CLIVIA YEARBOOK 1998

ACKNOWLEDGEMENTS

The Clivia Club acknowledges with appreciation the consent given as follows to publish the photographs printed in this Yearbook.

Mr Yoshikazu Nakamura, Clivia Plantation, Mobara-city, Japan:

Page 1: Photograph 1; Page 11: Photographs 3 and 4;
Page 21: Photographs 8 and 9; Page 22 Photographs 10 to 13;
Page 23: Photographs 14to 17; Page 29 Photographs 18 to 20;
Page 30: Photographs 22 and 23; Page 35 Photograph 27;
Page 37: Photographs 32 and 33; Page 43 Photographs 36 to 38;
Page 44: Photographs 39 and 40; Page 50 Photographs 41 and 42;
Page 51: Photographs 43 to 45;

Mr Graham Duncan, National Botanical Institute :

Page 12: Photographs 5 and 6; Page 35: Photographs 24 to 26;
Page 61: Photographs 48 and 49; Back cover

Mr John Winter, National Botanical Institute :

Page 61: Photograph 50;

Mr Jean-Luc Bestel:

Page 12: Photograph 7; Page 38: Photograph 34;

Mr Wessel Lotter :

Page 11: Photograph 2; Page 30 Photograph 21;
Page 36: Photographs 28 to 30; Page 37 Photograph 31;
Page 52: Photograph 46; Page 62 Photograph 53;
Page 64: Photographs 54 and 55; Page 72 Photographs 56 and 57;

Mr Jim Holmes, Cape Seed and Bulb:

Page 38: Photograph 35; Page 64: Photographs 54 and 55;

Mr Bob Adshade:

Page 52: Photograph 47; Page 62: photographs 51 and 52;
Page 72: Photograph 58;

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Nakamura Hybrid 1

The naming of plants in this publication is informal and subject to official recognition.

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Mr Nakamura presented his address in the form of slides. A selection of those slides, as well as others, are printed throughout this publication.

EDITORIAL

The genus clivia is endemic to South Africa. It consists of four species, three of which i.e. *C. nobilis, C.gardenii* and *C.caulescens* are pendulous-flowered. The fourth, *C.miniata,* is the most well known and generally considered the most attractive.

Lindley named the genus clivia in 1828, in honour of Lady Charlotte Clive, Duchess of Northumberland who flowered *C.nobilis* in her conservatory in England.

C.miniata was collected in the forests of Natal and sent to Kew in 1853. It became a popular indoor plant in Europe where horticulturists developed and named a number of hybrids and colour variants.

Although their popularity waned when they did not thrive in the new era of air conditioning, specialist breeders at Bodnant in Wales and in California, Australia and Japan continued to develop new colour and leaf variations, especially the rare yellow flowered *C.miniata* which had been collected in Natal in 1893. This development also continued with variegated and broad leafed *C.miniata* which are popular in Japan and China, as well as interspecific hybrids.

With these developments there has been a renewed interest in clivia as a pot plant amongst professional horticulturists, amateur breeders and the public.

This inspired Nick Primich to bring together enthusiasts in South Africa, California, Australia and Japan in 1992, to form the Clivia Club, which held its first International Conference at Pretoria in 1994.

CLIVIA '98, the Second International Clivia Conference, was hosted by the Cape Province Branch of the Clivia Club and held at Kirstenbosch National Botanical Gardens, Cape Town, in September 1998. This Garden displays approximately 5000 of the 8000 species of the rich and diverse Cape floral kingdom. Situated in natural vegetation, on the eastern slopes of Table Mountain, this was a unique and magnificent setting for the coming together of clivia enthusiasts from across South Africa and the world.

The theme of **CLIVIA '98** was GROWING CLIVIA, the focus being on the cultivation of these magnificent plants. The conference was attended by 122 delegates representing seven countries and speakers were drawn from researchers, eminent clivia growers and specialist enthusiasts.

This, the first Clivia Yearbook, is based on those proceedings and is intended to not only serve the interests of the members of the Clivia Club, but also to stimulate world wide public interest in this remarkable plant.

INTRODUCTORY REVIEW

by

DR JOHN ROURKE

DR JOHN ROURKE *is the Curator of the Compton Herbarium, National Botanical Institute at Kirstenbosch.*

This, the first Clivia Yearbook, centers on the presentations made at the second International Clivia Conference held at Kirstenbosch National Botanical Gardens in September, 1998. This summary was originally made as an overview at the conclusion of the conference.

It was an informative, fascinating and exciting day. We had a remarkable gathering with delegates from no less than seven different countries and an extraordinary range of topics was presented. As a simple amateur clivia grower, it was a great delight to me.

I was particularly intrigued by Jeff Finnie's account of *in vitro* tissue culture. For years one has been brought up on the notion that clivia is almost impossible to culture *in vitro* but today a chink has been opened in which we now learn that clivia will respond to *in vitro* and can ultimately give rise to a reasonable number of plants being produced in this way.

It was enormously interesting to hear from Dr Johan van Huylenbroeck how flowering is dependent on leaf number and that this can be manipulated by increasing and modifying the temperature and the atmosphere in which the clivias grow. This surely is an important piece of information for us all.

We listened with rapt attention to the breeders, Pierre de Coster, Yoshikazu Nakamura and Pen Henry on the very interesting forms and variations that have been cultivated in different parts of the world and the different tastes and styles in China, Japan, Belgium and Australia. Many of these are illustrated in this Yearbook.

Chris Lotter gave us some very practical information on issues of cultivation and especially on nutrition, which seems to be so easily overlooked.

Nick Primich discussed the subject of variegations, also a thorny problem and a matter of taste according to one's fancy.

Being a taxonomist, I do work in the field as well as with dry specimens! Although, as Keith Hammett suggests, I'm mostly like a mortician in a morgue, I do actually get out into the field! Recently I had the good fortune of travelling with John Winter and Mick Dower for two weeks on a series of excursions into the Transkei and Natal to look at wild populations of clivia. It was truly amazing to see the degree of variation within an area scarcely half the size of the conference room. Some populations are definitely evolving or mutating very much more rapidly than others. I found Keith Hammett's comment on the importance of preserving our wild resources incredibly relevant to our situation today. In this regard I want to give you a text for the day - rather like a preacher! It is the words of a very famous Australian scientist, Sir Otto Frankel: *"Cherish variation, for without it life will perish"*.

The whole issue of clivia growing and clivia breeding revolves to a large degree around variation. Fashion is a very fickle human foible and although we may be very interested today in broad leaves, short leaves, bright red Clivias or yellow Clivias, they may be out of fashion in a century or two from now. We are not to know what human beings will desire in the future. The only certainty about fashion is that there will be change. For that reason we do have a huge responsibility to preserve a broad base of material for future breeding.

I go back to Otto Frankel's words "Cherish variation". Variation unfortunately is an expensive commodity to preserve. John Winter has begun to develop a collection of *C.miniata* variants and other species here at Kirstenbosch - but even that is not enough. It is desirable that every country that has a substantial clivia collection should try to set aside a good collection of variants, which will be preserved and perpetuated for future breeders. That is the thought that I would like to leave with you.

Wessel Lotter spoke to us at some length about variation and he also talked about cultivar names. Cultivar names are very useful but they are regulated by a rather curious document called the "International Code of Nomenclature of Cultivated Plants". I would like to suggest that the Clivia Club should look into that document before deciding on names. Its use is generally acknowledged the world over and we need to bow to higher authority on these matters. It is really quite important.

It was a great privilege to attend this conference. May the publication, in this Yearbook, of its proceedings and of some of the variations which have been achieved continue to inspire even greater achievements with this rewarding genus.

OPENING ADDRESS

by

PROFESSOR CHARLES STIRTON

PROFESSOR STIRTON is the Director of the National Botanic Garden of Wales situated in Carmarthenshire. He was previously Deputy Director of the Royal Botanic Gardens, Kew. He was educated at the University of Natal in Pietermaritzburg. His garden in Wales is one of the more modern and innovative gardens in Britain. He is a frequent visitor to South Africa and particularly Cape Town.

Welcome to **CLIVIA '98** held in beautiful Kirstenbosch and this fantastic country.

Clivia miniata grows all over South Africa and perhaps all around the world. It's bursting into bloom; it's spring again, the passions are stirring. All three branches of the Clivia Club in South Africa are really getting going and here we are gathered today from all over the world. I wonder what John Lindley, who gave us the genus *Clivia* in 1828, would think of this gathering and this venue? I am sure that Lady Charlotte Florentina would have been thrilled.

Clivia is one of the many groups of magnificent South African bulbous plants of the family Amaryllidaceae, plus Iridaceae and Liliaceae. These are being studied by a series of distinguished taxonomists. I have met many of them and I work with some of them. I would like to mention a few, as much as a tribute to the South African flora as to the passion and excitement and the joy that they have brought to so many people throughout the world.

John Gilbert Baker, from Kew, Allan Dyer from Pretoria, Amelia Obermeyer (Mrs Mauve), Professor Miriam de Vos from Stellenbosch, Joyce Lewis for her work on *Agapanthus,* Leslie Codd, Professor Tom Barnard for *Gladioli,* Kostokowitch from Poland, Captain Paymaster, T M Salter for *Oxalis,* Peter Goldblatt for *Gladioli,* Pauline Perry on *Eriospermum,* Dr Deidre Snijman for *Haemanthus,* Graham Duncan, and many, many more. Without the dedication of these people, we would not be here nor would we have the taxa to grow and hybridise. Do we pay them enough tribute?

