CLIVIA

7


Photo: Helen Marriott

Winner of the Interspecific Section Photo Competition. C. *miniata* x C. *caulescens*, Owner: Laurens Rijke.

Front cover: C. *miniata* var. *citrina*. Overall and Single Flower Section Winner, Photo Competition.
Photographer: Gordon Fraser.

Back Cover: C. *miniata* 'Hirao'. Bred by Toshio Koike. Photographer: Shigetaka Sasaki.

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CLIVIA

7

Photo: Tony Barnes

Clivia nobilis — Winner *nobilis* Section of the Photographic Competition

Editors

Roger Dixon
Claude Felbert
John van der Linde

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Editorial

This Yearbook is mainly about the various *Clivia* species as they are found in the wild. The reason for this will become apparent to you as you read this Editorial.

A wide range of topics is covered. For the first time we have some clarity on the nature of the pollinators of the various species and on how the plants so artfully attract them to visit their flowers. Articles about *Clivia* breeding, the main interest of many of us, feature again, though less prominently than last year. There are also photographs of Show winners, and the best of the entries in the Clivia Society Photographic competition.

Speaking of photographs, we are delighted to be able to provide a forum for the publication of pictures, not only of plants in the wild, but also of some of the wonderful plants that are increasingly being bred by enthusiasts around the world. Please continue to share them with us. The old saying that a picture is worth a thousand words has much validity for many of our readers, especially where photos provide them a neat balance to the more scientific or technical articles that are meat and drink to others.

Several articles, and the photographs which illustrate them, highlight the diversity of the gene pools in the wild, diversity that is increasingly under threat. Indeed, habitat destruction and the relentlessly growing demand for *Clivia* for traditional medicine ('muti') purposes may lead to some local populations becoming highly endangered or even extinct, as Vivienne Williams warns in her article, "*Clivia* Under Threat".

Even where cultivated plants have been made available to traditional medicine practitioners, their wild cousins are regarded as more potent in medicinal and magic properties, the slow-growing *C. nobilis* being highly sought-after. The problem with this indiscriminate harvesting of *Clivia* – the whole plant is pulled out by the roots, which are usually chopped off for easier transportation of the parts – is its total and utter unsustainability. Possibly as many as 30 000 to 40 000 plants a year of all the species, except *C. mirabilis*, are being taken from their natural habitats in the Eastern Province, KwaZulu-Natal, Mpumalanga, and even the neighbouring country of Swaziland, for sale in traditional medicine markets throughout South Africa. *Clivia* grow in isolated stands, and whole populations, with bewildering genetic diversity that has arisen over thousands or even millions of years, can be wiped out quite easily. A rare population of naturally occurring hybrids is a case in point, as described for us by Allan Tait in his article, "The *Clivia* at Mbashe". Indeed, many populations of *Clivia* in many parts of the country have long since disappeared.

The largest known population of yellow-flowering *C. gardenii* is in the news. The plants grow in the protected Ngome Forest in northern KwaZulu-Natal, some 120 km north of where the first yellow-flowering *C. miniata* was found. This variety has recently been described and named *C. gardenii* var. *citrina*. The article "*Clivia gardenii* – Autumn's Delight" by Brian Tarr places this variety in the context of the entire *C. gardenii* complex. Their relative inaccessibility should have provided them with some protection against illegal plant collecting, but unfortunately even they are not safe – some of the best populations have already been removed.

South Africa has laws to protect the most endangered species within its borders. Penalties for violating these laws include heavy fines and imprisonment. But, as so often happens, there is a discrepancy between law and practice, and *Clivia* parts are freely transported from where they are collected to where they are displayed and sold. It would appear that the reason the authorities are not prepared to enforce the laws to protect *Clivia* is because of their importance as powerful 'muti' and because the 'industry' provides at least some employment for thousands of otherwise poverty-stricken people.

Also, as John Winter said in his paper "Collecting *Clivia* in their natural habitat", delivered in 2002 at the Third International Clivia Conference, "....many *Clivia* populations have been destroyed through the harvesting of timber for building, firewood, and to establish arable land. This destroys the shade canopy and ultimately results in the death of the *Clivia* population which grew in the shade of these trees". In addition, some members of the horticultural trade and some *Clivia* enthusiasts have collected selected forms from the wild.

The world-renowned Pondoland centre of plant endemism, the habitat of the recently named *C. robusta*, which is described for us in an article by Keith Hammett, is also at risk, but for another reason. There is a proposal for a major new toll-road to be built through the area.

So, dear readers, we trust that you will enjoy reading about *Clivia* in the wild. May these articles and the accompanying pictures inspire you to join the tours to *Clivia* habitats that are being arranged as part of the 2006 International Clivia Conference. This occasion may well provide one of the last opportunities to see *Clivia* in their habitat, other than on privately-owned land.

There is of course an intimate relationship between naturally occurring diversity and *Clivia* breeding. Plant breeding has often been described as 'the management of evolution', with selection by man replacing natural selection. As we raise more highly-bred 'domesticated' plants it becomes all the more important that a wide pool of genetic diversity is preserved in nature, in national botanical gardens and in the collections of private individuals – let 'Conservation by propagation' be our motto. Unless this is done, we the current generation of *Clivia* breeders, with our ever-increasing emphasis on the creation of highly-specialized plants with a narrow genetic base are, in effect, working against the interests of future generations of breeders.

There has been much comment and also heated exchanges in the *Clivia* world for many years now, mainly about a taxon which had not been clearly and categorically placed, due to its somewhat variable nature and appearance. We are referring to the saga of the 'Swamp *Clivia*', now formally described as *C. robusta*. This taxon has been variously identified and misidentified on the basis of its size, its leaf shape, its habit and its habitat. A number of papers in this Yearbook pertinently address the issue in looking at what exactly is a species and how does one circumscribe it, and also consider the variation to be found within such a species.

The evolution of the genus itself is also looked at, and Ben Zonneveld's contribution on DNA content supports the progressive evolution of *Clivia* from the most primitive form *C. mirabilis* through *C. nobilis*, *C. robusta*, *C. gardenii* and *C. caulescens*. Previous work has shown that *C. miniata* is closer to either *C. gardenii* or *C. caulescens*. The difference between these pendulous species and the open-flowered *C. miniata* is very noticeable, but genetically small. Is it not possible that the mutation that gave rise to the open flower arose at various places within the distribution of the pendulous species, thus explaining the very wide range of *C. miniata* when compared to the very distinct ranges of the pendulous species? This would also explain the very great variation found in *C. miniata*, both physically and genetically. The DNA-based research published to date does not always give locations for the plants included in the analyses. It would be interesting to see where the plants used in the different phylogenetic analyses came from - maybe the location plays a much bigger role than previously thought.

A recent highlight for many of us has been the release of *C. mirabilis* seedlings to *Clivia* enthusiasts all over the world. These were grown on by John Winter at the Kirstenbosch National Botanical Gardens in Cape Town from seed collected in the habitat at the Oorlogskloof Nature Reserve in the Northern Cape – a real labour of love by John and his small team of helpers. The reserve is managed by the Northern Cape Nature Conservation Department and the proceeds from the sale of these plants will be used to benefit the local people.

This is an excellent example of enlightened authorities cooperating with *Clivia* enthusiasts to put into practice the dictum of 'conservation by propagation' for the preservation in private collections of specimens of a rare and endangered species. As a matter of interest, we understand that plants were distributed throughout South Africa, and also to enthusiasts in Germany, U.S.A, Australia, U.K, Netherlands, Japan, Switzerland, Hungary, Portugal, Sweden Denmark, France and Belgium. Also, plants are being grown on for possible future importation into New Zealand, when the laws of that country permit.

With this exciting species in mind, we trust that you will especially appreciate Hein Grebe's stimulating article about his visits to *C. mirabilis* habitat, and enjoy the photos that illustrate it.

Clivia in the wild appear to be hardier than many of the pampered highly-bred plants in our collections. The Clivia Society is sponsoring research into the diseases that affect our home-grown plants. The article by Wijnand Swart sets out some of the early results that have so far been obtained.

Finally, we thank all those who have prepared the articles and sent the photographs that have made this publication possible. There is a large and growing body of knowledge and experience within our world-wide '*Clivia* fellowship'. We encourage more of you to share what you know, and to show off the beauty of your plants, by submitting articles and photos for publication in the next Yearbook.

The Editors, July 2005

Roger Dixon

Claude Felbert

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Photos: Claude Felbert

Genetic Variation in Clivia

Johan Spies, South Africa

Without genetic variation in *Clivia* no breeders, no collectors and no Clivia Society would have existed! All plants would have been exactly the same and the interest of the majority of us would have dwindled. However, genetic variation exists and we have a common hobby or, in some cases, even whole enterprises, which have been built on this phenomenal plant. This paper will try to determine the source(s) of the genetic variation and give a few guidelines on exploiting this variation.

Genetic variation in wild populations

The early issues of the Clivia Newsletter were filled with debates on the correct "cultivar" name for plants collected in the wild. Are 'Howick Yellow', 'Karkloof Yellow', 'Mare's Yellow' and 'Watkins Yellow' the same "cultivar"?[1] Every collector and breeder argued that their material represented the true cultivar since other collectors' material deviated slightly from their concept of "the real thing". One specimen may have a fragrance or the sepals may be slightly more recurved but no differences (genetic variation) were recognised!

A common mistake made with a genus like *Clivia* is that we forget that we are dealing with an evolving organism. Although the rate of evolution is very slow, it happened and continues to happen. Initially, *Clivia* consisted of a single plant. This plant found a niche and propagated. Seeds were distributed and gradually this plant (new species or even new genus) covered a larger geographical area. Almost no variation occurred in individual plants. Eventually mutations occurred. Most of these mutations disappeared again, as the majority of plants did not contain it, and during out-crossing (i.e. cross-pollination with other plants) the mutation was "outnumbered" and so it disappeared. But some mutations were more persistent. Because our new plant genus/species covered a large geographical area, different selection pressures were applied to these plants in different areas and mutations persisted. In due course this led to the formation of morphologically different populations in different areas and eventually new species were thus formed.

Now, thousands of years and many mutations later, we see a *Clivia* population in a "kloof" and start collecting and expecting all these plants to be similar! These plants will vary genetically. Although this population may appear very similar, individuals within the population will contain many different genotypic combinations. Use inbreeding (i.e. self-pollination) to test this hypothesis on a plant collected from the wild.

In an out-breeding (i.e. cross-pollinating) population we would expect the figures in Table 1. If 1% of the plants in a population show a certain trait (for example yellow flowers), 81% will represent true breeding orange flowers and 18% will split for yellow (i.e. carry the gene responsible for yellow flowers without showing signs of the gene) if self-pollinated[2]. If the trait we are interested in occurs at an even lower frequency, let us say 1 in 10000 individuals, approximately 2% of the population will split

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[1] See page 67 for article on naturally occuring yellow clones.

[2] These values are calculated in the following way: the frequency of occurrence of the rare (recessive) phenomenon equals q^2. The square root of that frequency will give the frequency of the gene in the population (q). The frequency of the other gene (the dominant gene) is represented by p and $p = 1 - q$. The frequency of true breeding dominant plants is p^2 and the frequency of the population that will split for the trait when selfed, is $2pq$. These ratios and the rules governing them can be studied in textbooks under the heading "Hardy-Weinberg equilibrium".

for that specific trait. Many such traits are present in *Clivia*. Therefore we should expect to see some minor differences within a wild population, but their actual genetic variation will be revealed only by self-pollination of these plants. Even then you will have to self-pollinate a large number of individuals to reveal all the "hidden" attributes, because the rarer the occurrence of a trait, the smaller the chance of collecting an individual that will exhibit (split for) that trait.

Table 1: Genotype frequency in a population for different frequencies of recessive individuals

	% of recessive individuals in a population		
	1%	0.1%	0.001%
True breeding dominant individuals (p^2)	0.81	0.938	0.98
Heterozygous (splitting) individuals (2pq)	0.18	0.061	0.0198
Recessive individuals (q^2)	0.01	0.001	0.0001

Thus, there are differences within any wild population but these differences are less frequently observed than the differences between different populations. This variation in the genetic composition of each population is vital for the survival of the population. If the whole population were genetically similar, a single catastrophic event could destroy the whole population. Due to genetic variation different plants in the population would react differently to such an event and the survival rate would be higher. Such a catastrophic event may be a certain disease, insect infestation, drought, excessive rains, a heat wave or a sudden cold. Some plants (with the "wrong" genetic constitution) would die, but others would be able to cope with the situation due to their genetic make-up and would survive.

Genetic variation in cultivated *Clivia*

When we compare the variation between natural populations of *Clivia* with the variation present in breeding programs, the cultivated plants seem to possess more variation than the plants in their natural habitat. Do not be fooled by this apparent increase in diversity! Mankind selected for features that suited him; so variation in flower and leaf morphology was emphasised by man. In this way plants were produced with an enormous variation that will not help them to survive in nature. During cultivation the plants are nursed and many growers use pre-emptive dosages of fungicides and other pesticides. The need for resistance genes disappeared.

Where plants are grown in greenhouses there is no need for plants to survive low temperatures. I have seen different responses to cold in an unprotected tray filled with young seedlings: at -1°C a seedling died, at -4°C more seedlings died (approximately 40%), at -6°C almost all seedlings died and -8°C proved to be fatal for the last survivors. This unscientific observation was made on one tray with approximately 80 seedlings from one specific cross. However, this clearly indicates differences in cold tolerance in this genetically relatively similar group. If more seedlings from various crosses could be compared I am convinced that greater cold tolerance could be obtained. But why waste good seed/seedlings on such a breeding program?

In protected areas variegated *Clivia* plants flourish, but will they be able to survive in nature? When transplanting seedlings in October 2004 (the seeds were sown in 2003) from a variegated mother, the expected quotas of for that specific trait. Many such traits are present in *Clivia*. Therefore we should expect to see some minor differences within a wild population, but their actual genetic variation will be revealed only by self-pollination of these plants. Even then you will have to self-pollinate a large number of individuals to reveal all the "hidden" attributes, because the rarer the occurrence of a trait, the smaller the chance of collecting an individual that will exhibit (split for) that trait.

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In protected areas variegated *Clivia* plants flourish, but will they be able to survive in nature? When transplanting seedlings in October 2004 (the seeds were sown in 2003) from a variegated mother, the expected quotas of albinos, variegated and non-variegated (green) seedlings were observed. The non-variegated seedlings were placed among seedlings from various other crosses (all covered with 80% shade cloth). Last week I observed sun damage to some seedlings. All the sun-damaged seedlings were non-variegated siblings from a variegated mother. They received the same light intensity as the non-damaged seedlings. This indicates that although these seedlings appeared normal, there was something wrong with their chlorophyll. Is variegation really only influenced by the chloroplasts (inherited from the mother plant) or is it the result of genes (in the nucleus, inherited from both parents) combined with a chloroplast action? Personally I think that variegation is the delayed result of nuclear gene action - where the genes influence the cytoplasmic factor that, in turn, influences the leaf colouration of the next generation.

The yellows and pastels are collectors' items in greenhouses, but what happened to the ultraviolet patterns that are recognised by pollinating insects? Are they still present in these human selected specimens? If not, these specimens will disappear if released into nature. So how do we exploit the genetic variability of *Clivia* in our attempts to breed a show-winner?

Breeding *Clivia* – genetic considerations

What do you want to get from your breeding program? Do you want broader leaves, brighter colours, more flowers, another shape of the petals, should the petals be curved inward or outward, etc.? Remember that you often have to sacrifice something to reach another goal. If you are interested in variegated leaves and eventually obtain the ultimate variegation, remember that you are actually dealing with a "sick" plant. Do not expect that plant to be as vigorous as plants with normal chlorophyll. Be realistic with your goals!

The process of making crosses seems simple. However, it needs careful planning. Before you do any crosses you should know the genetic background of your material. This means that you should know whether a plant is true-breeding for a certain character. In many instances *Clivia* breeders cross two F_1 siblings (first generation hybrids from the same parents). In this way it is impossible to predict the outcome of your cross. In annuals you produce true-breeding plants by line breeding, i.e. by selfing two sets of siblings selected for the desired characteristic in every generation for at least seven generations and then you produce a hybrid between the end result of two such lines. Only then can you predict exactly how the hybrid (F_1) will look. It is also possible to predict what will happen when that hybrid is self-fertilised – when dealing with only one character you will get a ratio of 3:1 (for example 3 orange to 1 yellow); with two characters you will get a ratio of 9:3:3:1 (for example 9 orange bugle (recurved), 3 orange tulip (incurved), 3 yellow bugle, 1 yellow tulip), etc. However, it is impossible to follow this 'traditional' way of breeding in a slow propagating plant like *Clivia*, which takes not one, but three to five years to flower and thus show the results of your breeding. But, if you establish the genetic background of your plants you will be able to estimate the probability of obtaining your desired result.

By keeping a record of all your breeding material and using this material in test crosses you will be able to determine each plant's genetic make-up. Use 2-3 flowers for self-pollination to determine for which traits your plant is true breeding and for which one it is still segregating. Do test crosses (again 2-3 flowers) with plants with a known genetic background (for example group 1 or 2 yellow) to determine to which group your yellows belong. Keep in mind that the more characters you are looking for, the slimmer your chances of obtaining all those characters at once. A formula, $\frac{1}{4}^n$, can be used to calculate the number of true breeding recessive stock you will get from a cross involving n different characters. So when two characters are involved the chance for a true breeding recessive offspring is $\frac{1}{16}$. If you try to get a true breeding plant for 5 recessive characters, you will have to produce at least 1024 F_2 offspring to get one desired plant.

The moral of the story is that the more characters you want to improve, the more offspring should be produced and the more vigorous the selection process will be. Starting with material containing most of the desired traits can accelerate the process.

In a breeding program certain genetic principles must be acknowledged. Most of us know about "normal" (or Mendelian) inheritance [i.e. where a recessive trait is caused by a single gene, for example yellow colour in *Clivia*, and this trait will be inherited in a fixed ratio in the second generation (F_2) if the hybrid or first generation (F_1) siblings are crossed]. Few of us know that many factors may influence Mendelian inheritance. Firstly, genes may be linked and will be inherited together. This may be the case with narrow leaves and the "group 1 yellow gene". If two genes are linked, thousands of offspring are needed to find a few plants where the genes have segregated.

If we start looking at the genes responsible for flower colour in *Clivia* we find no information in a database like Genbank (a worldwide database where all sequences of DNA are stored). However, genes responsible for similar chemical substances are found in other plants. It is interesting to note that the majority of genes responsible for the 'red' colouring in *Clivia*, the anthocyanins, are located on one chromosome (chromosome 10) in rice. Similarly the 'yellow genes' (carotenoids) are clustered on chromosome 2 in rice. So the 'red' genes are linked as well as the 'yellow genes'. Is this also the case in *Clivia*? Are the genes in *Clivia* similar to those described in rice and other plants[3]? Linkage of these genes may explain the rarity of pastels in *Clivia*.

The next deviation from Mendelian inheritance is called epistasis. With epistasis one gene influences or masks the expression of another gene. Unfortunately for us epistasis may be a major force of colour inheritance in *Clivia*. Many genes contribute to the formation of anthocyanin (red) and carotene (yellow). What causes these pigments not to be formed? Is it a defect in one of the genes along the way, or is it a different gene that inhibits the pigment formation? In humans many genes form pigment; the more genes you have the more pigment will be formed. A totally different gene exists that can stop the formation of all pigment, regardless of the number of pigmentation genes you have. When you have this albino gene you will be an albino. In maize a similar gene exists. If present, different genes may produce purple, red or yellow seeds. Otherwise all seeds will be colourless (white). The absence of inbred pure-breeding *Clivia* makes it almost impossible to determine the mode of colour inheritance.

Another contributing problem to colour inheritance in *Clivia* is the throat. What regulates the inheritance of throat colour and the size of the throat? In Holstein cattle a gene determines whether the animal will have the well-known black and white pattern or a brown and white pattern. A totally different set of genes regulates the form of the pattern. Are we dealing with genes controlling the "normal colour genes" in various degrees in

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[3] A molecular study on the different genes controlling the inheritance of colour in *Clivia* has been started at the University of the Free State. If everything goes well, results should be available in a few years time.

different parts of the flower or are we dealing with a totally different set of genes controlling the size of the throat?

Polygenic inheritance (where many genes influence the same trait) also contributes to the problems in understanding the genetics of *Clivia*. Polygenic traits are usually associated with patterns of inheritance where you observe a continuum rather than a specific class. Probable polygenic traits in *Clivia* include leaf width and length (these two may also be linked or may influence one another), number of flowers, length of tepals, etc.

Inheritance may also be influenced by a phenomenon called genomic imprinting. This means that the working of the genes is dependent on the environment (the cytoplasmic constitution) in which they operate. Only certain genes are affected and it will usually be genes responsible for disease resistance or other factors where the chloroplasts play a role. Genomic imprinting is the reason why reciprocal crosses may differ from one another: it is not cytoplasmic (maternal) inheritance but the genes may operate differently depending on the cytoplasm present. In extreme cases a trait inherited from one parent will be more strongly expressed than when that same trait is inherited from the other parent.

During the last part of 2004 Mick Dower shared his results on "De Villiers variegated peach" with us on the Internet. When crossed with a group 1 yellow, "De Villiers variegated peach" will produce peach offspring when used as pod-parent and yellow offspring when used as pollen-parent. Since low numbers of offspring were obtained, these results may be fortuitous. However, if larger numbers of offspring confirm the initial results, this may clearly be a case of genomic imprinting. Something in the cytoplasm influences the colour 'prescribed' by the genes. It will be very interesting to see what happens when he self-pollinates the yellows and peaches from this cross: will the imprinting last in the offspring from the yellow plants or will it change in the next generation? How many generations will be needed to determine whether the genomic imprinting lasts? How many other cases of genomic imprinting exist in *Clivia*? The lifespan of a human being is too short to solve all these problems. To truly understand *Clivia* we must share information. Even then we should keep the Biblical text in mind: "For now we see through a glass, darkly, but then face-to-face, now I know in part, but then shall I know even as also I am known."

