher still.

But then the bubble burst. Tulip prices dropped suddenly and without warning. Within a matter of days confidence evaporated and flowers plummeted to one-tenth or less of their old values.

By the end of February 1637 men who had been amongst the richest in Holland had lost everything they had, and those who had invested heavily in tulips faced bankruptcy and ruin. The tulip mania had run its course.

Similar plant-related manias have recurred from time to time, fed on the human emotions of appreciation of beauty and greed for money. There was a craze for dahlias in France around 1838. In 1912 it was the turn of Dutch gladioli to enjoy a very similar, but equally short-lived, boom.

Clivia had their turn in the 1980's when a mania broke out in China, almost exactly following the pattern of the Dutch tulip craze three and a half centuries before.

Clivia reached China from Europe in the latter half of the 19th century, introduced by German missionaries. A secondary introduction occurred when the Japanese invaded China from 1931 onwards. They annexed Manchuria in the north-east and set up Puyi, ('the last Emperor' who had been forced to abdicate as a six year old boy as Emperor of China in 1912) as their 'ruler' of the occupied territory. Changchun was made the seat of government of the Japanese puppet state and Puyi had his palace and court there. Changchun lies just below the 44th parallel, some 850 kilometres to the Northeast of Beijing. It is today the capital of Jilin Province, which has over 26 million inhabitants.

Japanese horticulturists brought some excellent flowers from Japan, including *Clivia.* Also, rare *Clivia* were presented to Puyi by the Japanese emperor. These 'royal' plants could only be seen at the palace in Changchun at receptions, banquets, funerals, etc, as ornamental plants. Thus they could only, in practice, be enjoyed by a small number of the Japanese, the royal family, courtiers and high government officials. Laymen had no access to these particular plants.

At the end of the Second World War the three north-eastern provinces were recovered and Puyi was disgraced. From 1945 onwards *Clivia,* including the rarer specimens, slowly became accessible to a wider public, but how did this occur?

The Emperor's second concubine, Jade Years, had died in 1942 and her funeral was held at the Guardian Wisdom Temple in Changchun where a pot of *Clivia* was displayed on the orders of Emperor Puyi. This pot was not returned to the palace after the funeral and the plant continued to be cultivated by a monk of the temple. This plant was duly named 'Monk' when it reappeared in the 1960's.

A pot of *Clivia* taken from the palace was later presented to Chanchun Park. To celebrate the People's Liberation this plant was named 'Great Victory'. Another pot came into the possession of the manager of the Changchun Tung Hsing Dyeing Factory This plant became known as 'Dyer'.

Until the later 1950's plants only became available from offsets, so it was difficult for many *Clivia* enthusiasts to have even one super quality plant. Then growers began to pollinate the flowers, as they did with cherry flowers, and in the early 1960's a crossbreeding union was established. Over the next few years excellent plants were developed, like 'Engineer Huang' and 'Painter' (Botanists are known in China as Plant Engineers, and Huang was a botanist or horticulturist rather than someone working with machines). Ownership of special plants rapidly became more widespread.

Then came the Cultural Revolution, which lasted from 1966 to 1976. Young people, the so-called Red Guards, campaigned to destroy remnants of the old society. They destroyed temples and historic sites, and broke into private homes to smash and burn books, jewellery and art. In Changchun many special *Clivia*, which had historically been seen as a mark of distinction and thus elitist, were destroyed, and prominent *Clivia* growers were amongst those who faced persecution and even death.

Clearly, many *Clivia* plants escaped destruction because by 1980, it is estimated, half the families (maybe 150,000) in Changchun grew the flower. Indeed, the flower was so prominent that it was designated the official flower of the City.

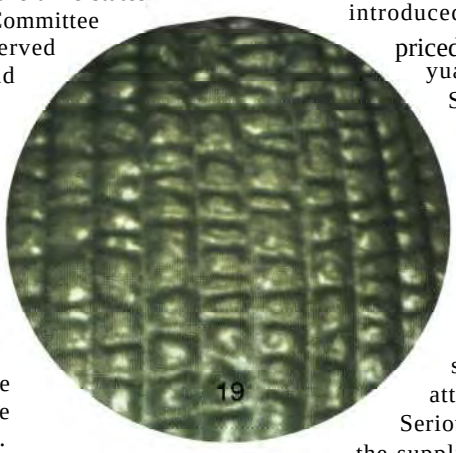
Until this point it would seem that *Clivia* growing, and serious breeding, was largely confined to just one city, Changchun.

Clivia mania only broke out in earnest a few years later, after the Chinese government had commenced a process of economic reform. Markets sprang up for all sorts of products, including household plants. The situation in Changchun was then quite similar to that in Holland during the 1630's. Because of the increased economic activity people had surplus cash at their disposal, but investment (as opposed to spending) opportunities were few. In these circumstances, the *Clivia* growers, especially the serious breeders in Changchun, took advantage of the increasing investment demand for their flowers from neighbouring regions. As one pair of writers put it, 'The development came into a sudden luxuriant phase, and *Clivia* fever quickly occurred in the three provinces in the North-eastern Region of China, and the wave later reached nation-wide. At a time *Clivia* swept the whole nation.' As prices began their inevitable rise, speculation - financed in many cases with borrowed money - followed right behind.

In 1981 or 1982, prior to the boom, desirable plants were selling for 100 yuan. I don't

know the equivalents at the time, but at 2001 rates of exchange 100 yuan would get you around R100 or 12 US dollars. This was already a considerable sum of money for a plant, given the low level of incomes then usual in China. But by 1985, plants with the loveliest characteristics are reported to have changed hands for the stratospheric amount of 200,000 yuan, an amount that puts even the sums paid at the height of the Dutch tulip craze to shame. In fact, the highest prices quoted during the Chinese *Clivia* mania were equivalent to around 300 times the then annual earnings of the typical Chinese University graduate, a quite staggering sum.

A newspaper article of the time states The Communist Party Committee of Changchun City observed these cases seriously and established a *Clivia* control public office to watch transactions and prosecute tax evasion. However, it does not seem to be an easy thing because many of the officials of the City and the authorities themselves are *Clivia* enthusiasts!' At one time up to 30000 people were trading plants each day.



In such circumstances it is hardly surprising that the *Clivia* craze was short-lived even by the standards of flower manias. It collapsed in the northern summer of 1985. The whole market was quickly flooded with panicked dealers desperate to sell, and prices fell sharply. Just as the Chinese boom had exceeded even the heights attained during the tulip years, so the crash, when it came, was still more severe. By the time the *Clivia* market stabilised at last, prices had plunged by anything up to 99 per cent. As contemporary Chinese writers have said, Trice of *Clivia* fell into the bottomless pit.'

Through the boom and bust of every flower mania there are those who persist in their enthusiasm. The same writers refer to *Clivia* lovers who are 'unchanged in their infatuation' and who 'respect and are intoxicated with such richly elegant royal beauty'. They add 'as consistent introduction of excellent cultivars of *Clivia* continues, its history of development will lead to the brilliant future'.

Thus, as *Clivia* ceased to be a public craze, they nevertheless remained a private passion amongst dedicated collectors. Large sums were still demanded for highly regarded plants. For example, 'Sparrow *Clivia'* was introduced to the market in 1992, priced post-mania at 180000 yuan. A plant 'Steel Wall Short-Leaf which had been awarded a gold prize at a Chinese Flower Exhibition was traded at a price in the order of 100,000 yuan. The fashion amongst serious collectors tends to be to cultivate single specimens of the most attractive plants.

Serious growers try to keep the supplies of the most favoured plants low. They thus try to maintain prices - rather like pharmaceutical companies exploiting the drugs they have developed and patented - and resist the temptation to risk flooding this specialist market, because rarity commands a premium. In time, even rare plants become more commonplace, so growers continually try to breed new plants that will be attractive to connoisseurs; how many Chinese *Clivia* are today being sold around the world? There is nothing new in this - it is all good capitalistic logic and marketing strategy, is it not?

Looking at the four flower manias I have mentioned - tulips ex Central Asia, dahlias ex Mexico, gladioli from Africa and the Middle East, and *Clivia* ex South Africa - and their associated price 'bubbles', there seem to be several common factors, including

In each case the plants were not indigenous;

They were relative newcomers to the markets in which they had become highly desirable;

It was not the native species that were in demand, rather people craved the newly developed advanced strains;

There was a long time lag in years from seed to mature flowering plant, i.e. a high 'anticipation factor';

Demand, fuelled by borrowings, increased substantially but, because of the long growing time, supplies could not be increased immediately;

In each case, confidence, which had fed on itself and sustained prices, collapsed, bringing the market crashing down.

In the case of *Clivia*, there is an additional factor, possibly unique to China, which may explain why their boom reached such dizzying heights. *Clivia* (Jun zi Ian, or noble orchid in Mandarin) beautify and are hardy and long-lived. They are symbolic of long life, strength and fortitude, qualities highly admired in Chinese culture. Mystique commands a premium price.

Finally two speculations: Just before Japan surrendered to the Allies in August 1945,Soviet forces in north-east China dismantled key industrial installations and removed them to the Soviet Union. Did they 'liberate' any *Clivia* plants at the same time, especially any of those in Puyi's palace?

In March 1960, after release from prison and 're-education', the former Emperor Puyi was given a part-time job as an assistant at the Beijing Botanical Gardens, transplanting seedlings and cleaning hothouses. Who knows, he may even have worked with *Clivia* seedlings bred from the very plants taken from the palace where he had reigned as Emperor?

In writing this article I have relied heavily on four primary sources:

'A random walk down Wall Street', by Burton Malkiel;

'Tulipomania', by Mike Dash;

'Chinese *Clivia'*, by Tao Men and Wang Yung Pao; and

A newspaper cutting sent to John Winter by Yoshikazu Nakamura.

I am sure that there will be readers of this article who will be able to add to (or correct) my interpretation of this interesting episode in the ongoing Great *Clivia* Story.

CLIVIA IN JAPAN

Shigetaka Sasaki

In our view this Clivia Three is incomplete without a full report on the proceedings at the Clivia Symposium held in San Francisco during March 2001. Despite every effort, we have not succeeded in sourcing any part of those proceedings, including any photographs, except this paper, which was translated by Masashi Yamaguchi. The translation was revised by Nicholas Primich and by us. Eds.

Introduction

I am sorry to tell you that Mr Nakamura is not here to join us. As you know, he is Japanese, and one of the best clivia breeders in the world. March is the flowering season of *Clivia miniata* in Japan and he is busy with pollinating his *Clivia* now. One day, he told me, 'Go to Huntington, take photos of *Clivia* instead of me'. I thought he was joking, but afterwards I made up my mind to join the symposium. The reason I came here is that it might be useful for all *Clivia* enthusiasts to share the information of *Clivia* in Japan and Mr Nakamura's breeding results.

Clivia **in Japan**

Clivia generally means *C. miniata* in Japan. Other species, C. *caulescens,* C. *gardenii* and C. *nobilis* are not well known in the Japanese market. Most of the *Clivia* enthusiasts there find the beauty of C. *miniata* in its leaves. They have aimed to breed a *Clivia* with short and broad leaves. They call this strain of C. *miniata* with broad and short leaves 'Daruma'. There are many commercial names in the 'Daruma' strain, based on subtle differences in their unique leaf shapes and variegations. Japanese enthusiasts prefer the variegated C. *miniata* to the usual green one; they also prefer the dwarf shapes to the large one. I do not know much about the naming of 'Daruma'. Daruma is a small doll sold at Buddhist temples as a symbol of good fortune. According to some books, there was a monk called 'Daruma' in old China. Japanese people made a round shaped statue in his image to worship him. I imagine some people thought that the shape of C. *miniata* with round and short leaves looked like a 'Daruma' doll in some ways, and came to call that type of C. *miniata* the 'Daruma' strain.

I go on to explain the variegation types. There are seven types of variegation in Japan as follows (FU means 'variegation' in the Japanese language):

1. FUKURIN 2. SHIMA-FU 3. AKEBONO-FU 4. NEGISHI-FU 5. NAKA-FU 6. TORA-FU 7. GENPEI-FU

TORA-FU means 'Tiger Variegation' because the variegation looks like the stripes on a tiger's body. A TORA-FU Clivia named 'TAIHOH' is well known to Japanese enthusiasts, but the variegation is caused by virus infection. Japanese enthusiasts consider that variegation like very thin strings is the best form of variegation but it seems that a more contrasting variegation is preferred in other countries.

AKEBONO-FU is very popular among enthusiasts in Japan. Multiplication of these

plants usually depends on production of offsets, because we cannot breed good AKEBONO from seed easily. AKEBONO plants are still rare in Japan and therefore much sought after by enthusiasts.

AKEBONO plants with long and narrow leaves have been common for a long time but AKEBONO Daruma (short and broad leaf type) plants are not common. According to some *Clivia* breeders, when they tried pollinating common AKEBONO plants by using Daruma strain's pollen, most of the seedlings did not keep the vivid white colour of the AKEBONO variegation when they matured, and were not suitable for sale. Therefore AKEBONO Daruma plants are still rare.

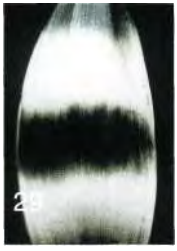
I remember that Mr and Mrs Abel raised AKEBONO plants from Nakamura seeds and recently one of them had a yellow flower. I think AKEBONO will be more popular all over the world in the future. In Japan because we prefer the Daruma strain of *Clivia*, we must breed AKEBONO Daruma that will keep a good variegation after it matures.

I think that the Japanese favouring the dwarf C. *miniata* with variegation and unique leaf shapes is related to the history of Japanese horticulture. In the Edo period of Japan (1603- 1867), gardening popularity was at its height. This enthusiasm ranged from the ordinary citizens to the ruler called 'Shogun'. All of them tried to collect wild mutations and to trade these plants at very high prices.

There are two plants upon which the Japanese model their *Clivia;* one is 'OMOTO' *(Rhodea japonica* Roth) which belongs to the *Liliaceae* family; the other is 'FUHKIRAN' *(Neofinetia faciata)* which belongs to *Orchidaceae* family. These two species look like the 'Daruma' strain in leaf shape, they have various forms of variegation and some of the commercial names of both these plants are the same as those of the Daruma strain *Clivia.* There are many points of appreciation in their leaf shapes and variegations. In the case of 'FUHKIRAN', enthusiasts also appreciate their beautiful red or blue roots. The variety of leaf shape and variegation in the 'Daruma' strain is not yet more perfect than what is found in these two plants. I hope that another new form of variegation will be bred in the future to please *Clivia* enthusiasts.

As mentioned earlier, the 'Daruma' strain has been welcomed by Japanese traditional plant enthusiasts. They have dominated *Clivia* in Japan and consequently the Japanese have not focused on the flower. Twin type C. *miniata* plants have been on sale at gardening shops for the past few years. They are called 'GRANDIFLORA' in the Japanese market. They are quite small in size and flower in two or three years from germination. They are useful for breeders because they do not need a large space and shorten the growing period. What is now required is to breed a yellow or variegated one in this strain. In fact 'yellow' C. *miniata* has become quite common in the past few years and I can say that interest in flower variety is now becoming popular in Japan. *Clivia* breeders may well now aim to breed better *Clivia* in this country, which have a well balanced appearance with both beautiful flowers and leaves with a good variegation.