The world is changing in terms of the biological diversity, global climatic change, trade and economic pursuits. Enormous profits are being made from the Cape flora. The Cape *Pelargonium* alone, I heard this week, was probably worth one and a half million US dollars annually.

Could clivia become a multi-billion industry? I would say potentially yes. There is an opportunity here for you to set a new path, not only for the country which has given us the resource *Clivia* but also for those people who enabled us to take and develop it.

I would therefore like to ask you to consider creating a Clivia Development Fund to study its taxonomy, physiology and horticulture. There are many *Clivia* in the wild disappearing at a phenomenal rate. I spoke to some horticulturists in Natal - *Clivia* is a muti plant and it has been unsustainably harmed. NBI has just started a project to conserve these natural resources.

What I'm saying is that your industry could collapse around you because the diversity is disappearing.

In 1976 I wrote a small paper. I wrote about the potential exploitation of the monocots of South Africa. Ten years later I am staggered at how this industry, has developed. I am also upset that so little of that money has gone back to the country of origin or to the study of the flora.

I leave that thought with you - a Clivia Development Fund - or something like that.

I have pleasure in declaring **CLIVIA '98** open.

IN VITRO CULTURE OF CLIVIA MINIATA

By

J.F. FINNIE

DR JEFFREY FINNIE is Senior Lecturer at the Botany Department of the University of Natal, Pietermaritzburg.

Abstract:

The highly sought after *Clivia miniata* var. *citrina* can be successfully cultured using fruit and floral explants. Use of these explants may limit the number of plants produced in culture due to the seasonal nature of flowering.

Clivia miniata Regel bears an inflorescence of red to orange flowers, many hybrids have been cultivated, but the horticulturally most valuable form of *Clivia* is the yellow flowering *Clivia miniata* var. *citrina* Watson. The long maturation period of five to seven years for seedlings, variable flower quality, and the poor vegetative growth of selfed plants makes cultivation difficult.

Explants were taken from the root; rhizome/corm; meristem; leaf; inflorescence peduncle; flower; fruit; seed and embryo at all the stages during the growth season. Sterile explants were placed on Murashige and Skoog's medium with 30g 1-1 sucrose added and supplemented with varying levels of plant growth regulators. Cultures were maintained in a growth room at 25 + 2°C with a 16 h light/ 8 h dark cycle. Illumination was supplied by cool white fluorescent tubes with a light intensity of 27u mol m-2s-1.

All floral explants, except the style, showed some callusing and regenerative ability. Callus tissue derived from the petal, ovary and pedicel became embryogenic, pedicel tissue taken closest to the receptacle was found to be a region of major plantlet regeneration. *Clivia* inflorescence cultures were markedly affected by hormone levels, with both equal and higher ratios of cytokin to auxin proving stimulatory. Fruit explants (berries) were used to maximise callus production. This led to the production of multiple plantlets (5mgl-lBA & NAA). Anatomical investigations of the surface of the fruit tissue showed that it was covered with crystalline callus. Within the fruit wall, areas showing meristematic activity was observed. From these areas proembryonic structures developed. These proembryoids enlarged and eventually protruded beyond the explant surface. If separated out individually they developed into entire plantlets.

The highly sought after *Clivia miniata* var. *citrina* can be successfully cultured using fruit and floral explants. Anatomical investigation revealed that the plantlets were derived from proembryonic structures within the fruit wall. Use of these explants may limit the number of plants produced in culture due to the seasonal nature of flowering.

INTRODUCTION

There are numerous horticultural studies on *Clivia* for propagation and growth (Hieke 1971: Mori & Sakanishi 1974; Eldabh et al 1978; Niu et al 1986); but very little has been published on the *in vitro* culture of *Clivia. Clivia* has been cultured using direct adventitious organogenesis, indirect organogenesis and multiple axillary shoot techniques (Holdgate et al 1975; George & Sherrington 1984; Vasil 1985). *Clivia nobilis* has also been cultured using immature embryos as an explant source. Petals and ovary walls have been used for *in vitro* experi-

mentation and "different kinds of calli and plantlets appeared" (Min & Jinsheng 1984), although specific details are lacking. This study explored possible explant sources and techniques for *Clivia* tissue culture.

MATERIALS and METHODS

Explants from the root; rhizome/corm; meristem; leaf; inflorescence peduncle; flower; fruit; seed and embryo at all stages during the growth season, were surface sterilized in either 2% NaOCl (leaf, fruits, flowers), 0,1% HgC12 (root, rhizome) or 10% H_20_2 (ovary) for 15 minutes. Sterile explants were placed on Murashige and Skoog's (MS) with 30 g $1-^{1}$ sucrose and supplemented with varying levels of naphaleneacetic acid (NAA); idoleacetic acid (IAA); 2,4- dichlorophenoxyacetic acid (2,4-D); benzyladenine (BA); kinetin and zeatin. Media was adjusted to pH 5.8 and solidified with 0.8% agar. Cultures were maintained in a growth room at 25 ± 2°C with a 16 h light/ 8 h dark cycle (27 u mol $m-^{2}$ $s-^{1}$).

Fruit explants were taken at three developmental stages:

1. Just after pollination;
2. During seed development;
3. With the onset of ripening.

Explants were cultured on full strength MS medium supplemented with 0.8% agar, 40 g 1-1 sucrose, BA and NAA.

RESULTS and DISCUSSION

All *Clivia* explants apart from the root produced callus. Rhizome, leaf and peduncle explants produced "wound" callus. These callus cells, despite large nuclei, were non-meristematic with minimal amounts of cytoplasm. Isolation of meristem explants resulted in the destruction of the plant, and although the meristem developed into a plantlet, multiple shooting was not obtained. Excised embryos grown on media containing 1 mg 1-1 BA and 1 mg 1-1 NAA, were stimulated to produce shoots, when sections were cut into the embryo axis.

All floral explants, except from the style, showed some callusing and regenerative ability. Callus tissue derived from the petal, ovary and pedicel became embryogenic. *Clivia* inflorescence cultures were markedly affected by hormone levels, with both equal and higher ratios of cytokinin to auxin proving stimulatory. BA was the most effective cytokinin.

Subculture of initiated callus did not result in plantlet formation, however, some callus was inherently rhizogenic.

Fruit explants (berries) led to the production of multiple plantlets using certain concentrations of cytokinin to auxin. Anatomical investigations, of the surface of the fruit tissue showed that it was covered with crystalline callus. Within the fruit wall, areas showing meristematic activity was observed. From these areas proembryonic structures developed. These proembryoids enlarged and eventually protruded beyond the explant surface. If separated out individually they developed into entire plantlets.

This study has shown that the fruit wall is the most successful explant for in vitro multiplication of *Clivia.* Plantlet regeneration was, however, very slow.

There are two major drawbacks with respect to commercial application of the described technique. Firstly, fruit wall material is only available seasonally. The ideal stage for taking explants is very specific, with no easy morphological or physiological means to ascertain the critical stage. Secondly, embryoid formation is slow. It is, however, interesting to note that the response of *Clivia miniata* and *Clivia nobilis* (Min & Jinsheng 1984), in terms of explant selection and plantlet formation, in culture appears to be similar.

The response of different *Clivia* explants in culture

Explant	No. Response	Callus	Direct Organogenesis	Indirect Organogenesis
Root	+			
Rhizome		+		
Meristem		+	+	
Leaf		+		
Inflorescence peduncle		+		
Flower		+		+
Fruit		+	+	
Seed/Embryo		+	+	+

The *in vitro* regenerative ability of *Clivia* floral explants.

EXPLANT	CALLUS REGENE-RATION	PLANTLET	REMARKS
Petal stage			
1 (1-3 mm)	+		
2 (3-10 mm)	+		
3 (10-15 mm)	+		Extension growth of petal, formation of pigments as in normal flower.
4 (15-20 mm)			
5 (> 20mm)			
Ovary	+	+	
Pedicel	+	+	Plant production via callus.
Filament	+		
Style			Extension growth, no callus
Entire Bud	+		

Clivia berry explant response to a cytokinin/auxin hormone grid (Full strength MS medium plus 1 g 1-1 PVP and 40 g 1-1)

Key:

1. No callus
2. Fine yellow non embryonic callus
3. Yellow/green marginally embryonic callus
4. yel low/green/red callus, embryogenic

		BA	Mg1-1	
		0	1	5
NAA	0	1	1	3
Mg1-1	1	2	4	-
	5	3	-	4

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Acknowledgments

Mr and Mrs English are thanked for providing *Clivia miniata* var *citrina* explant material.

Pat Gore's "Diana" 2

Nakamura hybrid 3

Nakamura hybrid 4

5

6

Two forms of Clivia nobilis collected from the habitat in the Eastern Cape Province, South Africa

"Wittig's Peach"

7

CLIVIA MINIATA REGEL
CONTROL OF PLANT DEVELOPMENT AND FLOWERING

by

JOHAN M. VAN HUYLENBROECK

DR JOHAN VAN HUYLENBROECK is a plant breeder with the Department of Plant Genetics and Breeding at the Agricultural Research Centre, Ghent.