Breeding *Clivia* – practical considerations

At this point you may become discouraged. You want to breed with *Clivia* and now I am telling you that we know almost nothing about the inheritance of most traits in *Clivia*. Many of you may tell me that you have used your green fingers and plantsman instincts to achieve good breeding results with little, if any, genetic knowledge. However, an understanding of the underlying genetics will undoubtedly improve those successes. We therefore have a magnificent opportunity: if all of us share[4] our practical knowledge gained over many years, we may be able to build up a genetic interpretation of those results for the benefit of all of us, so breeding *Clivia* will become a lot more predictable and we will have to rely less on a "hit and miss" approach!

Polyploidy

Much has been written on polyploidy in *Clivia*. Do we really want polyploid plants? Usually a polyploid will be a larger plant with

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[4] If you are willing to share your knowledge please contact the author at spiesj.sci@mail.uovs.ac.za. Information needed includes a description (or photo) of the parents and the offspring, the number of offspring with each trait, and if possible the numbers of second generation offspring with each trait. The direction of each cross should also be supplied.

bigger flowers. The majority of us stopped after reading that introductory part and did not read the negative aspects. Polyploids usually develop more slowly than diploids. Polyploidy is the doubling of the chromosomes of an individual and the larger number of chromosomes slows down cell division. In some plants the growth rate is so inhibited that the plant cannot produce flowers during the growing season. I don't know the effect in *Clivia*, but with *Clivia's* large genome size, growth may be inhibited substantially.

If a tetraploid (a tetraploid contains four sets of chromosomes instead of the usual two) is crossed with a normal plant (diploid), a sterile triploid (three sets of chromosomes) is produced. If two tetraploids are crossed, you will not get a ¼ offspring with the recessive trait, but the figure drops to 1/16. Breeding with polyploids will further complicate this already very intricate issue.

Hybrid vigour

Lastly I would like to address the issue of hybrid vigour. It is a well-known fact that hybrids are often stronger and grow more vigorously than their parents. This effect is known as hybrid vigour and is especially pronounced in organisms where two highly inbred lines are crossed, for example in maize. It is also known that the combination of certain lines provides more hybrid vigour than others. Hybrid vigour is probably the result of the combination of as many genes in the heterozygous (split format) condition as possible.

The majority of *Clivia* plants we use can be classified as hybrids and inbred lines do not exist. Even the widespread strains are products of the pollination of similar individuals, rather than the self-pollination of an individual for at least seven generations to produce an inbred line as with annuals. Therefore no hybrid vigour will be observed, not even if we produce interspecifics.

Conclusion

Clivia is a wonderful plant with a very high degree of genetic variability. This variability makes it ideally suited for a breeding program. Keep records of your crosses and count the number of offspring that have each particular trait. In the long run this will be the only way to determine the mode of inheritance of traits and make it possible to predict the outcome of a specific cross. This means that, ideally you should monitor all the seedlings of the cross you have made. For most of us this is not physically possible, but the more who monitor and report on even samples of the seed they have bred, the more information will become available for genetic interpretation of those results.

Photo: Claude Felbert

C. mirabilis the oldest *Clivia species*.

Photo: Ken Smith

C. caulescens a younger genetic variation.

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Clivia is a wonderful plant with a very high degree of genetic variability. This variability makes it ideally suited for a breeding program. Keep records of your crosses and count the number of offspring that have each particular trait. In the long run this will be the only way to determine the mode of inheritance of traits and make it possible to predict the outcome of a specific cross. This means that, ideally you should monitor all the seedlings of the cross you have made. For most of us this is not physically possible, but the more who monitor and report on even samples of the seed they have bred, the more information will become available for genetic interpretation of those results.

Photo: Claude Felbert

C. *mirabilis* the oldest *Clivia species*.

Photo: Ken Smith

C. *caulescens* a younger genetic variation.

Clivia Under Threat

Vivienne Williams, South Africa

The use of the *Clivia* species

Five of the six *Clivia* species found in South Africa are harvested for the traditional medicine ('muti') trade. Known as *umayime*, the whole plant (except for the flowers) is utilized and the tops of the leaves are typically cut off, hence making it difficult to tell the species apart in the *muti* markets and shops.


Photos: Vivienne Williams

Clivia with leaf tops and roots removed.

The genus is used by traditional healers to treat a range of ailments of both physiological and spiritual origin. The name *umayime* means 'let it stop' and the plant is reportedly sprinkled around homesteads to stop people from damaging property. *Clivia* rhizomes are reported to be extremely toxic to humans due to the presence of numerous Amaryllidaceae alkaloids. Root infusions of *Clivia miniata* are taken orally to treat fevers, snake bites, infertility, urinary tract disorders and *inembe* - a childbirth therapy to ensure successful confinement and the birth of a healthy child. Additionally, leaf infusions are used in *isihlambezo* ('that which cleanses'). Despite their toxicity, species of *Clivia* remain the most popular of the Amaryllidaceae sold for traditional medicine.

The author conducted two surveys of the medicinal plant trade on the Witwatersrand. In 1994, plants sold in 50 *muti* shops were investigated and in 2001, 101 street vendors in the informal Faraday Street *muti* market were surveyed on behalf of DACEL (Department of Agriculture, Conservation, Environment & Land Affairs). Described as a multi-million rand 'hidden economy', the trade in indigenous plant medicines employs and supports hundreds of thousands of people in the capacity of plant gatherer, street vendor, shop trader and traditional healer. The annual volume of plants in trade in Faraday is in excess of 800 tonnes per annum. *Clivia* is one of at least 300 genera sold to consumers of traditional medicine on the Witwatersrand, and this article discusses aspects of this trade.

The species used

Except for *Clivia mirabilis*, which occurs in the Northern Cape, the remaining five *Clivia* species are all used for traditional medicine. Species of *Clivia* are sold in all the major medicinal plant markets of South Africa, namely KwaZulu-Natal (KZN), Witwatersrand, Mpumalanga and Grahamstown/Eastern Cape.

The trade in traditional medicines on the Witwatersrand is multicultural and reflects historical processes (related to labour and urbanisation) working in different ethnic groups, which shaped the development of migrancy. These same historical processes also shaped the preponderance of different ethnic and language groups in various sectors of the emerging South African capitalist economy from the late 1800s when the medicinal plant trade was being established

Table 1

Probable Species		Faraday 2001	Muti shops 2004
C. gardenii / C. miniata	Bought from traders from KZN	8	11
	Gathered self in KZN	4	4
C. nobilis / C. miniata	Bought from Harvesters from the Transkei	-	1
?	Collected in Johannesburg †	2	1
?	Location not Specified *	7	6
C. caulescens	Bought from Harvesters from Polokwane	-	4
C. caulescens / C. miniata	Gathered self or bought from harvesters from MP and Swaziland	2	7
C. gardenii	Gathered self in KZN	4	1

The species of *Clivia* likely to have been sold by traders in muti shops (in 1994) and the Faraday market (in 2001). The information was extracted from citations by the owners of the shops/stalls regarding from whom purchased, and where the plants were harvested. The information was then compared with the *Clivia* distribution map on pages 96 and 97 of CLIVIA 5 to determine the likely species. ('Gathered self' means that the trader personally harvested the plants from the cited location) (LMP = Limpopo Province; MP = Mpumalanga Province; KZN = KwaZulu-Natal Province).

* The plants could have originated from the provinces of Mpumalanga, Limpopo, Eastern Cape and KwaZulu-Natal as well as from Swaziland. The plants therefore belong to any one of the four species of *Clivia*.

† Likely to be cultivated.

on the Witwatersrand. While the Zulus dominate the present medicinal plant trade in the region, and at least two-thirds of the plants are harvested from KZN, traders in the Faraday market have extensive trade and family links with gatherers from all over the country, including the Eastern Cape and Mpumalanga. These links are reflected in the plant supply network to Faraday. There are more than 15 buses operating between collecting areas in KZN, Mpumalanga, Limpopo, Free State and the Eastern Cape that transport gatherers and plants to the market.

As a result, all *Clivia* species (except for *C. mirabilis*), regardless of whether or not the plant was historically used by the local ethnic group in its area of occupancy, are potentially vulnerable to being harvested by gatherers for the medicinal plant trade. That all the *Clivia* species are given the name *umayime* when sold in the market reflects the similarity of the plants, especially when the flowers and leaf tips are removed. While traders may acknowledge the different regional origins of the plants, and may have preferences for plants harvested in certain parts of the country, customers don't differentiate between the species of *Clivia* when requesting *umayime*.

Photo: Vivienne Williams

Bus with luggage compartments packed with *Clivia* and other plants.

Distinguishing between the species sold

The intra-species variation in characteristics such as leaf width and length, depending on the habitat conditions, confounds the ability to distinguish between species, particularly since the leaf tips and flowers are often absent in plants sold in medicinal plant markets.

Given these difficulties, a way of determining which species are traded in the *muti* markets is to compare the known distribution of *Clivia* species with the harvesting localities reported by the vendors selling the plants (Table 1). *C. miniata* and *C. gardenii* appear, from harvesting records, to be the most prevalent species sold by both *muti* shops and street vendors in 1994 and 2001. Records further indicate that *C. caulescens* is also available, but not with the same incidence. There was one specific reference to *Clivia* having been harvested from a locality in the former Transkei that would indicate that *C. nobilis* is also present in the Witwatersrand markets. However, interviews with traders from Faraday revealed the likelihood of *C. nobilis* being more prevalent than the trade records suggest.

Several traders were unable to recall where plants they sold originated (Table 1). As a result, these plants could potentially represent any one or all of the five *Clivia* species. Further, three traders cited that the plants they sold had been harvested in Johannesburg, suggesting that cultivated plants are also being targeted by harvesters. According to one siSwati traditional healer in Faraday the "best" Clivias for *muti* (in terms of efficacy) are from Mpumalanga (likely to be *C. caulescens*) followed, interestingly, by plants harvested from Pretoria.

Red Data listing

Based on their distribution and extinction risk, the Threatened Species Programme of the South African National Biodiversity Institute (SANBI) categorises the threat status of *Clivia* in the following way: *C. miniata*, the most likely species in trade, is considered *LR-nt* (Low Risk-Near Threatened) or *LC* (Least Concern) in both Swaziland and South Africa respectively. However, the species is noted to be 'declining' in South Africa in terms of the "Orange List"[1]. One author, writing in 1999, said that *C. miniata* is *LR-nt* in KZN, and was becoming very rare as accessible colonies were decimated and that there was a continuous threat of exploitation by the medicinal plant trade. The species was then considered to be medium priority for conservation action, and it was recommended that its conservation status should be reassessed in eight years.

C. gardenii is probably the next most popular *Clivia* species in trade and, while endemic to KZN, is considered to be *LC* in South Africa. The legal status of *C. gardenii* in KZN (in terms of the as yet unenacted KwaZulu-Natal Nature Conservation Bill) is described as 'protected', i.e. a species that may be purchased from any person legally entitled to sell them (i.e. the seller has the relevant permit).

Trade records indicated the presence of *C. caulescens* in the Witwatersrand markets. While collection threats are an acknowledged risk for the species, it is classified as NT (Near Threatened) in South Africa and DD (Data Deficient) in Swaziland.

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[1] It is generally accepted that species on a Red List are a conservation priority. Conversely, it is an assumption that species that do not qualify for Red Listing need not be subject to conservation efforts. Some taxa that qualify as Least Concern (LC), e.g. *C. miniata* in South Africa, do not meet the criteria for a category of threat in the Red Listing process. However, this does not mean that these taxa are not worthy of consideration for conservation. As a result, the 'Orange List' was proposed. It comprises taxa that require anticipatory conservation planning to avoid future Red Listing. In terms of the Orange List, *C. miniata* is classed as 'declining'. In terms of this categorisation, species generally have large population numbers or distributional areas, but are threatened by commercial harvesting, horticultural acquisitions or are declining for other reasons.

Just before sending this article off for publication, a paper appeared that describes a new species of *Clivia* from the Pondoland Centre of Endemism, Transkei, South Africa. *Clivia robusta* was previously known as the 'robust form' of *C. gardenii*.

In terms of the species' conservation status, it has been proposed in that paper that *C. robusta* be categorised as EN B1a + 2a, i.e. Endangered and facing a very high risk of extinction in the wild because the extent of occurrence and area of occupancy is estimated to be less than 5000 km^2 and 500 km^2 respectively, and the populations are severely fragmented or known to exist in no more than five locations. This categorisation was based on the 2001 IUCN Red List Categories.

C. nobilis is the most threatened of the *Clivia* species. Originally listed as *LR-nt*, its conservation status has been upgraded to *VU B1b(v)*, i.e. Vulnerable owing to its extent of occurrence being less than 20,000km^2 and estimates indicating that there is a continuing decline in the number of mature individuals. As long ago as 1999 it was felt that there were pointers to local scale extinctions of the species in its area of occupancy.

Red List assessments of species are aided by information on observed, estimated or suspected population size reduction based on actual or potential levels of exploitation. The *muti* trade is an example of how exploitation has caused serious declines in population size for several species. The threats faced by *Clivia* species are further exacerbated by habitat degradation and habitat reduction caused by development. However, sustained harvesting for the *muti* trade will impact on the population size in the long term if current levels of exploitation persist in conjunction with other threats to its habitat. In 1988 in one of the first assessments of threats to plants used for *muti*, the *Clivia* sp. were listed and classified as 'rare and vulnerable', i.e. "*a species with relatively small populations that are vulnerable to over-exploitation if exploitation for medicinal purposes increases*". One author, writing in1988, considered vulnerability to over-exploitation to be partly a function of demand. Demand was deemed to be a direct representation of the number of bags sold annually by 54 traders, which probably represented ¼ of the total quantity sold in the region. In the 1988 assessment, 397 50kg-size maize bags were sold annually by 54 traders.

Trade records

No other records of the volume traded annually appear to exist until the Faraday street trader survey in 2001 by the current author. Twenty-six percent of the traders sold *Clivia* and 11 50kg-size sacks were present during the inventory. This does not represent the quantity traded annually. Conservatively, however, it is estimated that at least 200 50kg-size bags are


Photo: Neil Crouch

A Muti Market.

sold to the Faraday market annually. Not much is known about the annual volume and value of the *Clivia* trade in the other medicinal plant markets around the country.

Based on its popularity and the volume known to be traded, *Clivia* ranked within the top ten plants for conservation action according to the 2001 Faraday survey. Over-harvesting is clearly a real threat to the species.

On a visit to Faraday in early November 2004, none of the traders had any *Clivia* in stock and were awaiting delivery later in the week. Amongst the traders, opinion was that *umayime* was now "*very, very scarce*". This is the first time the author has not encountered *Clivia* in the market, and its current availability does not represent its popularity. Clearly, more traders would sell the plants if they could obtain the stock, and this current scarcity is of concern. By late November, the traders had taken delivery of a consignment of mature *Clivia* harvested in Swaziland (either *C. caulescens* or *C. miniata*). Observations made it clear that no more than 7 traders were able to purchase the plants that arrived, and each trader had a volume equivalent to two plastic supermarket bags or less. Given the shape of the leaf tip and the rough margins, the species was probably *C. caulescens* (Figure 1).

In 1988, it was reported that the standard price for a 50kg maize bag filled with *Clivia* was R10 in KZN. In Faraday in November 2004, the cost of a 50kg-size bag was R60-R70 for smaller plants and up to R80 per bag for more mature individuals. The resale price in the market was R5 for 3-4 individual stems, whereas in 2003 it was reported that bundles cost R2 in KZN.

Conclusions

Clivia spp. (especially *C. miniata*) are widely traded and are at risk of being over-harvested. They have been reported as scarce in several regional medicinal plant markets, and are sold in large volumes. There is clearly a need to monitor and manage wild populations of the species before they become eligible for Red Listing. Propagation of *C. miniata* has been recommended. It is extremely difficult to identify the species sold in the markets, but knowing where the plant originated allows a preliminary judgment to be made. Thereafter, some macroscopic leaf features, such as margin and apex shape on immature leaves, could be used for inter-species differentiations. However, intra-species variations in leaf morphology do not guarantee that a correct identification will be made.

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This article has been abridged from a paper supported by 28, mainly academic, references. The full article, including detailed references, is available from the author: Vivienne L. Williams, School of Animal, Plant & Environmental Sciences, University of the Witwatersrand. vivwill@planetac.co.za **Eds.**

Photo: Charl Coetzee

C. *nobilis* the most sort after 'muti' *Clivia*.

Pollination in Clivia

John Manning, South Africa

Introduction

Very little is known about the pollination biology of Amaryllidaceae although it is evidently diverse, judging from the variety of flower forms found within the family. The first documented record of moth-pollination in a southern African representative of the family, *Crinum variabile*, for instance, is just a few years old (Manning & Snijman, 2002). Observed or inferred pollinating agents include sunbirds, butterflies and moths, bees, and long-proboscid flies (Meerow & Snijman, 1998) – in fact most of the common pollinating agents. Actual observations based on wild plants are in the minority. This is not unusual, however, and it is only Iridaceae among the geophytes that have been at all intensively studied. Observations on cultivated plants are of little use since the natural pollinators are unlikely to be present in such situations, and in the majority of instances we must infer the pollination systems from the form of the flower. This can, however, often be done with a high degree of certainty because of the close relationship between pollinator type and floral form. The close correlation between pollinator needs (in the form of floral rewards) and floral attractants (shape, colour, and odour) led to the recognition of the existence of distinct floral syndromes (Faegri & van der Pijl, 1979). These are associations of floral characteristics that correlate with specific pollinator groups. As a consequence it is often possible to predict with some degree of certainty the pollinator group for which a particular plant species is adapted from the appearance of the flowers alone. Nectar is by far the most common floral reward, valuable to many insects as an energy-rich carbohydrate source, but other species are visited for the proteins in pollen, or for floral oils, or even for the shelter offered by certain flowers. Plant species differ in the degree to which they are specialised for a particular group of pollinator. Some are generalists that attract a wide variety of pollinating agents, while others are specialists, attracting just a single group (or even species) of pollinator. The more specialised, or exclusive, the pollination system, the easier it is to infer the pollinator. Even the specialised pollination systems, however, are seldom exclusive, showing some degree of 'leakiness', by which we mean that other groups of floral visitors may also act as pollinators, although always to a lesser extent.

Specialised pollination systems are frequent in the southern African flora (Johnson & Steiner, 2000) and may in fact be the norm in many parts of the world. Certainly the extensive studies on the pollination of Iridaceae have confirmed their existence and predominance

Photo: Roger Fisher

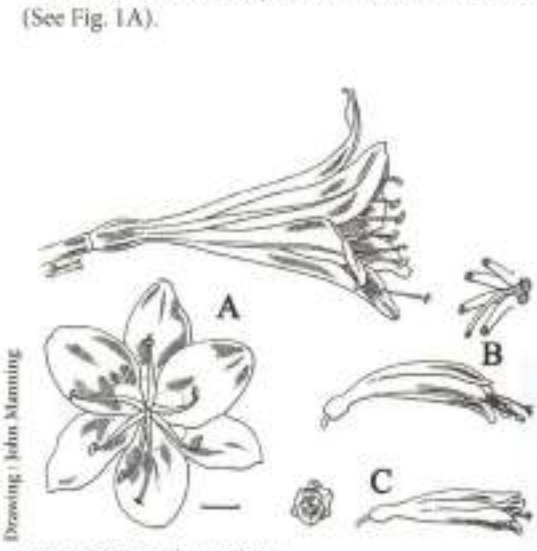
Moths on *Clivia miniata*

Photo: Roger Fisher

in this family. With this background, therefore, let us look at what is known and what can be inferred about the pollination systems in *Clivia*.

Floral Morphology

Two distinct floral types are evident in *Clivia*: **Tubular:** Flowers nodding; perianth sub-cylindrical, 35–50 mm long and 8–10 mm in diameter, the tepals not or scarcely flaring at the mouth, orange with green tips; stamens erect, the anthers close together, protruding up to 8 mm beyond the tepals or hidden in the mouth of the flower; style central; unscented. (See Fig. 1A).



Drawing : John Manning

Fig. 1: Distinct Flower Shapes

Funnel-shaped: Flowers spreading; perianth funnel-shaped, 70–80 mm long and 50–60 mm in diameter, the tepals flaring widely at the mouth, orange with a paler, yellowish throat; stamens slightly spreading, the anthers well-spaced in a ring at the mouth of the flower; style declinate and lying on the bottom tepal; usually unscented but sometimes reported to have a sweet-floral fragrance. (See Fig. 1B & C).

In both types the nectar accumulates in a reservoir in the lower 5–10 mm of the perianth, within the floral tube below the level of filament insertion. The base of the filaments presses against the style and act as a valve to close the mouth of the floral tube, preventing the nectar from exuding out of the tube.

Floral Longevity

Individual flowers of *Clivia* are long-lasting, with unpollinated flowers remaining fresh for 2–3 weeks. There does not appear to be a significant difference in longevity between the two floral types but further observations are required.

Nectar

Clivia flowers produce large amounts of moderately concentrated nectar (Table 2). Volumes secreted per day range between 13–36 microlitres (one microlitre is equivalent to one thousandth of a millilitre, or one millionth of a litre), and there does not appear to be a difference in nectar volumes between the two floral types. Nectar concentration ranges between 13–27% sucrose equivalents. Species with tubular flowers appear to secrete slightly more dilute nectar (13–18 %) than the species with funnel-shaped flowers (22–27%) but further observations are required to confirm this.

Photo: Rob Drake

Bees — Secondary pollinators?

Table 1: Floral and nectar characteristics of *Clivia*. (— indicates no observations)

Species	Flower Shape	Scent	Longevity (Days)	Nectar Volume (Microlitres)	Nectar Concentration (% Sucrose Equivalents)
C. caulescens	Tube	x	—	13	18
C. gardenii	Tube	x	—	36	13-14
C. miniata	Funnel	x/✓	18 - 20	24-26	22-27
C. mirabilis	Tube	x	±14	—	—
C. nobilis	Tube	x	—	—	—
C. robusta	Tube	x	—	—	—

Floral visitors

Wild plants: Observations have been made on single populations of four species of *Clivia*. These indicate that the species with tubular flowers are visited by various species of sunbirds, while *C. miniata*, with funnel-shaped flowers, is visited by swallowtail butterflies. Sunbirds alight on the stout peduncle and reach into the nodding flowers with their beaks. Pollen is deposited at the base of the beak. The butterflies, in contrast, alight directly on the flowers, brushing the anthers with their bodies and wings.