Over the past twenty years, Mr Nakamura has dedicated himself to breed special *Clivia*



Left to right:
FUKURIN;
SHIMA-FU;
AKEBONO-FU;
NEGISHI-FU;
NAKA-FU;
TORA-FU (TAIHOH);
GENPEI-FU;
AKEBONO TORA-FU

hybrids including new flower forms and colours. Having regard to the preferences in the Japanese market, which I have described above, by doing this Mr Nakamura has isolated himself in that market and has suffered hardship for many years.

I think his excellent breeding results have been based on 'VICO Yellow'.

Mr Nakamura's breeding results based on 'VICO Yellow'

There are already several articles explaining how Sir Peter Smithers created this wonder 'VICO Yellow' and why the plant was introduced to Japan, but I will tell you the story briefly. Sir Peter Smithers kindly sent an offset of 'VICO Yellow' to Dr Shuichi Hirao who was an innovative botanist in Japan. The plant flowered in 1984. After Dr Hirao's death, Mr Nakamura took over his whole collection including 'VICO Yellow' and then started to breed new *Clivia.* The reason why Mr Nakamura used 'VICO Yellow' as a pollen parent is because it has special genetic qualities as follows :

1. 'VICO Yellow' hybrids will produce large flowers with good forms.
2. 'VICO Yellow' hybrids will produce a well reflexed petal.
3. 'VICO Yellow' pollen is very fertile and produces a good seed set.

I will introduce you to four typical Nakamura hybrids that are good samples of the above three points.

C. miniata 'Chiba Orange'

'CHIBA Orange' and 'CHIBA Yellow'

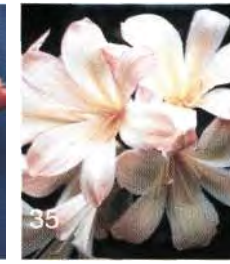
These two plants have the characteristic large flowers. Mr Nakamura says that 'CHIBA Orange' has the largest flower of his hybrids. The flower size is three times that of the usual C. *miniata.* The petals are well reflexed as a result of the genetic influence of 'VICO Yellow'. The outer petals of 'CHIBA Yellow' are more reflexed than those of 'VICO Yellow'. The flower form as a whole looks more sophisticated than 'VICO Yellow'.

C.miniata var. *citrina* 'Chiba Yellow'

'Waved-Petal Yellow' and 'Rolled-Petal Orange'

As an experiment in naming I called these two plants 'Waved-Petal Yellow' and 'Rolled-Petal Orange' after their flower forms. 'Waved-Petal Yellow' (photo 32) has a very unique flower form with playful spirits. It might be interesting to create a 'Waved-Veined-Petal' *Clivia,* 'Waved-Petal with red tips' Clivia and 'Waved-Petal Peach' *Clivia* and so on. 'Rolled-Petal Orange' (photo 33) also has a unique flower form which might not appeal to everybody. However, this plant has the potential to develop new flower forms. If one crosses 'Rolled-Petal Orange' with C. *gardenii,* C. *caulescens* or C. *nobilis,* extremely unique hybrids may result.

Mr Nakamura says that although the pollen of 'VICO Yellow' fertilizes other *Clivia* well, the seeds from this pollen tend to be large. Consequently we cannot expect to harvest a good quantity of seed from 'VICO Yellow' pollen.



When you use 'VICO Yellow' pollen only once {eg. (orange x yellow)xVico Yellow}, it is possible to get a high percentage of good flowers with twice the size of the usual *C. miniata* and also with good rolled and waved petals.

One problem is that 'VICO Yellow' hybrids are quite large sized plants just like 'VICO Yellow'. When I think about the Japanese *Clivia* market, the next goal of 'VICO Yellow' hybrids is to create dwarf leafed hybrids or multi-petal hybrids based on these special 'VICO Yellow'hybrids.

Mr Nakamura's Interspecific Hybrids

I would like to introduce Mr Nakamura's interspecific hybrids to you. His Fl hybrids of (C. m*iniata* x C. *gardenii)* are called 'Candoll' (photo 34), a name inspired by 'Christmas Candle' because they usually begin to flower at Christmas time. These hybrids have tubular orange flowers, the flowers are half-erect from the stem (this is because of the C. *miniata* influence), some have open flowers, some have pale orange petals, some have green tips on the petals (this is because of C. *gardenii* influence) and they show a range of variations (e.g. see photograph 41 on Page 50 of CLIVIA YEARBOOK 1998 - Eds.)

He mostly used orange C. *miniata* as the mother plant of"Candoll'. Therefore, the plants often have flowers in which anthocyanin dominates chlorophyll on the petals. If you pollinate yellow C. *miniata* with C. *gardenii*, it is possible to create a new 'Candoll' with marked green tips on the petals. I would like to share with you more information about interspecific hybrids. They show a light white stripe on the centre of the leaf. Mr Nakamura told me that this stripe is one of the characteristics of interspecific hybrids, not only in the case of (C. *miniata* x C. *gardenii).*

His Fl hybrids of (C. *miniata* x C. *caulescens)* mostly have pendulous flowers. The genetic influence of C. *caulescens* seems to be stronger than that of C. *miniata* in this case. It seems that the characteristic of C. *caulescens* also appears on the tip of their leaves. There is a Fl hybrid called 'Day Dream' (see photo 29 in Yearbook 2): {(orange C. *miniata* x yellow C. *miniata)* x (C. *caulescens* x yellow C. *miniata)}.* This plant shows excellent pendulous flowers and we can also recognize a characteristic of C. *caulescens* in its leaves. The flowers are quite open compared with other interspecific hybrids. The inside of the petals is green to start with, then changes its colour to yellow. I am not certain how he created such a good flower, but it really is outstanding and is of a very high quality. He has also created hybrids of which the flowers look like C. *miniata.* He tried breeding hybrids by using cobalt 60 before. He created 'CHIBA ZAKURA' (photo 35) in the end. This plant has so many flowers that the umbel is like a ball. The flower colour is slightly orange. This may be because of the influence of cobalt 60.

I was able to see a totally white flower when I visited Mr Nakamura's greenhouse in February of last year. The flower was small and not well open. The base was strong green. Actually it was an interspecific hybrid. There is also a near white interspecific flower called 'Chameleon', the colour of which

Interspecific hybrid - white

Clivia miniata 'Veined Petal'

changes from strong green to near white, then a little red appears on the tips at the end. This means this flower contains some anthocyanin. In this regard I can refer to Mr Wessel Lotter's comments about the genetic dilution of anthocyanin in his article in CLIVIA YEARBOOK 1998. So it is possible to create a totally white flower by interspecific hybridization.

It seems that one of the Nakamura hybrids called 'Veined Petal' (photo 37) was bred by crossing orange C. *miniata* with yellow C. *miniata.* His F1 hybrid between 'Veined Petal' and yellow C. *miniata* will produce both pigmented and unpigmented seedlings, but I think pigmented seedlings will grow to have more interesting flowers.

He has also created a 'Super Multi-Petal' flower, which is a mutation of a multipetaled plant and has forty to fifty petals. What is more he created a 'Folded Petal' flower of which the stamens are attached to the inner petals.

Mr Nakamura is very interested in Chinese people's enthusiasm for *Clivia.* However up to now their interest has been mainly based on leaf shapes and the form of the plants seen as a whole. He often says if their interest will extend to the variety of flowers, they will communicate more with South Africa, the *Clivia* homeland, USA and Australia - countries in which *Clivia* breeding is far advanced. Then *Clivia* will become even more popular in the future. That is his dream. He sometimes visits China and provides Chinese breeders with his various *Clivia* hybrids. He has made continuous efforts to report wonderful developments in the breeding of *Clivia* to the Chinese people.

Clivia flower colour mutation

Finally, I would like to share with you two articles written by Japanese botanists. Both articles explain about the pigment 'anthocyanin' which I am most interested in these days.

One is from a report 'Analysis of pigmentation in C. *miniata'* written by Professor Takao Matsuno.

'As the result of analysis, I can say as follows. Orange C. *miniata* contains pelargonidin (which is one of the anthocyanidin pigments) and carotinoid. On the other hand, yellow C. *miniata* contains only carotinoid. In other words, orange C. *miniata* contains red pigment and yellow pigment. Please refer to the following data. The content of pigment is expressed by (ug/g).

	Anthocyanidin Content:	Carotinoid Content:
Commercial C. *miniata*	21.4	21.4
Wild C. *miniata A*	26.5	35.6
Wild C. *miniata* B	20.2	24.6
Yellow C. *miniata*	0.0	16.0

According to the above data, orange C. *miniata* contains both pigments equally or some plants contain more carotinoid than anthocyanidin. However, yellow C. *miniata* contains no anthocyanidin and in addition contains less carotinoid compared with orange C. *miniata.* There are many kinds of anthocyanidin which make factors of red, pink or purple colours. Some plants contain several anthocyanidin pigments. C. *miniata* contains only pelargonidin. It is possible to make a flower colour variation from just pelargonidin, but we cannot anticipate a purple or blue flower unless there is a sudden mutation. There are so many kinds of carotinoid: carrot contains *Bc*arotene; yellow *Ginkgo* leaf contains lutein; C. *miniata* contains both carotinoids as follows.

	lutein	*B*carotene
commercial C. *miniata*	61%	13%
wild C. *miniata*	68-70%	12%
yellow C. *miniata*	61%	9%

According to the above data, a plant with less carotinoids will show a whiter flower, a plant with more carotinoids will show a more yellow flower. C. *miniata* also contains other carotinoids; they might be a half generation of carotinoids/

Another article is from a book named The Mystery of Flower Colour' written by Dr. Hitoshi Yasuda.

The process of generating various kinds of anthocyanin is as follows. At first, some gene generates orange coloured pelargonidin type anthocyanin. We call it gene B. Gene B is essential for generating pelargonidin type anthocyanin. Then we suppose gene C that is essential for generating red coloured cyanidin type anthocyanin. Gene C generates cyanidin type anthocyanin from pelargonidin type anthocyanin. Then we suppose gene D. Gene D generates purple-blue coloured delphinidin type anthocyanin. Without gene D, purple-blue coloured pigment is not generated from cyanidin type anthocyanin. The genetic dominance of flower colour is in the following order in nature: orange-red-purple-blue. This means that a pelargonidin type will be dominant to a cyanidin type and a cyanidin type will be dominant to a delphinidin type.'

While the thought may be far from reality, we could try to make a sudden mutation of pelargonidin in C. *miniata* by using cobalt 60 or chemicals. Then it might be possible to breed blue *Clivia.* Then this might lead us in another direction to extend the range of flower colour of *Clivia.*

Clivia minita 'Ghost'

I am not a *Clivia* specialist. I am just one of the *Clivia* enthusiasts and my breeding ability is limited. But as one of the enthusiasts who believe in the potential of *Clivia,* I would like to put my breeding ideas into practice and cooperate with other *Clivia* lovers. I wonder if I can create just one new flower so that I can share that joy with all *Clivia* lovers.

Note that where the author refers to 'yellow C. *miniata'* the taxanomically correct description is *C. miniata* var. *citrina.* Eds.

MANIPULATION OF FLOWERING PERIOD AND SHOOT MULTIPLICATION IN CLIVIA MINIATA REGEL

SUPERVISOR: Prof P. I. ROBBERTSE Craig Brenton Honiball

DEPARTMENT: Plant Production and Soil Science DEGREE: MSc(Agric): Ornamental Horticulture

Craig Honiball completed his MSc on flower manipulation and shoot multiplication of Clivia miniata *in the Department of Plant Production and soil Science (Horticulture), University of Pretoria, concurrently with a BCom. degree.*

Abstract

Clivia miniata Regel is widely cultivated as a garden ornamental and a pot plant and can be forced to flower outside the natural flowering period by applying a cold treatment. Under local conditions this could be achieved by using a treatment of *7.5* to 10 °C for 14 days. This caused a significant number of the cold treated plants to flower earlier in the season with the result that the naturally short flowering period could be extended. The 14 day period of cold treatment which was required was shorter than a period of 60 days previously described.

Little information exists regarding its use as a cut flower. It was found that inflorescences could be harvested at the stage when all flowers were still closed and that more than 90% of flowers opened and developed normal colouration either in distilled water or in a commercial postharvest product (Chrysal AKC™). The product also reduced the incidence of stem splitting.

Clivia has been propagated *in vitro* with varying degrees of success but the methods are still relatively slow. Commercial protocols for propagation exist but have not been published. Therefore, the use of *in vivo* foliar applications of paclobutrazol (PAC) and Promalin™ (PRO), to stimulate branching and shoot formation, was investigated.

The main effect of PAC could be seen as the stimulation of bud formation from meristematic zones on the abaxial side of leaf bases in the older, proximal axils. The mean number of shoots produced by PAC at concentrations between 250 and 25 000 ppm varied from 2.3 to 7.1 per plant, without any statistically significant difference between treatments. However, at concentrations of 5 000 ppm and higher, growth inhibition was unacceptable. PRO had the effect of stimulating bud formation from leaf bases situated near the apical meristem, in the younger distal axils. PRO also caused dichotomous branching of apical meristems. PRO applied 10 times, at 200 or 500 ppm a.i., resulted in branching of 50% of treated plants into 2 or 3 modules. However, the latter results could not be analysed statistically. The most significant benefit arising from the use of PRO was survival of the parent plant without any inhibition of vegetative growth. Both PAC and PRO had a negative effect on flowering at the concentrations tested. The use of PAC to stimulate *in vitro* shoot formation was attempted unsuccessfully, probably due to an inappropriate medium composition.

An understanding of plant architecture is important when trying to manipulate propagation and phenology. *Clivia* has a modular growth form and exhibits sympodial branching under natural circumstances.

CONTENTS

Abbreviations

a. i.	: active ingredient	l	: litre
CHRYS	:ChrysalAKC™	ml	: millilitre
cm	: centimeter	mm	: millimeter
2,4-D	: 2,4-dichlorophenoxyacetic acid	mg	: milligram
dH_20	: distilled water	M	: Mol/ litre
g	: gram	MS	: Murashige and Skoog
GA_3	: gibberellic acid	PRO	: Promalin™
GA_4	: gibberellin no.4	PAC	: paclobutrazol
GA_7	: gibberellin no. 7	ppm	: parts per million

INTRODUCTION

Literature Review

Botany and history

The genus *Clivia* Lindl. belongs to the family Amaryllidaceae and comprises 4 species; C. *miniata* Regel, *C. nobilis* Lindl., C. *caulescens* R A Dyer and C. *gardenii* Hook. Interspecific hybrids have been created (Lotter, 2000) but no reliable reports of successful intergeneric hybrids involving *Clivia* could be found, despite attempts at such crosses having been made (Niederwieser, 2000). The chromosome number in all four species of *Clivia* is 2n = 22 (Ran, Murray & Hammet, 1999). *Clivia* spp. are indigenous to the eastern regions of southern Africa and their natural habitat varies from coastal forest to secondary coastal dunes and tree trunks (Winter, 2000). Many attractive forms exist in shades of pink, orange (Glover, 1985), apricot (Smith, 1999), yellow (Morris, 1990), red (Lotter, 1998) and near white (McNeil, 1985). *Clivia* has a modular, sympodial growth form and inflorescences are produced terminally on modules. This pattern is similar to that seen in other amarylids such as *Hippeastrum* sp. (Rees, 1985) and *Cyrtanthus* sp. (Slabbert, 1997).