Abstract:

During the last decade a new commercial interest in *Clivia miniata* is seen in Europe. Especially early flowering (before Christmas), compact plants with the umbel above the foliage are desired. Traditionally, plants are cultured in frost protected greenhouses and from seed to a marketable flowering plant takes about three years. This long culture period together with an unpredictable flowering (flowering percentage vary from year to year and frequently unwanted summer flowering is observed), increased considerably the production costs. In order to come to a better control of growth and flowering of *Clivia*, the impact of temperature, supplementary lighting, photoperiod, drought and cold treatments were examined.

Increasing the temperature significantly hastened leaf formation. Compared to control plants grown at 7°C, average monthly leaf formation increased by 50 to 100% when temperature was increased to 16°C or 20°C respectively. Supplementary lighting (to reach a photoperiod of 16h) during winter time did not hasten leaf formation but promoted leaf elongation especially in young plants, resulting in poorer plant quality. Neither higher temperature nor supplementary lighting influenced leaf width.

Flower initiation was not influenced by temperature or light conditions. Also drought stresses or cold treatments, applied at different times during culture, had no significant effect on flower initiation. In all our experiments the first flower bud was initiated after 12-13 leaves were formed. Subsequent flower buds were initiated after each set of 4 -5 leaves. This apparently strict juvenile period explains why under traditional culture practices plants only flower in the third year, since it takes more than two years before 13 leaves are formed. When vegetative growth is hastened (by higher growing temperatures), this stage is already reached after 14-16 months.

In contrast with flower initiation, flower bud development and scape elongation can be influenced by light and cold treatments. Additional lighting resulted in a higher percentage of flowering plants and hastened flower development. For scape elongation a cold treatment during several weeks is required. Lighting can partially replace this cold treatment. It seems that the minimum flower bud height required to have a good reaction on the cold stimulus is +20mfn. Smaller buds do not react. This can explain why a cold treatment in August is not efficient. Further research should focus on the interaction between a cold stimulus and the level of the endogenous hormones.

Introduction

In the second part of the 19th century: *Clivia miniata* Regel first came to Europe. Since then numerous new varieties were introduced to the market, from which the compact type, with broad leaves, became the most popular one. Until 1960 Clivia was a common flowering pot plant, but due to the long culture period and an "old-fashioned" image a decrease in the production was observed. However, during the last decade new commercial interest in *Clivia* is seen in some European countries (e.g. England). Especially early flowering (before Christmas), compact plants with broad leaves and the umbel above the

foliage are desired. Today, Belgium is the most important *Clivia* producer in Europe with a yearly production of about 700000 flowering plants

Traditionally, plants are cultured in frost protected greenhouses and from seed to a marketable flowering plant takes about 3 years. This long culture period together with an unpredictable flowering (flowering percentage vary from year to year and frequently unwanted summer flowering or flower abortion is observed), increases considerably the production costs. In order to come to a better control of growth and flowering of *Clivia,* the impact of temperature, supplementary lighting, photoperiod, drought stress and a cold treatment was examined.

Materials and methods

In the experiments, both seedlings and 1-year-old *Clivia miniata* plants were used. Plants were sown in November (1992 for the 1-year-old plants; 1993 for the fresh seedlings) and potted 6 weeks later in an 8 cm pot with a peat/leaf mould mixture. In October of the following year, plants were transplanted into 13-cm pots. During the experiments plants were regularly fertilised with Peters Professional (15N-11P-29K). Henceforth in the text seedlings and 1-year-old plants will always refer to the start of the experiment.

Following parameters were tested in different experiments:

1. Effect of paclobutrazol soil treatments (1, 2.5 or 5 mg a.s. per pot) and spraying (1,2 or 5 mg a.s.) on growth and development of Clivia
2. Effect of different growing temperatures (7, 16 and 20°C) and supplementary lighting (for the 16 and 20°C treatment) on growth and flowering. Supplementary lighting was given each year from the end of September until the beginning of May (photoperiod 16 h with a light intensity of 35 umo1 m-2 s-1 from 03:00 until 09:00 h and from 17:00 until 19:00 h).
3. Effect of different inductive treatments cold (4°C), long day (16 h), short day (8 h) and drought on flowering of Clivia. The inductive treatments were applied at 4 differ ent times in the year each time during a 2 months period. Afterwards plants were grown at 7 or 16°C under natural light conditions.

Results

Vegetative growth
Paclobutrazol, both as spray or as soil drench, retarded vegetative growth of *Clivia miniata* as is shown in Table 1. However flowering was also negatively influenced, so that in practice paclobutrazol is not satisfactory. In some treatments side shoot formation was stimulated (Table 1).

Leaf formation was hastened by increasing the growing temperature as is illustrated in Fig. 1. This promotive effect was already visible after a few months and continued throughout the whole experimental period (more than two years). The average monthly leaf formation increased from 30 % (1-year-old-plants) to 50 % (seedlings) at 16°C, and from 80 % (1-year-old-plants) to 110 % (seedlings) at 20°C compared with reference

plants at 7°C (Table 2). New leaves were formed at an almost constant rate during the whole year for plants growing at higher temperatures, while the control plants had certain rest periods. By increasing the culture temperature, natural periods of slow growth (summer and winter) could be minimised. Supplementary lighting did not influence leaf formation at all (Fig. 1 and Table 2).

Higher temperatures and supplementary lighting promoted leaf development, especially in younger plants, as was seen in the monthly increase of leaf length (Table 2). However, these results should be interpreted cautiously, as only the longest leaf was measured. Each newly formed leaf of a *Clivia* will, once it is fully developed, be larger then the older ones. As temperature influenced leaf number, it is logical to find higher growth rates at higher temperatures. To the contrary, supplementary lighting had almost no effect on leaf formation, while leaf growth is hastened. This resulted in a more open plant structure and poorer quality. Leaf width was not influenced by any of the treatments.

Flower initiation and flowering

First flower bud is initiated after 12 to 13 leaves are formed (Table 3). This juvenile period was found to be constant and neither temperature nor supplementary lighting had any influence on it. Once the juvenile period is over, or once 12 to 13 leaves are developed, subsequent flower buds are initiated every four to five leaves (Table 3). Also this rhythmic initiation of flower buds is independent of climatic parameters or growth rate. Besides growing temperature and supplementary lighting, we also investigated the effect of various inductive treatments: cold, drought stress, long and short days. These inductive treatments were applied at different periods of the year during 8 weeks, but none of them had effect on flower initiation (Fig. 4). From these results, we can conclude that *Clivia* clearly exhibits an autonomous flower induction. The juvenile period of the plants (= the number of leaves that has to be formed before the first flower bud is initiated) is most probably genetically determined. This means that it can be shortened by continuous selection on flower precocity.

Since increasing the culture temperature significantly hastened leaf formation (Fig. 1), also the time to the initiation of the first flower bud (12-13 leaves formed) is shortened as is illustrated in Fig. 2. A linear relation between both temperature and time to first flower initiation is observed. Starting from a seedling, it takes about 16 months at 20°C before the first flower bud is initiated, while the reference plants, grown at 7°C, reach the same stage almost one year later. This is also reflected in the percentage of flowering plants in the second year of culture (Fig. 3). At 20°C about 80 % of the plants flowered within the second year, at 16°C this was about 30 %, while none of the reference plants at 7°C flowered, since these plants were still in a juvenile stage. Supplementary lighting at 20°C resulted in earlier flowering plants (50 % flowered before Christmas). In the third year almost 90 % of the plants (also of the control) flowered (data not shown). Also then supplementary lighting hastened flower development, but a better quality of the flower was observed in the control plants (scape elongation was better and the umbel was standing above the leaves). These findings are in agreement with other researchers who reported that for flower scape elongation a cold treatment is necessary. The duration of this chilling period should be at least 45 days at 10°C. Insufficient chilling can partly

be compensated by supplementary light. Once the chilling period is finished, higher temperatures hasten flower development. The positive effect of colder growing conditions is also illustrated in Fig. 4. More good quality flowers were observed in three year old plants grown at 7°C compared to those at 16°C without supplementary lighting, while none of the inductive treatments had effect on the percentage of flowering plants.

By advancing the chilling period, plants can be forced for earlier flowering, although the earliest date to start with a cold treatment is said to be September. Also in some of our trials it was found that when a cold period started early August, less good results were obtained However, our results suggest that there might be a correlation between bud development (height) at the moment the cold treatment starts and the success of the treatment. It seems that the minimum flower bud height required to have a good reaction on the cold stimulus is ± 20 mm (data not shown). Smaller buds do not react. This can possibly explain why a cold treatment is not efficient when it is applied too early.

Conclusions

The culture of *Clivia miniata* as flowering potplant is economically feasible when the culture period can be shortened and homogenous flowering can be obtained. By increasing the growing temperature, vegetative growth is hastened and hence the period to the initiation of the first flower can be reduced drastically. This resulted in 80 % flowering plants within the second year of culture at 20°C (Fig. 5). Still, a cold period of several weeks is necessary to stimulate flower stalk elongation and to obtain high quality flowers. Afterwards flower development can be hastened by higher temperatures and supplementary lighting. However, before a controlled year round production system is possible, more information about the relation between flower initiation, flower bud development, growing conditions and the exact time the cold period should be applied, is needed.