Cultivated plants: Various observations have been made of insects visiting cultivated plants of *C. miniata*. These mostly involve honeybees, *Apis mellifera* (Hymenoptera: Anthophoridae) and hoverflies (Diptera: Syrphidae) (Abel *pers. comm.)* but also noctuid moths (Fisher, 2004). The flies and bees alight on the anthers only, where they gather pollen (Fig. 2), while the moths settled within the flowers.

Conclusions

Species of *Clivia* produce two floral types that accord with two different specialised floral syndromes. The tubular flowers that characterise the majority of species are typical of other southern African bird-pollinated plants of the gullet-type, both in shape and coloration (Rebelo, 1987; Goldblatt *et al.*, 1999). The long beaks of sunbirds are adapted to probing for nectar in narrow, tubular flowers, from which visitors with shorter mouthparts are denied access to the nectar. The division of the flower into two sections: a tubular, nectar-containing portion at the base that is more or less blocked by the insertion of the filaments; and a cylindrical upper portion is

Table 2: Pollinator observations in wild populations of *Clivia*. (— indicates no observations)

Species	Visitor	Locality data
C. caulescens	Black Sunbird	God's Window (Manning pers. obs.)
C. gardenii	Sunbird species	KZN coast (Val Thurston pers. obs.)
C. miniata	Citrus Swallowtail	Morgan's Bay (Colin Paterson-Jones pers. obs.)
C. mirabilis	Malachite Sunbird	Oorlogskloof (Manning pers. obs.)
C. nobilis	—	—


Photo Peter Steyn

Photo Graham Duncan

Photo: Piet Theron

Sunbird on an *Erica* *Cyrtanthus obliquus* Sunbird pollinator on pendulous *Clivia*

Note the similarity of the flowers above in order to attract the same pollinators

consistent with many bird-pollinated Iridaceae (Goldblatt *et al.*, 1999). In such flowers the bird is able to insert its beak into the upper portion of the tube but can only reach the nectar in the lower reservoir by extending its slender tongue through the valve formed by the filaments and the style. This valve has an obvious function in preventing the nectar from flowing out of the pendant flowers but may also serve to protect the ovary tissue from damage by the birds' beak. The upper cylindrical portion of the tube in bird-pollinated *Clivia* species measures between 25–28 mm, which accords with the dimensions recorded for Iridaceae of this type. The nodding or drooping presentation of the flowers is also commonly encountered among bird-pollinated species, including *Aloe*, *Gasteria*, *Kniphofia* (Asphodelaceae), *Agapanthus inapertus* (Amaryllidaceae) and *Watsonia aletroides* (Iridaceae). Orange and red are the dominant colours among bird-pollinated flowers, largely because these colours are invisible to insects and not because birds have an intrinsic preference for these colours (Raven, 1973), and bicoloured flowers tipped with green or black are essentially restricted to bird-pollinated species. The resemblance between the flowers of these species of *Clivia* and other bird-pollinated species such as *Cyrtanthus obliquus* (Amaryllidaceae) is a striking example of convergent evolution. It is likely that the tubular-flowered species are visited and pollinated by a variety of sunbirds, depending on the local avifauna.

The strategy of swallowtail (Papilionidae) pollination has not been studied among the South African flora but is undoubtedly an important one. Several plant species from subtropical South Africa, among them *Bauhinia galpinii* (Fabaceae), *Crossandra* (Acanthaceae), *Freesia grandiflora* and *F. laxa* (Iridaceae), and *Gloriosa* (Colchicaceae), conform to the floral syndrome displayed by *Clivia miniata* and are apparently also adapted to pollination by swallowtail butterflies. The large, funnel-shaped flowers of *Clivia miniata* also match the brush-type flowers of several plant species that are adapted to pollination by another butterfly species, *Aeropetes tulbaghia* (Johnson & Bond, 1994), bearing an especially close resemblance to those of *Cyrtanthus elatus*. This syndrome has been well-studied in the Western Cape, and involves several plant species of montane habitats. Butterflies are one of the few insect groups that are able to distinguish red or orange. Although the plant species adapted to pollination by *Aeropetes* in the Western Cape have converged on a very precise shade of red (Johnson & Bond, 1994), this is not the case further north, where this butterfly species visits flowers in a range of hues between orange and red. Orange or red flowers are also highly attractive to swallowtail butterflies, including *Papilio nireus*, which are also attracted to the pale blue of *Plumbago* (personal observation). The exposed anthers in *C. miniata* are well-placed to brush the body and wings of visiting butterflies and the position of the stigma along the circumference of the ring of anthers ensures that it is best positioned to brush pollen off the insect. The Citrus Swallowtail, *Papilio demodocus*, is widespread through Africa, and although it favours more open, wooded country (Van Son, 1949) it is often seen patrolling the edges of forest patches and bush clumps, where its larval food plants grow. These are mainly forest trees in the Citrus family, such as *Calodendron*, *Clausena* and *Toddalia*. It is highly probable that other species of *Papilio* also visit *Clivia miniata*.

The large amounts of more dilute nectar secreted by the bird-pollinated species of *Clivia* are typical of other bird-pollinated plants. Nectar of bird-pollinated Iridaceae typically ranges between 15–40 microlitres (as much as 119 microlitres in large-flowered *Watsonia* species), at a concentration of 10–25% (rarely up to 35%) sucrose equivalents (Goldblatt *et al.*, 1999). Plants adapted to pollination by *Aeropetes*, in contrast, typically secrete smaller quantities, ranging between 2–27 microlitres, of moderately concentrated nectar in the range 15–35% sucrose equivalents (Johnson & Bond, 1994) but there is substantial overlap between the two. The more concentrated nectar secreted by *Clivia miniata* is consistent with pollination by large butterflies, as is the development of fragrance in some forms. Fragrance is an important attractant in several butterfly-pollinated species (Andersson *et al.*, 2002) but is not part of the floral syndrome in bird-pollinated species.

The short mouthparts of the honeybees and hoverflies observed visiting cultivated plants of *C. miniata* preclude them from reaching the nectar and it is also evident that these insects were concerned respectively with gathering and eating pollen. It is not inconceivable, however, that the bees in particular (hoverflies are far more accomplished fliers), may accidentally brush against the stigma and succeed in transferring pollen to it. Noctuid moths, however, may be more successful as pollinators. During field studies around Nieuwoudtville I have frequently observed that noctuid moths become active during the late afternoon, when they visit a variety of flowers that are adapted to pollination by other agents. The extent of their involvement as such secondary pollinators has not been assessed but may be significant. There is no doubt, however, that these insects are incidental pollinators of *Clivia* at best, and their role in wild populations remains to be assessed.

Photo: Claude Felbert

Though frequent floral visitors, ants are unlikely *Clivia* pollinators.

Both groups of primary pollinators in *Clivia*, sunbirds and swallowtail butterflies, are polylectic foragers that visit a wide variety of flowers for nectar. They are thus not dependent on *Clivia* as a food source. In contrast, *Clivia* species have evolved specialised pollination systems that rely on a single group of pollinators. Further observations are likely to reveal that each *Clivia* species is pollinated by several different species of sunbird or swallowtail that comprise local suites of species present at the different localities.

Evolutionary considerations

The cladistic analysis of *Clivia* (Conrad & Reeves, 2002) is consistent with the hypothesis that bird-pollination is ancestral in the genus and that the switch to butterfly pollination is a subsequent, derived characteristic. In this context it is highly significant that the divergence among the bird-pollinated taxa in the genus has taken place along a geographical cline, with little or no overlap between each. It is only *C. miniata*, that is adapted to pollination by butterflies, which occurs across the range of any other species (in this case across the ranges of three different species). Fertile hybrids can be produced between all of the species of *Clivia* and it is presumably this adaptation to different pollinators that made it possible for *C. miniata* to expand its range in this way. The substantial overlap in floral coloration and nectar quality between bird and large butterfly pollination makes the shift between them an easy evolutionary event.

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Photo: Peter Lambert

Northern Club Show, Owner: Dawie van Heerden

Photo: Gordon Fraser

A moth on a light coloured *Clivia*.

The Significance of Colour and Ultraviolet Patterning in Clivia miniata

John Manning, South Africa

Light is the term used to describe that segment of electromagnetic radiation that is visible to living organisms, more particularly humans. Our visual spectrum includes light with wavelengths between 400–750 nm, covering the range of colours from blue, through blue-green, green and yellow to red. Not all organisms have the same spectral range as us, however. The visual spectrum of bees, for example, extends from 300–650 nm. The colour vision of bees, although sensitive to a similarly wide range of wavelengths as ours, is shifted towards the blue end of the spectrum. Thus bees are unable to see red, which has a wavelength of 650–750 nm and is therefore beyond their range of vision, but they are able to perceive ultraviolet light as a distinct colour, with a wavelength of 300–390 nm. Humans, in contrast, cannot. We owe much of what we know about colour vision in bees to the remarkable work done by the German scientist Daumer (1958), and Table 1, which compares the colours seen by humans with those perceived by bees, is drawn from his work.

Most insect groups are able to perceive ultraviolet light and it is not surprising, therefore, that the colours and patterns of many insect-pollinated flowers include ultraviolet components that are visible to pollinating insects but not to humans. The patterns on these flowers may appear very different to the insect than they do to us. Several surveys of ultraviolet reflectance and patterning in flowers have been published but these cover just a few species and the UV characteristics of the great majority of flowers are unknown.

Flowers that appear white to the human eye normally absorb UV light strongly below about 400 nm and it is now clear that the class of water-soluble floral pigments known as flavones and flavonols, which occur dissolved in the cell sap, are largely responsible for

Table 1: Flower colours as seen by bees and humans (Daumer, 1958)

Reflected light	Colour to Bees	Colour to Humans
Yellow + UV	Bee Purple	Yellow
Yellow	Yellow	Yellow
Green	Yellow	Green
Green + Blue + Red	Blue-Green	White
Blue	Blue	Blue
Blue + Red	Blue	Purple
Blue + UV	Violet	Blue
Blue + UV + Red	Violet	Purple
UV + Red	UV	Red
Red	Black	Red

UV absorption. The orange pigmentation in typical *Clivia miniata* is due to a special class of flavonoids, known as anthocyanins, that are not UV-absorbing. A second class of floral pigments, the carotenoids, which are oil-soluble and occur in discrete bodies within the cells, do not absorb UV. They are responsible for many of the yellow colours in flowers. In many yellow flowers, however, the carotenoids occur along with certain flavonoids, which also appear yellow but are able to absorb UV light as well. It is these flavonoids that are responsible for the UV-absorbing nectar-guides that are found in many yellow flowers, including evening primroses (*Oenothera*) and sunflowers (*Helianthus*) (Kay, 1987). Contrastingly, flowers that are adapted to pollination by birds, which have a similar visual spectrum to ours, lack UV patterns. Three important colours have been recognised that are differentiated only by insects with vision extending into the near UV. These are "insect-yellow" for UV-absorbing white, "insect-red" for UV-absorbing yellow, and "insect-purple" for UV-reflecting yellow.

Photographs of the flowers of *Clivia miniata* that visualise UV light, taken by Ian Coates (Fig. 1) show that the stamens and style are strongly UV-absorbing, whereas the perianth is not. Note that the pale central star in the mouth of the tube does not reflect UV any differently than the rest of the perianth. The stamens in *Clivia miniata*, although not distinctively coloured to us, are therefore highly visible to insects as "insect-yellow". This may explain why honeybees are strongly drawn to the anthers of this species, where they collect pollen and may occasionally effect pollination, although the available evidence indicates that *Clivia miniata* is actually adapted to pollination by swallowtail butterflies (Manning, 2005).

Colour vision is widespread in butterflies, which have a wide visual spectral range, 300–700 nm, from ultraviolet to red (Silberglied, 1984). Within this range, different species show distinct preferences for certain colours. Studies on colour discrimination in swallowtails (*Papilionidae*) carried out by Ilse (1941) have shown that they, like whites (*Pieridae*), have advanced trichromatic colour vision, enabling them to distinguish at least 3 groups of colours: red-to-yellow; green-to-blue green; and blue-to-violet. The orange and yellow flowers of *Clivia miniata* are thus quite visible to these insects, as well as the UV reflectance of the stamens and anthers. The significance of this, however, is difficult to explain since the butterflies do not visit the flowers in search of pollen. Possibly the UV reflectance plays a role in guiding the butterflies towards the source of nectar at the centre of the flower, analagous to the role of nectar guides on the petals of many bee-pollinated flowers.

Different butterfly species vary in the way in which they locate food, with some species guided principally by scent and others by sight. Whites, which have the same advanced eyesight as swallowails, are guided by sight and evince a full feeding response in the complete absence of scent (Ilse, 1928). Swallowtails are thus also likely to respond to visual cues, following them to nectar and responding to them in their feeding behaviour.

Interestingly, learning can be important in some butterfly species. Newly hatched adults of the White Admiral, for instance, are directed by scent in their first visits to flowers but are guided visually in later visits. The inconsistent presence of scent in the flowers of *Clivia miniata* may, therefore, indicate that it is less important for attracting butterflies in some populations than in others. Even colour preferences can change as a result of experience. The swallowtail *Papilio troilus* shows a strong spontaneous preference for blue and is only weakly attracted to orange but after training showed an increased response to this colour.

Finally, studies on the effects of size and form of coloured objects carried out by Ilse (1932) found that larger objects were more attractive to butterflies, most particularly the extent of the outline of the object as opposed to the surface area *per se*. This is an obvious reason for the greater size of the flowers of *Clivia miniata* in relation to bird-pollinated species, an effect that is heightened by the aggregation of these flowers into large heads.

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Photo: Kevin Mansfield

Selected from the KwaZulu-Natal Garden Show.

Photographing Clivia in the Ultraviolet

Ian Coates, United Kingdom

An insect with good eyesight and a well marked plant seemed destined to survive. However, an insect's vision is strong in ultraviolet, so successful plants which rely on such insects for pollination must be attractive to them in that region of the spectrum as they are competing with all the other flowers in the area. For this reason, *Clivia* put out markers, rather like runway lights, to make it easy for their nectar seeking pollinators to target them.

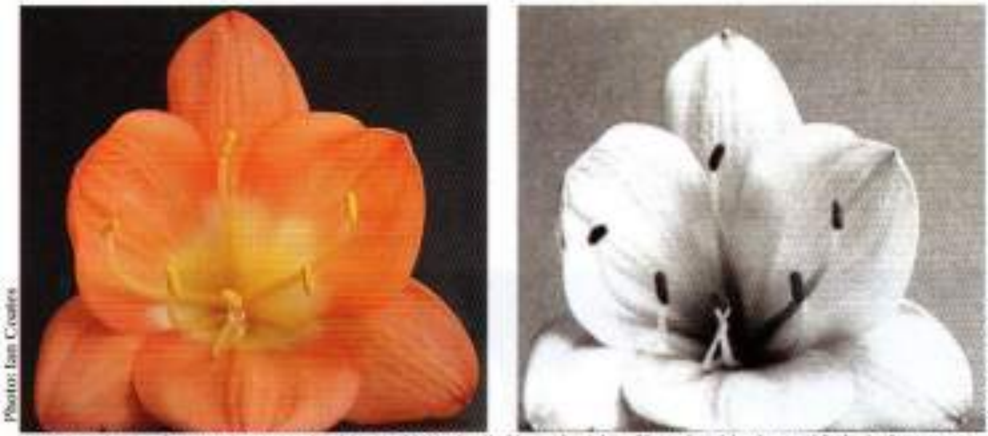
Photo: Ian Coates

Photo: Ian Coates

Clivia miniata flower photographed in visible light (left), and with a filter that blocks visible light but passes UV (right), showing that the anthers, lower portions of the filaments and style, and the mouth of the perianth tube absorb UV light.

Since these markings can only be seen beyond the violet end of our visible spectrum, we cannot see them with the naked eye. Of further inconvenience is the fact that ever since the invention of photography the manufacturers of equipment and materials have all strived to match their results to those seen by our eyes and have therefore eliminated ultraviolet sensitivity.

I hope in CLIVIA 8 to show you how to overcome these and the many other associated problems so that you can photograph your *Clivia* in ultraviolet for just a small outlay. Results from a wide range of varieties across the species, including interspecifics, can only help our understanding of the genus.


Photo: Charl Coetzee

Runner-up to Best on 2003 E.P. Show. Owner: Charl Coetzee


Photo: Charl Coetzee

Charl Malan's pastel class winner at the E.P. Show

Why do Clivia Flower when they do?

John van der Linde, South Africa

The quick answer to the question above is: Because that is when their pollinators are around. But how do the plants know when it is time to get ready and dress up in their very best flower colours and switch on their ultraviolet "come hither" looks to attract the wandering eyes of the pollinators flitting by?

Clivia have to cope with the conditions in which they find themselves - they can't change or avoid them; their evolutionary success totally depends on their ability to get their timing just right. Blossoming, and then pollination, fertilization, and nursing of their seeds all follow on logically from the timing of one key decision: when to flower?

Plants, as well as other organisms, respond to temperature change and also to night length to control certain functions, like flowering, dormancy, general growth, etc. This latter ability is called photoperiodism, and it, in turn, is regulated by special proteins called photoreceptors, molecules that respond to different wave lengths of light. Plants also have internal clocks which control daily rhythms. They can actually detect that nights are growing shorter as days grow longer, and that summer is on its way.

This day/night rhythm occurs in every plant and animal. This is hardly surprising since life arose under the influence of the earth's rotation, which has dictated exposure to solar and lunar cycles over many millions of years. One of the more obvious photoperiodic responses of plants is flowering. Many plants, including *C. miniata*, have evolved a mechanism to delay flowering until nights are shorter and days longer and the weather begins to warm up. The very same climatic factors operate to cue the pupae of Swallowtail butterflies to hatch, and for the adult butterflies to emerge to begin patrolling their habitat, the outskirts and glades of the relic patches of Afromontane forests up the eastern parts of South Africa, where *C. miniata* have been growing and evolving for thousands or even millions of years. In summary, the same circumstances independently affecting both plant and pollinator ensure the happy "coincidence" that the *C.miniata* bloom at the very time that their chief pollinating insects can be expected to be present.

Clivia adapted to growing in the most heavily shaded parts of the forests are unlikely to be visited by butterflies, who avoid the very darkest areas and prefer to flit around where there is enough light for them to see. These plants may multiply vegetatively without ever flowering. It would be tempting to conclude that they are saving valuable energy by not flowering, because they somehow sense that no pollinators will visit them. It is more likely however that the common factor affecting both plant and pollinator is the lack of the necessary daylight to spur them to "do what is necessary to do what comes naturally".

A wild mustard called *Arabidopsis thaliana* is a laboratory favourite, often used by scientists studying the inner workings of plants – the plant equivalent of the fruit fly or the mouse. Researchers have found that two of this plant's genes, involved in their internal clocks, make receptors for glutamate. This is interesting because in the human brain glutamate plays a part in acquiring and storing memories. Do plants also "remember", and maybe even "learn", as they react to their external environments?

It has been known for a long time that flowering is activated by light. But only in the last few years have scientists been able to establish how the process works: Through their work with *Arabidopsis* they have found that its internal clock controls the activity of a gene called CONSTANS. This gene's protein is influenced by light, but only starts to be produced about 12 hours after dawn. In the late afternoon/evening, one kind of photoreceptor stabilizes the CONSTANS protein if it senses blue light, which scatters more than the other components of sunlight, leaving the dominant yellow-orange that we see in sunsets. Blue light has a very short wave length and is a good sensor because it is not absorbed by plant chlorophyll as other types of light are. In the morning another photoreceptor starts to break down any unstabilised protein.

On short days, there is not enough light later in the day for much stabilization to occur and flowering is delayed. But as spring approaches and the days grow longer, with more afternoon sun, the balance shifts in favour of a build-up of protein. When the protein reaches a high enough level, the genes that cause flowering are switched on.

Because flowering is so vital to their survival, plants apparently also have back up systems in place. For example, there is also a gene that suppresses flowering but which is switched off by cold. This may well explain why *C. miniata* needs a cold spell in early to middle winter, not for flower initiation *per se*, but for the "bodyclock" genes to then begin the countdown for bud development and scape elongation, for when the plants deem it safe enough to bloom in the spring, when activated by CONSTANS.

Also, each *C.miniata* cleverly gets its flowers to bloom sequentially, rather than all at once, to give the plant the best possible chance of being visited by pollinators over an extended flowering period .There is another good reason for this timing strategy: upward facing flowers are always at risk of pollen getting wet and being ruined by occasional spring rains, so all the more important to spread flowering over a period.

Even the experts don't know all the answers to how plants organize themselves so well. There seems to be a delicate interaction of pathways to promote and suppress flowering. What are the triggers for *C. gardenii* and *C.robusta*, which flower in late autumn, instead of early spring, like the other species? Is the CONSTANS mechanism somehow reversed, with flowering being triggered in effect by the days growing shorter, as has been shown to happen with rice? Why do interspecific hybrids, even those between species like *C. miniata* and *C. nobilis*, which both flower in spring, often flower in early to mid winter?

It is quite possible that CONSTANS is only one way that plants regulate flowering by day (or night) length, and that there are other factors involved. There may be hundreds of genes working together to get the timing of flowering just right. The pace of scientific progress is such that we may well know far more about this subject within the next few years.

But what I want to know, now rather than later, is why some of my best *C.miniata* plants don't obey the rules. Why don't they flower when they are supposed to?

I found most of the information above about CONSTANS by searching the Internet, but my interpretations of the possible effects on *Clivia* are my own. Please read what I have written in that light.

This single flower view is of an Interspecific, owned by John van der Linde and bred by Mick Dower.

Photo: Mick Dower

Odd Umbels

Roger Dixon, South Africa

The normal inflorescence of a *Clivia* is an umbel, which is a raceme where the axis is not elongated, so that the flower stalks arise at the same point. The flowers are in a head with the oldest on the outside.

Fairly often, a plant will produce an inflorescence which consists of a normal umbel but with a smaller stalk with a few flowers on it sticking out of the top. This does not usually repeat the next season. It may also produce several branched stalks such as in *C. mirabilis* (Rourke, 2003). In this case, all branched stalks, or pseudo-umbellulae, arise from the same point.

Photo: Bill Dijk

Clivia caulescens.

However, in extreme cases, the plant can revert to an ancestral inflorescence such as the one illustrated here. This is a *C. miniata* from near Greytown in KwaZulu-Natal belonging to Pieter van Rooyen which always flowers in the same fashion. Brian Tarr has a *C. caulescens* that behaves similarly.