Clivia has been in cultivation in Belgium for approximately 150 years where it is still grown today (De Koster, 1998a). It also enjoys popularity in China (Nakamura, 2000), Japan (Nakamura, 1998), Australia (Smith & Henry, 1998) and North America (Koopowitz, 2000).

Cultivation

Investigation of optimal growing conditions for *Clivia* with respect to lighting and temperature have been undertaken in Japan (Mori & Sakanishi, 1974), and Europe (Vissers & Haleydt, 1994, De Smedt, Van Huylenbroeck & Debergh, 1996). An outline of growing conditions and stages of *Clivia* production in Belgium has also been described (De Koster, 1998 b). By contrast, in local production of *Clivia* there is often no control of growing temperature and flowering occurs mainly from August to September. Propagation of *Clivia* occurs largely through seed which results in heterogeneous offspring. However, amongst certain groups or strains, elucidation of the mechanism of inheritance of flower colour makes this characteristic predictable (Morris, 1990, Lotter, 1998, Tarr, 2000). Commercial tissue culture methods for clonal propagation have been developed (Smithers, 2000, Chapman, 1999) but these protocols have not been published. No reports could be found on commercial *Clivia* cut flower production and few reports exist on postharvest treatment of cut flowers (Nowak & Rudnicki, 1990, Zhang *et al,* 1991).

Biochemistry and physiology

Various biochemical and physiological studies have been conducted on *Clivia,* for example an investigation of the chemical composition of endodermal and hypodermal cell walls (Schreiber *et al.,* 1999) and water relations of the hypodermis (Casado & Heredia, 1998). The structure and function of leaf cuticles has also been studied (Dominguez & Heredia, 1999) and various secondary metabolites have been isolated (Evidente *et al,* 1999).

Aims

The aim of this project was to determine whether manipulation of growing temperature as used in Europe could be applied under local conditions to extend the short natural flowering period of C. *miniata.* It was then felt that if better control of the flowering period could be achieved, more attention might be given to the possibility of *Clivia* as a cut flower crop. Therefore, peduncle splitting and picking stage of *Clivia* cut flowers was investigated. Cut flower

cultivation or accurately programmed cultivation requires having large quantities of clonal material available. However, the success gained by following published sources of information on *Clivia* tissue culture is limited. No reports could be found on the use of paclobutrazol to stimulate *in vitro* shoot formation and this was investigated. Nevertheless, tissue culture is not always available to growers and *Clivia* collectors may be reluctant to sacrifice plant material of superior clones. As a result, another alternative was sought. The use of foliar sprays of plant growth regulators to promote shoot formation was seen as a feasible method which could be applied by individual growers.

EXTENDING FLOWERING PERIOD IN *CLIVIA MINIATA* REGEL USING A COLD TREATMENT

Summary

Clivia miniata can be forced to flower out of season by applying a cold treatment which brings about emergence and development of quiescent inflorescences. Plants growing outdoors were exposed to a cold treatment of *7.5* -10 °C for 14 days, commencing during the last week of April. This caused a significant number of the cold treated plants to flower earlier in the season. The implication was that the period during which *Clivia* in flower was available for sale could be extended. The difference in the number of cold treated and control plants in flower was most noticeable in the period from 12-19 weeks after commencement of the cold treatment. The 14 day period of cold treatment which was required for successful forcing under local conditions was shorter than a period of 60 days previously described.

Introduction

Flower forcing is undertaken in many species in order to prolong the period in which plants are in flower or to have plants in flower for specific occasions (De Hertogh *et al*, 1997). *Hippeastrum* sp. is an example of the Amaryllidaceae which can be successfully forced (Sandler-Ziv *et al*, 1997). It has been shown that *Clivia miniata* can be brought into flower outside its natural flowering period by manipulating growing temperature (Mori & Sakanishi, 1974, Vissers & Haleydt, 1994, De Smedt, Van Huylenbroeck & Debergh, 1996). *Clivia* has a modular, sympodial growth form and inflorescences form terminally on modules. Modules are produced as two or more recurrent flushes per growing season, depending on cultural conditions. Inflorescences remain quiescent until a cold stimulus is received which stimulates elongation of the peduncle and further development of the inflorescence. It appears that the inflorescence is only able to respond to the cold stimulus once it has reached a minimum size and it is known that flower initiation is linked to the production of a certain number of leaves (De Smedt et al., 1996). In local production of *Clivia*, there is often no control of growing temperature and flowering occurs mainly from August to September. The aim of this experiment was to determine whether a cold treatment could bring plants grown outdoors into flower earlier. It was hoped that this would extend the naturally short flowering period and ultimately increase sales and revenue to *Clivia* growers. In addition, the fruit wall is a source of explant which can be used in *in vitro* culture of *Clivia*, but the seasonality of flowering has been a limiting factor in the application of this technique (Finnie, 1998).

Materials and methods

The trial was conducted in the east of Pretoria at a nursery situated on the north facing slope of a hill where *Clivia* are grown under

70% black shade net. The experiment comprised 100 mature plants with at least 12 mature (fully elongated) leaves on each plant. Plants were growing in 6 liter plastic bags. Fifty randomly selected plants were removed from the nursery for the cold treatment and 50 plants remained as the control. The cold treatment comprised placing plants with plastic bags intact, in a dark, unventilated cold room for 14 days. The temperature was maintained between *7.5* and 10 °C and oscillated from minimum - maximum - minimum every 4 hours. The period of cold treatment was chosen after exploratory investigations indicated that 14 days was sufficient to bring plants into flower. This is in contrast to a period of 60 days at 10 °C previously described for successful forcing of *Clivia* (Mori & Sakanishi, 1974). After the cold treatment, plants were returned to the nursery. At weekly intervals, the number of plants whch had reached the marketable stage was recorded for both treatments. A plant was defined as marketable when it had a normally elongated peduncle with some orange colouration in the perianth, but before any flowers were open. The air temperature in the nursery, at leaf canopy level, was recorded for the duration of the experiment using a thermograph which had been calibrated with a mercury thermometer. A Chi square test was used for the statistical analysis and required data from weekly observations to be combined into fortnightly data. The number of observations at each fortnightly interval was large enough for analysis only from week 12 onwards. A two way table of the two treatments versus time for the four fortnightly periods (effective sample size = 87) was used to test the null hypothesis which proposed that there was no relationship between treatment and time.

Results and discussion

Figure 2.1 shows the weekly minimum and maximum air temperatures in the nursery for the duration of the experiment from 24 April 2000 (week 0) to 04 September 2000 (week 19). It is apparent that maximum temperatures fluctuated between 16 and 27°C and minimum temperatures between 2 and 11°C. Figure 2.2 shows on a weekly basis, over 19 weeks, the percentage of plants in each of the two treatments which had reached the marketable stage. Figure 2.3 (combined data) shows the percentage of plants in each treatment which had reached the marketable stage for the four fortnightly periods from week 12-19. The number of plants at marketable stage was equal to zero until and including week 6. After 19 weeks, 96% of cold treated plants and 94% of controls had flowered, but Figure 2.2 and 2.3 indicate the trend whereby cold treated plants flowered before controls. Table 2.1 is the two way table of treatment versus time and shows title observed and expected values from the Chi square test for cold treated and control plants ($P < 0.0001$). It indicates that for the first two fortnightly periods (week 12-13 & 14-15), the number of cold treated plants which were marketable, was significantly higher than expected while in the control treatment the number was significantly lower than expected. Conversely, during the last two periods (weekl6 -17 & 18-19), the number of plants at the marketable stage was significantly lower than expected for cold treated plants and significantly higher for controls. This result allowed rejection of the null hypothesis and it was concluded that the cold treatment was effective in increasing the number of plants available for sale early in the season when control plants were not marketable yet. It can therefore be deduced that one will be able to extend the period during which *Clivia* is available in flower by applying a cold treatment of relatively short duration, as described, to a portion of plants intended for sale in a specific season.

Prior to the abovementioned experiment, two exploratory investigations were carried out. In the first, a similar cold treatment was applied to outdoor grown plants at the beginning of February and flowering occurred in March and April.

In the second, flowering size plants were placed in a greenhouse which was heated from the beginning of April to the end of August so that exposure to winter cold was eliminated. These plants did not flower during the natural flowering period when plants outside were in flower. A cold treatment was then applied at the end of November and brought some of the plants into flower in January and February. Therefore, it is felt that it may be possible to even further extend the flowering period in *Clivia.* However, these results could not be statistically tested and will need to be verified. Further work could try to find out whether a cold treatment can be effectively applied earlier or later than the last week in April. The earliest and latest dates for successful forcing could also be determined. The phenomenon of negation of the effect of a cold treatment when followed by high growing temperature can also be investigated.

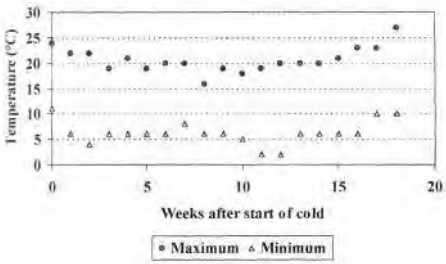


Figure 2.1 Weekly minimum and maximum air temperatures at leaf canopy level from week 0-19

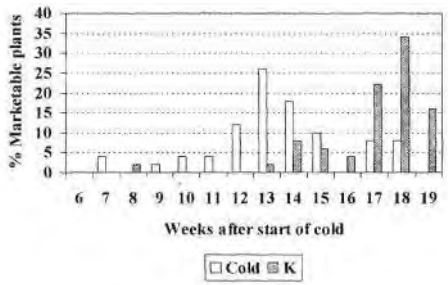


Figure 2.2 Percentage of plants at the marketable stage from week 6-19

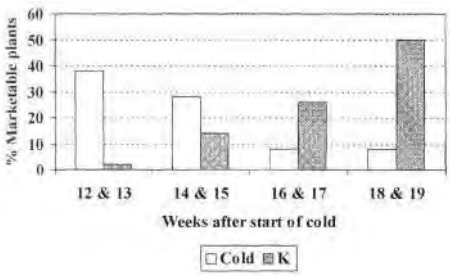


Figure 2.3 Percentage of plants at the marketable stage for the fortnightly periods from week 12 - 19

Treatment	Week			
	12 & 13	14 & 15	16 & 17	18 & 19
Cold	19 (9)	14 (10)	4 (8)	4 (14)
K	1 (11)	7 (11)	13 (9)	25 (15)

Table 2.1 Two way table of treatment versus time with observed and expected () values for cold treated (Cold) and control (K) plants. Expected values were btained from a Chi aquare test ($P<0.0001$) Effective sample size = 87

THE POTENTIAL OF *CLIVIA MINIATA* REGEL AS A CUT FLOWER

Summary

Clivia miniatA RegeL is widely cultivated as a garden ornamental and a pot plant. It occurs in many attractive shades of orange, red, yellow and pink but little information exists regarding its use as a cut flower. The possibility of picking cut flowers when all the flowers on the inflorescence were still closed and forcing flowers to open in distilled water and in Chrysal AKC™ (CHRYS) was examined. A forcing temperature of 21 ± 2°C and an irradiance of 22 ± 3.10^{-6} mol photons m^2S^{-1} was used. After 190 hours, in both distilled water and CHRYS, more than 90% of flowers had opened and developed normal colouration. However, after 96 hours, 90% of inflorescences held in distilled water and 10% of those in CHRYS had developed peduncle splitting. The mechanism involved in the prevention of splitting is unknown but it is suspected that sucrose may have caused this.

Introduction

Clivia miniata is widely cultivated as a garden plant in South Africa and has been cultivated as a pot plant in Europe for many years. Many attractive forms exist in shades of pink, orange, (Glover, 1985), yellow (Morris, 1990) and near white (McNeil, 1985) but few reports on *Clivia* cut flowers could be found (Drysdale, 1990, Nowak & Rudnicki, 1990). Furthermore, it appears that the flowering period of *Clivia miniata* can be manipulated to some extent by regulating growing temperature (Mori & Sakanishi 1974, De Smedt, Van Huylenbroeck & Debergh, 1996, Chapter 2 of this dissertation) and lighting (Vissers & Haleydt, 1994). Therefore, it was felt that the subject of *Clivia* cut flowers warranted further attention and that picking stage and the occurrence of peduncle splitting should be investigated.
The recommended cutting stage for *Clivia* (Nowak & Rudnicki, 1990) is when 25% of the flowers on the inflorescence have already opened. In order to facilitate handling, packaging and longer vase life it was felt that it was important to determine whether flowers could be picked at a more closed stage.

Materials and methods

Flowers were picked from a suburban garden during late afternoon and transported dry to the laboratory within an hour. It follows then that the effect of extended periods of dry storage of flowers such as may occur, for example, if flowers are transported by airfreight, was not investigated. The prevailing air temperature in the laboratory was 21 ± 2°C and the irradiance at a height of 25 cm above the inflorescences was 22 ± 3.10^{-6} mol photons m^2s, provided by Osram™ cool white fluorescent tubes. Figure 3.1 shows the developmental m^2s^{-1} of the inflorescences when picked; all flowers were closed but some colouration could be seen in the perianth. Ten inflorescences were placed in CHRYS (40g CHRYS/litre distilled water) and ten in distilled water. The Chrysal product was chosen because it is used to enhance opening of carnations and other flowers cut in the bud stage. The number of open flowers was recorded as a percentage of the total number of flowers on each inflorescence over a period of 190 hours. Furthermore, the number of split peduncles which occurred in each treatment was recorded. Longitudinal sections of split peduncles which had been embedded in paraffin wax were examined. A meaningful statistical analysis was not possible due to scarcity of material and the short natural flowering period.

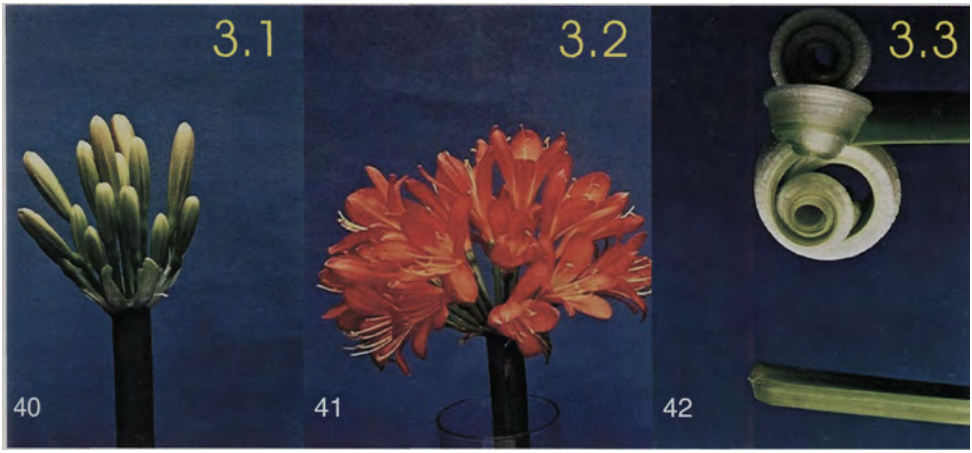


Figure 3.1 Development stage of *Clivia miniata* infloresences at picking.