Table 1. Effects of paclobutrazol soil treatments and spraying on growth (cm) and shoot formation in *Clivia miniata*

Treatment	mg a.s./pot	Leaf length		Number of new
		Day 80	Day 500	Shoots
Control	0	26	3	0
Soil drench	1	25	26	0.7
	2.5	25	26	0
	5	24	24	4.7
Spraying	1	23	24	0.7
	2	23	23	0
	5	23	23	1.3

Table 2. Average number of leaves, formed monthly, and average monthly leaf growth (cm per month) for *Clivia miniata* seedlings and 1-year-old plants as influenced by growing temperature (°C) and supplementary lighting

Temperature	Supplementary	Number of leaves formed		Leaf growth	
	lighting	Seedling	1-year-old plant	Seedling	1-year-old plant
7	No	0.33 az	0.46 a	0.80 a	1.15 a
16	No	0.49 b	0.60 b	1.18 b	1.48 c
16	Yes	0.50 b	0.59 b	1.32 c	1.35 b
20	No	0.68 c	0.81 c	1.57 d	1.24 ab
20	Yes	0.73 d	0.85 c	2.10 e	1.55 c

'Mean separation in columns by LSD, P=0.05

Table 3. Average number of leaves until first or between two subsequent flower buds (results are averages of different experiments and of different plant ages)

Temperature	Supplementary lighting	1 st bud	1 st-2nd bud	2nd-3rd bud
7	No	12.5 ±0.47	4.3 ± 0.43	—
16	No	13.1 ±0.91	4.2 ±0.41	3.8 ±0.45
16	Yes	12.9 ± 1.11	4.5 ± 0.67	4.3 ± 0.42
20	No	12.7 ± 1.53	4.8 ± 0.99	4.7 ± 0.80
20	Yes	12.1 ± 1.49	4.6 ± 0.60	4.2 ±0.41

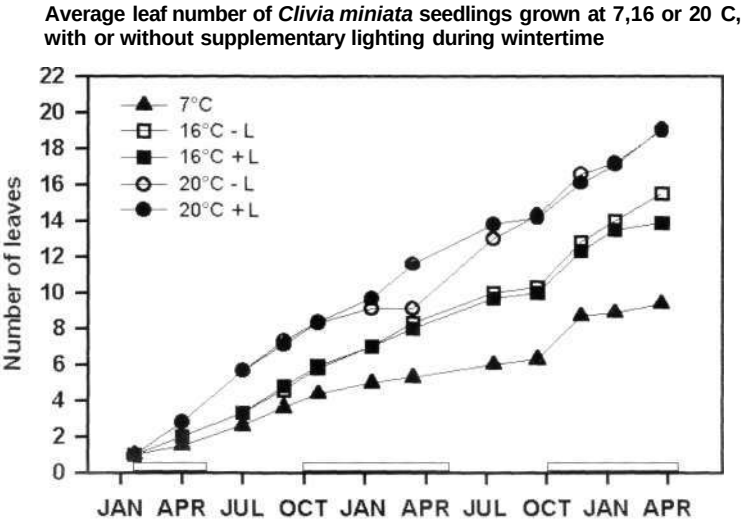

Figure 1. Average leaf number (>2cm) of *Clivia miniata* seedlings grown at 7, 16 or 20 °C, with or without supplementary lighting during wintertime (lighting period is indicated in the X-axis)

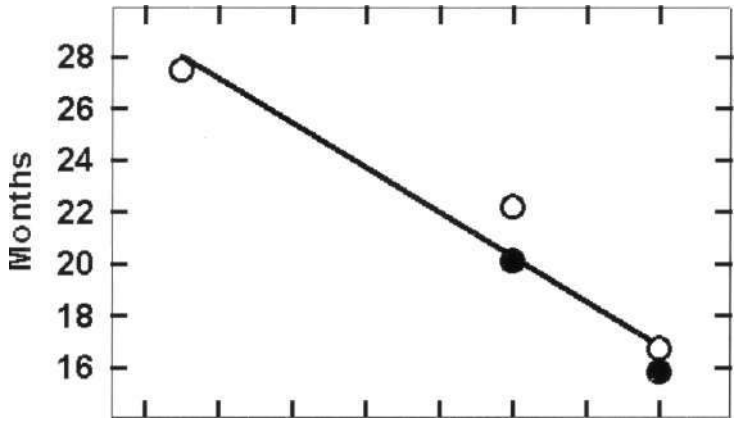

Figure 2. Relation between growing temperature with (closed symbols) or without (open symbols) supplementary lighting and time (months) before the initiation of the first flower bud in *Clivia miniata* seedlings

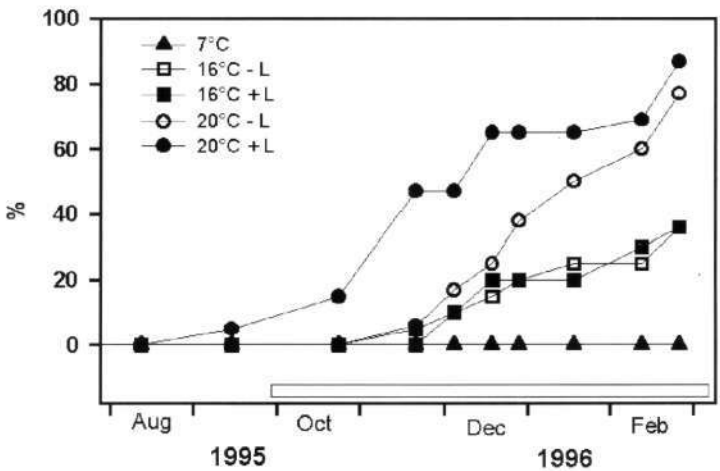

Figure 3. Percentage of flowering *Clivia miniata* plants in the second year of culture as influenced by growing temperature and supplementary lighting (lighting period is indicated in the X-axis)

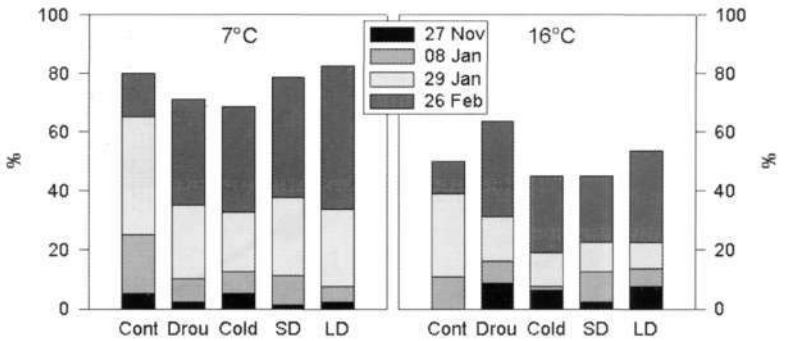

Figure 4. Influence of several inductive treatments and the growing temperature (7°C or 16°C without supplementary lighting) on the percentage *Clivia miniata* plants with visible flower buds in the third year (Cont, control; Drou, drought stress; Cold, cold treatment at 4°C; SD, short day: photoperiod 8h; LD, long day: photoperiod 16h)

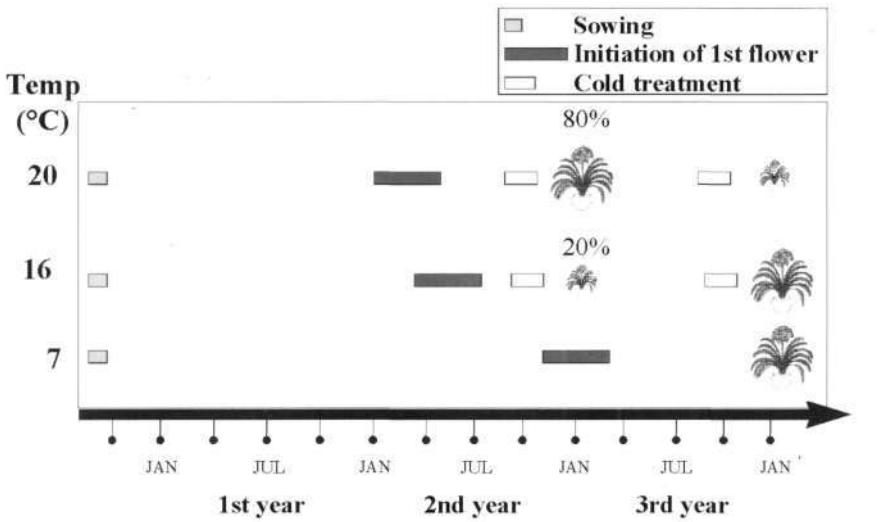

Figure 5. Schematic overview of the culture of *Clivia miniata* (from seed to flowering plant) at

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CLIVIA BREEDING IN JAPAN

Presented by

YOSHIKAZU NAKAMURA

(assisted by interpreter **TADAHIRO MINAMI)**

Abstract:

Clivias are very commercialised in Japan and are widely used as general pot plants. The Japanese, however, do not place emphasis on the flower alone, but on the whole plant. This is why Japan does not have a wide variety of flowers as is the case in other parts of the world. Nevertheless Japan has succeeded in producing plants with beautiful foliage, short and medium width leaves, and variegated foliage.