Photo: Pieter van Rooyen

Clivia miniata with a candelabra-like crown.

Photo: Pieter van Rooyen

Clivia miniata with elongated pedicels. Here the peduncle is greatly reduced.

These 'throwback' inflorescences show two distinct features, which when combined would probably produce a cyme, which is an inflorescence in which the terminal bud is a flower-bud and other flowers are formed at the ends of lateral branches. The small tubular red flowers in such an open inflorescence would not present a particularly striking target for pollinators, and I suggest that evolutionary pressures caused the flowers to become closer spaced, both vertically and laterally, leading to the umbel that is typical of *Clivia* today.

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The Photographic

Winning C. *gardenii*:
Awarded second place — best of four entries.
Caption: Praise and Prayer.
Breeder: Dr. M. Barker. Grower: Gordon Fraser.
Photo: Gordon Fraser.

BEST PHOTO:
Winning – Single Flower. Best of 33 entries.
Caption: Lemon and Lime.
(See Front Cover)
Owner: Edgar Fevrier. **Photo: Gordon Fraser.**

Winning Habitat Photo: C. *caulescens*
Best of 16 entries. Photographed at
Orighstadrivier on the Farm Breytenbachskraal.
Photo: Eli van der Merwe.

Winning Interspecific: C. *miniata* x C. *caulescens*
Best of 14 entries.
(See Inside Front Cover)
Owner: Laurens Rijke. **Photo: Helen Marriott.**

Competition Winners

Winning *C. miniata*: Best of 64 entries. Owner: Laurens Rijke. **Photo: Helen Marriott.**

Winning *C. caulescens*: Best of two entries.
Owner: Laurens Rijke. **Photo: Helen Marriott.**

Winning *C. nobilis*: Best of five entries.
(See Frontispiece) Photo: Tony Barnes.

What's in a Name?

Johan Spies, South Africa

With the publication of a sixth *Clivia* species, *C. robusta*, some *Clivia* lovers wanted to know how many differences are needed to form a new species. To answer this question we will have to look at the way in which taxonomists describe new species.

Usually a taxonomist will look at all herbarium specimens and decide that a certain group forms a separate species. This is normally followed by field investigations in which the differences between populations, and the natural range of morphological variation within each population, are further assessed. The taxonomist will then describe the variation within the species in a valid taxonomic way and use one specimen as the type specimen for the species name. According to the *International Code of Botanical Nomemclature*, the type specimen is a specimen to which the name of a species is permanently attached and need not necessarily be typical of the species, though obviously it should fall within the range of variation accepted for that species. It will be housed in a separate cover in a special place in the herbarium. The type specimen will be available for restricted viewing and is usually considered as one of the important reference sources of the herbarium.

In the time before the 18th century no taxonomists lived in South Africa. Plants were collected in a haphazard way, mostly by laymen. These specimens were transported to Europe where they were named without the luxury of field investigations. The early taxonomists often had only one specimen per species and no variation was accounted for in the species description. It may have happened that two extreme forms of a species were collected and described as different species, or even as different genera, i.e. *Imanthophyllum aitoni* (=*Clivia nobilis*) and *Vallota miniata* (=*Clivia miniata*). At a later stage with more specimens available a taxonomist might see that the two taxa should represent one taxon and another valid publication follows. The oldest name is usually retained as the correct name for the taxon and the other names are considered to be synonyms. This whole process is ruled by the international code for nomenclature.

Species concepts

Another point that may be of interest to *Clivia* lovers is that there is no consensus on the definition of a species. Hundreds of definitions (or species concepts) exist but in this paper we will cluster them in three different groups, i.e. the classical (or morphological), biological and evolutionary species concepts.

The **morphological species concept** states that a species consists of a population or populations that are morphologically similar but differ from other such populations in several morphological characters. If populations are linked by continuous variation in their morphological characters then there is no justification for separating the extreme forms into different species. The main problem with this species concept is that different people interpret those "allowable" differences between different populations differently. Taxonomists are often classified themselves as being either "splitters" or "lumpers". A splitter will use the slightest difference between two populations to describe a new species. If we use this approach in *Clivia* we could end up with at least 15-20 species. On the other extreme a lumper will describe only two *Clivia* species, the trumpet shaped *C. miniata* and the tubular flowered *C. nobilis*. As the oldest described name in the tubular flowered group, *C. nobilis* would be the valid name. Included in the latter species will be the subspecies *caulescens*, *gardenii*, *mirabilis* and *nobilis*. The lumper will further describe different varieties or forma (different forms) in each subspecies, for example *C. nobilis* subsp. *gardenii* f. *robusta*.

According to the **biological species concept** a species is a population or populations than can freely interbreed but are reproductively isolated from other such populations. This species concept was developed to get a more objective way to delimit species. Since all *Clivia* species can be crossed and produce fertile offspring, only one species should be described. However, even this "objective" species concept proved to be subjective. Should the reproductive isolation exist in nature or in the laboratory? In the case of *Clivia*, should the different flowering times of the different species and their geographical separation act as isolation mechanisms to justify the description of the current species?

The **evolutionary species concept** states that a new species is a divergence from the ancestor-offspring lineage, where no gene flow exists between the new species and the original lineage. This species concept is very popular among molecular scientists. A closer examination of this concept indicates that it contains elements of the first two concepts and adds a new dimension. A deviation from a lineage implies a mutation (a novel-looking individual implying the morphological species concept) that does not exchange genes (reproductive isolation as in the biological species concept). Unfortunately even this latest concept can be interpreted in different ways; how many mutations are necessary for a new species and under what circumstances should gene flow be restricted?

To be "a new species" or not to be "a new species", that is the question.

The foregoing part indicates that taxonomy or the classification of plants is not the exact science we believed it to be. However, the majority of taxonomists will try to achieve the same goal: a realistic classification of plants.

Will it be realistic to use only one character to separate species? If we use humans as an example: should blue-eyed people form a separate species from brown-eyed people? Everybody will agree that it would be absurd. Yet we consider yellow flowering *C. miniata* to be a separate variety (*C. miniata* var. *citrina*) to orange flowering ones (var. *miniata*). We should therefore keep in mind that a certain amount of variation within a species is quite normal.

If we look at another practical example: I received a number of *C. nobilis* specimens from different localities. The Nahoon specimens are much more robust than the Kei River Mouth specimens. In comparison with specimens from Grahamstown, both coastal strains/cultivars/species appear to be gigantic. In addition the Grahamstown form has a light median line along all leaves, absent from the coastal forms. These three forms can easily be identified at a glance and they were originally geographically isolated. Should these three forms be described as different species, subspecies, varieties, cultivars, forms, strains or some other taxonomic unit? They all share a rough leaf edge, the same leaf texture and blunt leaf tips. These shared characters indicate to me that these plants should be grouped together in a separate group to the other *Clivia* species. So I will not describe them as new species, but consider them as entities at a taxonomic level below that of species. A splitter will disagree and describe them as three separate species.

What characters should be used to decide at what taxonomic level different collections should be placed? Is there any sense in using obscure characters that cannot be seen in a classification? In my opinion anything that cannot easily be seen should not be used to classify taxa. These characters may help to study the evolution of a group or the genetic variation but are not proper taxonomic characters. If you need an electron microscope to see whether a certain form of gland is present or a certain structure is present in the cells of an organism, it is taxonomically impractical to use such characters to separate species. In a similar way if you have to test for the presence of a certain chemical in a plant to decide to which species a specimen belongs, this impractical character should not be used to separate them. The same principle applies to DNA sequences and chromosomal characters.

If we study the DNA sequences available in Genbank (an international database where DNA or protein sequences are stored for all organisms) and the approximately 30 sequences produced in my own laboratory, we observe differences in the same species. This can be expected. If the DNA did not differ, all specimens would have been exactly the same with no genetic variation. We all know that a lot of genetic variation is present in *Clivia*. Is a single difference in one gene sufficient to give the deviating form 'species' status? In my opinion it is not.

Very little genetic work has been done in any plant species when compared to humans. In humans satellites (a little knob at the end of a chromosome) may be present on certain chromosomes. These satellites are inherited in a Mendelian fashion. If you study a certain family you will, for example, observe satellites on both number 13 chromosomes. In an unrelated family no satellites may be present. Should these two families be considered as separate species? This phenomenon has not been observed in plants. I think it is just because of our insufficient knowledge of plant chromosomes. We are always limited by funds and so the number of specimens studied per population and per species is limited. With humans literally millions of specimens are studied around the world. This overwhelming number of studies offers much more information than the few studies conducted on a particular plant species.

Should something like the "fragile X-syndrome" in humans (with a specific staining procedure the X-chromosome will stain differently) be considered as a separate species (this deviation is also linked to a number of morphological and mental characters)? Definitely not. Why should a similar phenomenon in a plant be considered to indicate a separate species?

In conclusion it is certain that different people will consider the delimitation of species in different ways. As a natural lumper my view will differ from that of a splitter. To remain the practical, useful and workable tool that it is, taxonomy should be based on easily observable characters. My plea to the *Clivia* taxonomists: please do not split more species. The more species we have the more difficult it becomes to classify your plants. Ask yourself whether the "new species" will really contribute to our handling of this wonderful genus.


Photo: Keith Barlow

The beauty of a single flower.

Nuclear DNA Content in Clivia

Ben Zonneveld, The Netherlands

Summary

Genome size was investigated in all six published species. The species of *Clivia* have the same chromosome number ($2n = 2x = 22$) but the nuclear DNA contents ranged from 31.2 to 39.2 picogram. (1 pg is 10 to the minus twelve gram). *C. miniata* and *C. caulescens* have nearly the same nuclear DNA content and the same is true for *C. gardenii* and *C. robusta*. *C. mirabilis*, having the lowest DNA content, could be the most primitive species. A difference of 8 pg in nuclear DNA content implies that the largest genome has chromosomes that are on average 30% larger. Flow cytometry can be used with non-flowering plants, and therefore has applications in conservation monitoring and the determination of the results of interspecific crosses.

Introduction

The genus *Clivia* Lindl. (*Amaryllidaceae*) comprises six described species and occurs naturally in South Africa and Swaziland.

Clivia nobilis Lindl. was the first to be described in 1828. The next one, *C. miniata* (Lindl.) Regel was described in 1853 differing in its open, not tubular, flowers. It is the species most often encountered in culture. Several cultivars are described, including one with yellow instead of orange-red flowers. In 1856 another species with tubular flowers, *C. gardenii* Hook. was described, followed in 1943 by *C. caulescens* R.A. Dyer. Ran *et al.* (2001) point to a possible fifth species (colloquially known as 'Robust *gardenii*', or 'Swamp *Clivia*') also having tubular flowers, but differing e.g. in DNA sequence. It also grows in wet places contrary to the others that grow in shady, rocky places. It was described as *C. robusta* by Murray *et al.* (2004). Great was the surprise when in 2001 another species was found 800 km to the west. It is not only far removed from the other species but grows at least part of the day in full sun (Rourke, 2002).

Clivia are popular plants both for indoors or outside in the more favourable climates. All species are in cultivation, and several cultivars have been described, mainly of *C. miniata*. The tubular flowered taxa that are in culture are often confused. All species counted have the same chromosome number, $2n = 2x = 22$.

By doing DNA analysis Ran *et al.* (1999; 2001a; 2001b) and Conrad & Reeves (2002) have substantially clarified systematic relationships within *Clivia*. However, *C. mirabilis* was not available to Ran *et al.* and Conrad & Reeves did not investigate *C. robusta*. To elucidate the relationships between all *Clivia* species, a character was investigated that was not used earlier in the systematic study of *Clivia*. Nuclear DNA content was measured in all species by flow cytometry with propidium iodide. The classical taxonomic traits based on morphology and the available molecular data are here supplemented with data on nuclear DNA content.

Nuclear DNA content

Nuclear DNA content can conveniently be measured by flow cytometry using propidium iodide, a stain for DNA. Species in a genus can have the same chromosome numbers, but still differ up to 3 times in nuclear DNA content. Genome size has been demonstrated to vary between taxa with identical chromosome numbers (Zonneveld & van Iren, 2001; Zonneveld, 2001).

Plant material was obtained from the collection of K.R.W. Hammett via B.G. Murray and the recently described *C. mirabilis* Rourke was obtained from the author of that species, J.P. Rourke. Where possible, we used material of known wild origin. For the isolation of nuclei, about 0.5 cm^2 of leaf was chopped together with a piece of *Agave americana* L. with 15.9 pg as an internal standard. After adding propidium iodide solution the suspension with nuclei was filtered and the fluorescence of at least 5000 nuclei was measured. The more DNA in the nucleus the higher the fluorescence.

Genome size

All known *Clivia* species were investigated and if they clearly differ in nuclear DNA amount they are considered to be good species. This does not mean that taxa with identical DNA amounts, must always be considered as constituting a single species. The nuclear DNA amounts should always be evaluated in combination with morphological/molecular data, just as any other taxonomic characters. The species are listed according to a decreasing nuclear DNA content. The genome size in *Clivia* varies between 31.2 and 39.2 pg (Table 1). The DNA values are close suggesting that they are strongly related. This is also indicated by the fact that most species are cross-compatible and produce fertile progeny (Hammett, 2002). The DNA contents of *C. gardenii* and *C. robusta* with 35.7 and 36.4 pg are nearly identical. This suggests that they may be the same species and that *C. robusta* is at most a variety of *C. gardenii.* However, *C. caulescens* and *C. miniata* with 38.7 and 39.2 pg respectively are also nearly identical in DNA content.

The difference between the highest and lowest DNA contents is about 8 pg or 8 x 10^9 base pairs. This should be compared with the change from orange to a yellow flower colour that could be due to a single base pair, something that this method is not able to detect.

It is shown here that *C. mirabilis* has the lowest DNA content, suggesting that *C. mirabilis* can be considered as the most primitive species.The close relationship between *C. miniata* and *C. caulescens* fits with the results of Conrad & Reeves (2002) based on analysis of chloroplast DNA, but not with the results based on analysis of nuclear DNA sequences of Ran *et al.* (2001b).

Grime and Mowforth (1982) suggested that in dry and growth-limited situations species adapt over evolutionary times with an increase in DNA content and a decrease in permanently wet situations. This was confirmed for *Hosta* (Zonneveld & van Iren, 2001), but is not found here in *Clivia. C. mirabilis,* growing in the most dry conditions, does not have the highest nuclear DNA content nor has *C. robusta* the lowest DNA content.

Photo: Claude Felbert

Cape Clivia Club Show, Winner Multitepal Class. Owner Eric Heine.

Application

Flow cytometry is a cheap and fast method, up to 25 plants can easily be done in a day. Now the amounts of nuclear DNA are known the species can be distinguished up to a degree.

This makes it useful as a tool for identifying the vulnerable species *C. mirabilis*. Moreover, hybrids of crosses between species can be checked soon after germination, provided the parents are different in their nuclear DNA content. The hybrid will be intermediate between the parents. So one does not have to wait until flowering to know if a cross was successful. Alternatively if the values of the seed parent and the hybrid are known the nuclear DNA content of the other parent can be calculated. Even a single seed can be measured but in that case the plant is lost. I have started now to measure the nuclear DNA content of the *Clivia* relative *Cryptostephanus*. So if anyone has a single fresh leaf available, I would be most grateful.

Table 1: Nuclear DNA Content in *Clivia*

	DNA in pg
C. miniata	39.2
C. caulescens	38.7
C. gardenii	36.4
C. robusta	35.7
C. nobilis	34.7
C. mirabilis	31.2

Acknowledgements

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Photo: Peter Lambert

Northern Club Show Selection.
Owner: Fritz van Schalkwyk

In Search of Clivia mirabilis —some Observations from the Wild

Hein Grebe, South Africa

Some two years ago my work involved me in a building project in Clanwilliam, some 185 km due north of Cape Town. This project gave me the opportunity to visit the southern part of Namaqualand, and to do so at least once a month. The country around Clanwilliam is known for its indigenous Rooibos (*Aspalathus linearis*). The farmers deep in the hills harvest the bushes for their leaves, which are dried and used to make a herbal tea which is now sold all over the world. Several hours north of the town, and accessible only by four-wheel drive vehicles, is a mountainous area in which I hoped one might be able to find *C. mirabilis*.

Whenever I was able to get away from my business commitments I took the difficult drive into the mountains to look for suitable *mirabilis* habitat. I soon realised that it would not be easy to trace *mirabilis* on my own. It took hours to climb a mountain and even longer to look for the plants, and my time on each trip was very limited.

One day while lunching with Pieter, a friend and colleague also involved in the building project, I told him about the plant and how important and rare it was. His involvement in the expansion of the Rooibos tea factory in Clanwilliam had brought him into contact with several local business people and farmers. He promised to contact some farmers from the outlying areas if I gave him photos and a description of the plant.

Months later, I received the exciting news that Pieter, through a contact, Johan, who was a farmer as well as an engineer like us, had found people who had recognised the photos and descriptions; yes, they had *mirabilis* on their farms.

I visited Johan one weekend in September 2004. I left Cape Town at 05:00 in the morning to arrive early. He had told me that it gets extremely hot where the plants grow. After speeding like a madman to Clanwilliam I still could not make it to his farm in less than 4 hours. There we met up with his friend Mias, who was to guide us to a farm where *mirabilis* grew. We travelled in a convoy of three four-wheel drive vehicles over some really difficult "off-the-map" dirt roads.

When we finally arrived, the farmer, Izak, was in a hurry to get moving as the temperature was rising steadily to an almost unbearable heat. We worked our way up a hill almost the size of Lions Head, but steeper, to get to the plants. When we got ¾ of the way to the top he led us sideways and then told us to look down through the tangle of bushes. Even at a distance I immediately recognised the *mirabilis*. Upwards through the trees and bushes we saw more plants. We suddenly seemed to be surrounded by *mirabilis*.

Photo: Hein Grebe

C. mirabilis in flower, red / orange form.

Photo: Claude Felbert

Oorlogskloof *C. mirabilis* habitat.

My heart jumped with joy. After almost two years' search I had found what I was looking for. And do you know what? This was the very first time that I had seen *Clivia* of **any** kind in their natural habitat!

We looked for more plants between the rocks and thick bushes. I found some that were coming into flower. From my experience with other *Clivia*, I judged that the flowers would open in one or two' weeks time. Izak told me that he also knew of other populations. Well, I thought, eventually I had met the right person! I had wanted to spend more time with the plants and take photos but we had to leave to escape the heat and prepare for a braaivleis (barbeque) that had been arranged.

Back at the farmhouse I asked Izak as many questions as I could without irritating him. He had discovered the plants way back in 1961, the year I was born. He had removed some plants years ago and planted them at his beach house but they had all died. Does this mean *mirabilis* does not tolerate sea air, or was the soil type not right?

While helping him with the fire he casually mentioned that he had *mirabilis* here at his home as well. When he showed me the plants I realised that I had walked right past them without noticing! One had been planted in a pot more than 15 years ago and another one was planted in the ground approximately 10 years ago. I did not notice at the time that both were single plants, without suckers.

Photo: Hein Grebe

Hein Grebe with a fifteen year old plant.

I told Izak more about *Clivia* in general, showed him photos in the Clivia Yearbooks, and gave him a copy of the article in Clivia 4 by John Rourke about the then newly discovered *C. mirabilis* populations in the Oorlogskloof Nature Reserve, to the north of where we were. I told him that, in my view, there was a huge interest in *mirabilis*, and that I would like to sell his seeds and pollen if possible. I offered to show him how to pollinate the flowers so that more seed would be formed. He showed interest and promised to let me know when the flowers opened.

On my next visit I was able to spend more time with the plants, some of which were in flower. I had expected to come across thinnish red pendulous flowers, similar to the pictures I had seen of the Oorlogskloof populations. But, in fact, I got the surprise of my life. There was so much diversity in flower colour and shape as well as in leaf size. The flowers came in exciting neon-like colours. With the help of my Clivia Colour Chart I identified the darker colours as dark red, red, orange red and watermelon, and the inside as peach. Then there were lighter colours like orange, papaya, salmon and apricot with peach inside and with green tips. I looked for a yellow, but without luck. However, with this wide colour range I think it is not impossible to find a yellow.

I noticed that they self-pollinate very easily. Numerous small insects were crawling up and down the flowers. I found very few flowers which had not already been pollinated.

Because of the tangled bush it was difficult to get close to the plants. In the process I tore my clothes while trying to protect my camera and other belongings. I carefully pollinated several plants with pollen I had brought with me: variegated yellow, Starlight Light of Budha and pollen from my own and other people's show plants.

Snakes lying in the sun on the rocks were always on my mind, and there were many hiding places for them between the rocks. What makes it more dangerous is that one has to jump from rock to rock to get to the plants. Sometimes the rocks give way under you and then you have to grab the nearest tree while in the same time protecting your camera and other valuables from damage. Away from the rocks it must already have been at least 35ºC in the shade, but it seemed cool deep inside the cracks where the *mirabilis* grew. I noticed that they shared the same space with arum lilies (the common calla, *Zantedeschia aethiopica*), which means there must be sufficient moisture there for their needs.


Photo: Hein Grebe

A *Zantedeschia* alongside a barely visible *C. mirabilis*.


Photo: Hein Grebe

C. mirabilis, with a darker flower form.


Photo: Hein Grebe

An unopened *mirabilis*.

I could not help thinking that an arum was not a good companion plant as it is one of the porcupines' favourites, and there are plenty of those spiny creatures in this part of the world. The *mirabilis* could be disturbed in the process of a porcupine looking for an arum lily dish, but I could not find any lying around uprooted. Maybe the porcupines also respected these very special plants!

We examined the plants closely, counted and measured the flowers, leaves, etc. Scapes bore between 38 and 54 flowers. The flower length varied, some were longer than *nobilis*, most were the same length as my *gardenii*, and some were longer. Some plants had short leaves, others had long leaves and it looked as though only 60% or so had the median white stripe in the centre. But what struck me the most was that I could not find a single plant that had made an offshoot.

I remembered that the plants at the farmhouse had not suckered, though they were 10 and 15 years old. Does this mean *mirabilis* has only one life? At least I knew they could survive longer than 15 years as the plant in the pot looked very healthy indeed.