Figure 3.2 Colour development in *Clivia miniata* flowers on an infloresence picked at the stage when all flowers were unopened and kept in distilled water for 6 days at 21 ± 2°C and an irradiance of 22 ± 3.10^{-6} mol photons m^{-2}s^{-1}.

Figure 3.3 Split (top) and unsplit (bottom) peduncles of *Clivia miniata* held in distilled water and 40g/l Chrysal AKC™, respectively

Results and discussion

After 190 hours (8 days), 99% of flowers kept in CHRYS and 95% of those in distilled water had opened (Table 3.1). In addition, colour development in the open flowers was normal (Figure 3.2). It was also observed that 90% of the inflorescences held in distilled water had developed peduncle splitting after 96 hours. This only occurred in 10% of stems held in CHRYS over the same period. In addition, the degree of splitting was much less severe when using CHRYS and was restricted to the tip of the peduncle. It appeared that equal numbers of flowers opened on inflorescences with split and unsplit peduncles. Figure 3.3 shows split and unsplit peduncles kept in distilled water and CHRYS, respectively. The mechanism by which splitting was prevented is unclear. However, the same problem occurs in *Hippeastrum* cut flowers due to extensive expansion of the inner parenchyma tissues. Splitting could be prevented by pulsing *Hippeastrum* stems in a 0.125 M sucrose or KNO_3 (potassium nitrate) solution which was thought to have conditioned the parenchyma in the basal portion of peduncles to withstand rapid expansion (Halevy & Kofranek, 1984). From sections of split *Clivia* peduncles, a difference in the size of inner and outer parenchyma cells could be seen (Figure 3.4). The chemical composition of CHRYS is a trade secret and is therefore not known. However, it is suspected that sucrose is an ingredient and that it may have reduced the incidence of splitting.

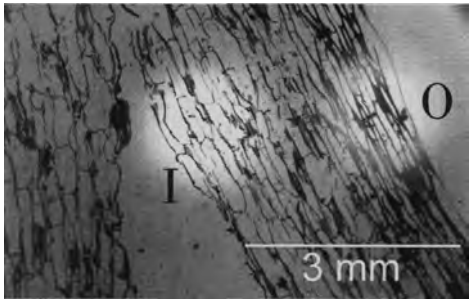


Figure 3.4 Longitudinal section of a split peduncle, showing inner (I) and outer (O) parenchyma tissues

Table 3.1 Mean number of open flowers (x) with standard deviation (s) on inflorescences held in 40g/l Chrysal AKC™ and distilled water (dH_20) over a period of 190 hours at 21 ± 2°C and an irradiance of 22 ± 3.10^{-6} mol photons m^2s^{-1}. The number of open flowers is expressed as a percentage of the total number of flowers on the inflorescence, n = 20

Hours		0	29	63	113	190
Chrysal	x	0	27	65	93	99
	s		7	15	8	1
dH_2O	x	0	23	48	78	95
	s		13	15	14	12

From the investigation it is concluded that it is possible to harvest *Clivia* cut flowers at a stage when all flowers are still closed and that a large proportion of the flowers will open with normal colour development under the conditions described. It seems that the problem of stem splitting can also be overcome by placing stems in CHRYS. Further work can be done to establish whether flowers will successfully open under conditions of lower irradiance than used in this experiment and to clarify the processes which cause and prevent stem splitting. The optimum treatment time and the possibility of using pulse treatments for prevention of stem splitting could also be determined. In addition, the effect of commercially available pretreatment products on the rate of flower opening and longevity could also be examined. Furthermore, the effect of dry storage of flowers on vase life, flower opening and stem splitting should be investigated.

PROMOTION OF SHOOT FORMATION IN *CLIVIA MINIATA* REGEL WITH PACLOBUTRAZOL AND PROMALIN™

Summary

Propagation of superior clones of *Clivia* occurs through division of basaly produced suckers which is relatively slow or by tissue culture which is not always readily available to growers. This study investigates the use of paclobutrazol (PAC) and Promalin™ (PRO) (benzyl adenine + GA_4 + GA_7) as a foliar spray to promote shoot formation. It was found that PAC promoted bud formation in the axils of older proximal leaf bases and the mean number of shoots produced at concentrations between 250 and 25 000 ppm PAC varied from 2.3 to 7.1 without any statistically significant difference among treatments, 7 months after application. However, at concentrations of 5 000 ppm and higher, growth inhibition was unacceptable and death of the parent plant occurred in some individuals due to abortion of the apical meristem. GA_3 applied 3 times, at 500 ppm, appeared to be useful in alleviating growth inhibition caused by PAC, but the effect could not be quantified. It was found that PRO also promoted branching, but from the axils of younger, distal leaf bases. PRO also resulted in dichotomous branching of apical meristems. When applied 10 times, at either 200 or 500 ppm a.L, PRO resulted in acrotonic branching of 50% of treated plants into 2 or 3 modules. However, the latter results could not be analysed statistically. The most significant benefit arising from the use of PRO was survival of the parent plant without any inhibition of growth.

Introduction

Clivia miniata can be vegetatively propagated by division of suckers. The rate at which suckers are produced varies from clone to clone and is often not satisfactory.

Published tissue culture methods are still imperfect, resulting in varying degrees of success (Wang, Li & Yang, 1995, Finnie, 1998, Chapman, 1999). In addition, tissue culture facilities are not available to many amateur growers who are in possession of desirable clones. This investigation was undertaken to determine whether the plant growth regulators paclobutrazol and Promalin™ could be used as a foliar spray to promote shoot formation and branching in *Clivia.*

Paclobutrazol (PAC) has been used in *in vitro* propagation to stimulate shoot formation in a range of plants such as *Nerine* sp. (Ziv, Kahany & Lilien-Kipnis, 1994), *Gladiolus* sp. (Nagaraju, Parthasarathy & Bhowmik, 1997) and *Tulipa* (Kuijpers & Langens-Gerrits, 1997). PAC applied as a foliar spray resulted in production of side shoots in *Cordyline* sp. (Higiladi & Watad, 1992) and when applied to *Clivia* to reduce plant size, caused the same effect (Van Huylenbroeck, 1998). However, in the latter work, a wide range of concentrations was not tested and the yield of shoots was relatively low. PAC is a plant growth regulator which inhibits the synthesis of gibberellic acid (Grossmann, 1990). However, in *in vitro* culture of potato, growth inhibition could be reversed by using GA_3 in the medium (Simko, 1993).

Benzyl adenine (BA) can also be used to stimulate shoot formation. This was achieved in *Cordyline* sp. (Maene & Debergh, 1982) and *Geranium* (Foley & Keever, 1992). In *Spathyphyllum* sp. grown *in vitro,* shoot induction by B A was dramatically enhanced in the presence of imidazole fungicides. As with PAC, the latter effect was obtained by inhibition of GA_3 production (Werbrouck & Debergh, 1995, Werbrouck *et al,* 1996). PRO (GA_4 + GA_7 + BA; 19g/l active ingredient) is registered in South Africa for the promotion of branching in apples (Vermeulen, Grobler & Van Zyl, 1997).

Materials and methods

PAC (Cultar™; 250g/l active ingredient) was applied to flowering size plants as a foliar spray until run off, at concentrations of 1, 2, 4,10, 20, 50 and 100ml Cultar™ /l corresponding respectively to 250,500,1000, 2500, 5000,12500 and 25000 ppm a.i. Eight replicates per treatment were used. The number of shoots formed was then recorded and the statistical analysis comprised a regression analysis of the number of shoots formed as a function of concentration. An analysis of variance (ANOVA) using Tukey's least significant difference was done to determine whether the mean number of shoots differed significantly among the treatments (a = 0.05).

Alleviation of PAC induced growth inhibition by GA_3

A small number of plants (8) were used to determine if the growth retarding effect of PAC could be alleviated by GA_3. Ten months following a PAC spray at 25 000 ppm, GA_3 (Berelex™ 1OOg/kg a.i.), at a concentration of 500 ppm, was applied to 4 of the plants treated with PAC. Three applications were made; a single spray until runoff, every fortnight, for six weeks. The plants treated with PAC had produced a large number of stunted, basal shoot primordia.

Promalin™ application through the leaves

In a second set of flowering size plants, a foliar spray of PRO until runoff, was applied during April when plants were not in flower. Concentrations of 5.3,10.4 and 26.3 ml PRO/1 were used (corresponding respectively to 100, 200 & 500 ppm a.i.). Ten applications were made; one application every second day, for 20 days. Eight replicates of each treatment were used. The number of plants which reacted was then recorded.

After observation of the effects of the first PRO application, PRO was applied to a third set of plants for the purpose of an anatomical investigation (page 42). A concentration of 375ml PRO/1 (7125 ppm a.i.) was applied to a small number of seedlings at the six leaf

43

44

THE HABITAT

43 & 44 *Clivia miniata* from the same mutating population

45 *Clivia gardenii* from the same population as the yellow form shown in CLIVIA YEARBOOK 2 - photo 25

46 *Clivia caulescens* yellow form

stage. The solution was painted onto the crown and leaf axils of each plant with a paint brush, wetting the areas until runoff. Two application regimes were used; a single application per plant and three applications per plant. In the case of three applications, one application was given fortnightly, for six weeks. At various intervals, plants were harvested for anatomical investigation.

Promalin™ application through the roots

In a fourth set of plants, seedlings at the 6-8 leaf stage, an attempt was made to apply PRO via the root system. All soil was washed from the roots before plants were placed in an aerated water medium (hydroculture). The nutrient solution comprised Chemicult™ hydroponic nutrient powder at the rate of 0.5g /l. After 1 month, a PRO spray was applied to the roots at concentrations of 0,4 750 and 7 125 ppm a.i. comparing one and three applications. In the case of three applications, roots were sprayed once every evening, for three days. After removing plants from hydroculture in the early evening and allowing them to dry for 10 minutes, PRO was sprayed onto roots until runoff. After spraying, roots were covered in a plastic bag to prevent evaporation, left overnight and returned to hydroculture in the morning. After the last spray, plants were replanted in a decomposed bark medium. Each treatment was replicated eight times.

Anatomical investigation

An anatomical investigation was conducted to elucidate shoot architecture and to identify the origin of shoots produced after PRO and PAC treatments. Material was prepared by fixation in formalin acetic acid alcohol followed by dehydration in sequential alcohol and alcohol xylene mixtures. After embedding in paraffin wax, microtome sections were cut and stained with toluidine blue (O'Brien & McCully, 1981).

Results and discussion

The effect of paclobutrazol

Ten months after the application of a 2 500 ppm PAC foliar spray, a clearly visible reduction in plant height could be seen (Figure 4.1). This was accompanied by branching in the older proximal axils of leaf bases (basitonic branching) which was especially prolific at higher concentrations. At and above concentrations of 5 000 ppm PAC, complete and near complete disintegration of the parent plant and much of the root system occurred in some individuals (Figure 4.2). However, it follows that the viability and probability of survival of shoots on plants compromised to this extent would be much reduced. It was interesting to note that PAC caused the death of the apical meristem, but stimulated bud formation in the meristematic zones in the axils of basal leaves (Figure 4.10).

Seven months after PAC application, a relationship between PAC concentration and the number of shoots formed could be found and was given by $S = 2.799 + 0.179\ k - 0.001\ k^2$ where S and k represented the number of shoots and PAC concentration, in ml Cultar/l water, respectively (Figure 4.3). All three terms were highly significant ($Pr > t$; <0.0001, <0.0007 and <0.0044 respectively). A low value for R^2 (0.22) was obtained and indicates that there were other factors which also played a role in the number of shoots formed. Since the plants used were raised from seed, genetic variation is likely to have played a role. This was true for the response of different cultivars of *Gladiolus* to PAC (Nagaraju *et al*, 1997). The ANOVA indicated that the number of shoots formed at all PAC concentrations differed significantly from the control, but not from one another (Table 4.1). The effect of PAC on flowering was negative because of death of the apical meristem. Furthermore, existing inflorescences disintegrated completely at concentrations of 5 OOOppm and higher and where this did not occur, peduncles were unacceptably short.

Figure 4.1 Reduction in plant height 11 months after application of 2 500 ppm paclobutrazol (front) compared to the untreated control (back).

Figure 4.2 Disintegration of the parent plant and root system 13 months after application of 25 000 ppm paclobutrazol.

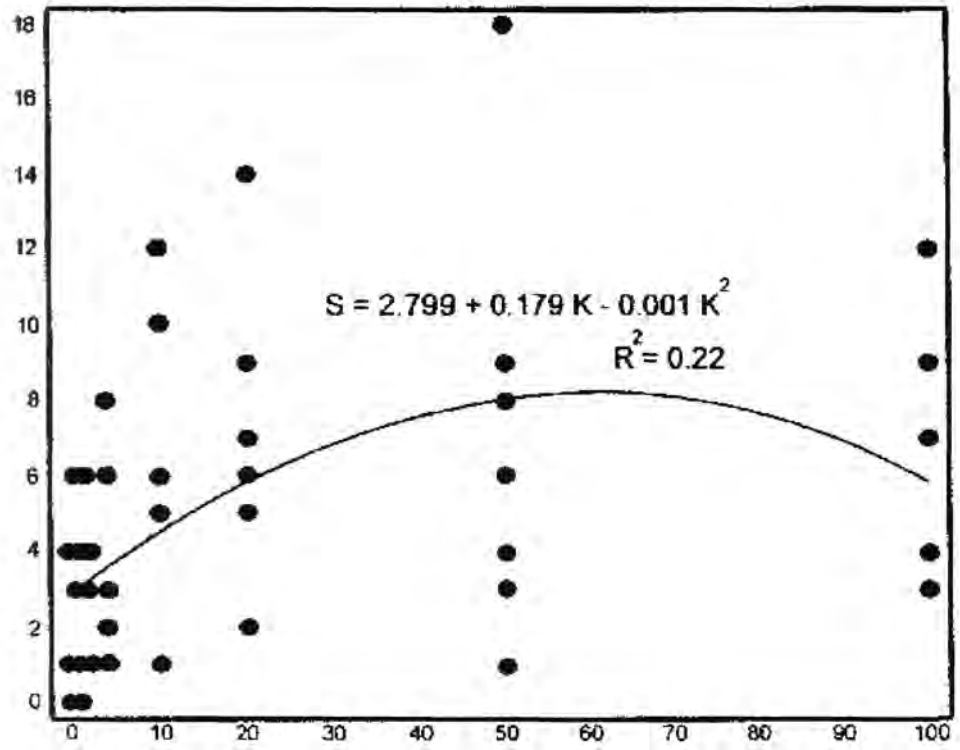


Figure 4.3 Regression analysis of number of shoots as a function of paclobutrazol concentration (ml Cultar™/l). $R^2 = 0.22$.