The variegated leaf is especially popular. There are two types of variegated leaf, that propagated by seed and that propagated by division. The type produced from seed is commercialized.

The present target is to breed a variegated yellow *Clivia* with as short and wide a leaf as possible. My 77 year old mother has succeeded in propagating a variegated cross yellow with only one crossing.

Clivia breeding in Japan is developing through the dedication of Clivia enthusiasts.

The slides presented, with explanations, by Mr Nakamura were translated into English by Mr Minami. A selection of these slides, as well as others, are printed throughout this publication.

Nakamura hybrid 8

Nakamura hybrid 9

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NAKAMURA HYBRIDS

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NAKAMURA HYBRIDS

A COMPREHENSIVE DISCUSSION OF THE CULTIVATION OF CLIVIA

by

CHRISTO LOTTER

Abstract:

1. Potting soil and growing mediums
2. Nutrition
3. Spraying of pesticides
4. Collecting and storing pollen
5. Collecting, cleaning, sterilizing and germinating seeds

1. POTTING SOIL and GROWING MEDIUMS

When one has to decide on a potting mixture, two important factors have to be borne in mind: pore space and good drainage. Clivias are to a great extent lithophytic or epiphytic and therefore will require more oxygen around the root system and this is where pore space becomes important. Let us also bear in mind that when we feed plants, the dissolved salts from the fertilizer will stay behind as the water evaporates. Consecutive feedings will result in a quick build-up of salts to such an extent that the roots will be damaged. It is advisable to flush the containers once a month using only tap water. Make sure that the water runs out through the drain holes at the bottom of the container.

1.1 Colloids

These are the very fine particles in any soil and are represented by humus and clay. Because these particles have an electric charge on the surface and because dissolved salts are also electrically charged (either positively or negatively) they will adhere to the colloidal system of the potting mixture.

Allow me to explain this in more scientific detail. Water, H_20, is polar; on the one side, the Oxygen side, it is negatively charged and on the other side, the Hydrogen side, it is positively charged. It is for this reason that a salt like Potassium nitrate, $KN0_3$, can dissolve in water. It becomes dissociated to form K+ and $KN0_3$- called ions. The potassium will be drawn towards the oxygen side of the water molecule and the nitrate toward the hydrogen side of the molecule. When it gets to the colloids in the growing medium, it will adhere to these electrically charged particles and can therefore not be leached out easily.

1.2 Growing - or potting mediums

I use 50/50 mixture of sand and milled pine bark. Alternatively a potting soil that will drain well containing leaf mould, sand and a good quality compost will also be suitable (even crumpled newspaper with a layer of sand (+ 3 cm) on top and - last but not least - even pure building sand!).

2. NUTRITION

You will always find the letters N.P.K. on the container in which you buy your fertilizer. N (Nitrogen) stimulates luxuriant growth, but has to be balanced by K (Potash), otherwise the plant tissues will become soft (thin cell walls) and will have less resistance to disease and drought. Assisted by Calcium, Potash plays an important part in the growth zone at the bases of leaves and peduncles.

A deficiency of Potash will result in flowers blooming between leaves. It also affects the size, intensity of colours, quality and lifespan of flowers. P (Phosphorous) plays an important role in the development of a good root system AND will determine the number of flowers in the umbel and the number of ovules in the locules.

2.1 Nutrition and the quality of your seeds

The food supply of your seeds is exendospermous which simply means that it is a separate food supply for the embryo plant and is stored outside the cotyledon, (seed leaf of the embryo) but the embryo plant is attached to the food supply by the epicotyl and serves as a channel through which the food - after it has been made soluble by enzymes - can reach the developing embryo plant. Just below the longitudinal slit through which the first seed leaf appears, we find the hypocotyl from which the radical develops. On the radical you will see a dense growth of adhesive root hairs. In nature this serves to adhere to anything with which it comes into contact (even a radical from another seed). The radical tends to grow straight down to anchor the developing embryo plant firmly. For all this growth, a lot of energy (food) is needed.

The chlorophyll in the leaves of a plant form simple sugars from $C0_2$ and H_20 during photosynthesis. Potassium is needed to convert the simple sugars into starch which is stored in the food supply of the seed. Plant protein is also synthesized from sugars and mineral salts (especially nitrogenous salts) and is likewise stored in the seeds as a good supply for the developing embryo after germination.

It is therefore important to feed your plants well with at least a basic 3.1.5 fertilizer and, if possible, with the necessary trace elements. The Scotts Peters Professional fertilizers (15 . 11 . 29 = ± N3 : P2 :K6) has the important additional Phosphorous and Potash for reasons already explained. I feed my plants at least once a month with a hydroponic mixture just to make sure that the plant medium does not become deficient in trace elements which are equally important (for example: Fe and Mg are both necessary to form chlorophyll).

So, if you feed your plants well during the development of the seeds, they will be larger and germinate and develop faster with an adequate food supply available for development until the first true leaf has developed to a stage where the seedling can manufacture its own food. If the seeds do not have an ample food supply, the developing seedlings become runts and the subsequent development will be slow.

2.2 Nutrition of seedlings

I can recommend spraying seedlings with a plant stimulant like concentrated liquid seaweed extract (Kelpak) which contains auxins like Gibberellins and Cytokinins or Supranure which contains indoleacetic acid. (Commence this programme only after all the stored food in the seed has been used up.) Use a hydroponic mixture - mainly for the trace elements - about once a month.

3. SPRAYING PESTICIDES

3.1 The most important spray for seedlings is a systemic fungicide (like Benlate). The same applies to mature plants that develop brown spots (brown rust).

3.2 The best insecticide to use is chlorpiriphos because it is systemic and kills beetles, lily borers, mealy bug and scale. As an alternative one can use garden Ripcord.
If you are allergic to these substances, use a watering can.

4. COLLECTING AND STORING POLLEN

One can pick the ripe anthers with the aid of tweezers and a very small container. Put this small container in a big container containing a drying agent (silica gel) for 24 hours. After this, one can transfer the pollen to a numbered gelatine capsule which can then be entered in your record book. The capsule can be placed in an airtight small container with a drying agent and placed in your deepfreeze. If you keep it dry and cold enough, it will still be viable after three years!

To pollinate, wait until all the anthers of the flowers to be pollinated are mature. Use a very fine brush to take the pollen from the capsule. Clean the brush afterwards by submerging in methylated spirits - do not dry! Pollinate early in the morning before the bees start collecting pollen!

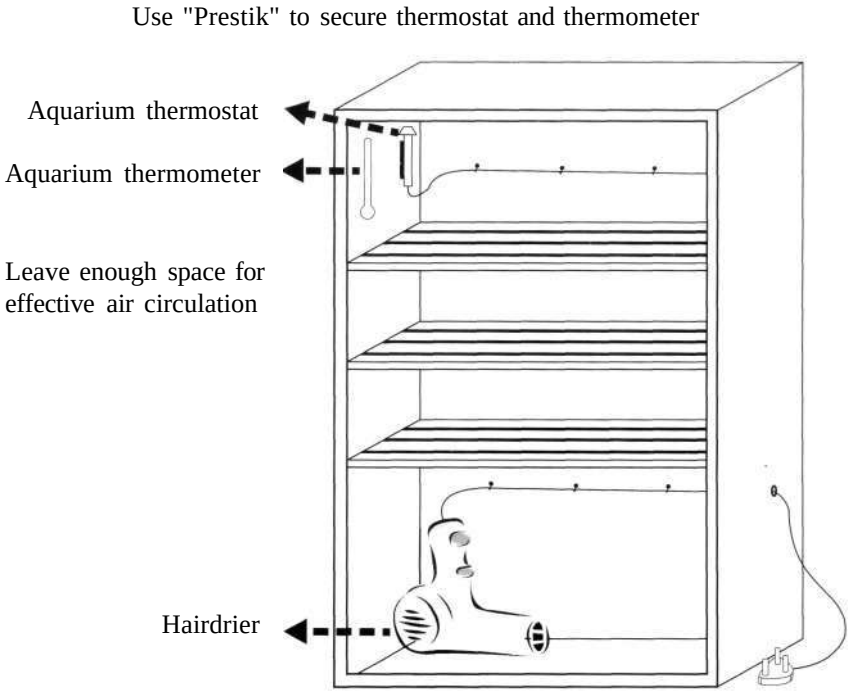
If the stigmas are dry or damaged, cut off the style halfway down to the ovary and apply sugar solution (6 level teaspoons to one cup of water). Wait for + 5 minutes and place pollen on the cut surface. The sugar solution can also be used on stigmas that are reluctant to allow pollen to germinate. If you have a microscope, you can establish the viability of your pollen by placing the pollen + sugar solution on a microscope slide, cover, and leave overnight. Inspection the next morning will show pollen tubes developing should the pollen still be viable. Pollen stored at -18°C in a deep freeze will still be 100% viable after 3 years.

5. COLLECTING AND GERMINATING SEEDS

5.1 "Green pod sowing": One can pick the berries after 5 1/2 months. The seeds will come out easily because the fruit-wall is still firm. However, should you harvest the berries in July, it is better to put them in a basin of water before you crush and wash them to separate the seeds from what remains of the pulp and membranes. You will find this a much easier and cleaner operation. You must make sure that the inner membrane of the fruit-wall surrounding the seed coat is also removed, otherwise the membrane will become infected with bacteria or fungi.