Here, out in the mountains, there were single plants to be found, but most plants were growing close together, almost in clumps. The next thing that struck me was that I could not find any flowering plants that had also flowered the previous year. It was very easy to see which plants had previously flowered as the old scape was still greenish and intact. In fact, the majority of plants did not even have a current flower scape. Yet, Izak told me that he made a trip into the mountains to see the flowers every year, and that he had not seen so many in flower as this year.

This suggested to me that *mirabilis* is a poor flowerer. I reckon that, at best, it flowers only every third year in the wild. If it flowers, on average, only every 5th year say, then that means it can flower only 2 or 3 times in 15 years. Can this be the reason why it is on the verge of extinction? Its reproduction rate seems to be inferior to that of other *Clivia*.

Nevertheless, all the plants looked very healthy. I could not find any plant with a sign of a fungal disease or of any insect attacks. But the plants were clearly in danger from fire since there seemed to be so much dead dry wood next to them and inside the crevices where they hide. A fire could destroy everything - that's for sure. Another feature that struck me was that I was in a pristine wilderness area. I had not seen a single plant that I recognised as an alien species. Not many farmers in South Africa can say that their farms are alien free.

While we were looking for more plants in flower, I asked Izak and his wife to keep their eyes open for any plants that looked a little different. I think it was the farmers' wife who made the discovery. She called me to look at some lovely flowers but then I noticed something different about the plant's foliage. Yes, it was a *mirabilis* in flower, but the leaves looked like those of a *nobilis* with its typically indented tips. I understand that in some *Clivia* growing areas in the wild, overlapping takes place. *Nobilis* and *miniata*, *miniata* and *gardenii*, *miniata* and *caulescens*, and, I believe, *miniata* and *robusta*. But where were the other *nobilis* plants? I looked again to make quite sure I was right. Yes, the flower definitely looked like that of a *mirabilis*, but the leaves were like those of a *nobilis*. We searched for similar plants, but in vain. Only that one could be found.

That afternoon I was taken to other populations. At one place I saw the most beautiful *mirabilis* - a superior form with large, big tubular flowers that looks like the *C. robusta* 'Maxima'. It was much bigger than the average *mirabilis* and was very vigorous, with leaves 7cm wide. I spent some time pollinating the flowers and then removed as much pollen as I could from this plant.

While on the issue of pollen, I was disappointed time and time again. No matter how early I got up in the mornings to get to the plants, most of the pollen bags were dry and it was extremely difficult to harvest any pollen. One day I started climbing a hill with a flowering population early in the morning, an hour before sunrise, just to find, yet again, most of the pollen dried

Photo: Hein Grebe

A superior plant form.

Photo: Hein Grebe

Photo: Hein Grebe

Variation in flower colour found amongst the populations of *C. mirabilis*.

Photo: Claude Felbert

Photo: Hein Grebe

out. I found usable pollen on only a few plants, placed it immediately in a special cooler bag with plastic ice blocks in it, which I then kept cold until I reached home. I am holding thumbs that this pollen will be viable when I come to use it on some of my best plants when they flower this September.

I left the *mirabilis* populations a happy man, all the time thinking of the *mirabilis* that looked like a *nobilis*, and of the superior 'Maxima'- like plant with the semi-broad leaves.

What I also learned from my visits was that *mirabilis* grows only in selected cool spots on certain sides of a mountain or hill, at around 800-1000 m above sea level. One thing that I picked up was the growth of moss on the rocks and trees, as well as arum lilies sharing the same growing spots. This to me was an indication that at least at certain times of the year there was plenty of water available.

My plan was to re-visit the plants around the end of November/beginning December to see and photograph the development of the berries. However, on short notice I had to go to Cuba on business, and when I returned home on 24th December the holiday season and other obligations made it impossible for me to visit the plants. In March I made appointments with the farmers as I thought that the seed might be ready to be harvested, using the information in Clivia 4 as a guideline. However, my visit took place only on 9th April 2005.

As I drove, I had the vision of full heads of fruit in my mind, and thought about harvesting at least 1 000 seeds. On the other hand, I had read that berries drop from the pedicels as early as mid March. I was indeed glad that I had obtained a permit to sell the seeds I intended collecting.

When we arrived at the farmhouse we wasted no time and, with Izak, headed straight for the first *mirabilis* population. I looked for my special "*nobilis*-like" *mirabilis*. I was disappointed when I saw the plant - only two berries with one seed each. One was a greenish colour, and the other watermelon red. I noticed that the seed heads changed colour from green to yellow, then to yellow with red spots and finally to red. The second discovery I made was that I had pollinated this plant with a Broadleaf Daruma. I should have selfed it. I removed the seed heads and we then decided to split up and collect seeds on our own. It was a perfect autumn day, around 25°C.

It did not take us long to realise that we had arrived too late. Either the heavy rains had washed the berries away, or mice and rats had carried them away after eating the fleshy parts. The berries that we found between the rocks and leaves were fresh and undamaged. Here and there we found a berry still on a flower stalk. The berries looked similar to those of *miniata* or especially *gardenii*. We found only a maximum of 3 seeds per berry, with most fruit containing only one seed. The seed distribution was good with some seeds at least 2 metres away from the nearest mother plant. Other seeds could be found within 60 cm from the adult plant, but the majority of the seeds had disappeared. According to the Izak there were lots of berries on the scapes only two weeks ago. I could have kicked myself for not having come earlier.

While the seed search was on, I discovered plants I had not seen previously, plants with a wide white median stripe of at least 6mm in the centre of the leaves, with two thinner white lines on both sides of the centre white line. After looking around I found a few more. I noticed the difference in leaf length, with some plants with leaves as short as 25 cm and others as long as 60 cm. The width of the leaves varied between 2 cm and 7 cm.

After two hours of searching for seed we decided to visit another population, hoping to have better luck. There we experienced the same problem, we had again arrived too late. We collected seeds for another hour or so while inspecting the plants for diversity, and then called it a day as the sun was almost setting. In all, we collected fewer than 100 seeds. I told them it would not be worthwhile to sell so few seeds and advised them to rather plant the seeds themselves.

I left the *mirabilis* populations with mixed feelings – and with the two seeds of the special "*nobilis*" *mirabilis*. Maybe I should have left them there out on the mountainside as it looked as though the survival rate of small seedlings there must be close to 100%. On the other hand, I hope my *Clivia*-growing skills will pull them through and that they will become big plants one day, like their special mother parent.

Note:

Aliases have been used to protect the identity of the farmers, and hence the *mirabilis* populations. The plants may well be in danger of extinction, but even so it would be unwise to remove them from the habitat as they are in good condition. Strict measures will have to be put in place to protect the C. *mirabilis* in the Western Cape. This is not a simple process and only time will tell whether *mirabilis* will continue to survive on its own in its natural habitat.

Photo: Claude Felbert

A distinct single white stripe showing on this leaf.

Photo: Hein Grebe

What a view!

Competition or protection – perhaps both? This is typical of where *C. mirabilis* grows.

Photo: Claude Felbert

Clivia nobilis —Cinderella of the Clivia World

Charl Malan, South Africa

The distribution and ecology of *Clivia nobilis* is well documented and a number of articles on the subject have appeared in previous Society publications. I am going to look at this species, which I regard as the Cinderella of the genus, from a different perspective.

C. nobilis is normally poorly represented at Clivia Shows as well as in the collections of Society members. The reasons for this may be ascribed to the following factors:-

- As it grows very slowly from seed, most collectors probably do not have the patience or time to see through a propagation programme.
- *C. nobilis* is not a particularly attractive plant from a horticultural perspective. Plants removed from the natural habitat have the tendency to die back and may take years to recover, particularly if injured in the process of removal.
- *C. nobilis* is not readily available in the market, even in the Eastern Cape, where it originates.


Photo: Courtesy Mike Christie

A red form of *C. nobilis*

How then do we solve the dilemma of popularising this Cinderella of the *Clivia* world. There may be several ways, one of which is to involve *C. nobilis* in hybridisation programmes. *C. nobilis* has unique features which makes it an ideal candidate for such programmes, particularly with *C. miniata* as a participant. These features are:-

- The number of flowers in the inflorescence. I have recorded 51 flowers in a specimen from a population at Riet River near Port Alfred!
- The leaf structure – A tough, rigid and leathery leaf which is well adapted to variable climates.
- A range of flower colours – from dark red to very light pastel.

From my own experience, crossing *C. nobilis* (pod parent) with *C. miniata* (pollen parent) produces the typical *Clivia cyrtanthiflora* hybrids which most knowledgeable members can recognize at a glance. See Photos 53 and 54 in CLIVIA 2. Conversely, however, hybrids comprising *C. miniata* (pod parent) and *C. nobilis* (pollen parent) result in much more varied forms, colours and shapes.

Although my own breeding programme is in its infancy and is awaiting flowering of an F_1 generation, I have no doubt that there are exciting times ahead and the advantages to be derived will be many. These include:-

- Flowering outside the normal spring season which could open up a totally new flowering window.
- A wonderful colour range.
- Large inflorescences with many flowers of all shapes and sizes.
- Attractive variegated leaves with a different

form to the usual *C. miniata* and Daruma types.

- Hybrid vigour which is often the result of interpecific hybridisation.

The first two characteristics mentioned above were first observed by Miss Gladys Blackbeard during her early hybridisation attempts at Scott's Farm in Grahamstown (see CLIVIA 2: 42).

While the purists amongst us may not like all this talk about hybridisation, such work opens up new horizons, and if in the process it can turn a Cinderella into a pretty and desirable Princess, let us enjoy it.

Photos: Charl Malan

C. miniata 'Vico Yellow' x *C. nobilis*

Two examples of *C. miniata* 'Shima Fu' x *C. nobilis*

Photo: John van der Linde

F_2 *C. miniata* x *C. nobilis* cross. Breeder: Jim Holmes; Owner: John van der Linde.

The Clivia at Mbashe

Allan Tait, South Africa

From my earliest days, South Africa's flora has interested me. I started my horticultural career in the Eastern Cape where I met the botanical artist Auriol Batten, who fostered my interest in exploring the indigenous flora of this region.

After leaving this beautiful part of the world I went back to Pretoria and in 1996 I was awarded the Kirstenbosch scholarship. Here I was introduced to the finer details of botany, as opposed to horticulture, by Ernst van Jaarsveld and John Winter. John, the then curator, aroused my interest in the genus *Clivia*.

It became my mission to visit as many field localities of *Clivia* as possible and it was on one of these expeditions to the Transkei/ Border region that I came across the interesting plants at Mbashe. The Mbashe river feeds into the sea at The Haven on the Wild Coast, about half-way between Port St Johns in the north and East London in the south. I stayed across the river, in a traditional rondavel with minimum luxuries. This entailed carting drinking water from a couple of kilometres away!


Photo: Allan Tait

Vegetation on the banks of the Mbashe River.

On my first day in the forest, I approached from the river side and immediately realized what a spectacular place it was, with the beautiful forest form of *Stangeria eriopus* abounding and it was not long before I found the first stands of *Clivia* occurring in great profusion. The plants, however, did not look like the usual plants that I have encountered in similar areas along the Wild Coast, including the Kei River.


Photo: Allan Tait

A broad-leafed *Clivia* from the same population as the narrow-leafed *Clivia* below.


Photo: Allan Tait

I started investigating and the difference soon became apparent. The foliage of the plants in general was far more robust. Some specimens had long, narrow leaves, in sharp contrast other plants, where the leaves were also long but broad. The margins of the leaves were also variable and some were sharply serrated and the apices were often emarginate. In many, there was a small acute apex within the dent of an emarginated apex. Flower colour was very variable, unlike the very uniform colour of the plants in the stands that I encountered on the Kei. However the most profound differences were to be found in the fruit. The berries displayed a wide variety of colour, from yellowish orange to deep crimson red. Even more remarkable was the fact that despite their size they each contained only one, to a maximum of three, very large seeds!

A natural hybrid?

The picture at once became clear to me. Natural hybridization has taken place between *C. miniata* and *C. nobilis*. To prove this, I had to find *C. nobilis*. I climbed higher and the vegetation changed, with the forest becoming less dense and drier. *C. miniata* were still to be found but in smaller numbers. Suddenly I found the first *C. nobilis* plants of a declining population growing amongst *C. miniata*. This was a great find because, although the flowering times of the species overlap, they are rarely found growing together like this.

The mystery now deepened and I decided to revisit the site in June / July to see if I could find any natural F_1 hybrids (*Cyrtanthiflora*-type) in bloom. I returned in June but to my great disappointment, there were none.

I now had to rethink whether these were indeed hybrids or not. With no visible evidence of hybrids present I re-formulated my theory. After finding the first *C. nobilis* plant, I discovered that it was part of a population that was declining due to excessive collection of material for traditional herbal medicine "muti". After the initial F1 cross, could not hybridizing in many successive generations have produced plants with flowers that resemble *C. miniata*, with great variation of colour in the same stand, and also with distinctive foliage and fruit?

Further research in this population could well lead to the finding of F_1 hybrids. Material of these plants was forwarded to Kirstenbosch, where with advanced genetic technology the true state of affairs might well be revealed.

I would like to thank Dr. Auriol Batten and Dianne Batten for reviewing my text.

Interspecific hybrids often flower in winter, so a return visit to Mbashe in June to look for F_1 hybrids showing signs of flowering makes good sense. John Rourke found natural hybrids between *C. miniata* and *C. caulescens* in flower on his mid-winter visit to the Bearded Man mountains, as he described in his article in CLIVIA 5. The collectors may well have taken any pendulous flowering plants as *C. nobilis* is prefered to *C. miniata* since nobilis is perceived to be the "more powerful muti".

Eds.

Apple Blossom complex, first time flowering from seed. Owner: Ian Brown

Clivia miniata 'Bella Donna Oprah'

A rose by any other name smells as sweet, but nothing can be sweeter than when an unusually beautiful, rare flower is named after you. One such flower, a *Clivia miniata*, was recently named after Oprah Winfrey, to commemorate her 50th birthday. The name given to a special cultivar of this species, endemic to South Africa and Swaziland, is 'Bella Donna Oprah'.

Bred by Bertie Guillaume from Makhado (previously known as Louis Trichardt) in the Limpopo Province, the plant was chosen by a panel of judges consisting of the editor of the Oprah magazine, South African edition, and representatives of the Clivia Society.

Clivia miniata 'Bella Donna Oprah'.

Photo: Courtesy Bertie Guillaume

Although several breathtaking entries were received, the judges were unanimous that Bella Donna, which means "beautiful lady" in Italian, was the winning plant.

"In fact, when we chose this specific clivia, we did not know that Mr.Guillaume's unofficial name for his plant was Bella Donna. Adding Oprah's name to Bella Donna made perfect sense for this stunning flower," said O Magazine SA editor Kgomotso Matsunyane.

"It would have been inappropriate to name a clivia after Oprah without being able to present her with a specimen of the winning entry," said Chris Vlok, chairperson of the Clivia Society.

It was therefore a requirement of the competition that all entries have an offshoot that could be presented to Oprah. Another rule was that the owner of the winning entry should start a breeding programme to develop a "Bella Donna Oprah" *Clivia* strain.

During a recent visit to a taping of the Oprah Winfrey Show in Chicago, Matsunyane presented Winfrey with a photo of the Clivia Miniata named for her. An offshoot has been sent to her home in California, as a birthday gift from O Magazine SA.

"The meeting with Oprah meant a lot to me because it was my first opportunity to meet Oprah in person. I got the opportunity to tap into her energetic spirit and share ideas on how to enhance O in South Africa. We also announced to Oprah the naming of a *Clivia*, endemic to South Africa and Swaziland, after her in celebration of her 50th birthday," said Matsunyane.

"We had an absolutely amazing time at the show and were completely blown away in true Oprah style. Watching the taping of the show was definitely the highlight, and we were all very surprised when Oprah welcomed and introduced our South African delegation to the studio audience – a memorable moment indeed," Matsunyane said.

Adapted from an article "Flower for a beautiful lady" by Kashiefa Ajam in the Johannesburg "Star", Saturday 6 November 2004.

2004 Show

Photo: Peter Lambert

Best on Show. Northern Clivia Club. Owner: Norman Weitz.

Runner-up. Norther Clivia Club. 'Pat's Peach', Owner: Pat Gore.

Photo: Peter Lambert

Selection


Photo: Clive Graham

Best on Show, KwaZulu-Natal Clivia Club. Owners: Edsel & Brenda Nuss.

Runner-up, Northern KwaZulu-Natal Clivia Show. Owners: Clive & Ebb Graham.


Photo: Clive Graham

Best on Show, Eastern Cape Clivia Club. Owner Charl Malan

Photo: Charl Coetzee

Photo: Clive Graham

Runner-up, KwaZulu-Natal Show.
Owner: Conrad Vermaak.

Runner-up, JCC Show. Owner: Chris Viljoen

Photo: Kevin Mansfield

Photo: Claude Felbert

Runner-up, CCC Show. Owner Mick Dower.

Runner-up, ECCC Show. Owner: L. De Beer

Photo: Charl Coetzee

Photo: Clive Graham

Best on Show, KwaZulu-Natal Garden Show. Owner: Sean Chubb.

Photo: Courtesy NZCC

From the New Zealand Show, a varie gated Daruma
Owner: Keith Hammett.

Photo: Courtesy NZCC

From the NZCC Show an F_2 Hybrid.
Owner: Terry Hatch,

Photo: Courtesy NZCC

From the New Zealand Show, a Variegated Red.
Owner: Tony Barnes.

Photo: Kevin Mansfield

Best on Show, Jo'burg Clivia Club. Owner: Dawie Strydom

Photo: Courtesy GRCC

Runner-up, Garden Route Clivia Club Show, 'Charls Green'. Owner: Charl Coetzee.

Photo: Claude Felbert

Best on Show, Cape Clivia Club. Owner: Coen & Diné Calitz.

Photo: Courtesy GRCC

Best on Show, Garden Route Clivia Club. Owner: Gerrit van Coppenhagen.

Clivia robusta — the "Swamp Clivia"

Keith Hammett, New Zealand

Every person on earth has an individual view or paradigm of the world. Such paradigms are influenced by the culture in which we are raised, our education and by individual experiences as we pass through life. Problems often arise when discussing a topic if we do not check out the other person's understanding, or we do not clearly explain our own.

It is clear to me that there are several quite different concepts of what constitutes a species. This was brought home to me when I posed the question "what is a species" to a meeting of a Rhododendron Society. The consensus answer was "a weedy version of the nice hybrids we grow".

As a botanist / plant breeder, this was an eye-opener for me as I realised that had I not asked the question I would have talked right past my audience. Similarly, if we are to discuss *Clivia* species, we must first establish some common ground.

Clivia is a small genus confined to Southern Africa. I feel that there is sufficient evidence to believe that the species that constitute the genus have evolved over time from ancestral types, rather than having been created at a single point in time by a supernatural force.

This distinction is critically important. If someone happens to believe in Creation, it is likely that they will see species as entities waiting around for us to discover and to give them a name. This is rather like a sculptor who sees his role as liberating a form that already exists within a block of stone or wood. Such a view is essentially static and species are likely to be seen as being well defined and capable of being fitted into neat pigeonholes. In contrast, the evolutionary view is fluid and in consequence defining the limits of a species is seen to be more a matter of opinion based on an accumulated body of information.

If we take *Clivia miniata* as an example, the work of John Winter and others, who have spent much time looking at populations in the wild, has shown us that there is a lot of naturally occurring variation within this species. I chose *C. miniata* deliberately because, as it has the single trait of having upright flowers, there is seldom much dispute about its identity, despite exhibiting considerable variability in floral and leaf characteristics.

Variability is extremely important as it encompasses many physiological traits in addition to morphological and pigment variation. Without adequate inherent variation, plants and animals are unable to survive and adapt as the climate changes. This same variability is equally important to the plant breeder.

Often the term **gene pool**[1] is used to describe the range of variability that we have gathered together in our collections. In using this term it will be seen that there has been a shift in focus from whole plants to the genes or chemical entities that code for the characters we see. A breeder's gene pool is akin to a painter's box of paints.

An extension of this train of thought is the paradigm encapsulated by the term **germ plasm**. Here the genetic material is seen as a river flowing through time and all the plants and animals that exist at any point in time are simply manifestations of this. The idea was first put forward by the German, August Weismann, towards the end of the Nineteenth Century.

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[1] I note a tendency in commercial circles for people to talk about a breeder's **genetics** rather than gene pool. This is a misuse of the term.

Conceptually this idea is very helpful to plant breeders and evolutionary botanists alike. I like to think of a genus as a bank of cumulus clouds moving across the sky. **The act of a cloud breaking into two separate clouds is analogous to speciation in nature. Similarly, when clouds aggregate together this is analogous to species being crossed in cultivation to form hybrids.** With this model, you will realise that the clouds making up the genus have many characters in common, and whether clouds are seen to still be connected or are separate will depend to a large extent on viewpoint.

Hopefully having established some common ground, it is now appropriate to discuss the recent establishment of the taxon *Clivia robusta* (Murray *et al.*, 2004). Most of the background to this was discussed in CLIVIA 3. Little has changed since that time except that a few additional accessions have been positively identified as being *C. robusta*, while South African botanists Truter and Swanevelder have added to our understanding of the natural distribution of this taxon.

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.

Between 1996 and 2000 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 CLIVIA 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 both.

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 was 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,

Photo: Courtesy Sean Chubb

C. robusta

Photo: Keith Hammett

Single flower of *C. robusta* (centre) with flowers from four different accessions of *C. gardenii*, two on each side, showing the clear difference in stamen exsertion between the two species

Courtesy SANBI collection

Plate 2094 from Flowering Plants of Africa, 53 (1994) incorrectly identified as *Clivia nobilis*. Artist Claire Smith.

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*". He provided details of herbarium specimens held at the National Herbarium in Pretoria and at Kirstenbosch and he indicated that geographically its distribution fitted in between *C. nobilis* from the southern Kwazulu-Natal and the 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 6-9 inches 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).

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 *nobilis* or *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 Society 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 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 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 KwaZulu-Natal.

After returning to New Zealand I was able to raise seedling populations of these collections and Yidong was able to confirm that three of them have the same chromosome staining pattern as the original Eloff "Robust *gardenii*".

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*. While visiting South Africa for the Second International Clivia Conference in 1998 Nick Primich showed me a plant owned by Pat Gore. This was a very large plant which could not be assigned to any of the then recognised species, but was informally being called "robust *nobilis*". After sterling efforts by James Abel and many subsequent trials and tribulations, I was able to get an offset of Pat's plant as far as quarantine confinement here in New Zealand. Yidong was able to determine the chromosome staining pattern of the plant which enabled us to identify it as what we now call *C. robusta*.