Table 4.1 Mean number of shoots as a function of paclobutrazol (PAC) concentration (ml Cultar™ /l), seven months after application. Means with the same letter do not differ significantly a = 0.05, Tukey, n = 64.

ml Cultar™ /l	0	1	2	4	10	20	50	100
Mean number of shoots	1	2.3[a]	3.3[a]	3.5[a]	7.1[a]	6.5[a]	6.6[a]	6.1[a]

Alleviation of PAC induced growth inhibition by GA3

It appeared that the 3 applications of GA_3 at 500 ppm alleviated the inhibition caused by PAC to some extent (Figure 4.4). It was felt that the use of GA_3 could have practical benefits but its effect could not be quantified or statistically analysed.

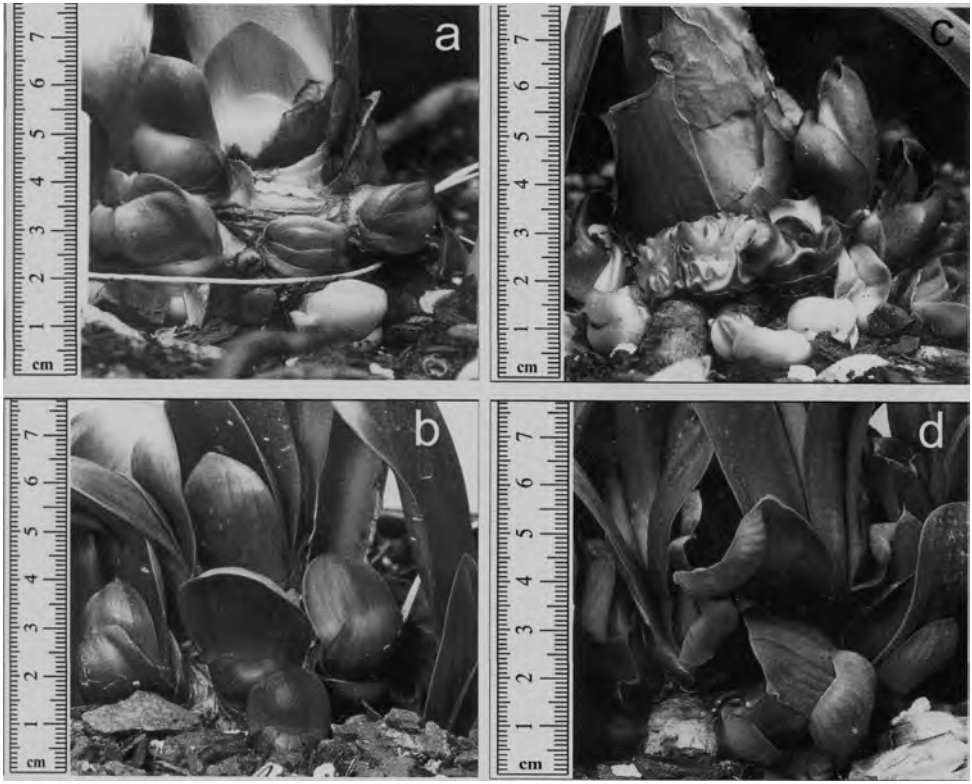


Figure 4.4 Alleviation of growth inhibition after application of 25 000 ppm paclobutrazol. Ten months after application of PAC, following formation of shoot primordia, 3 fortnightly applications of GA_3 at 500 ppm were made. Photo taken two months after the last application of GA.

a: Plant no. 1 before, without GA_3. c: Plant no. 2 before, with GA_3.
b: Plant no. 1 after, without GA_3. d: Plant no. 2 after, with GA_3.

Promalin™ application through the leaves

The result of PRO application was branching of treated plants in the region around the apical meristem. Shoots formed in this way were different in morphology to those formed by PAC in the sense that leaf size and shape were normal (Figure 4.5). One year following the 10 applications of PRO at 0,100, 200 and 500 ppm, the percentage of plants exhibiting formation of additional shoots was 0%, 25%, 50% and 50% respectively. However, these results could not be statistically analysed. The most significant benefit which arose from the use of PRO was that there was no inhibition of vegetative growth or destruction of the parent plant. However, flowering was negatively affected and deformed flowers could be observed when using 100, 200, 300 or 7 125 ppm PRO (Figure 4.6). The green tissue in the perianth probably occurred because cytokinins promote chloroplast development and chlorophyl synthesis (Salisbury & Ross, 1992) while the abnormal thickness of the tissue in the perianth could be due to cell proliferation and expansion caused respectively by BA and gibberellins in PRO.

Figure 4.5 New (1 & 3) and original (2) modules, 1 year following 10 applications of 500 ppm a.i. Promalin™.

Figure 4.6 Abnormal flower development (right) compared to control (left), after a single foliar application of 7 125 ppm a.i. Promalin™, before emergence of the infloresence.

Promalin™ application through the roots

PRO at 7 125 ppm a.i. proved to be phytotoxic when applied through the roots. When applied at 7 125 ppm a.i., 100% of individuals exhibited necrosis of the root system within two weeks, followed by gradual death of the entire plant. Phytotoxicity could also be observed, to a lesser extent, at 4 750 ppm a.i. Table 4.2 shows the number of plants surviving at the various application rates, 4 months after the last PRO application. From the first experiment in which PRO was applied through the leaves (page 39), it was apparent that visible branching could only be detected approximately 1 year after application. At the date of publication it was not possible to determine whether PRO application through the roots had achieved

Table 4.2 Percentage of plants surviving 4 months after application of PRO to the roots once (lx) and 3 times (3x) at concentrations of 4 750 and 7 125 ppm a.i.

PRO (ppm a.i.)	0	4 750; lx	4 750; 3x	7 125; lx	7 125; 3x
% survival	100	100	62.5	87.5	0

Anatomical investigation

In an untreated mature plant, Figure 4.7 depicts the development of a new module adjacent to the old one which has terminated in an inflorescence. This suggests a modular, sympodial plant architecture (page 51). Potentially meristematic zones are located in leaf axils, on the abaxial side of leaf bases, but no differentiated axillary buds are present (Figure 4.8). These meristematic zones are believed to be the source of new modules produced when a PAC treatment is applied. This would be consistent with the findings that PAC enhanced meristem formation on stem explants of *Tulipa* (Kuijpers & Langens-Gerrits, 1997). Figure 4.9 indicates these zones, accentuated in a seedling, 5 months after treatment with 5 000 ppm PAC while Figure 4.10 indicates a new bud forming in the most proximal axil of another seedling following the same treatment. It is evident that the bud is facing downwards and this is consistent with the 'U' shape which can be observed in suckers attached to the parent plant. At high PAC concentrations, it is believed that bud formation from proximal axillary meristems occurs continuously in subsequent modules and that this is responsible for the prolific regeneration of shoots not characterised by any distinguishable pattern (Figure 4.3). It is believed that the action of PRO is different to that of PAC. Modules formed in response to PRO also appear to arise from axillary meristems but from those directly adjacent to the apical meristem. This is illustrated in a seedling, 3 months after application of PRO at 7 125 p pm a.i., where axillary meristems have given rise to a new module on either side of the original apical meristem (Figure 4.11). In addition, it appears that following the application of PRO to seedlings, dichotomous branching of the apical meristem may occur (Figure 4.12). The occurrence of both dichotomous and axillary branching in the same individual has been observed in a seedling (Figure 4.13).

In mature plants, axillary branching would explain the formation of the shoots in Figure 4.5. It is thought that dichotomy also occurs in mature plants because leaf pairs, fused along the abaxial surface, were seen emerging from the apical meristem after treatment with PRO. These leaves were followed by the emergence of two new modules of similar size; one next to each adaxial surface of the fused leaf pair. Furthermore, it is proposed that in mature plants, pseudodichotomous branching may be the result of an early switch or reversion of the terminal bud from a reproductive to a vegetative stage. (In an untreated plant the reproductive bud would have given rise to the inflorescence.) Following reversion, the new vegetative bud and the axillary bud which was to form the new module after flowering, may then develop further, in the form of two vegetative buds of more or less equal size.

C. *miniata* var. *citrina* "Sarie 50'. Cape Clivia Club Best on Show 2000. Gert Wiese

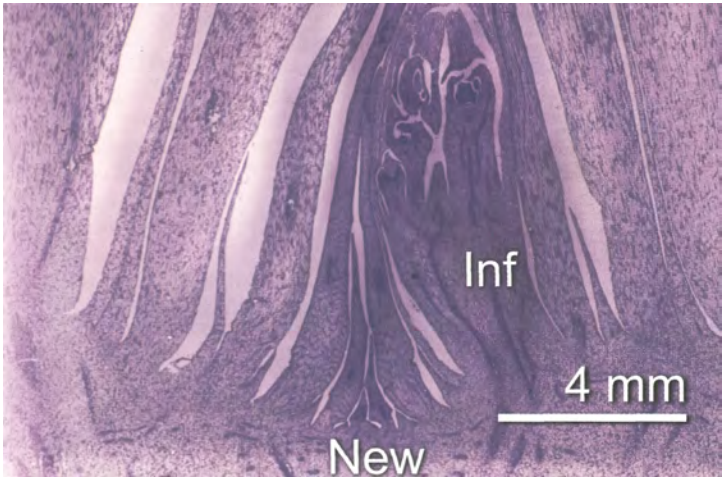
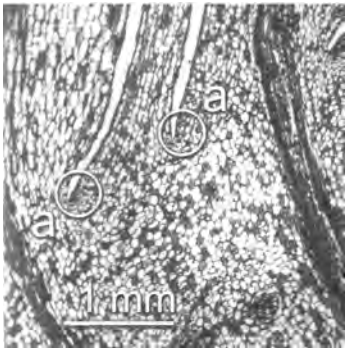


Figure 4.7 Longitudinal section of an untreated mature shoot showing termination of the old module in an infloresence (Inf) and formation of the new module (New).



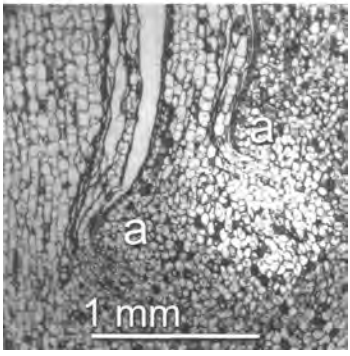


Figure 4.8 (Left) Longitudinal section of an untreated seedling at the 6 leaf stage, showing potentially meristematic zones (a) located on the abaxial side of leaf bases.

Figure 4.9 Longitudinal section of a seedling, 5 months after treatment at the 6 leaf stage, with 5 000 ppm paclobutrazol, indicating accentuated meristematic zones (a).

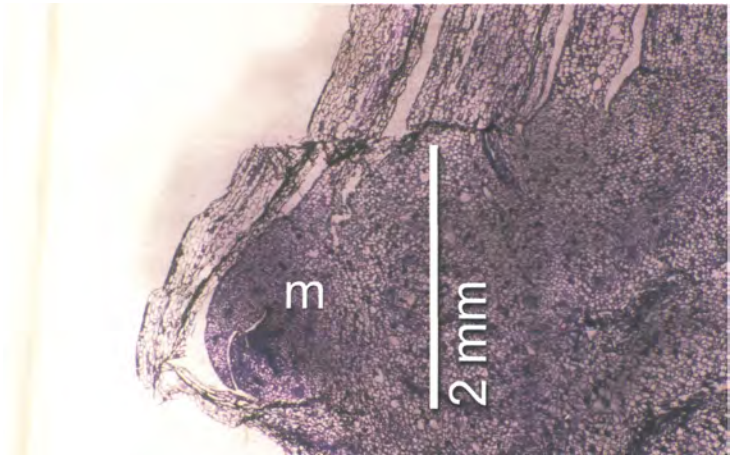


Figure 4.10 Longitudinal section of the most proximal axil of a seedling, 5 months after treatment at the six leaf stage, with 5 000 ppm paclobutrazol, indicating bud formation (m).

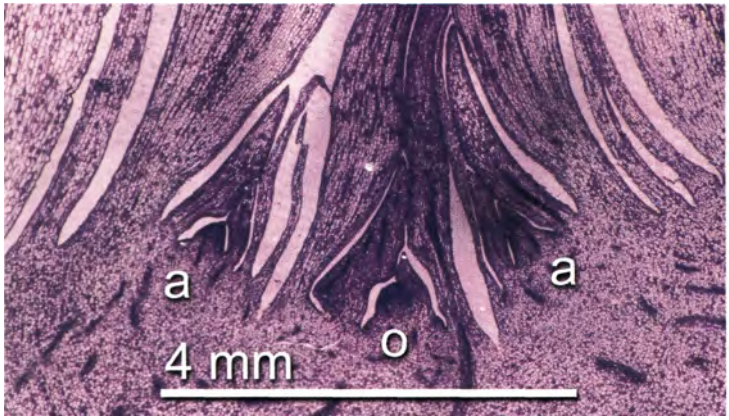


Figure 4.11 Longitudinal section of the apical meristem of a seedling, 3 months after treatment at the six leaf stage, with 7 125 ppm a.i. Promalin™, indicating new modules (a) adjacent to the original apical meristem (o). Note adnation of the buds (a) to the abaxial, basal part of the leaves.

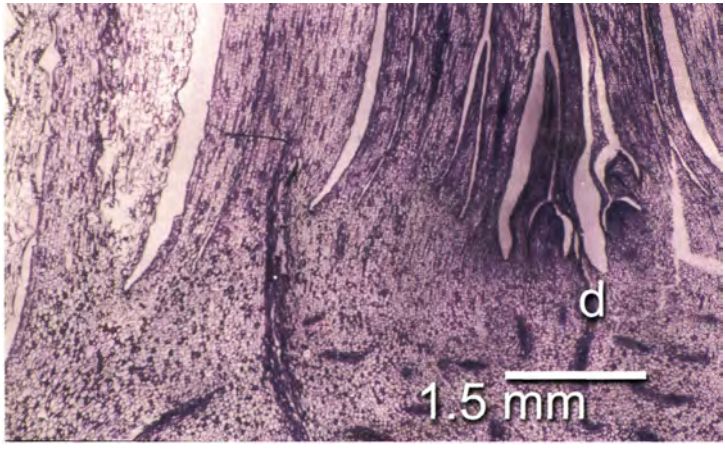


Figure 4.12 Longitudinal section of the apical meristem of a seedling, 2 months after treatment at the six leaf stage, with the first 3 fortnightly applications of 7 125 ppm a.i. Promalin™. Dichotomous branching (d) of an apical meristem is shown.