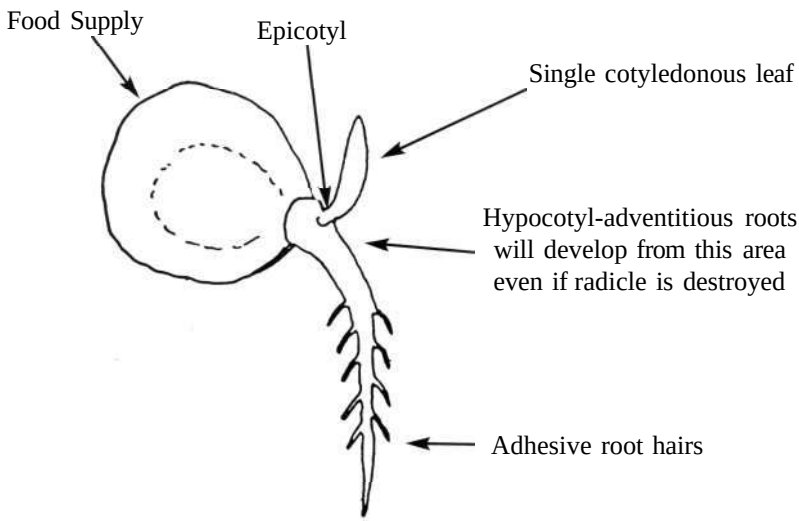
5.2 Sterilizing by washing with Sunlight dishwasher liquid (one teaspoon to one litre of water), followed by rinsing with clean water, is usually adequate. Wash your containers (plastic ice cream containers) with Sunlight liquid and rinse. Place a folded paper towel at the bottom, then moisten, place seeds on moist towelling and close the lid firmly. It can now be placed in a propagator. (Sunlight liquid dissolves cell walls of microbes and fungus spores.)

5.3 You can make your own propagator as follows : Construct a wooden box, approximately 75cm x 45cm x 25cm, with a close-fitting door. Construct a slatted shelf under which you can place a hair dryer. This should be placed centred at the bottom of the box. Place an aquarium thermostat (without the test-tube) right at the top of the box. More slatted shelves on which one can place the seed containers can now be installed. Use an aquarium thermometer to monitor the temperature. An average temperature of 25°C will give the best results. Do not be upset if the thermometer reads 27°C. It usually switches off at that temperature and on again at 24°C. Use the setting screw at the back of the thermostat to attain an optimally functioning system.



A SIMPLE PROPAGATOR

5.4 After about one month, the radicle should be - at an average - 2cm long. Use a container - pot or bag - + 15cm in diameter and plant the seeds - about 25 to a container. Use a pencil-thick screwdriver to push holes into the medium (sand) to receive only the radicle. Push down on the seed to let it sit firmly on the medium and water with a spray can. These seedlings will need protection from rain until the first leaf is about 4cm long, otherwise they may be washed out. Should the seed be lifted up by a developing taproot, make a new hole deep enough to receive the entire taproot, then water as indicated above. Transplant into individual bags (after + 10 months) at the beginning of spring the following year.



18 Multipetal floret compared with standard floret

New leaf variations developed in Japan 19

Japanese fan leafed form 20

Wessel Lotter interspecific Hybrid 21

22 Nakamura Hybrid

Nakamura Hybrid 23

HISTORY OF THE *CLIVIA* IN BELGIUM

By

PIERRE DE COSTER

Abstract:

This paper will trace the history of clivia through to the present day.

The city of Ghent and the surrounding region is the centre of ornamental plant cultivation in Belgium. As early as 1648, the growers were united in the "Conferie Sint Dorothea" (Brotherhood of St. Dorothy). In 1808 the "Agricultural and Botanical Society of Ghent" was founded, whose goal was to organise annual exhibitions following the English example. There can be no doubt that within this group of collectors there was a cross-border trade in plants, and thus the clivia entered Belgium.

In Flore des serres (1853-1854), we have the description of *Clivia (Imanthophyllum) miniatum*, with its narrow leaves and 50 cm long flower stalk containing 12 to 15 flowers. The Clivia miniata was the most highly prized variety in the last century - and is still the most popular in our own. Another popular variety was the cross made by Charles Raes between *C. nobilis* and *C. miniata,* which was called the "*Clivia cyrtantiflora* (Flore des serres, 1869).

"Many new varieties of *C. miniata* were introduced at the expositions held between 1873 and 1878. Progress was made in the number of flowers per stalk and in the colour of these flowers. But none of these varieties surpasses the C. *miniata lindeni,* developed by Mr. Theodore REIMERS, who was the head gardener for Mrs. DONNER in Ottenhousen near Hamburg, Germany. It has a very heavy flower stalk and a nice arrangement of the perianths, with lovely colour and flowers which are reminiscent of Vallota. The umbel can contain up to 39 flowers" (Illustration Horticole, 1879, vol. 26, by J. Linden). The MARIE REIMERS variety from the same grower has a lot in common with the *C. miniata lindeni* (Flore des serres, 1880, vol. 23).

From 1879 onward, the seedlings of the *C miniata lindeni* variety were very much in demand. Some of the seedlings reflected the type in its purest form, while other divergent specimens gave us numerous new varieties with large umbels, large flowers and/or broad leaves. Dozens of varieties have been described (Revue de 1'Horticulture Beige et Etrangere of 1875 to 1913).

After the First World War, BIER & ANKERSMIT introduced the C. *miniata compacta robusta* to the market. "A more compact plant, with leaves twice as broad as we are accustomed to and rounded rather than pointed (Gartenwelt, 1967). Through its participation in exhibitions and its catalogue publications, this large commercial grower in Melle near Ghent, Belgium, made this type known around the world. It was to become the starting point for the 'Belgian strain (Gartenwelt, 1976, E. Hahn).

This does not take away from the fact that in this period other growers won the first prize in the exhibitions ('Floralien') in Ghent from 1922 to 1950, including the CAMPENS Bros, in Melle and Louis DE CALUWE in Merelbeke, along with many others in the Ghent region. It was these growers who selected the clivia with the most beautiful flowers and the broadest leaves (8 to 12 cm).

After the Second World War there was a greater demand for less expensive plants. The 3 to 5 year cultivation cycle of the 'Belgian strain' was no longer profitable. In addition, clivias in general had gone out of fashion. Beginning in the 1950s, Ernest DE COSTER in Melle selected for early flowering clivias. These are compact plants, with 5 to 7 cm broad leaves, and 20% of the plants are already flowering after two years.

In 1990 the Clivia Study Group was set up on the initiative of a horticultural engineer employed by the Ministry of Agriculture, Mr. Adrien SAVERWYNS. The group functions to bring clivia growers together to discuss the technical problems of cultivation and, in some instances, to propose testing by the Provincial Research Station.

In 1998 most clivia growers are cultivating early flowering varieties, and the 'Belgian strain' is in danger of becoming a rarity.

SELECTION AND COMMERCIAL PRODUCTION OF CLIVIA IN EUROPE

by

PIERRE DE COSTER

Abstract:

This paper looks at the techniques of commercial cultivation and production of Clivia in Europe, diseases and pests, sales, packaging and transport.

1. SELECTION

In the 1960s, most growers in Europe found the old 'Belgian hybrid'- big and beautiful as it was - to be no longer marketable (too large) or profitable (4-6 year growing cycle). A more compact, rapid grower with highly supple, broad short leaves that would not break during packing was developed. It had to be an early flowering variety (10%-20% after two years, and the rest after three years). The umbels, which ideally stick out above the leaves, needed to be closed and globular in form. The flowers themselves needed to have broad petals - either touching or overlapping one another, and curving slightly outward. The desired colour was dark orange.

BELGIUM: is the country in which the most important developments in selection have taken place. (See previous page: HISTORY OF THE CLIVIA IN BELGIUM.)

GERMANY: has a long history of clivia breeders. REIMERS in Neumuhlen, followed by E. NEUBERT in Wandsbek, and LOBNER in Bonn-Friesdorf, who developed the

dark orange Friesdorfer type in 1917. Other breeders, such as BALL in Gaggenau, SHAFER in Rastatt and SCHMID in Donzdorf, developed the compact "PALMEN-GARTEN-RASSE" (Gartenwelt by O.Koch / E. Hahn, and Pareys Blumen Gartnerei).

ITALY: has for years been importing young plant material from Belgium, which is then raised to maturity. Now they have also developed their own production to cover domestic needs, which is supplemented only to a minor extent by Belgian clivias.

FRANCE: "has limited production, and they have the Belgian growers to thank for their most beautiful varieties." (Plantes des serres, Bellair & Saint-Leger, Paris, 1939).

GENERAL: Northern Europeans seem to prefer smaller plants, whereas Southern Europeans prefer the larger varieties.

2. CULTIVATION

2.1 Multiplication

2.1.1. From seed: Mother plants possessing all the right characteristics are kept for years. Each year, improved types are added to the stock. There are some growers, however, who totally renew their stocks every year. Pollination is done with a brush. Cross pollination is used for making selections.