It has been demonstrated that all the named species except *C. mirabilis* (because that was not available to us) can be recognized both by gross morphology of the whole plant and by chromosome and DNA characters. In the case of *C. robusta*, the most obvious feature is the sheer size of the mature plants and their ability to grow in both running and stagnant water as well as in better-drained situations. When grown in damp conditions prominent prop or stilt roots are developed. Leaves are broad with rounded tips and contrast markedly with the narrow tapering leaves of *C. gardenii*. Like the other pendulous species except *C. gardenii* the stigma and stamens are essentially retained within the flower tube. Accessions of *C. gardenii* are notable for the protrusion of these organs.

The distribution of *C. robusta* has been shown to be endemic to Pondoland and to be separate from that of *C. gardenii*, which is recorded only from the Durban area northwards.

I have been asked why we did not try to locate the type herbarium specimen of *C. gardenii* as described by Hooker in 1856 and compare the DNA of this with living material of *C. robusta*. All our work was done with living plants. An adequate number of distinct living accessions for each species was used and these were identifiable both by concurrence with accepted morphological descriptions for each species and their karyotypes.

In the course of the work, the "Swamp *Clivia*" was seen to be distinct, both morphologically and by karyotype from the other taxa. I went to considerable personal expense to ensure that an adequate number of different accessions was obtained and tested. Four different DNA/phylogenetic tests confirmed that the "Swamp

Clivia" was distinct from the then known species. *C. mirabilis*, which was described subsequently, is based only on morphological and geographic criteria.

C. gardenii was described 149 years ago. Presumably a herbarium specimen was prepared somewhat earlier than this. As the plant was first grown at Kew, this presumably would be the place to look. Whether it would be possible to get permission to borrow and to make DNA samples from a type specimen is a moot point. It is also a moot point whether after 150 years the DNA had degraded or not and whether a comparison between fresh and long dried material would be valid.

Hooker's original description and illustration closely match the accessions that we have determined to be *C. gardenii* and are quite distinct from *C. robusta*.

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Table 1. Summary of the key differences between *Clivia gardenii* and *C. robusta*

Morphology	*Clivia gardenii*	*Clivia robusta*
Habit	Gracile plant, strongly clump-forming, ±1 m in height	Massive plant with stout rhizome, often with prop roots, ± 2 m in height
Leaves	Linear-acuminate, strongly sulcate in cross-section	Broad, strap-shaped with with obtuse-apiculate apex, planar in cross section
Flowers	Stigma and stamens strongly exserted	Stigma barely protrudes and stamens usually retained within corolla tube
Karyology	45S rDNA site + C-band on chromosome 2 45S rDNA site but no C-band on chromosome 2 No 45S rDNA site or associated C-band chromosome 8	45S rDNA site or associated C-band chromosome 2 45S rDNA site + C-band on chromosome 8
Distribution	Widespread in KwaZulu-Natal	Confined to Pondoland Centre of Endemism

Notes on the sketch of C. *robusta* by W.L. Chiazzari .

We are indebted to Mr W. L Chiazzari for permission to reproduce his sketch, shown here. An extract from a letter that he wrote from Pietermaritzburg on 14 July 1965 to the National Herbarium, Pretoria, is set out below:

"The Clivia was taken from a small patch of isolated swamp forest growing in dense masses beneath the trees. I first located this same group of Clivia in 1943 when I was serving with the S.A.A.F. during the last war and had been sent with No. 29 Squadron to a landing strip named Lombazi approximately 1 mile from this patch of forest. A coloured sketch was prepared from a flowering head at the time, and is still in my possession. However about four years ago, I again visited the areas and brought back a number of plants, one of which I took to the Herbarium, Botanic Gardens, Durban, from where it was consigned to your Department in Pretoria for identification by a Miss Johnson. To this date I have not heard as to the identity of this species.

The main characteristic of this species is the procumbent or semi-procumbent stem more than 18" long and with leaves strap shaped, forming a plant on an average of well grown plants 4'0" - 5'0" height. The heads contained between 22-35 flowers each. From available literature, it does not appear to be C. gardenii which has from 10-14 flowers in an umbel nor is procumbent, as far as I am aware. This also applies to C. nobilis which is also diminutive by comparison. The description of C. caulescens nearest meets the description except for its locality and fewer flowers.

I have successfully grown and flowered plants in my plant houses at Richmond. I should be pleased to forward another plant to your Department should the original be mislaid or the species be of interest?" Eds.

C. *robusta* by W.L. Chiazzari, 1943.

Courtesy W.L. Chiazzari

C. *robusta* seed.

A C. robu*sta* inflorescence.

Photo: Keith Hammett

A Red form of C. *robusta*

Photos: Courtesy Sean Chubb

Clivia robusta 'Maxima'

Roger Dixon, South Africa

A plant which catches the eye is Fred van Niekerk's 'Maxima'. Known to him from his mother's garden from the early 1930's, he collected this form of *C. robusta* from the Umtentu River Valley, near the sea, in the Bizana District of Pondoland in the Eastern Cape Province in 1989. This stunning geographical variant has up to 49 flowers per umbel which can be up to 20 cm across, and appears to be at the one end of the *C. robusta* spectrum.

The southernmost populations of *C. robusta* occur in the Lusikisiki, Flagstaff and Bizana areas and are differentiated from the plants to the north near Port Edward by having many short broad flowers, a light stripe down the middle of the leaf and a slightly serrated leaf edge. Those from Port Edward northwards look more like *C. gardenii* with fewer, long narrow flowers. It appears that although they are genetically distinct from *C. gardenii* and *C. nobilis*, where they grow closer to *C. gardenii*, they tend to look more like them and similarly at the southern end of their distribution they are more like *C. nobilis*. *C. robusta* generally are bigger plants with higher flower counts, broader, longer and lighter green leaves than *C. gardenii*, with leaf tips which are more rounded and in the south sometimes notched as in *C. nobilis*.

Photo: Roger Dixon

One of Fred van Niekerk's 'Maxima' plants.

An unusual feature of Fred's 'Maxima' plants is that when selfed they produce up to 10% albino progeny, and none of the parent plants are variegated. A possible reason for this is that many populations of *Clivia* in the Pondoland area are fragmented and isolated into narrow gorges, and this geographic constraint might act as a barrier to cross-pollination with other populations, eventually leading to a preponderance of recessive genes, such as albinism. One of Fred's plants puts forth a split peduncle each year with two umbels, one below the other.

Photo: Roger Dixon

This 'Maxima' plant produces split peduncles each year. Each peduncle produces two umbels, one below the other.

Clivia gardenii – Autumn's Delight

Brian Tarr, South Africa

History

Clivia gardenii was discovered and collected by Major Robert J. Garden of the 45th Regiment. He collected specimens while stationed in the Colony of Natal and sent them to the Royal Botanic Gardens at Kew. It was here that Sir W. Hooker named the new species *Clivia gardenii* when it flowered in 1856, in honour of the collector.

Distribution

Clivia gardenii occurs in the forests and forest patches of Pondoland and KwaZulu-Natal from near the coast to an altitude of 1200 m on south- and southeast-facing slopes in shale or sandstone-derived soils. From personal observation, it is possible to identify four main areas where *C. gardenii* occurs:

- Durban / Pietermaritzburg / Stanger
- Southern KwaZulu-Natal and Northern Pondoland
- Eshowe
- Vryheid / Louwsberg

C. gardenii is one of six species of *Clivia* found in South Africa, the others being: *C. miniata*, *C. nobilis*, *C. caulescens*, *C. mirabilis* and the most recently described *C. robusta*, previously known as the 'Swamp *gardenii*'.

C. gardenii is concurrent with *C. miniata* in all regions. It is often confused with (and sometimes sold as) its more southern sister, *C. nobilis*, the main differences being in the arching, soft, pointed leaves in *C. gardenii* as opposed to semi-erect leathery, notched leaves in *C. nobilis*.

Flowering time for *C. gardenii* is from early to mid winter when heads of 10-25 pendulous or semi pendulous green- or, infrequently, yellow-tipped flowers appear. The overall colour is variable, ranging from pale yellow to deep red.

Courtesy SANBI collection

Clivia gardenii from Ngome Forest by Cythna Letty from *Flowering Plants of Africa* 42, (1972).

Durban/Pietermaritzburg/Stanger

This region comprises Stanger, Hillcrest, Pietermaritzburg, Karkloof, Greytown and and is generally referred to as the 'Midlands'. The plants here are 900mm – 1200mm tall with lax, deep-green pointed leaves loosely clasping

Photo: Brian Tarr

'Green Ivory' from KZN Midlands.

the base. They seldom develop significant, taller, stems and can occur in large colonies in moist as well as dry habitats. Flower colour is variable in this region from red with green tips in the Greytown area, blush yellow and green around Harburg and pale red and green in the Hillcrest area. The flowers are held semi-erect on the umbel and are well spaced with between 15-25 per head.


Photo: Brian Tarr

'Green Blush' from Ngome Forest, Northern KZN.

Southern KwaZulu-Natal and Northern Pondoland

Two pendulous forms are found in this area, both flowering in early to mid-winter. Both were previously regarded as being forms of *C. gardenii*. Their habitats are quite different.

One form, known for many years as the 'Swamp *gardenii*', is significantly the larger and has recently been named *C. robusta*, the sixth *Clivia* species. It is always found in or near swamp forests, certainly not far from water. Its flowers come in a range of colours from cream to red.

The other form is smaller, and is found in drier areas, usually amongst rocks. Unlike *C. robusta*, with its range of colours, the flowers of these plants are generally only a brick red with green tips. No other colour forms have been found.


Photo: Brian Tarr

Pink form from Southern KZN.

They also differ in several respects from the geographically closest *C. gardenii* form, the 'Midlands' form. The leaves have a rounded tip as opposed to the acutely pointed tip of the 'Midlands' plants. A plant collected in the Port St Johns area has leaf tips with a distinct indentation, similar to those of *C. nobilis*. The leaf colour tends towards a grey-green to light green and tightly clasps the stem. Also, the flowers do not have the flared tepal tips found in the Midlands form, nor do they have the range of colours.


Photo: Brian Tarr

'Bongie' from Southern KZN.

On the face of it, these plants seem to me more like a form of *C. gardenii* than a form of *C. robusta*, though Hammett *et al.* state that *C. gardenii* occur only to the north of the Durban area, and that


Photo: Brian Tarr

Leaf tips from Southern KZN.

the plants in southern KwaZulu-Natal and N. Pondoland are all *C. robusta*. In my view, more field work in this area could prove rewarding.


Photo: Brian Tarr

A good colour form from KZN Midlands.

Eshowe

Plants from this region tend to be somewhat smaller than the 'Midlands' form, ranging in size from 300mm-500mm and averaging 10-15 flowers per umbel. The flowers are held sub-erect and are brick red with flared green tips. With further exploration of the region it is likely that populations of *C. gardenii* could be found in the Lebombo Mountains.

Vryheid / Louwsberg

Plants from this region are distinct in that they have a growth form which differs from the norm in that a well defined 'stem' is formed by the leaf bases tightly clasping the rhizome, giving the young plant an "onion-like" appearance. The plant develops a stem similar to *C. caulescens*. The leaves are 700mm-900mm long, with a pointed tip, less acute than the 'Midlands' form. Flower colour is predominantly a yellow/rose pink with green tips although green tipped pink/red flowered plants have been found. The plant bears large umbels of between 20-35 sub-erect flowers. The umbel is held well above the


Photo: Brian Tarr

'Harburg Blush' from KZN Midlands.


Photo: Brian Tarr

C. gardenii var. *citrina*.

Photo: Brian Tarr

'Jade Ivory' from KZN Midlands.

Photo: Brian Tarr

Red form from Ngome Forest.

leaves. Yellow-flowered plants from this region have recently been described and published as *Clivia gardenii* var. *citrina*.

Conclusion

C. gardenii, rather like *C. nobilis*, is viewed as very much the poor relation behind its more flamboyant sister *C. miniata*. Undoubtedly there are poor forms of *C. gardenii* but nevertheless it has much to offer both the enthusiast and the gardener in that it flowers at a time when colour in the garden and shade house is in short supply, there are a number of colours and forms to add variety, and it is not as susceptible to lilyborer attacks. It is a plant that deserves a place or two in every collection and garden and we look forward to a time when *C. gardenii* shows are held throughout South Africa.

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Photo: Brian Tarr

'Greeney' – from Ngome Forest

Yellow Clivia miniata from the Habitat

Fred van Niekerk, South Africa

There has been much confusion over the last century or more as to the status of the yellow-flowering *C. miniata*. The first record of a yellow *C. miniata* was in a note in a German gardening journal in 1888, reporting a novel yellow form displayed at a show. The first recorded example from habitat was discovered that same year. Subsequently, a number of yellow-flowering wild plants have been found and more have arisen in cultivation. Many of these clones have been passed along from one person to another, and along the way have acquired different names, which has given rise to much confusion, especially when directed breeding using these yellow plants has been attempted. The existence of different mutations, each resulting in yellow flowers, has been identified (e.g. Group 1 and Group 2, although there are more), and therefore when breeding is attempted, it is important to be able to identify similar plants.

I have personally visited many of the people and locations from where the various habitat yellows have been found in an attempt to unravel the name confusion, and to ascertain which plants were in fact from habitat and which have arisen in cultivation. Where this has not been possible I have consulted with a number of knowledgeable *Clivia* enthusiasts and the result of this investigation is presented below. I have not included all the details, but have provided a brief summary describing where each plant originated from, who found it and when it was collected, together, where possible, with a photograph. All the information, to my knowledge, is accurate – many stories were found to be either confused or inconsistent and where such information was not able to be confirmed, it was not used.

Painting of *Clivia miniata* var. *citrina* Katharine Saunders (Bayer, 1979).

Clivia miniata was already well-known in cultivation in England, Belgium and elsewhere in Europe, having been discovered in the early 1850's. The first yellow came to light in Eshowe, KwaZulu-Natal, around 1888. It was found by a Zulu cook of Sir Melmoth Osborne (the Resident Commissioner at Eshowe) while collecting firewood in the Hlinza Forest, Eshowe. Plants were given to Sir Charles Saunders, who in turn sent a plant and an inflorescence to his mother, Katharine Saunders. She made a watercolour painting of the inflorescence, which in turn was sent, together with a plant, to Kew Gardens.

An extract from the book "Flower Paintings of Katharine Saunders" reads: "Yellow *Imantophyllum* from Eshowe, flower withering after being two days in post bag. Most lovely, delicate, peculiar shade of yellow, not orange, but like straw-colour mixed with pink, quite inimitable by me. October 8th, 1893. This drawing has been sent to Kew with the bulb by Maud." (Katharine's daughter.). *Imantophyllum* was an earlier name for *Clivia*. *Clivia miniata* is one of the most striking and best known of all Natal flowering plants, occurring in all forests from Port St. Johns to Zululand and from the coast to the Midlands. The flower colour varies from cream through various shades of yellow and red to dark red. Some of the yellow flowering heads are truly magnificent. It is little wonder, therefore, that Katharine Saunders was delighted with what was apparently her first view of these flowers. The plant sent to Kew by Maud Saunders was successfully established and flowered under glass in one of the greenhouses (Bayer,1979). The plant was later described and published as *C. miniata* Regel var. *citrina*.W. Watson 1899.

Mrs. M.M.R. Robinson, the daughter of Sir Charles Saunders, inherited his plants and continued growing them in Pietermaritzburg until the mid 1960's. Sir Melmoth Osborne's plant was grown by Mrs. Essie Osborne, whose husband was a nephew of Sir Melmoth. One of these plants was given to Mrs. Joyce de Villiers of Manderston outside Pietermaritzburg by her father Mr William E. Marriott, curator of the Pietermaritzburg Botanical Gardens from 1906 to1910.

'Mare's Yellow'

This well-documented yellow clone was grown and sold by Miss Grace Mare from her home, "Silver Oak", Mare Street, Howick. The original plant was collected from the foot of the Howick Falls in 1891. When Miss Mare left Howick, she gave her plants to Mrs. A. D. Tanner who grew them at her home in Blackridge, Pietermaritzburg. She described these plants as having dark green narrow leaves and the flowers a clear, deep, butter yellow with no trace of orange (or green). She tried self-pollinating them but the resulting plants were all orange with more yellow in the throat than her other plants. Clones of this plant can be found in many gardens in Howick and Karkloof.


'Mare's Yellow'

Photo: Sean & Terri Chubb

'Dwesa Yellow'

This plant was collected from the Mbashe River mouth prior to 1939 by the Wood family who owned a trading post in the Transkei (Eastern Province). The plant has been in the family for some seventy years. These details were given to Dr Bing Wiese of Pretoria some fifteen years ago when he obtained a piece of the plant from the Wood family. Robert Moss (son-in-law of the late Eric Dodd of Pioneer Nursery, East London.) states that a piece of this clone was given to Eric by a trader's wife in the early 1980's and is still being grown at the Pioneer Nursery. The plant has an extremely beautiful, small light-


'Dwesa Yellow'

Photo: Sean & Terri Chubb

cream full bloom. Upon self-pollination the plant produces berries each with a single large seed. Despite their large size the seeds germinate poorly, grow very slowly and only orange-flowering plants are produced.

'King Hamelin Yellow'

This clone was collected by Mr. King Hamelin on his farm in the Darnell area of KwaZulu-Natal approximately thirty years ago. King Hamelin was a conservationist and arranged walking tours through the natural bush occurring on his farm. The highlight of these tours was to view the clump of yellow *Clivia* growing in the bush. This *Clivia* clone has been distributed to a fair number of people but is still little-known. The plant offsets fairly well, has medium to broad leaves that are pale green and is fairly susceptible to stem rot. The good flower with overlapping petals has an attractive deep yellow colour.

'Byrne Valley Yellow'

Photo: Sean & Terri Chubb

'Byrne Valley Yellow'

Mrs. Mary Hosking collected this plant in the Byrne Valley between 1925 and 1935, and planted it in her garden at Etterby. After her death the plant was moved to the garden of Mrs. Pam Pottow, her daughter. The plant is considered a family heirloom and is thus undistributed. It has an attractive bright, star-shaped yellow flower.

Photo: Fred van Niekerk

'Natal Yellow'

'Natal Yellow'

The late Cynthia Giddy collected this plant on a farm in the Bainesfield area near Richmond, in KwaZulu-Natal. This plant, which is the true 'Natal Yellow' as named by her, was **not** the plant described and recorded by Kirstenbosch as 'Natal Yellow' - that was 'Cynthia's Best', described below. The spread of the 'Natal Yellow' throughout South Africa was partly due to a friend of Cynthia's, Anna Höll, who bought a plant from her at the end of September 1978, and grew it in her garden in Swellendam to where she and her husband had retired. It suckered profusely (a characteristic of the clone) and she gave away or sold many of these offsets which can be found in collections around the country under a number of different names. It is very easily distinguished from other yellows due to the tips of the older leaves that are inclined to die back. From correspondence between Cynthia and the late Prof. Christo Pienaar it is apparent that Yoshikazu Nakamura bought all the yellow plants that she could produce. 'Natal Yellow' is a wonderful horticultural subject - it is a robust plant that suckers well and has very attractive butter-yellow flowers on well-presented umbels.

(See Shigetaka Sasaki's article for insight to the value of this clone in a breeding programme.) Eds.

'Blinkwater Yellow'

Dr. Bing Wiese of Pretoria obtained a clone of this yellow *Clivia* from a Mr. Koch of Wartburg, KwaZulu-Natal. The plant had been collected during the 1960's from the Blinkwater stream that flows into the Sterkrivier that in turn flows into the Umgeni River below the Albert Falls Dam in KwaZulu-Natal. The 'Blinkwater Yellow' is light creamy yellow in colour with an average sized open trumpet flower. Its most distinctive feature is the semi-pendulous disposition of the flowers. The plant is receptive to its own pollen and produces 100% yellow progeny. This is the reason why Dr. Wiese included this clone in the gene pool of his yellow *miniata* breeding program. After six generations of line breeding the progeny of this program still segregate within a wide range as far as shape and size of the flowers is concerned.

'Crookes Yellow'

A little-known plant collected by Mr. Vernon Crookes on the farm Mgai of Mrs. Molly Reynolds in the Umzinto district of KwaZulu-Natal in the early sixties. He grew the plant in the Orchid House at Selbourne Estate. This plant has not been distributed at all.

Photo: Sean & Terri Chubb

'Mpumulo Yellow'

'Mpumulo Yellow'

The plant was collected by Darrel and Marrion Bignoux at Mpumulo in KwaZulu-Natal during the late fifties. A new road was being built in the area destroying many *Clivia* populations: Darrell and Marrion were on a motorcycle trip and collected the yellow plant as well as seed. The plants in habitat are said to be growing in clumps on top of a cliff above a waterfall, where at one stage 20 to 30 plants were seen flowering around late December or early January. The medium yellow flower is star-shaped and offsets fairly well. It is at this stage undistributed.

Photo: Sean & Terri Chubb

'Whyte Yellow'

'Whyte Yellow'

This plant was found about 20 years ago on a farm in the Upper Tongaat area of KwaZulu-Natal, along the Umhlali River. When self-pollinated it produces green base seedlings. The berries ripen yellow and the plant produces 12 to 14 flowers that hang in a very open pendulous umbel at the end of long pedicles.

'Mvuma Yellow'

This plant was collected by Ian and Colleen Goble on their farm Mvuma, upper Tongaat, KwaZulu-Natal, during September 1978. The flower opens with a green tinge and changes to a beautiful yellow that fades to a creamy yellow

'Mvuma Yellow'

with age. This robust, upright plant has full flowers with rather broad petals. It is not a true-breeding yellow. It has not been distributed.

'Oribi Yellow'

Mrs. Nilssen was a Primary School teacher on the KwaZulu-Natal South Coast and she owned the farm Gibraltar in the Oribi Gorge where wild *Clivia* grew. She informed Mick Dower that this plant had come up amongst orange plants that she had grown from seed collected from the habitat. It has leaves approximately 6 cm wide. It has no green colouring in the flower but as it ages these very beautifully shaped flowers take on a distinct pink blush. Mrs. Nilssen died a couple of years ago and Mick mentions that the mother plant has not been traced and nobody else has a piece of this clone except him.