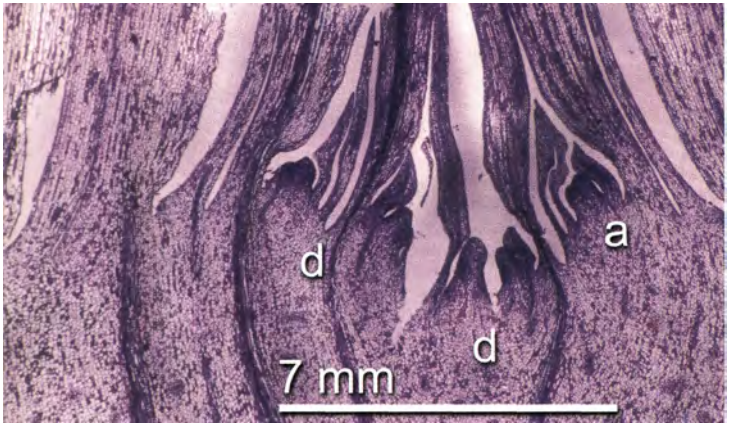


Figure 4.13 Longitudinal section of the apical meristem of a seedling, 3 months after treatment at the six leaf stage, with 7 125 ppm a.i. Promalin™, indicating dichotomous (d) and axillary (a) branching.

Costs of paclobutrazol and Promalin™ treatments

An estimate of the cost of treatment with PAC is based on a price of R480.00/1 for Cultar™. Assume that 10ml of the product is made up to 1 litre with water (2500 ppm a.i.) and that a volume of 10 - 20ml of this solution is applied per plant as a foliar spray. The cost per application, per plant is therefore R0.05 - R0.10. A price of Rl 018.00/l for Promalin™ is assumed. Assume that 375 ml of the product is made up to 1 litre with water (7125 ppm a.i.) and that a volume of 5 -10ml of this solution is applied per plant with a paint brush. The cost per plant, per application is therefore R2.03 - R4.05.

Conclusions and recommendations

From this investigation it is concluded that PRO and PAC can be used to increase shoot production in *Clivia* when applied to foliage but the action of the two agents seemed to differ. PAC stimulated formation of buds in the axils of older, proximal leaf bases while PRO stimulated dichotomous branching of the apical meristem or formation of buds in the axils of younger, distal leaf bases. The negative effect of PAC on flowering was attributable to disintegration of existing inflorescences and death of the apical meristem. In PRO, the negative effect on flowering was attributable to deformation of existing flowers and possible interference with progression of the apical meristem, in mature plants, from the vegetative to the reproductive phase. In addition, vegetative growth inhibition caused by PAC was unacceptable at and above concentrations of 5 000 ppm. PRO had no such effect at all concentrations which were applied to foliage. Further work should be carried out to optimise the use of these substances both in terms of yield and cost. A comparison should be made between the use of a large number of PRO applications at low concentration (approximately 500- 1 000 ppm a.i.) and a small number of applications at high concentration (approximately 5 000 - 7 000 ppm a.i.). It should furthermore be determined at which intervals PRO can be re-applied in order to stimulate successive cycles of branching. The possibility of combining the two agents, for example in a low dose of PAC followed some months later by a high dose of PRO, should be investigated. Other substances such as the imidazole fungicides, which promote shoot formation in the presence of BA could also be tested.

THE USE OF PACLO-BUTRAZOL TO STIMULATE MULTIPLE SHOOT FORMATION IN *CLIVIA MINIATA* REGEL *IN VITRO*

Summary

Clivia has been propagated *in vitro* with varying degrees of success using embryos and fruit wall material as explants but the methods are relatively slow. However, commercial protocols for propagation exist, but have not been published. After observing the stimulatory effect which paclobutrazol (PAC) had on shoot formation *in vivo,* the same technique was attempted *in vitro.* Seeds were germinated on a MS medium supplemented with 20g/l sucrose, 3g/l agar, 0.6g/l Gelrite™, 19/1 myo inositol, 1.4mg/l 2,4-D, 2mg/l benzyl adenine and 3mg/l kinetin. After seven months, the seedlings were dipped in paclobutrazol (PAC) at concentrations of 125 -1 000 ppm before being placed on fresh medium. Five months following application of PAC, there was no evidence of multiple shoot formation and mortality was approximately 70%.

Introduction

Moderate success has been achieved with the *in vitro* propagation of *Clivia.* Zygotic embryos from seeds could be used as the explant material for C. *miniata* (Wang, Li & Yang, 1995, Wang, 1998) and for C. *nobilis* (Min & Jmsheng, 1984). For purposes of propagating a mature plant, fruit wall material could be used (Finnie, 1998). However, seasonal availability of fruit walls at the right developmental stage together with slow plantlet regeneration hampered the development of a commercial protocol. The same conclusion was reached in another study (Chapman, 1999). Nevertheless, it appears that *Clivia* is successfully propagated *in vitro* on a commercial scale in Japan (Smithers, 2000) but the protocols used have not been published. The aim of this study was to examine whether paclobutrazol (PAC) could be used for generation of multiple shoots *in vitro.*

Materials and methods

Seeds were used as the explant material and were germinated *in vitro* following surface sterilisation. Disinfestation occurred in a 2.5% NaOCl solution (JIK™) for 10 minutes followed by rinsing 3 times in sterile distilled water. A Murashige & Skoog (MS) medium supplemented with 20g/l sucrose, 3g/l agar, 0.6g/l Gelrite™, 19/1 myoinositol, 1.4mg/l 2,4-D, 2mg/l benzyl adenine and 3mg/l kinetin, adjusted to pH 5.6, was used. The higher relative cytokinin concentration was chosen in order to promote development of shoots and to suppress root growth. After seven months, plants were dipped in autoclaved PAC solutions and placed on fresh medium. PAC concentrations of 0,125, 250,500 and 1000 ppm were used with 20 replicates of each treatment.

Results and discussion

After 5 months of culture there were no significant signs of new growth or any indication of formation of multiple shoots. Approximately 70 % of explants exhibited necrosis of the shoot in all treatments, including the control. The cause of the low survival rate was probably related to the medium composition, since much better growth was achieved when explants from the same batch were grown under the same conditions but with a different medium (Swanevelder, 2000). Furthermore, the formulation of PAC (Cultar™, 250g/l active ingredient) could not be filter sterilised and therefore necessitated autoclaving. The effect which this may have had on its efficacy is not known.

ILLUSTRATION OF THE NATURAL AND MANIPULATED PLANT ARCHITECTURE OF *CLIVIA MINIATA* REGEL.

Summary

Schematic representations of the natural and manipulated plant architecture of *Clivia* can be used to better understand its phenology and propagation. It is proposed that *Clivia* has a modular growth form in which inflorescences are borne terminally. Under natural conditions, sympodial branching occurs after flower initiation in a module. The number of inflorescences which are produced per season depends on the number of modules produced and this can be manipulated by modifying cultural conditions. The effect of paclobutrazol on architecture could be seen in highly repetitive, basitonic axillary branching while the effect of PRO was to stimulate less repetitive, acrotonic axillary branching and/or dichtomous division of the apical meristem.

Introduction

The juvenile period in *Clivia,* during which no inflorescences are initiated, ends after the production of 12 -13 leaves and may be as short as 12 months depending on growing

conditions and genotype. In general, initiated inflorescences develop up to a certain stage and then enter a dormant period before exposure to a low temperature causes their emergence. Emergence of the inflorescence follows about one year after initiation. Following initiation of the first inflorescence, further inflorescences are produced, on average, after every set of 4-5 leaves. (De Smedt, Van Huylenbroeck & Debergh, 1996). However, no mention is made of modules in the former work and this chapter describes the growth of *Clivia* in terms thereof.

Materials and methods

A thorough morphological study of *Clivia* is not discussed in this dissertation and results obtained in previous chapters were interpreted in terms of existing terminology (Halle, Oldeman & Tomlinson, 1978, Bell & Bryan, 1991).

Results and discussion

Natural architecture

It is proposed that *Clivia* has a modular growth form and that it exhibits sympodial branching under natural conditions. After the juvenile phase, a module consists of about four leaves and a terminal inflorescence. Following initiation of the inflorescence, growth of the flowering module ceases and a new module arises in the axil of a leaf base, adjacent to the inflorescence (Figure 6.1., corresponding to Figure 4.7). When the juvenile stage is ended at the 12-13 leaf stage (De Smedt *et al.*, 1996), it is not known whether the 12-13 leaves present are the product of 3 successive modules with aborted terminal buds or of a single module.

No axillary buds could be seen in *Clivia* and it is interesting to note that instead, meristematic zones which give rise to new buds and modules are situated on the abaxial surface of leaf bases (Figure 4.8 & 4.9). The position of the bud can be described as being displaced in an acropetal direction and adnation to the abaxial surface of the above leaf base occurs (Bell & Bryan, 1991).

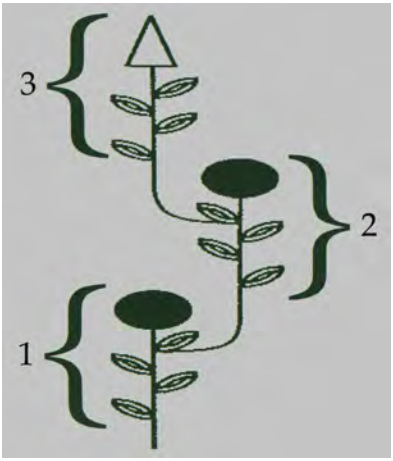


Figure 6.1 Schematic representation of sympodial branching of Clivia under natural conditions indicating a plant with 3 modules (1-3).

More than one module can be produced per year if cultural conditions are favourable, with the result tha.t there may be up to three inflorescences within a plant at a given moment. Two of these may be sufficiently developed to emerge together, or within close succession of each other, once exposed to either a natural or an artificial cold stimulus. Such plants have been referred to as 'twins'. However, if cultural conditions are not favourable, the production of leaves and therefore inflorescences may be slow and plants may not flower every year. Damage by pests or diseases may result in death of the inflorescence at an early stage with the result that not every inflorescence which has been initiated will emerge.
A specific temperature regime is important in the initiation of flowers in a wide range of plants and it seems likely that this may also be true for *Clivia.* From the information available, it appears that at a temperature

of 20 °C, both initiation of flowers and the rate of production of leaves is satisfactory (Mori & Sakanishi, 1974, De Smedt *et al*, 1996, De Koster, 1998). However, emergence of quiescent inflorescences relies on exposure to temperatures below 20°C. The effect of higher temperatures on flower initiation, as may occur under outdoor tropical or subtropical climates is not known.

Manipulated architecture

The effect of paclobutrazol could be seen in highly repetitive, basitonix axillary branching from leaf bases in the proximal, older axils. This is illustrated in Figure 6.2 (corresponding to Figures 4.2 & 4.10).

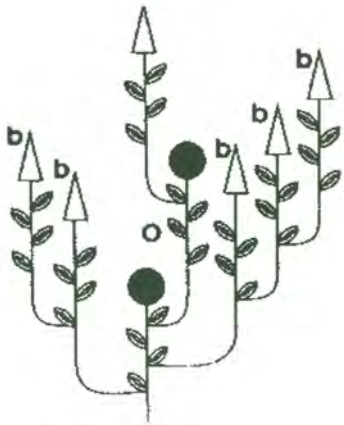


Figure 6.2 Schematic illustration of repetitive basitonic branching in *Clivia* caused by paclobutrazol. The original branch consisting of 3 modules (o) and new branches (b) are indicated.

By contrast, the effectof PRO sprays could be seen in less repetitive, acroronix axillary branching from leaf bases in the younger, distal axils (Figure 6.3A, corresponding to Figures 4.5 & 4.11).
PRO also caused dichotomous branching (a symmetrical split or division) of apical meristems (Figure 6.3B, corresponding to Figure 4.12). The fact that the response to PAC and PRO occurred in the specific regions could probably be explained by the different balance of plant hormones which occurs in the different locations of activity.

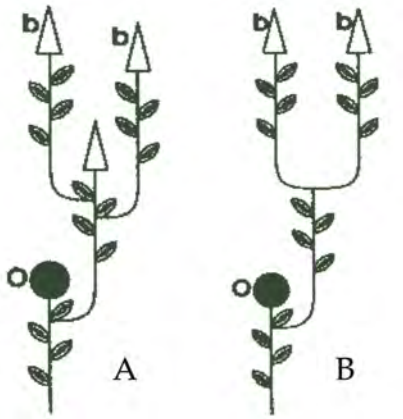


Figure 6.3 Acrotonic (A) and dichotomous (B) branching caused by Promalin™. The original module (o) and new branches (b) are indicated.

It follows from the above discussion that there is an interaction between the physiology, plant morphology and phenology of *Clivia* and that an understanding thereof will influence the success with which these can be manipulated.

'Pixy', an interspecific hybrid bred by Shigetaka Sasaki

General conclusions

From this study it is concluded that rich, diverse and 'underutilised' variation exists in the genus *Clivia.* Methods which will enable more rapid 'clonal' multiplication would enable propagation of plants with desirable characteristics. This would stimulate further research into cultural aspects such as the control of 'phenology ' in commercial production. Once further work has been conducted on the specific cultural requirements of particular clones, their 'commercialisation ' will lead to development of more new cultivars either through conventional breeding or the use of modern biotechnology. In combination, successful control of propagation and 'phenology ' will lead to increased popularity of *Clivia* in a market which constantly demands new and improved products which are attractive to consumers and profitable for producers.

Although the propagation techniques presented in this study may not be adequate for commercial scale propagation, it is felt that they will be useful in allowing wider distribution of desirable genotypes which are in the possession of individual collectors or a small number of growers.

Since significant advances have been made in the cultivation and breeding of *Clivia* in Japan and Europe, a concerted research effort will need to be applied locally in order to gain any competitive advantage. It is hoped that the results of this study will serve to illustrate what may be achieved if further work is conducted in the areas which were examined and where preliminary results were obtained.