In Europe, the fruit ripens between mid-November and January. The coloured, ripe fruit is extruded, washed, rinsed and dried. The other method is to let the extruded fruit dry, and then extract the seeds from the dried pulp. The seeds are often disinfected by submerging them in a fungicide (e.g. captan).

2.1.2. Vegetative multiplication: Side-shoots are not used very much. In vitro culturing is possible, but the process takes too long and does not provide a cost-effective means of multiplication. It does, however, offer possibilities for developing lines from superior plants.

2.2 Raising

Clivias are raised in heated greenhouses. Each grower has his own growing methods, which work best for his farm and fit best with the working customs in his own particular culture. The following is an example of one particular growing method.

TIME (IN MONTHS) AFTER SOWING

MONTH 1 SOWING: In multi-pot trays containing 51 to 73 cups per tray.

Substrate: 50% pine needle compost and 50% peat, unfertilized, with Mg-Ca added to bring the Ph to between 5.5 and 6.0.

The seeds are pressed lightly into the soil, and kept damp and covered.

Light is not important. Temperature: 18-20°C.

MONTH 9 TRANSFERRING FROM MULTIPOTS TO 9 cm POTS (MECHANIZED)

The largest plants are repotted first. This results in the plants being sorted by size. They are arranged pot to pot, with 140 pots per M^2.

Substrate: The same soil is used as for sowing, though with 0.5 kg organic or inorganic fertilizer added per M^3 (14/16/18 + trace elements) and 1 kg coated fertilizer (e.g. 8-9 months, 9/11/18 + 1.5 mg Mg + trace elements).

Temperature: 16-18°C.

MONTHS 15-19 REPOTTING FROM 9 cm TO 13 cm CONTAINERS (MECHANIZED)

The largest plants are sorted first. The same substrate is used. The plants are then arranged in rows, with the leaves in the same position, 48 plants per M^2.

Temperature: 16-18°C, and 10-14°C in winter.

MONTHS 24-25 FLOWERING: 10-20% of the 2-year-old plants

MONTH 27 INCREASE SPACING BETWEEN PLANTS: 32/m^2

MONTHS 34-35 RESTING PERIOD: under 10°C

MONTHS 35-38 FLOWERING: 90% of the 3-year-old plants

SUPPLEMENTARY FERTILIZER: as needed, according to Ph and salt concentration, usually in the ratio of 2/1/5.

2.3 LIGHT: MAX. LIGHT INTENSITY +110 W/m^2

3. DISEASES AND PESTS

3.1 ANIMAL PARASITES	PESTICIDES
Woolly aphid: Pseudococcus citri	Carbamates
Scale insects: Diaspinae	Carbamates
Thrips: Thysanoptera	Methiocarb., synth. pyrethroide
Red spider mites and other mites:	Endosulphan, Bromopropylate, Amitraz,
Cicofol	Carbofuran
Sciara fly	Mercaptomethur
Slugs	

➤ 39

24 "Kirstenbosch Yellow

'Natal Yellow" 25

26 'Noyce's Sunburst'

27

28 Bred by Michael Bertram

Bred by Wessel Lotter 29

Bred by Wessel Lotter 30

Tienie Holzhausen "Green Girl"
Best on Show: Pretoria 1997

31

32 Nakamura Hybrid

Nakamura Hybrid 33

Ndedwe "Gamma Peach" 34

Clivia miniata var. citrina 35

3.2 FUNGI

Fusarium, Verticillium, Cylindrocarpon, Rhizoctonia, Sclerotinia, Phytophthora and *Phytium* can attack roots in the primary form of the infection. In their secondary form, they can occur on weakened plants due to poor growing conditions.

PREVENTIVE TREATMENT

Systemic remedies

CURATIVE TREATMENT

***B.C.M. remedies

3.3 BACTERIAL DISEASES: Remove affected plants.

3.4 PHYSIOLOGICAL DISEASES

Cork proliferation: Air humidity too high.
Flower stalk does not extend: Failure to provide for rest period.
Leaf spots on the edge and top: Probably due to disturbed growing conditions.

4. PRODUCTION

Belgium is the largest producer of CLIVIA in Europe, producing an estimated 700,000 plants per year. Most of the clivia sold in the Dutch auctions in 1997 (278,000 plants) was of Belgian origin. The average price paid at these auctions was 7.76 NLG (3.9 USD) per plant. Approximately 200,000 clivias are raised in Holland each year. Italy also has a significant level of production, followed by Germany and France.

5. SALES

Sales are carried out either by the grower himself or by a local wholesaler, who sells to wholesalers abroad, to wholesale markets or to supermarkets. The Dutch auctions also sell a large portion of the production through auctions or middlemen.

6. TRANSPORT

- PACKAGING: In boxes or palettes custom made to fit the trolley.

- The Danish 'CC' trolley is used throughout all of Europe.

- TRANSPORT: By truck.

VARIEGATION IN CLIVIA MINIATA

by

NICHOLAS PRIMICH

Abstract:

Ornamental flowers are, by their nature, blessed with parts that attract them to human beings. Variegated plants have attractive (to many people) leaves which cause them to be sought after. It will be found on closer investigation that other parts are also variegated, and it is problematical as to how one may define these plants. We will take a cursory look at types of variegation and what causes them. We will deal by and large with chimeras, which are the main, if not the only type of variegation that is found among *Clivia.*

Assumptions are made as there is no direct evidence that *Clivia* do have what has been found in other monocots. Yet it would seem that on the balance of probabilities there would be no other possibility. The transfer of genetic material through the plastids is discussed, and the results obtained by *Clivia miniata* breeders is compared with the theoretical probabilities.

Various successful clones are discussed and compared. The future for variegated *Clivia miniata* comes under review.

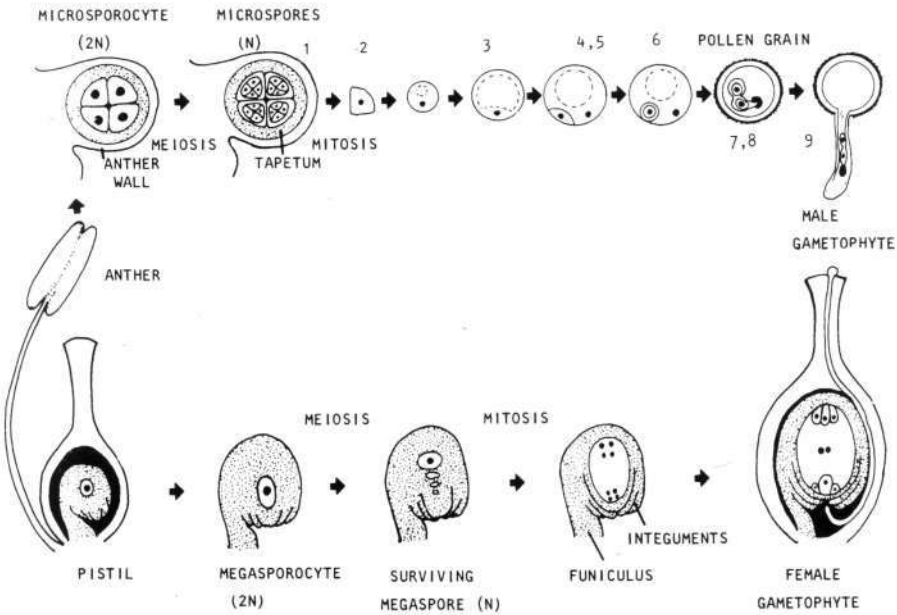
Ornamental plants are grown to be looked at. When I looked at variegated plants I often wondered why they were variegated whilst others were not. Nobody seemed to know very much about them at all. This was in my youth, and as I left home to work I lost my intimate contact with plants that I had with my parents and became involved in the technical world where I was making my living. Later on in my life I re-oriented myself and my underlying interest in plants resurfaced. The question was still there. What exactly are variegated plants, and why are they variegated? I often looked for references to them when visiting libraries, but found the facts to be few and far between. One day in 1996 I read the September New Plantsman and found many answers in Carlos Sombrero's article "Enigma of Variegation". This was followed by Ken Burras' article in the January 1997 The Garden. Through these articles I was then referred to a book by Drs. Richard Tilney-Basset and J. Kirk, as well as two more by Tilney-Basset alone. The problem of obtaining these works was solved for me by our editor, Meg Hart, and Mick Dower of Cape Town. My thanks to these people for their help.

As the aforementioned good Doctors have battled to give a good definition of variegation, I shall not attempt to do so except to say that with clivia we are talking about the striped leaves, some white, some yellow and some shades of green that appear on some of our plants. It is thought that variegated plants may be found amongst all of the species, and they consist in about four percent of modern plants in the nursery trade. I do not think that they are up to that percentage yet amongst the *Clivia* collectors, but I feel they will eventually overtake that mark. Most people like a variegated plant. Of course there are many shades of opinion among the aficionados. It does have the benefit of being decorative even without its flower. Naturally some are more decorative than others. It has also been my observation that the variegation changes, sometimes getting stronger, and sometimes disappearing altogether.