'Oribi Yellow'

Photo: Sean & Terri Chubb

'Ndwedwe Alpha Thurston'

Photo: Sean & Terri Chubb

'Ndwedwe Beta Thurston' (see overleaf)

'Ndwedwe Alpha Thurston'

This plant was found in August 1985 in the Upper Tongaat area of Indwedwe growing high up on the rock face above the Mona River. A robust plant, it has rich cream coloured flowers which are closely bunched together giving the umbel a good shape. There are up to 29 flowers in an umbel and they have a faint scent. When Sean Chubb crossed this plant with a range of yellows from other groups the stems of the resulting seedlings were all pigmented. However, seedlings with unpigmented stems were produced when it was self-pollinated. They flowered yellow, as do the seedlings that are produced when the F1s are sibling-crossed or back-crossed to the mother plant. Sean has defined this group of yellows as "Alpha Group", because of their distinctive breeding behaviour.

'Ndwedwe Beta Thurston'

This yellow was found September 1986 in the same area as the 'Ndwedwe AlphaThurston' lower down on the same krantz. Again there were no suckers and no fruit from a previous flowering. The plant is not as robust as 'Alpha' and has only produced one sucker since discovery. It produces up to 15 flowers per umbel. The flowers are not as closely bunched as 'Alpha'. When selfed or crossed with Group 1 or Group 2 it produces pigmented seedlings.

'Port St Johns Yellow'

The original 'Port St Johns Yellow' plant was collected in the mountains near the Umzimvubu River mouth at Port St Johns by Mr. Bill Strachan of Umtata in the Eastern Cape. In 1964 Neville Wylie obtained an offset of the plant from Mrs. Mona Heard of the farm Hluleka, near Port St Johns, who had received a plant from Bill Strachan some time previously. Mrs. Heard's plant consisted of about a dozen mature growths in a large clump. The plant has narrow leaves and produces offsets regularly. About seven flowers are borne in each umbel, and the individual flowers have narrow petals with no gap between petals and sepals. Old or rain-damaged blooms show small orange spots. The seed is large with one to three seeds per berry and mostly up to three berries per umbel. The flowers are self-fertile and produce about 50% yellow offspring. When crossed with other Group 2 yellows nearly 100% yellows result.

'Centani Yellow'

This plant was found by Rodney Ellis of East London in about 1985 in a typically small forest approximately 5 km east of Centani village in the Eastern Cape. The plant is of medium size, offsets freely and needs to be repotted every 3 to 4 years. The forest where the plant was found no longer exists. It was apparently razed by the local populace and has reverted to grassland. This clone is fertile but the progeny are orange.

'Qora Yellow'

This plant was also found by Rodney Ellis during September 2003 in a forest in the Qora River valley close to the coast. Other plants in the area were predominantly orange although there were also pastels. The plant is sterile but very little else is known about it and it has as yet not been distributed.

I have been unable to prove that 'Noyce's Yellow' (the so-called 2nd Eshowe Yellow'), 'Watkins Yellow' and 'Cynthia's Best' are out of habitat. However, because there is confusion concerning the origin of these strains I felt it fitting to treat them as well.

'Noyce's Yellow' Strain

This plant was first grown by an Eshowe doctor (name unknown) who had received it from a grateful patient. It was also grown at the Eshowe Hotel over the period 1920 /1925 by a Mrs. Russell. Mrs Russell gave a plant to Mrs. Gladice Munroe and her son John Munroe. This plant was passed down to all the Munroe family members. It is from this source that Sean Chubb acquired his clone.

During April 1955 Mr. and Mrs. Faircliffe of Hilton, KwaZulu-Natal, bought a clump of *Clivia* grown in a half drum from the retired widow of an Eshowe doctor then living in Pietermaritzburg. The plants were advertised in the Farmer's Weekly as "Rare plants for Sale". In turn, Michael Noyce purchased the clone from the Faircliffes. This magnificent robust plant with well-proportioned flowers on a tight umbel has the added characteristic of breeding true yellows when selfed.

Table 1: Yellow clones and their synonyms

Clones	Group	Synonyms
Eshowe Yellow	1	Saunders Yellow
Mare's Yellow	1	Howick Yellow
Dwesa Yellow	2	Bashee Yellow, Transkei Yellow, Smith's Yellow, Tsolo Yellow, Floradale Yellow
King Hamelin Yellow	1	
Byrne Valley Yellow	Unknown	
Natal Yellow	2	Giddy Yellow, Fred Gibello Yellow, Jardine Yellow, Swellendam Yellow, Höll Yellow, Stella Parish Yellow
Blinkwater Yellow	1	Karkloof yellow
Crookes Yellow	Unknown	
Mpumulo Yellow	1	
Whyte Yellow	Unknown	
Mvuma Yellow	Unknown	
Oribi Yellow	Unknown	
Ndwedwe Alpha Thurston	"Alpha"	
Ndwedwe Beta Thurston	Unknown	
Port St Johns Yellow	2	Very similar to Dwesa Yellow
Centani Yellow	2	Very similar to Natal Yellow
Qora Yellow	Unknown	

'Watkin's Yellow' Strain

Hal Watkins of Hilton had both Mare's Yellow and Noyce's Yellow and from these two clones bred Watkin's Yellow. This is a robust, free-flowering plant, which has a compact umbel of well-formed flowers carried well above the leaves. When selfed, the Watkins Yellow produces yellow-flowering plants. Therefore 'Watkins Yellow', which is an F2 plant, is a Group 1 clone. In view of the fact that both these clones have been available for more than a century, this cross must have been made in the past in South Africa as well as in other countries.


'Cynthia's Best'

Photo: Sean & Terri Chubb

'Cynthia's Best' Strain

Another Giddy yellow that deserves mention is 'Cynthia's Best', which she bred and named, and is still to be found in her collection, maintained by her daughter Caitlin Leach at Bathurst in the Eastern Cape. A plant of this F2

Strain was bought from Cynthia by Norman Weitz on 14th April 1984. Wessel Lötter noticed that this plant was a Group 2 as it had a red streak on one of its tepals and the berries were yellow and pink. Cross-pollination with 'Natal Yellow' proved that this was a second clone of the 'Natal Yellow' genotype, which is a Group 2. All seedlings were unpigmented and when some flowered during 2002 they were indeed yellow. This strain of yellow with its exceptionally pretty flower has been named 'Cynthia's Dream'.

Acknowledgements

I would like to thank the following persons and *Clivia* enthusiasts for their willing and kind co-operation with this undertaking: Mick Dower, Roger Dixon, Rodney Ellis, Claude Keytel, Rudo Lötter, Robert Moss, Chris Saunders, Gerald Schofield, Brian Tarr, Val Thurston, Dr Bing Wiese, Norman Weitz and Neville Wylie. In particular I must make particular mention of Sean and Terri Chubb, without whose knowledge and unselfish devotion to the task of timeously preserving naturally occurring *Clivia* out of habitat the task of recording the provenance of these plants, and indeed their identity, would have been very difficult.

Reference

Bayer, A., (1979). *Flower Paintings of Katharine Saunders*. The Tongaat Group Limited, p. 154-155.

Photo: Claude Felbert

A Light Orange / Apricot where the flowers get paler as they age. Note the distinct difference between the colour of the two inflorescenses. John Winter has bred this F_1 from a Jim Holmes Yellow crossed with a Kirstenbosch Garden Plant which has a compact crown and short leaves. The F_2 generation will flower in 2005.

Clivia miniata — Colour Mutations and their Breeding

Sean Chubb, South Africa

I don't profess to be a geneticist or to know very much about the way in which colour is inherited in *Clivia*, but by taking the very simple approach of line breeding and a lot of trial and error over many years I have managed to produce true-breeding lines of *Clivia*. I have decided to share what I have learnt with others, in the best interests of *Clivia*. I trust that breeders wishing to perpetuate a particular colour mutation will find it of value.

It is my opinion that, for a particular colour mutation to be inherited by sexual reproduction a pathway has to occur – i.e. the genes or other factors influencing the colour have to line up. A simple way in which to view the chromosomes, and the loci on which these chromosomes have mutated, is by taking two rulers and placing them side by side, each representing different plants with similar colour mutations. Only if both plants have mutated on the same point of the chromosomes, that is they line up at the same place on the rulers, would the mutation be transferred to the offspring by sexual reproduction.

Some plants are relatively easy to line-breed / inbreed because of the fact that they can be self-pollinated. Unfortunately with others, mechanisms seem to be in place that inhibit self-pollination. More effort is required to perpetuate these colour mutations.

The best-known colour mutation in *Clivia* is the yellow mutation occurring in *Clivia miniata*. Even here just because two plants are yellow doesn't necessarily mean they have mutated at the same locus on the chromosome. If they haven't, they will not produce yellow-flowering offspring if bred together.

Bill Morris classified the two best known yellow mutations as Group 1 and Group 2 yellows. These groups produce homozygous yellow flowering offspring if bred within their group but revert to orange when bred across the groups – i.e. where the groups have mutated at different points/loci on the chromosomes. Phenotypically (externally) these yellows are very similar but genotypically (in their genes) they are very different. Any yellow flowering *Clivia miniata* mutation should not be presumed to belong to one group or another, since many groups exist. These yellows should be tested by controlled breeding with plants from known groups before they can be classified into a group. Probably 99%+ of all yellow *miniata* available worldwide would be Group 1, the remaining 1% made up of 0.9% Group 2 yellow, with the remaining 0.1% falling into numerous other groups.

Examples of these other groups are:

- A group which I call Group 3: The plants display yellow flowers but develop red berries and show maroon stem pigmentation in both seedlings and adult plants. Work is still in progress to classify which and how many clones belong to this group.
- A further group is named in my breeding programme as "Alpha group". This group consists of plants which have mutated on the same point as Ndwedwe Alpha, a wild collected clone. All known plants in "Alpha group" thus far are direct descendants of 'Ndwedwe Alpha'. When bred together these plants give rise to unpigmented seedlings and resulting yellow flowering plants.

Even yellow plants wild collected in the same area do not necessarily belong to the same group. Examples of this feature are: 'Ndwedwe Alpha' belongs to "Alpha group" but 'Ndwedwe Beta' and 'Ndwedwe Echo', both wild originated from the same area don't belong to the same groups.

There are other wild collected yellow clones which do not seem to be part of any of the known groups and will have to be trial-bred with other yellows to be classified into groups. Perhaps many of them will be a group on their own, but time and carefully controlled trial breeding will prove this.

My approach to a yellow-flowering plant with unknown genealogy is to self-pollinate the plant, and to use it's pollen on known groups of plants, for example Group 1 and Group 2 (the two most common groups of yellows). The results of these crosses will then guide the breeding programme in the direction which would best perpetuate the colour mutation. Self-seedlings flowering the same colour as the parent should be selected and the breeding programme continued. Even if the offspring don't flower the same as the parent, the best seedlings should be selected and line bred back to the mother plant. This would give more desirable results. Remember, not all yellow-flowering groups produce unpigmented seedlings. A clue to this would be berry colour on the flowering plant. Red berries on yellow flowering plants can give rise to pigmented seedlings, which eventually flower yellow. If pigmented seedlings are produced when the unknown yellow is crossed with both Group 1 and Group 2 yellows, it can safely be assumed that the plant belongs to another yellow pigmentation group.

Not all naturally occurring clones of whatever group are worth perpetuating in any numbers, since they may be inferior to the existing yellow clones and hybrids already available. 'Ndwedwe Alpha' is spectacular and is a first class plant; thus the "Alpha group" line breeding is being continued in an attempt to perpetuate the excellent qualities in 'Ndwedwe Alpha'.

Colour mutations occur naturally in *Clivia miniata* populations, although very rarely. Mutations have been found in wild populations as well as in "chance" seedlings in commercially grown *Clivia* populations. These mutations include a large variety of colours including Peach, Pink and Apricot, as well as colour-related features such as Bicolour, Picotees, and many more.

The approach I take with plants with these colour mutations is to self-pollinate them and also to cross them with as many similarly coloured plants as possible, in the hope that some may have mutated on the same locus on the chromosome and will thus result in seedlings with a similar colour to the original parents.

'Emmie Wittig Pink'

What follows is an example of successful line breeding. Over the past nine years I have had the pleasure of being able to work with the plant 'Emmie Wittig Pink'. Described by Harold Koopowitz in his book Clivia as "the clearest and truest pink I have ever seen", this plant has delicate pink flowers, maroon berries and it's offspring seem to revert to orange. I first acquired a plant in 1996 from Mrs Emmie Wittig. My plant was self-pollinated and also crossed with other known groups of yellow mutation *Clivia miniata*.

All resulting offspring were pigmented as seedlings and produced orange-flowering plants (cross-pollination and selfing may have occurred as the pollination was not completely controlled). The best of the orange seedlings were selected and 'Emmie Wittig Pink' was used as a pollen parent onto these plants. The resulting offspring were interesting from the start, producing ⅓ unpigmented, ⅓ lightly pigmented and ⅓ heavily pigmented seedlings. These were grown to maturity, with all unpigmented seedlings producing pink-flowering plants. Some are similar to the original 'Emmie Wittig Pink', some are better, and a good percentage poorer. The pigmented seedlings, dark and light, produced normal orange flowering plants. The pink offspring were then crossed back to their mother, and also to siblings. Resulting seedlings are all unpigmented and it can be said that they will flower pink. A true-breeding line of pink *Clivia miniata* has thus been produced by breeding amongst related plants carrying the 'Emmie Wittig Pink' gene.

It is important, when using line breeding as a tool, to select seedlings carefully, to keep good records, and to note loss of vigour and other recessive undesirable genes which may occur in seedlings. Breed plenty but select only the best for further breeding. The more selection pressure placed on the seedlings the quicker the desired results will be achieved.

I first used line breeding/inbreeding to produce my line of true-breeding 'Chubb Peach' plants and have subsequently used it in many other lines with good results. Using these line breeding practices, it could be said that any *Clivia miniata* mutation or colour form can be reproduced as a true-breeding line within 5-9 years.

Photo: Courtesy NZCC.

'Chubb Peach' from New Zealand. Owner: Keith Hammett.

Have Genes, Will Travel — on the Trail of 'Vico Yellow'

Roger Dixon, South Africa

The first record of yellow-flowered *Clivia miniata* was in 1888 when a plant was displayed in Ghent at a show and was referred to as *Clivia sulphurea* (Anon., 1888). The report (in German) reads "In Ghent a colour novelty was praised – *Clivia sulphurea* Laing & Sons. We believe, however, that lasting success can only be expected from either a pronounced red or a pure white variety. All intermediate varieties which are yellowish or reddish in colour will disappear as fast as they pop up." As this was an informal description, the name is not officially recognised. At around the same time, a yellow-flowered plant was discovered in habitat in Eshowe in KwaZulu-Natal, and was subsequently formally described as *Clivia miniata* var. *citrina* in 1899 (Watson, 1899). This plant had been sent to Kew Gardens around 1893 (Bayer, 1979) and had also been distributed around Pietermaritzburg at the same time, where it has been in cultivation ever since (Gooding, 1964; Smithers, 1995) as 'Eshowe Yellow' (Van Niekerk, 2005).

Most probably due to the fact that journals dealing with botanical taxonomy were not widespread at the time, and an article published in one magazine might not be available to all botanists, another yellow-flowering plant from Eshowe was described in 1931 as *Clivia miniata* var. *flava* (Phillips, 1931). According to Phillips 'Mr Saunders informs us that one or two plants were found in the Eshowe Forest, Zululand,

'Eshowe Yellow' by Mairn Hulme (Hulme, 1954).

Clivia miniata var. *citrina* by H.G. Moon, from the original description from Watson (1899).

[illegible]

Clivia miniata var. *flava* by Cythna Letty from Phillips (1931).

Courtesy SANBI Collection

about the year 1888, and a number of plants have been propagated from these originals. Plants were propagated from seed, but took many years before they flowered. Mr. Saunders also informs us that two or three years ago a plant flowered at the Royal Botanic Gardens, Kew, but as far as we are aware has not been figured. The fact that all plants raised from seed have yellow flowers indicates that we are dealing with a pure strain; but except for the colour of the flowers we have not been able to detect any tangible characters which would separate it from *C. miniata* and have therefore kept it as a yellow variety.'

The plant described by Phillips was received from Mr B Nicholson of Swaziland, who had obtained it from Mr C R Saunders, the source of the original '*citrina*'. The plant that flowered at Kew had also been received from Saunders in October 1925 by The Hon. Lewis Palmer of the Royal Horticultural Society, who gave it to his father-in-law Lord Wakehurst who exhibited it at an RHS meeting in 1927 or 1928 under the epithet of '*citrina*'. Apparently this plant flowered, amongst orange-flowering plants, set seed and then died. The seeds flowered orange, but Charles Raffill of Kew started a program to breed back the yellow flowers. After some years he succeeded, and the resulting yellow-flowering plant was named *Clivia x Kewensis* 'Cream'. It, and others of the same breeding, had significantly larger flowers than the normal *C. miniata*, and much larger umbels. This is most probably due to the fact that Raffill would have used the best available orange plants in order to produce a better yellow that the original, and since *C. miniata* had been in Europe since the 1850's the original wild-collected material had been much improved upon.

The improvement of *C. miniata* was avidly pursued from the 1870's through until the early 1900's, and a number of excellent quality clones were bred, named and illustrated in this period. The most outstanding of these was 'Lindeni', the seedlings of which were highly sought after and gave rise to numerous new clones with large umbels, large flowers and broad leaves (De Coster, 1998). Its genes are thought to be widespread in the background of most modern *Clivia miniata* of European breeding (Koopowitz, 2002). One such clone

Clivia miniata 'Prince Albert'. A cross between C. 'Madame Donner' and C. 'Chevalier Heynderycx', exhibited by M. Charles Vermeire, horticulturalist in Gendbrugge, at the Exposition Internationale of Ledeberg (from L'Illustration Horticole, 1896).

might have been 'Prince Albert', which was originally figured in the Belgian publication *L'Illustration Horticole*.

Photo: David Brundell

Sir Peter Smithers pollinating 'Vico Yellow' at Vico Morcote in 1986.

In 1971 Sir Peter Smithers obtained a plant of *Clivia x Kewensis* 'Cream' and two of its orange siblings, *Clivia x Kewensis* 'A' and *Clivia x Kewensis* 'B'. He cross-pollinated these plants and raised a number of seedlings, most of which flowered orange. However, a later seedling flowered yellow. This was of much better quality than the original 'Eshowe Yellow' and he sent a plant to Dr Shuichi Hirao in Japan. This plant was of such superior quality that it became quite famous in Japan, and was referred to as 'Smithers' Yellow' (Smithers, 1995; Koopowitz, 2002).

In July 1986 David Brundell, a horticulturalist from New Zealand, visited Sir Peter at his home in Vico Morcote, Switzerland, and was given a piece of this yellow-flowering plant. After arriving back in New Zealand, David wrote to Sir Peter informing him that the plant had been placed in quarantine for a year. In reply, Sir Peter said:

"I am glad the yellow Clivia made it and hope they won't kill it in quarantine. We ought to name it, and in my opinion a name ought to tell us as much as possible about the plant: The Hon. Mrs. George Bumbleshutz tells us very little except that the lady was probably gratified, as I was when a Magnolia was called for me in the U.S.A.! What about 'Vico Yellow'? This gives us a clue as to its colour and where it originated."

'Vico Yellow' flowering in New Zealand in 1988.

David replied:

"I agree, your Clivia should be named 'Vico Yellow'. It is most suitable and will be used henceforth. Last week a researcher from a Japanese seed company sent me an original copy of the Journal of the Japanese Horticultural Society that had 'Vic Yellow' on the cover. For your information, the Japanese actually refer to it as 'Smithers Yellow'"

'Honey Moon', an F1 'Vico Yellow' hybrid. This was runner-up Peoples Choice at the New Zealand Clivia Club Show in 2004.

Yoshikazu Nakamura, who took over Hirao's *Clivia* plants, requested permission from Sir Peter to breed from the plant " 'Smithers' Yellow', world's best yellow *Clivia*, the one to beat". As 'Vico Yellow' the plant was micro-propagated by Miyoshi & Co. and the tissue-cultured plants were widely distributed. However, some growers have noted quite a variation in the flowers of the tissue-cultured plants and it would be interesting to find out which particular part of the plant was used in the propagation. In 1989 another yellow seedling of Sir Peter's breeding flowered, which he said was "a better plant than the original 'Vico Yellow'. He named it 'Vico Gold' and sent a piece to Nakamura, who used it in his breeding program. The influence of 'Vico Yellow' and its progeny emanating out of Japan has been enormous, and many modern clivias today include 'Vico Yellow' in their ancestry.

David's plant of 'Vico Yellow' flowered for him in 1988 for the first time, and he then started breeding with it. One of the important aspects of 'Vico Yellow' is that it imparts its robust character to most of its offspring, and this is a dominant characteristic which results in a great improvement in flowers, when used as either pod or pollen parent. The leaves of the clone are long and broad. Another characteristic is that it produces offsets fairly freely, just like the original 'Eshowe Yellow' plant.

Nakamura has used 'Vico Yellow' as a pollen parent because:

- its hybrids produce large flowers with good shapes
- its hybrids produce a well reflexed tepal
- its pollen is very compatible and results in a good seed set with large seeds.

According to him using 'Vico Yellow' as a pod parent with self-pollination does not result in a good seed set.

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I would like to thank Fred van Niekerk for stimulating my interest in yellow *Clivia*, which I used to consider boring, and providing me with obscure information; David Brundell for his enthusiasm and information, including access to his personal archives; John van der Linde for his support and help in locating references; Alberto Grossi for sourcing and providing the illustration of 'Prince Albert', and Roger Fisher for his assistance in sourcing and providing the illustration of *flava*.

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Accent on


Photo: Helen Marriott


Photo: Keith Barlow


Photo: Helen Marriott

Single Flowers

Photo: Keith Barlow

Photo: Keith Barlow

Photo: Karen de Jager

Photo: Sharron Booth

Photo: Helen Marriott

Photo: Gordon Fraser

Photo: Keith Barlow

Photo: Keith Barlow

Photo: Keith Barlow

Photo: Kevin Mansfield

Photo: Karen de Jager

Photo: Gordon Fraser


Photo: Gordon Fraser


Photo: Chris Welgemoed


Photo: Keith Barlow


Photo: Chris Welgemoed


Photo: Keith Barlow


Photo: Keith Barlow

New Developments in Clivia Breeding in Japan

Shigetaka Sasaki, Japan

New *Clivia* in Japan

Yoshikazu Nakamura has bred numerous *Clivia* hybrids that have enchanted us with their beautiful flowers. This time, I would like to introduce you to another significant *Clivia* breeder, Toshio Koike, who has also bred brilliant flowers by using different materials in his breeding program. I will also inform you about Nakamura's latest breeding results.