APPENDIX

Statistical analyses

Two way table of treatment versus time (page 33)

Frequency	Expected	Cell Chi-Square	Percent	Row Pct	Col Pct
1	1	2	3	4	41
	19	14	4	4	
	9.4253	9.8966	8.0115	13.667	
	9.7625	1.7014	2.0086	6.8374	
	21.84	16.09	4.6	4.6	47.13
	46.34	34.15	9.76	9.76	
	95.00	66.67	23.53	13.79	
2	1	7	13	25	46
	10.575	11.103	8.9885	15.333	
	8.6693	1.5165	1.7903	6.0942	
	1.15	8.05	14.94	28.74	52.87
	2.17	15.22	28.26	54.32	
	5.00	33.33	76.47	86.21	
Total	20	21	17	29	87
	22.99	24.14	19.54	33.33	100.00

Statistic	DF	VALUE	PROB
Chi-square	3	38.3442	<.0001
Likelihood Ratio Chi-Square	3	43-8267	<0001
Mantel-Haenszel Chi-Square	I	36.3627	<.0001
Phi Coefficient		0.6639	
Contingency Coefficient		0.5531	
Cramer's V		0.6639	

Effective Sample size = 87
Frequency missing = 8

Regression analysis of number of shoots as a function of concentration paclobutrazol (page 39)

Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	2	191.24356	95.62178	8.37	0.0006
Error	61	696.50644	11.41814		
Corrected Total	63	887.75000			

Root MSE	3.37907	R-Square	0.2154
Dependant Mean	4.56250	Adj R-Sq	0.1897
CoeffVar	74.06189		

Parameter Estimates

Variable	Label	DF	Parameter Estimate	Standard error	t Value	Pr>/(t)
Intercept	Intercept	1	2.79884	0.60343	4.64	<.0001
V4	Conc	1	0.17897	0.04993	3.58	0.0007
SQV4	Hormone	1	-0.00149	0.00050303	-2.96	0.0044

Analysis of variance (page 39)

The ANOVA Procedure	Tukey's Studentised Range (HSD)
Alpha	0.05
Error DF	56
Error Mean Square	0.066855
Critical Value of StudentisedRange	4.4523
Minimum Significant Difference	0.407

Means with the same letter are not significantly different

Tukey Grouping			Mean	N	V4
	A		0.8521	8	10
B	A		0.8200	8	20
B	A		0.8153	8	100
B	A		0.7974	8	50
B	A	C	0.6076	8	4
B	A	C	0.5935	8	2
B		C	0.4188	8	1
		C	0.2124	8	0

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Clivia miniata 'Imperial' - John Winter

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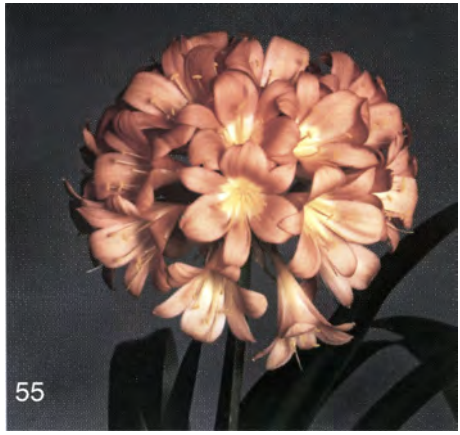
A DIFFERENT PERSPECTIVE ON CLIVIA

Elizabeth Andersson

Spring was always a beautiful season, mainly because of the splashes of orange under a large oak tree, viewed clearly from our bedroom window. The first *Clivia* to bloom each year made a clear announcement. It was always exciting waiting for the flowers to open for slowly hundreds joined in the declaration of spring and Des' *Clivia* were magnificent.He had started collecting them from the age of 15 years. We had moved from a rented property to our own newly built house in December, in the pouring rain, which seemed never to let up. There was no laid out garden, but a large 100 year old tree, which offered shelter to the dozens of *Clivia* which were part of the move. They were literally dumped on the ground. By the time their turn came for special attention,they had got on with establishing themselves. They grew and thrived and were enjoyed. For 20 years those *Clivia* lived where they had been put, increasing to hundreds. Occasionally one heard of yellow *Clivia*, but they were still scarce and had not taken on such a monetary flavour!

In the late 80's it was time to scale down and move to a town house. Again the new house had no garden and this time it was postage stamp size! As luck would have it, a huge avocado pear tree was there for the *Clivia* and they (the specially selected ones) were put under the tree. This time however, the moles moved in, and there was an urgency to pot the plants. This saved a lot of bad language usually reserved for the amaryllis worm.

The advent of the Clivia Club brought great changes to our lives. A variety of new names appeared and became part of the vocabulary. The plants were tagged, the dates noted and which type had been pollinated with which type. Playing the part of Mr Bee never changed over the years and it was perfected to a fine art! Lids, saucers, plates, cups are found all over the house with bits of paper identifying the seeds, while they await planting or distribution. The postage stamp garden now has six rather smart shade frames which protect the plants (and on occasion lodgers!). They grow and thrive, and this is purely because they are loved and appreciated, and they know it, I am



C. m*iniata* Teach' 1st in Class. Northern Club Show 2000. Koos Geldenhuys

I have grown used to all sorts of *Clivia* enthusiasts visiting our little garden and phone calls late at night *{Clivia* enthusiasts tend to forget the time and frequently phone at 10 o'clock at night!) There are a few draw-backs with this *Clivia* growing hobby, and one of them is the danger of small nieces, nephews and grandchildren.They have an absolute fascination with the lovely red berries, and before you know it, will present

you with a pot or tin full of berries, "look how busy I have been and helped you pick all the berries! " After a loving smile and a look of consternation its back to square one, for all the careful tabulating and noting is lost in a trice! We do tend to monitor small children in the garden but still have the occasional slip up. Rebekah, out from England, was the last berry gatherer. The dogs, by-and-large, cause no hassles. We do have one, a scotty who buries her bones in seedling trays if they are inadvertently left on the ground. This has now resulted in the trays being kept out of range, sometimes on the outside garden table if space is short, resulting in the grower's satisfaction, but not the grower's wife or scotty's acceptance. In the meantime I have become what I consider to be the best *Clivia* berry cleaner in the world! How lucky we are to be part of the *Clivia* enthusiasts club, for every spring brings a profusion of flowers in oranges, yellows and peach, all glorious and to be enjoyed, but never picked!

C. miniata 'Bertie's Bronze'. Bertie Guillaume

C. *miniata* "Bronze Green Girl'. Ian Vermaak

NATAL PEACHES

Terri & Sean Chubb

'GAIL'

Having an interest in *Clivia* is similar tothe expectations of the treasure hunters still seeking the Kruger Millions! We are looking for a pure white. Sean and I were invited to the Howick area to view a *Clivia* that had a different colour to the usual orange. We were in for a real surprise when we saw 'the' flower. The colour was in the range of peach to apricot (Kol skoot! Bulls eye! - something new). The owner Gail, told us she had found one plant on a newly rented property. She subsequently realised it was a *Clivia.* With care and attention, the plant duly flowered, suckered side shoots and self pollinated. In time, the seedlings also flowered true to type. With just one clone on the property, there was only a very remote possibility for colour pollination hybridisation.

Observation: The base of the adult plant is oval, approximately 150 mm on the larger axis. Outer overall height is 650 mm. The leaf tips are much less pointed than either the 'Natal Yellow' or 'Mare's Howick Yellow' with a very slight edge roughness at the end. The *Clivia miniata* 'Gail' was runner up selection on the 1999 Kwa-Zulu Natal Clivia Club show.

'NDWEDWE GAMMA PEACH'

This plant was found in the Ndwedwe area of Kwa-Zulu Natal on 26 September 1996. It was growing near the top of a very steep south facing cliff in the rock-face in very little soil and leaf compost.

It is spidery in appearance. The bloom opens a peach shade, slightly green down the centre initially, losing the green with age, darkening to peach in the centre of the petals, with the edges turning a whitish colour towards the end of the flowering period. There were two plants of similar size each with one bloom. The plant did not set seed the first season. There is plenty of pollen and the breeding parts are of good quality. The leaves are large and the plant is robust in appearance. No suckers have been produced to date.

The breeding performance of this plant is uncertain as so far it has only produced pigmented seedlings. Pollen from 'Chubb Peach', 'Alpha Thurston' and 'Beta Thurston' has been used on it and it was also self pollinated. A good seed crop was set with each crossing. It did not flower in 1999 but it had the usual two blooms in 2000, It has been crossed with pollen from 'Ndigi Pink Champagne' and 'Panache 2000' which are two pastel/pinks from the Ndwedwe area. It is thought to be an Orange showing peachy colourations.

C. *miniata* 'Gail'

C. *miniata* 'Ndwedwe Gamma Peach'

C. miniata 'Alpha Thurston'

'CHUBB PEACH'

The original plant was collected in the Ngwahumbe River Valley, in Eston, Kwa-Zulu Natal. It was found in a small patch of bush on the confluence of one of the tributaries and the Ngwahumbe River. The exact date of collection has not been accurately recorded but it was probably in the 1950's. No other plants of any colour variation have been collected from this area since. The *Clivia* population density in this area has also declined due to collection of plants by traditional healers.

'Chubb Peach' forms a well filled spherical umbel presented well above the foliage. The flowers are a deep peach colour with a distinct fragrance. Petals and tepals have slightly wavy edges and have a slight difference in width. The peach colour seems to intensify as the florets age. On ripening the seed pods turn a rich peach caramel colour. 'Chubb Peach' does produce offsets and mature plants may produce 2 or 3 per annum.

The initial breeding efforts with 'Chubb Peach' were not as successful as hoped. On realising that this plant was peach in colour and not being able to locate plants of a similar colour at the time, 'Chubb Peach' was self pollinated.

On average only 7 seeds were set per umbel flowered. These seed produced 30% peach flowering plants. This % was confusing and did not seem to conform to known genetic heritability patterns. In 1987 when the first peach flowering offspring flowered, this was

C. miniata 'Beta Thurston'

C. miniata 'Chubb Peach' F1

used to cross back onto the original 'Chubb Peach' clone, producing 100% peach offspring. This cross also had a remarkable improvement in seed set, on average 132 seed per umbel from 13 umbels. The orange flowering offspring were kept and crossed back with the original clone producing 50% peach flowering offspring.

These percentages conform to known genetic heritability patterns and it was confirmed that 'Chubb Peach' is in fact a homozygous recessive peach, group 1 peach. The original percentages recovered from self pollinating have been put down to foreign pollen producing the orange flowering plants and the low seed counts to the reluctance of 'Chubb Peach' to self pollinate. 'Chubb Peach' has also been crossed with group 1 or homozygous yellows producing 100% unpigmented seedlings which subsequently flower peach. 'Chubb Peach' is dominant over yellow but recessive to orange and red.

Since the first peach flowering in 1987 only the best of each years seedlings have been retained for breeding purposes. Up until 1999 flowering season only 5 plants have been used as pollen donors. The original selected plants have also been improved on and in 2000 only the very best, i.e. 2 plants, were used as pollen donors on the peach mother plants.

C. miniata 'Chubb Peach' F2

The intensity of peach pigment in the offspring seems to vary and some seedlings flower considerably darker than the original clone. Seedlings carrying green markings in the throat of the flowers seem to be the darkest peach.

A limited number of original clone offsets, flowering seedlings and seed, are made available for sale annually.

'NAUDE PEACH'

This magnificent plant belonging to Olive and Stoffel Naude came to the notice of *Clivia* enthusiasts in 1997 when it was entered in the Kwa-Zulu Natal *Clivia* Show.

Here it won the best 'any other colour' as well as Best on Show. It had at that time two umbels presented well above the foliage. The mature umbel was deep peach while the umbel still in the opening stage was buttercup yellow.

Mrs Olive Naude, on moving to Kloof, was very impressed by the display of both yellow and orange *Clivia miniata* in the neighbour's garden. The neighbour had a large number of yellows flowering in her garden and on her death, a single plant was obtained from the collection. Subsequent renovations to the property denuded the garden of *Clivia.* This single plant was carefully planted in a large concrete pot in about 1977. Here it remained on Mrs Naude's verandah producing two spikes of flowers every year, but never an offset. The plant remained in this pot for approximately 20 years. When repotted into a more practical container, it rotted leaving only 2 offsets.

The genetic make-up of 'Naude Peach' has not been accurately defined. The plant flowers open yellow, mature to peach and then produce red berries when the seeds ripen. Some results that do seem confusing have been obtained using 'Naude Peach':

'Naude Peach' (pod parent) x 'Chubb Peach' and also selfed resulted in only 5 unpigmented seedlings out of about 50 seed.

C. *miniata* Tanache 2000'

This cross was done in 1997. Some flowers had already been pollinated on arrival at the Show.

'Eshowe Yellow' (pod parent) group 1 yellow x 'Naude Peach' resulted in only four unpigmented seedlings out of 17 seed. Possible self pollination by 'Eshowe Yellow'. 'Natal Yellow' (pod parent) group 2 yellow x 'Naude Peach' resulted in 16 unpigmented seedlings out of 58 seed.

'Naude Peach' has not flowered since 1997 and an endeavour to do controlled crosses with it will be made as soon as it does flower.

C. miniata 'Ngidi Pink Champagne'

C. *miniata* 'Naude Peach'

C. *minata* - KwaZulu-Natal Club Best on Show 2000. Chris le Grange

A HYBRIDS STORY

Des Andersson

I have had an interest in *Clivia* from the time I first saw them as a teenager, being sold as wild cut flowers in our suburb by the local African women.

My early collection comprised a range from a light to dark orange collected from" Beauty Bush", a natural bush area below "World's View". Full of enthusiasm I made the acquaintance of Mr. Leighton, curator of the Pietermaritzburg Botanical Society (now Natal N.B.G.). I told him I had heard that there was a rare cream flowered plant, and, as an enthusiastic collector, could he please put me in touch with a grower. He graciously smiled and told me that I was fortunate as he happened to have a young unflowered plant for sale, and that I could purchase it, with the assurance that it would definitely be light yellow. The offer was snapped up in a trice and as a "bonsella" he gave me a young C. *gardenii*, which up to that time I had not even known existed.

The original C. *gardenii* parent

Time passed, and both carefully nurtured plants reached flowering stage together. (The *C. gardenii* was a late season flower, so the *C. miniata* var. *citrina*, was definitely early). The stage was set for Mr. Bee in the form of a small dry paint brush. Eagerly wanting more yellows, the C. *miniata* var. *citrina* was self pollinated. The C. *gardenii* was pollinated with C. *miniata* var. *citrina.*

Thinking back now, I am sure that the C. *miniata* var. *citrina* was a 'Natal Yellow' for it had the green trade mark. The C. *gardenii* was a good shade of red with a prominent green skirt. Only two seeds of the C. *gardenii* x *C. miniata* var. *citrina* reached flowering status, the better one being illustrated in photo 73.

None of the adult *C. miniata* var. *citrina* which were selfed flowered true to type, all shades of orange. This confirmed the advice from so called knowledgeable friends that the only possible route for propagation of a 'Natal Yellow' was an off-shoot plant.

Working totally as an amateur botanist, but a keen plantsman, I now waited for a repeat co-incidental flowering of the *C. miniata* var. *citrina* and my hybrid. About four or five years later my expectations materialized and the hybrid became the new berry bearing plant of a C. *miniata* var. *citrina* x 'C. Garmin'. Yet again, due to a variety of circumstances, only two seeds reached flowering stage.

The first one produced a tubular cream flower edged with a slight green tinge (photo 71).

The following year, to my great delight, the second plant flowered. The result was C. 'Garmin' 'Val' (right).

In the interim, with the input and association with members of the Clivia Club, I have acquired invaluable plant and breeding information such as deep freezing pollen, swapping pollen with other members, acquiring seeds and plants, either directly or indirectly from local or overseas members (Australia, Japan and Belgium for example) or purchasing seeds. I consider I have been able to extend the range of my collection. I still continue to give plants away to people who express an interest in *Clivia.* I am still keen to keep going for the exclusive "humdinger" but regret that I appear to be losing the race with old father time! (The above episode covered a period in excess of thirty years, believe it or not!)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CLIVIA, WHAT IS ALL THE FUSS ABOUT?

Jim Holmes

A great many people in South Africa grew up with *Clivia* in the garden, and few people paid them any mind, they had been there for as long as anyone could remember, the *Clivia* were admired in flower and then forgotten about until the next spring.

The same was probably true for many people living in Australia, New Zealand and parts of the Southern U.S.A. "An old Victorian plant that lost its favour decades ago", suddenly becomes ever so popular.