Green flower 'Hirao'

Koike owns a nursery in Gifu prefecture that sells many pot plants other than *Clivia*. For his *Clivia* sales, he mainly sells his original cultivar called 'TK Original'.

Photo : Shigetaka Sasaki

Clivia miniata - 'TK Original'.

The above *Clivia* belongs to Group 2 yellow and sometimes shows the typical red spots on its flowers and berries. He has not used any Group 1 yellows like Vico Yellow that Nakamura has often used in his own breeding program. On the contrary, Koike has only used a Group 2 yellow that he bought from a Japanese flower company for his breeding program and from the F_1 hybrids has bred his original yellow *Clivia*.

Photo courtesy of Shigetaka Sasaki

The author and Ryuko Hirao, widow of Dr. Hirao.

I think that the most beautiful flower bred by Toshio Koike is the green flower 'Hirao' which appears on the back cover of this Yearbook. The cultivar name 'Hirao' comes from the first name of the late Dr. Shuichi Hirao, who was a great gardener and introduced Vico Yellow to Japan. His *Clivia* collection was subsequently taken over by Nakamura, but that is another story.

The cultivar 'Hirao' can be described as a green type of yellow flower which was bred from Group 2 yellows. According to Koike, this flower keeps a beautiful green colour until the middle stage of its bloom. After the pollen sacs burst open on the anthers, the green colour on its tepals disappears gradually and finally becomes cream. In addition, he said that the plant displayed cream flowers several times when its nutritional status was compromised. He indicated that green flowers such as 'Hirao' probably need plenty of nitrogenous fertiliser to promote the growth of chlorophyll.

Koike had bred his Group 2 yellow hybrids for the purpose of getting green flowers for a few years before his first green flower actually appeared. When he was young, he crossed orange flowers with green centres several times and obtained quite a lot of dark orange (so-called bronze colour) *miniata* plants with strong green centers in the F_2 or F_3 generations. In his green flower breeding, he used these dark orange *miniata* as the mother plants. He pollinated these dark orange *miniata* with the pollen of Group 2 yellow, which he had obtained for his breeding. Then, he crossed the F_1 siblings and from this has bred 'Hirao'. Toshio Koike says that the reason why he was able to breed a green flower like 'Hirao' is that he could obtain many bronze-colored miniata and he used them as the mother plants in his breeding.

Photo : Shigetaka Sasaki

Picotee *Clivia miniata* 'Green Impact'

In Japan, there is another green flower called 'Green Impact' that was bred by Toshiyuki Hosoya. He claims to have bred this green flower using a yellow cultivar called 'Ohgonkaku', a Group 2 yellow that gives unpigmented seedlings when selfed. Green flowers might emerge in the future through crossing Group 1 yellows. However, according to the two breeding results reported above, I suggest that crossing Groups 2 yellows might be an effective way to create such green flowers.

Koike also paid attention to the red margins that sometimes appeared on the tepals of his 'TK Original' yellows. He crossed yellows which had these vivid red margins and has bred the flower shown below.

He reported as follows: "I could obtain yellows with more vivid red margins by crossing those yellows with red margins. However, I wonder if this red color might be caused by the tepals being wounded since they graze each other when they open."

Koike hypothesizes that Group 2 yellow flowers might have pre-pigments for anthocyanins in their tepals. Accordingly, Group 2 yellow flowers might show red on the margins of the tepals when the margins are damaged because these pre-pigments react to oxygen and become anthocyanins. He thinks that flowers with thin tepals can be easily damaged, and so he might have bred yellows with thinner margins and these yellows might appear to have redder margins on their tepals. Once when he deliberately injured the tepals of his 'TK Original' yellows, some plants revealed red spots on their tepals while others did not. Thus he concluded that the coloration of red spots might vary among the plants belonging to Group 2 yellows.

Peach interspecific hybrids

Using his 'TK Original' yellow, Koike has bred interspecific hybrids, such as those shown in the photos, which are peach or apricot coloured.

The hybrids shown **(See photos 4 - 5)** emerged from [(*C. miniata* orange x *C. gardenii*) x *C. miniata* orange] x Group 2 yellow. It is very interesting that this peach colour hybrid emerged without the use of 'Chubb Peach' or a peach from the USA. I have the impression that the colouring of Koike's peach and apricot interspecifics is very similar to those peaches that I previously saw in California, bred by James Comstock and Dave Conway.

Nakamura has also bred two peach-coloured hybrids to date in his interspecific crosses but he did not use any peach parent either. Furthermore, both of these peach interspecific hybrids arose

A peach interspecific.

Photo : Shigetaka Sasaki

'Orchid' a spectacular peach and green interspecific.

Photo : Shigetaka Sasaki

An apricot interspecific.

Photo : Shigetaka Sasaki

'Candoll' a peach interspecific with a yellow throat.

Photo : Shigetaka Sasaki

out of *C. miniata* x *C. gardenii* crosses (**See photo 6 - 7**). I feel that the colouring of Nakamura's two peach interspecific hybrids is closer to the delicate peach colour of 'Chubb Peach' that I saw in South Africa three years ago, in comparison with Koike's peach interspecific hybrid or the peaches from California.

According to Nakamura, both of these flowers came from the crosses that he calls 'Candoll'. We do not have the exact breeding records of these plants, but the breeding combination was one of the following three possibilities:

1. *C. miniata* orange x *C. gardenii*
2. (*C. miniata* orange x *C. gardenii*) x self
3. (*C. miniata* orange x *C. miniata* yellow (Group 1 yellow)) x *C. gardenii* x *C. miniata* yellow (Group 1 yellow)

In relation to the potential of *Clivia*, it is very noteworthy that both Nakamura's and Koike's peach flowers came from interspecific crosses using *C. gardenii*. This is a good example demonstrating the potential of *C. gardenii*. I think that this peach interspecific hybrid bred by Nakamura that has the open tepals of *C. gardenii*, just like the shape of an orchid flower, shows us the unlimited potential of *Clivia*.

Furthermore, by breeding a dark coloured peach from a Group 2 yellow and *C. gardenii*, Koike has further opened up the potential in relation to interspecific breeding of both *C. gardenii* and Group 2 yellows. In addition, another different Japanese breeder has bred a peach interspecific hybrid, shown **above**, from Group 2 yellow x *C. gardenii*.

Broad and short-leafed yellows

Lastly, I would like to introduce the broad and short-leafed yellow that Koike has bred using Group 2 yellow and Japanese Daruma. One of the *Clivia* that enthusiasts not only in Japan but throughout the world have been waiting for is the broad and short-leafed yellow. Recently, Chinese *Clivia* have become popular internationally, and many people want *Clivia* with good broad and short leaves. Koike has certainly bred a broad and short-leafed yellow but some more improvements will be necessary before we can actually call it a Daruma. Here I am using my own definition of "Best Daruma". Accordingly, "Best Daruma" applies where the width of the leaf is one, and the length is three, in other words, for Daruma the most beautiful leaf form is where the length of the leaf is three times its width. In summary, then, leaf width 1: leaf length 3 = "Best Daruma". The "daruma percentage" of Koike's broad and short-leafed yellow is leaf width 1: leaf length 4-5, with the best that I have seen having a leaf width of 8 cm and a leaf length of 33 cm.

Koike bred his broad and short-leafed yellow using Japanese Daruma x Group 2 yellow = F_1 orange hybrid.

The length of the leaf of the F_1 orange hybrid from this crossing was clearly shorter than that of the Group 2 yellow pollen parent and the width of the leaf was also definitely wider. However, in comparison with the F_1 orange hybrid, a broader and shorter leaf was evident in the F_2 hybrid made from a sibling cross of this F_1. **(See photos 8 - 10)**

Photo : Shigetaka Sasaki

Toshio Koike's broad short leaved yellow *Clivia* No.1.

Photo : Shigetaka Sasaki

Toshio Koike's broad short leaved yellow *Clivia* No.2.

Photo : Shigetaka Sasaki

The ruler shows the dimensions of these leaves.

Besides these, I have also seen a broad and short-leafed yellow with variegation that was an F_1 hybrid bred by Nakamura's mother, as well as a rather big broad and short-leafed yellow in the greenhouse of the Californian King of *Clivia*, Joe Solomone. According to Nakamura, when he used 'Vico Yellow' (Group 1 yellow) pollen on this short-leafed yellow with variegation (bred by his mother), all of the seedlings were pigmented. I think we can say from this result that there is a high possibility that his mother bred this plant using a Group 2 yellow as the pollen plant. If we used the pollen from a Group 2 yellow in place of 'Vico Yellow' and unpigmented seedlings emerge, then we could say with certainty that the broad and short-leafed yellow variegate was a group 2 yellow.

When I previously visited Solomone's green house he explained to me that all of the yellows he has been producing initially came from a single yellow. He continued breeding from this yellow, selecting his best to produce his own yellow hybrid. If his first yellow was a Group 2 yellow, then the broad and short-leafed yellow that I saw at Solomone's would also have been Group 2 yellow.

Photo : Shigetaka Sasaki

Joe Solomone's broad short leaved yellow.

I have the following hypothesis about Koike's breeding of a broad and short-leafed yellow from crossing Daruma with Group 2 yellow. In the F_1 hybrid yellow that was bred from crossing Group 2 yellow, the gene that determines the yellow colour and the gene that contributes the broad leaf type are independent and exist on different positions on the chromosome. If the gene determining the flower colour in Group 2 yellows and the gene influencing the leaf character were located in the same position on the chromosome and linked together, in addition to the yellow flower of an F_1 hybrid that comes from crossing Daruma and Group 2 yellows, we could expect a narrow leaf that is also characteristic of Group 2 yellows.

The above is just an hypothesis but from Koike's breeding of a broad and short-leafed yellow we can say that using Group 2 yellow in the breeding is the most effective method at present.

Through his breeding with Group 2 yellows of such *Clivia* as the green flower 'Hirao', the peach interspecific hybrid, and broad and short-leafed forms, Koike has shown us the high potential of this type of yellow. The breeding results of both Nakamura and Koike in Japan are likely to become the basic reference for the future breeding of unique *Clivia* hybrids.

This article is based on the author's presentation at the Huntington Clivia Symposium in March 2005. **Eds.**

Photo : Yoshikazu Nakamura

A Nakamura variegated yellow.

Photo : Shigetaka Sasaki

A *Clivia gardenii* cross produced this lovely peach.

Fungal Pathogens Associated with Clivia

Wijnand Swart, South Africa

Background

The following objectives were identified in a research proposal submitted to the Clivia Society during 2004:

- A systematic survey of organic organisms occurring on *Clivia* spp.
- Screening of *Clivia* genotypes for disease resistance.
- Screening fungicides and biocontrol agents for controlling *Clivia* diseases.

This report is a reflection of the most significant results obtained following the diagnosis of diseased *Clivia* leaves received during the course of the past 14 months at the NCPP laboratory of the Centre for Plant Health Management, UFS in Bloemfontein.

Modus operandi

- Samples were mostly received by post and kept in a refrigerator at 5°C pending examination.
- Prior to being manipulated for diagnosis all samples were photographed with a digital camera.
- Samples were then examined under a light microscope for any signs of fungal structures which would point to the presence of a possible pathogen.
- Samples were subsequently surface disinfected with 95% alcohol and 3% NaOCl (Jik) in order to remove any epiphytic or saprophytic fungi and bacteria on the surface of the leaves. This is standard plant pathology practise and a prerequisite for the isolation of micro-organisms from plant tissue.
- Small sections of diseased tissue (*ca.* 10 mm^2) were removed from the disinfected leaves and placed on corn meal agar (CMA)(2% strength) plates (Fig. 1A) to allow for the growth of fungi from inside the tissue.
- The remaining portion of the symptomatic leaf was then incubated in a humidity chamber at 25°C to allow for the development of fungal structures that might not grow on agar.
- Fungal colonies that emerged from the tissue pieces were selected according to their potential for being pathogens and sub-cultured on CMA plates for the next phase of diagnosis (Fig. 1B)
- Fungal structures that developed from leaves incubated in the humidity chamber were examined under a light microscope at 200-400x magnification and cultured on agar plates where possible.

Photos: Courtesy Wijnand Swart

Fig. 1. Growth of fungi from pieces of Clivia tissue in corn meal agar viewed from above(A) and below(B), and growth of a single sub-cultured colony on agar seen from above(C).

- The final phase of diagnosis involved the inoculation of a healthy plant with the isolated putative pathogen. This is in accordance with Koch's Postulates (KP). Where fungi were saprophytes KP was not performed.
- Potted plants obtained specifically for this purpose were inoculated in the glasshouse.
- Assays of detached leaves were also performed in the lab.
- Plants were observed for the development of symptoms similar to the original symptoms from which the fungus was isolated.
- The final phase was re-isolating the original fungus from symptoms on the inoculated plants.
- Failing the development of symptoms no firm diagnosis can be made and the primary cause of the symptoms remains open to speculation.

Results

Twenty seven samples of diseased *Clivia* tissue parts displaying various symptoms were received from *Clivia* growers throughout South Africa. Twenty four of these samples were of diseased leaves while two were of diseased roots and one of a diseased stem. A database of photographic images of symptoms and their putative/confirmed biotic or abiotic causes was compiled from this information.

Sample type 1

Each representative "sample type" is be depicted and discussed below.

- Lesions on leaf characterized by small black fruiting bodies containing spores and indicative of primary or secondary fungal colonization.
- Incubation of leaves and inspection of fruiting bodies revealed a *Phoma* sp. Isolation from tissue also yielded a *Phoma* sp.
- Koch's postulates were performed but no symptoms developed.
- Based on these results we can tentatively conclude that a *Phoma* sp. was associated with the symptoms but in a secondary capacity.
- The fungus isolated from the lesions is therefore:Probably a saprophyte and not associated with the onset of disease, or
- A very weak opportunistic pathogen not able to cause disease on a healthy undamaged leaf.
- No fruiting bodies were visible thus only tissue isolation was conducted.
- Isolation revealed only *Alternaria tenuissima*, a known leaf pathogen of plant hosts but also a facultative saprophyte.

Sample type 2

- Koch's postulates did not confirm the primary role of *A. tenuissima* as a pathogen.
- The conclusion is therefore that the primary cause was abiotic and either physiological (e.g. too many salts in soil or water) or possibly physical such as sun scald.
- Physiologically induced damage is either due to a mineral deficiency or toxicity and can lead to the plant becoming weakened with the result that opportunistic pathogens are able to colonize it.

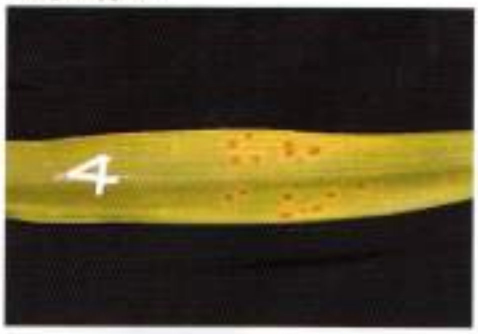
Sample type 3

- No fruiting bodies visible.
- The leaf damage was physical indicating the possibility that insects were the primary cause.
- Isolations revealed only the presence of saprophytes.

Sample type 4

- Leaf rot
- Only saprophytic fungi and bacteria isolated.
- Primary cause difficult to determine but could be mechanical with secondary bacterial infection.
- Samples that are in this condition are usually very difficult if not impossible to diagnose.

Sample type 5



- Symptoms described as leaf spots characterized by chlorosis surrounding the necrotic area.
- No fruiting bodies observed and none developed following incubation in a humidity chamber.
- These symptoms are more indicative of pathogen activity than the previous three types.
- They are not typical of a nutrient deficiency or toxicity.

- Isolation revealed *Colletotrichum* sp. but KP was negative.
- Possible cause in light of negative KP is very difficult to speculate on but it is also probably an insect with sucking/piercing mouthparts.
- Too localized to be a virus.

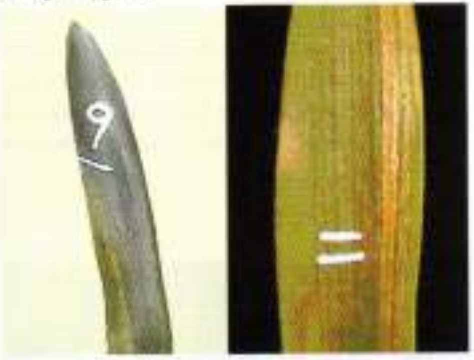
Sample type 6

- Very obviously insect damage with biting/chewing mouthparts.
- Small black spots are also insect damage but similar to sample type #4 although lacking chlorosis around penetration sites.
- Isolation from tissue revealed no fungi.

Sample type 7

- Leaf necrosis
- Isolation from the lesions revealed no fungal pathogens only saprophytes.
- KP not conducted.
- Atypical of nutrient deficiency or toxicity.
- Possible cause is insect damage.

Sample type 8



- No fungal pathogens isolated from tissue displaying the above general symptoms.
- Not typical of nutrient deficiency or toxicity.
- Cause is presumably physiological but could be a virus as well.

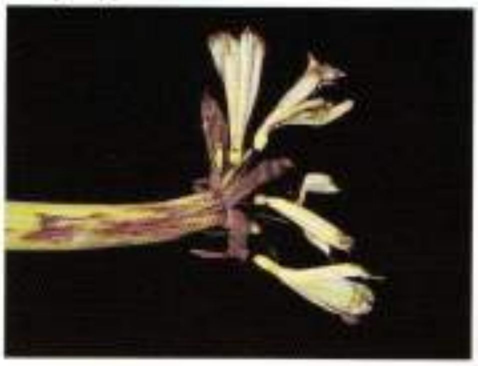
Sample type 9

- Basal stem rot : *Fusarium oxysporum* was isolated from tissue adjacent to the rotting tissue.
- KP negative.
- Cause therefore unknown although bacteria cannot be excluded despite the fact that we did not isolate bacteria on the specific medium we used in this instance.

Sample type 10

- Basal stem rot
- Isolation revealed saprophytic fungi and bacteria only that are both secondary.
- Primary cause is there probably mechanical damage during handling or transplanting.

Sample type 11



- Stem damage
- Physical damage caused by insects or other mechanical means.

Discussion

- The symptoms depicted above are in most cases indicative of physical tissue damage (i.e. insect damage, sun scald, etc.) or physiological problems associated with nutrient deficiencies.
- The fact that no fungi isolated from symptomatic tissue could induce the same, or any, symptoms substantiates this statement. The fungi that were isolated from certain samples, *Fusarium oxysporum*, *Alternaria tenuissima*, *Colletotrichum* sp., and *Phoma* sp. are known facultative parasites - meaning they are primarily saprophytes - living as epiphytes on leaves or in the soil - but able, under conditions of stress in the host plant (physiological, wounding, etc.) to induce disease.
- These specific species of fungi may also have an endophytic phase in their hosts meaning they exist in intercellular spaces where they feed on sugars that occur there naturally. Only when the host is exposed to stress (such as nutrient deficiencies) or ageing and the metabolism of the host is no longer able to suppress pathogenicity, do they express themselves by causing symptoms. This avenue of research is currently being pursued by a Master's student working under supervision of myself and Prof. Johan Spies of the UFS. **It is possibly the most important investigation on *Clivia* diseases at present and crucial to understanding the dynamics of disease in this particular plant. Funding for this project is therefore of crucial importance to the successful diagnosis of *Clivia* diseases.**
- In one instance only (sample type 8) were symptoms possibly due to a virus. This could not be confirmed however since the techniques to identify a plant virus are expensive and not possible within the confines of the present budget.
- Although bacteria were isolated from rotting tissue they are probably of a secondary nature (i.e. saprophytes) due to the advanced decomposed state of the tissue concerned.
- Due to the fact that pathogenicity could not be confirmed with any of the organisms isolated, the second and third objectives of

the present project could not be conducted as these require a confirmed pathogen for the experimental phase of the research.

Recommendations

In view of the fact that no specific pathogens were identified in the present study it is not possible to make specific recommendations. However, there are many ways by which healthy plants can be maintained. These will be discussed briefly below:

- Sanitation is probably the cheapest and safest method of controlling the spread of disease in a population of plants. Physically removing the bulk of symptomatic plant parts and destroying them or removing them entirely from the area.
- Spray regularly with an appropriate systemic (e.g. benomyl) or general fungicide (e.g. Dithane) to prevent opportunistic pathogens from causing infection to weakened/stressed plants.
- Keep a sharp eye out for insects that feed on plants - by night or day. Treat with a suitable insecticide.
- Be careful not to water too much or too little as this is an important cause of stress in plants.
- Do not expose plants to too much or too little sunlight.
- Resort to regular tests of the nutrient status and pH of soil/potting mixtures as well as the electrical conductivity (EC) of irrigation water. This is an extremely valuable indicator of which salts are present and their concentration, which if too high is the cause of toxicity problems that present themselves as symptomatic leaves.
- It is also a good idea to adapt the fertilizing of plants to the nutrient status of leaves. This, together with soil and water analyses is an excellent way in which to maintain the general health of plants.
- Good hygiene is also important. Wash hands before handling healthy plants after you have worked with sick plants. Sterilize garden tools after using them around diseased plants. Plant viruses can reach a *Clivia* plant through an insect or from the hands or unsterile tools of a gardener.

Photo Tony Barnes

Wouldn't we all like to make a meal of this delectable fruit salad dish!
The different colours of these fruits only hint at what the result of sowing this seed might be in four years time.

The Clivia Society

www.cliviasociety.org

The Clivia Society caters for *Clivia* enthusiasts throughout the World. It is the umbrella body for a number of constituent Clivia Clubs and Interest Groups which meet regularly in a number of South African cities and towns. In addition, the Society has individual members in many countries, some of which also have their own Clivia Clubs. An annual Yearbook and regular Newsletters are published by the Society. For information on becoming a member and / or for details for the following Clivia Clubs and Interest Groups contact the Clivia Society secretary or where appropriate, the International Contacts, at the addresses listed below.

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