My first yellow *Clivia* came from a friend in Howick, where I was living at the time. A retired farmer told me that his great grandfather had found it on the farm in the Karkloof area, back in 1907. They very carefully kept it in the family all those years, and he said I was the first person other than the family to be given one and I felt very honoured. When I moved to Cape Town a year later, the plant came with us.

Once a year when the Botanical Society held their spring flower show at Kirstenbosch, this single yellow *Clivia* plant was usually at its best and was displayed at the show, as far back as 1978. It was only then that it dawned on me, from the interest that it generated, that very few people knew that such a thing existed. With this plant being displayed on local flower shows for a number of consecutive years and as there were no plants available to the public for a very long time, at least a decade, this created a considerable demand and mystique of the rare and elusive plant. Though the National Botanical Institute at Kirstenbosch had a few yellow *Clivia* tucked away in the nursery area, they were never displayed to the public in those days.

Back about 1977 we had a visit from Dr. Hirao, a well known plant breeder from Japan. I met him when he visited Stellenbosch, and we spoke about his breeding of the *Iris kaempferi,* that he was doing, but I did not know at the time that he was a *Clivia* enthusiast. After his death a few years later, others took over his different breeding lines and his collection of *Clivia* was taken over by Yoshikazu Nakamura.

C. miniata var *citrina* - Second Prize. Cape Club Show 2000. Jim Holmes

Since then Mr Nakamura has been largely responsible (through his generosity) for making the *Clivia* so popular world wide, by distributing seeds of many of the selected forms in his collection, to people who took the time to write to him. It appears that he was eventually overwhelmed with requests and does not do this anymore.

During 1990 Nick Primich visited me several times to discuss his idea of starting the Clivia Club. He saw the passion with which many people were embracing the *Clivia.* Riding the crest of the wave was the rare yellow *Clivia.* At the time only a small handful of people were in posession of one of these plants. The Clivia Club was started by Nick in 1992.

One of the first people that I met who grew the yellow *Clivia,* was Cynthia Giddy, back in 1978. Although she grew a number of plants, she only propagated them by division.

C. *nobilis* - First Prize. Cape Club Show 2000. Ian Brown

I asked her at the time, why she did not go the seed route, as I was trying to do, and she explained that she had tried that and though she has flowered some 500 seedlings from her yellow stock, not one seedling had turned out to be yellow! She expressed the opinion that it was either not possible or practical and that seemed to be the general viewpoint at that time. The few propagations that Cynthia made during the 1970s and 1980s, went to a customer in Japan.

In line breeding

As no other material was available to me at the time, I started to inbreed with the plants I had. Using only the best forms, this resulted in a stable breeding population. The plants kept their vigor and characteristic of producing two flower stems at a time on each growth and carried a delicate vanilla fragrance on full flower heads. Others who have been out-breeding have encountered problems. One of these is a large percentage of throwbacks to orange.. The inbreeding quickly eliminates any recessive genes. Each season sees new and interesting selections emerging, from near whites to dark yellows, soft pastels in salmon and apricot, some with interesting variegations on the leaves and most of these have been bred from the original plants and have shown great variation in form.

Over the years, other *Clivia* forms and selections have come in from Europe and Japan. They have been bred in other directions with large orange and red flowers, tending towards the miniature and broad leaf types. Some truly beautiful hybrids have been developed at Cape Seed and Bulb, using C. *nobilis, C. caulescens* and C. *gardenii* crossed onto select forms of C. m*iniata.*

As we flower our new crosses and see the amazing variety of new forms and colours that are being produced by so many enthusiastic growers world wide, one begins to understand what the fuss is about!

SWAMP CL1VIA

Dr. Keith Hammett, Auckland, New Zealand

Dr Keith Hammett trained in botany and plant pathology and went to New Zealand 33 years ago. Gradually he changed his career and became a breeder. Today he is a private breeder but he retains his scientific link with a series of MSc and PhD students at Auckland and Massey Universities.

We live in a complex world and as we learn more about it the amount of information can become overwhelming. One way to cope is to break the information into smaller units and to establish a classification or indexing system.

We are so familiar with some classification systems that we do not really notice. When we go into a library we are conscious that a classification system operates which enables us to find books on specific topics. However when we go into a supermarket we are probably less aware that a comparable system is operating to enable us to find the items we require. In fact it is only when management decides to change where things are located that we really notice.

In general classification systems are arbitrary and only work by common consent. While we classify books most commonly on the basis of their content, we could equally well classify them on the basis of the colour of their covers, author name or even their size. Indeed most libraries have an oversize shelf for those books which will not fit the standard sized shelves.

So it is with plants. Classification systems have been developed so that we can more easily digest an often bewildering array of variation. Unlike man-made objects nature has created a continuum of variation and it is man who attempts to assign individual plants into the categories we have designated as genera, species and varieties.

As we learn more our paradigms change. With botanical classification ideas of what delimits a species depends on the opinions of individual botanists and these opinions reflect where they were trained and the plants with which they work. Over time botanical classification has attempted to reflect evolutionary relationships between species existing today. This is one of the reasons why botanists rearrange species and change names in an attempt to better reflect these relationships. However, at the end of the day, the measure of any classification system is whether it is useful or not.

The genus *Clivia* is a relatively small genus found only in Southern Africa.

The first species to be described was C. *nobilis* in 1828. This was followed in 1854 by C. *miniata* originally named Imantophyllum miniatum, but changed 10 years later. *Clivia gardenii* followed in 1856 while C. caulescens was named as recently as 1943. With the exception of C. *miniata* which has upright flowers, the other three species have pendulous flowers and have often been confused in cultivation.

Today wild populations of species occur in relatively small pockets often widely separated from each other and in reality the genus appears to be in retreat. As the plant is unable to tolerate full sunlight its current distribution reflects the progressive destruction of forest vegetation which was formerly much more extensive than it is today.

Traditionally botanical classification has been based on the morphology or shape of plants with particular emphasis on the flowers. It is also important to remember that a great deal of taxonomic work (classifying) has

been carried out on dried specimens mounted on sheets of paper (herbarium specimens) and that for many species the botanist will not have had the opportunity to see living plants. This came about because our ideas on botanical classification are European or Western in origin and much of the work was carried out at one or other of the great botanical institutes in Europe after specimens had been collected from around the world. For *Clivia* only *C. caulescens* was named in its country of origin.

Over time different pieces of information in addition to plant shape have been taken into consideration when delineating a species. For instance chromosome numbers and biochemical data have been used for various genera. Increasingly DNA data are being used.

Recently Dr Yidong Ran completed a cytogenetic analysis of the genus *Clivia* as a PhD. study here in Auckland jointly supervised by Professor Brian Murray and myself. This was made possible as I had brought together an extensive collection of both *Clivia* species and hybrids from around the world.

In this collection were some plants originally given to me as seed by Graham Duncan at Kirstenbosch following the inaugural Clivia Conference held in 1994. These plants were referred to as a robust form of C. *gardenii.*

Initially the seedlings looked pretty much like those of any other *Clivia* except C. *nobilis,* but as they became older the plants stood out from anything else.

They were very vigorous and with a tall stiff habit and rounded leaf tips quite distinct from the very pointed lax leaves of C. *gardenii,* although they did have the pale green almost white lower leaf surface that one associates with C. *gardenii.*

As shown in our scientific paper which was reprinted in the Clivia Yearbook 2, it is possible to identify the different named species of *Clivia* on the basis of banding patterns that develop when the chromosomes are stained in various ways.

When Yidong looked at the chromosomes of the 'Robust gardenii' he found that while the banding pattern was closer to C. *miniata* and C. *gardenii* than to C. *nobilis* or C. *caulescens,* it was distinguishable from either.

We hear much about DNA analyses and fingerprinting in connection with forensic work and criminal trials. Similar techniques are available to plant scientists and Yidong used two distinct methods, random amplified polymorphic DNA analysis (RAPD) and DNA sequencing. Two regions were sequenced, the internal transcribed spacers (ITS1 & ITS2) of nuclear ribosomal 45S DNA and the non transcribed spacers between the 5S RNA genes.

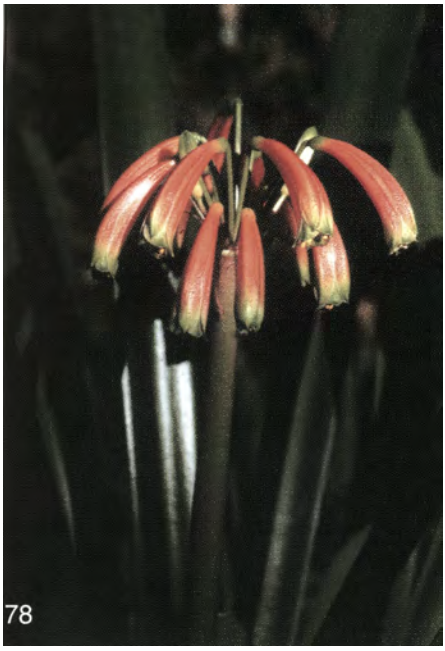
When these methods are combined with appropriate statistical models it is possible to estimate how closely related different species and varieties may be. Our DNA analyses showed that 'Robust gardenii' was distinct from the four species already named but most closely related to C. *gardenii* and C. *miniata.*

Correspondence with John Winter at Kirstenbosch established that the original accession of 'Robust gardenii' had been collected by Kobus Eloff from the Wild Coast. Dr John Rourke of the Compton Herbarium at Kirstenbosch in a letter dated 13 March 2000 indicated that he had recognised it as a distinct entity based both on its morphology and habitat and referred to it as the Swamp Forest *Clivia.*

John provided details of herbarium specimens held at the National Herbarium in Pretoria and at Kirstenbosch. He indicated that geographically its distribution fitted in between C. *nobilis* from the southern Transkei and Eastern Cape and C. *gardenii* in Natal.

He went on to say: "Most of the populations I am aware of are situated between Port St Johns and Umtamvuna at Port Edward. Ecologically it is very distinct and is mainly

found in swamp forest - those patches of *Syzigium* forest, like islands in the grassland which are situated in depressions and fill with water during summer. Thus the Swamp Forest *Clivia* is semi-aquatic standing in 15 - 22cm of water for several months. It also occurs along river banks in the area. Flowering takes place in June and July. This is the same species we collected at Mkambati in a swamp forest west of the Mtentu River (my no. 2145).



One of the swamp *Clivia gardenii*

The leaves tend to be pale green, rather fleshy and flaccid and the flowers tubular orange-red.

There are notes on the National Herbarium specimens written by Prof. Olive Hilliard indicating that it does not fit the C. *nobilis* or C. *gardenii* concepts, but she abandoned the problem at that point. Unfortunately, it was illustrated in colour in Flowering Plants of Africa plate 2094 in 1994 under the incorrect name *Clivia nobilis.* The plate is a very poor one confusing the matter even more".

This communication from John Rourke was especially valuable as it confirmed that a plant that Yidong had been able to identify at the genomic level had been recognised as being distinct in the field. It also explained why the description of *C. nobilis* published in 1994 differed so markedly from what most of us in the Clivia Club understand to be C. *nobilis.*

A coincidence with regard to the receipt of John's letter was that one of the herbarium specimens of the Swamp *Clivia* to which John referred was collected by Fanie Venter in 1976. Fanie now lives in New Zealand and happened to visit me on the very day that I received distinct material of a caulescent form of C. *gardenii* from South Africa and Fanie was able to examine it and discuss his knowledge of the Swamp *Clivia.*

John Rourke very wisely pointed out that while he felt sure the plant was a distinct taxon, before formally naming it more needed to be known about its distribution and ecology. I was very fortunate in June 2000 to be able to travel with John Rourke, John Winter and Brian Tarr to look at the Swamp *Clivia* in habitat and to collect seed from separate populations in the Transkei and KwaZulu-Natal.

Since returning to New Zealand I have been able to raise seedling populations of these collections and Yidong has been able to confirm that three of them have the same chromosome staining pattern as the original Eloff 'Robust gardenii'.

An important point to realise is that different populations of a species growing in the wild will vary from each other. The longer populations are separated from each other the greater the differences; eventually the

differences may be so great that they are considered to be different species.

All too often plants in cultivation have all been derived from a single collection or accession. That is why it is so important that the Clivia Society is based in South Africa and has access to a wide range of genetic material of each species.

Although I have not yet had time to grow the different accessions of Swamp *Clivia* to maturity and compare them side by side, it seems clear that there is appreciable variation between the various isolated populations.

Possibly the first record of the plant was that made by W.L. Chiazzari in 1943 who made notes on a plant which could not be fitted into one of the named species of *Clivia.* His story is recorded in the Clivia Club Newsletter Vol.4, No 2, April 1995 page 4 and was reprinted in Vol.9, No 2, Winter 2000 page 10. A good photograph of the plant appears on the front cover of this later edition.

More recently, 23 May 2001, James and Connie Abel reported in the email Clivia Group that Fred van Niekerk had known a similar plant since his childhood in the 1930s. Fred grew up in the Transkei and took a special interest in a vigorous form of *Clivia* which grew in his mother's garden.

"Later on he and his friends found them growing in the wild on the banks of the Umtentu River in the uMkambati Reserve, about 4 km from the sea and 25 km SW of the KwaZulu-Natal border. The umbel with over 40 flowers is indicative of a C. *nobilis* relationship, although the leaves are closer to those of C. *gardenii".*

James and Connie showed pictures taken by Fred Niekerk when he lived in the Cape of plants in cultivation. These have inflorescences more spectacular than any I have seen to date on Swamp *Clivia.*

Research is never fully complete and there is always more to learn.

However, here in Auckland we feel that on the basis of its distinct robust habit (up to 180cm), its ability to grow in running water, its distinct chromosome banding pattern and DNA fingerprint, that the Swamp *Clivia* can be clearly recognised as a fifth species.

Comment by Dr J.P. Rourke

Clivia gardenii *is a highly variable species with numerous local forms. One of these, the Swamp Forest* Clivia *is discussed in Keith Hammet's interesting article. There are other horticulturally desirable forms currently placed under* C. gardenii *such as the very robust pale lemon yellow form from Ngome forest, Zululand (Clivia Yearbook no.2 page 37), where orange and apricot colour variants also occur. Dwarf forms from around Eshowe with short scapes and rich orange perianths as well as numerous other variants crop up in different parts of KwaZulu-Natal. Thus as presently understood,* C. gardenii *is a mosaic of local races all grading into each other.*

One of the first steps to be faced in making some sort of taxonomic sense out of all this variation is determining which of these many forms Sir William Hooker used when he described C. gardenii *in 1856. The information given in the original description is singularly vague. "*C. gardenii *was discovered in the Natal Colony by our excellent friend Major Garden and by him introduced to the Royal Garden of Kew." Some historical research will be required to determine where Major Garden travelled in Natal, in order to narrow the field.*

It will be important to establish the type concept of the name, in other words, which of these many forms did Garden give to Hooker when the latter described the species. Careful examination of the type specimen at Kew will thus be essential. Natural variation in the C. gardenii *complex will hopefully form the subject of an article in a later edition of the yearbook.*

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