Sombrero (1996) describes six types of variegation to be found among the angiosperms:

1. Natural pigmentation: Many plants have a range of natural pigmentation where greens, whites, reds, yellows, etc. are caused by chlorophyll, lack of pigmentation, anthocyanin, carotene and several other pigments which are in the leaf. A great range of colour is possible by addition and diffusion of the various pigments. A good example is *Coleus.* Another is *Amaranthus.* This pigmentation is in the genes of the plant.
2. Unstable genes: Unstable nuclear gene mutations cause unpredictable leaf patterns as the pigments are turned on and off. A probable cause of this is transposable genes. That is a transposon, or section of gene coding that is capable of inserting itself in different positions in the gene chain. The *Nasturtium* is an example of this form.
3. Viruses: At one time many variegations were blamed upon viruses, and any pale yellow streaks or patches were thought to be caused by viruses. Only 12 plants out of 400 examined at the University of Oxford were found to have their variegation caused by disease (Burras 1967). The "Parrot" *Tulips,* and several *Orchids* exhibit flowers with "colour-break" caused by virus. *Abutilon pictum* is a shrub that has a specific virus mottling.
4. Air blisters: The aluminium plant, *Pilea cadierei,* is a well known example of a plant where cavities form under the surface layer of the leaf and cause silvery patterns. This is natural to the plant and breeds true to pattern. Another well known example is the *Cyclamen* which has such beautiful traceries on its leaves. There is a possibility that the *C. nobilis* that has the silvery stripe down the median line of its leaf may belong here. I am not at all sure about this, but it seems a distinct possibility to me.
5. Developmental: Certain plants attain certain colours, mostly in the leaves, at certain times of the year. *Photinia* is an example of this. The causes are not know, but it has been suggested that temperatures have a hand in this. Probably the best example are the autumn leaves that become suffused with anthocyanins before they drop.
6. Chimeras: This is the most important type of variegation as far as cultivated plants go, and the only type that concerns the clivia grower. Plant chimeras can be divided into three types, periclinal, mericlinal and sectorial. Periclinal are the most numerous and as the other types are highly unstable and do not concern the clivia grower, we will ignore them. Periclinal means "around the outer surface"; the growth of new cells takes place in an anticlinal direction, i.e. at right angles to the surface. The word chimera comes from the Greek, the chimera being a mythical monster like a fire-breathing lion with a goat's head growing out of his back and his tail being a venomous serpent. However, our plant chimeras are less offensive, the analogy coming from the different types of plant growing on the one unit. It is a difficult thing for the layman to understand, but the primordial buds that generate the leaves, or the apical meristem in the clivia's case, consist of at least two different plant types. There are various stages of this phenomenon. Some do not have any green parts or not enough, so the plants die as seedlings. Some have much white tissue which is parasitic on the green tissue so the plant grows very slowly or hardly at all. When seeds are produced, one finds that in clivia the pollen parent has no effect on the variegation. As far as I can find out, there appears to have been no work done on

clivia variegations as far as genealogy is concerned, but taking a line through other monocots, it seems certain that the variegation is passed by the plastids in the mother cell. In most monocot fertilisations, the plastids in the male cell are lost in the process, and only the nucleus fuses with the mother cell. This accounts for the mother plant alone being responsible for the variegation in the seeds. As the angiosperms have a very different meiosis to the animal kingdom, perhaps one should say a few words about it. The plant reproductive system is clearly illustrated as follows by Piyada Theerakulpisut et al in "Genetics and Breeding of Ornamental Species", J Harding et al (Edits) 1991, Vol 2 current. Plant Science and Biotechnology in Agriculture:



Plant Reproductive Systems. Male development (left to right) : The anther contains, the diploid microsporocytes which undergo meiosis to each produce (1) a tetrad of microspores; (2) microspores are released into another cavity; (3) microspore vacuolation; (4) microspore meiosis; (5) generative cell attached to pollen wall; (6) generative cell rounds off; (7) generative cell mitosis with sperm cells and vegetative nucleus forming and male germ unit; (8) vegetative cell accumulates reserves during maturation and dehydration; (9) pollen tube production and entry of male germ unit into tube. This is the male gametophyte. Female development (left to right) : the ovule is housed within the ovary of the pistil; a megasporocyte differentiates within the nucleus and undergoes meiosis to produce four haphloid megaspores, three of which generally degenerate; the surviving megaspore enlarges to form the embryo sac, and there are three mitosis to form the eight nucleate, seven-celled embyro sac. The egg (the female gamete) differentiates at the micropylar end while the pair of polar nucleii are in the central cell. This is the female gamophyte.

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NAKAMURA VARIEGATED FORMS

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NAKAMURA VARIEGATED FORMS 40

Thus in angiosperms (and a few others) the union of the male and female gamete is a bit more complicated than in the animal kingdom. The anther contains diploid microsporocytes, which undergo meiosis to each produce a tetrad of microspores. The microspores are released into the anther cavity where they undergo vacuolation. They then undergo mitosis. The generative cell undergoes mitosis again, the sperm cells and the vegetative nucleus form a male germ unit. The vegetative cell accumulates reserves during maturation and dehydration. The pollen tube is produced and the male unit enters the tube. This is male gametophyte. The female develops within the ovule in the ovary. A megasporocyte develops within the nucleus, and undergoes meiosis to produce four haploid megaspores; three of these usually degenerate. The survivor undergoes three mitoses to form the eight-nucleate, seven-celled embryo sac. The egg, the female gamete, differentiates at the micropylar end while the pair of polar muclei are in the central cell. This is the female gametophyte. What really interests us here is the fate of the plastids.

When a pollen grain carrying the two sperm cells and the vegetative nucleus falls on the stigma, the pollen tube grows down the style and enters the ovule through the micropyle. The one sperm cell fertilises the egg cell, while the other fuses with the endosperm nucleus, forming the endosperm mother cell. Usually the pollen parent plastids perish in the pollination process, but not always. There are records of occasional male plastids in some species and regular ones in a few others. As the seeds rely on the sorting-out of plastid conditions to account for their variegation or not, the numbers of variegated against non-variegated are not mendelian, but random numbers. Thus there is not a certain inheritance of variegation in clivia. One must, however, take good care to use a suitable male when pollinating a variegated, as there are the leaves and the flower to consider. The pollen parent will certainly have a say in these matters.

Radiation, stress and certain chemicals can and do cause mutations in plants. If mutations occur in the plastids of a normal mother cell it is possible that variegated plants will be produced. Plastids carry the pigments for the plant, and the leaves and petals could be affected by such changes. The flavones or anthocyanin group however, form in the vacuoles of the epiderm layer.

Perhaps we should have a word about the wonderful world of the plastid. This is really a cell within a cell. When cytologists were studying cells under the light microscope they were limited to magnifications of + 1200, which has been increased to 1500 by modern technology.

The advent of the electron microscope brought cytology alive. With magnifications in excess of 1000 times and resolutions far exceeding those of the light microscope, the window into the world of cells was opened. Between the transmission electron microscope, and the scanning type which gave a three-dimensional view of the microcosm, research surged forwards. If a plastid which was a few microns across appeared as a grain in the light microscope, it became a football in the electron microscope.

A plastid is usually lenticular in shape - it does vary and some become quite elongated. The outer membrane of the plastid is double. They start off as protoplastids and can develop into chloroplasts which carry the chlorophyll, amyloplasts which are colourless and carry starch, chromoplasts which carry carotenoids and other auxiliary pigments, and one for lipids. Plastids are filled with a proton dense matrix, which is called the stroma. In this are embedded ribosomes, globuli or drops of lipids, and the grana. The grana consists of an intricate system of vesicles that in the chloroplast, predominate. Seen from the side the vesicles seem to be stratified, and are indeed called lamella. Seen from above, the grana look like stacks of coins. There is however, a complicated connecting system with side linkages from one coin stack to another, and also into the stroma. The grana are usually called thylakoids. Sometimes there are 4-7 plastids in a cell. Shade plants can have as many as 70 in a cell.

The chlorophyll resides in the thylakoids and the light reaction takes place there whilst the dark reaction takes place in the stroma. All this in a tiny organelle about 5u across.

Now the plastids have their own chromosomes. In fact plants have three genomes, that of the nucleus, the plastids and the mitochondria. The plastids are fairly autonomous, with their own nucleus and chromosomes, and manufacture most of their own requirements. When pollination takes place, the male cell usually loses its plastids, whilst the female cell usually retains its. This is where the expression maternal inheritance comes from. This can be misleading, because sometimes the male plastid gets through, and the female one does not. That is why I prefer the term cytoplasmic inheritance.

The apical meristem, from where our clivia grows, is a three-layer system of cellular development (2 and 4 layer plants also occur). If one considers a hand in a glove, then the glove would be the outer layer, the skin of the hand the second layer and the flesh the third or inner layer. This is the tunica corpus principle. It's simple. The tunica is the shirt, and the corpus is the body. From the tunica only the epidermis or outer cell layer grows one or two layers thick. This grows in an anticlinal or at right angles to the surface mode. The others are a trifle more complicated like Rubik's cube. We know how it starts and we know how it ends, but the middle bit is a little tricky.

When a faulty chloroplast appears, it will divide and make further chloroplasts, as the good ones do, and then it is a matter of sorting out, as the cytologists call the random process when the white and green chloroplasts multiply and proliferate in a race to see which one dominates. Remember, these chloroplasts are within a cell, and the mutation is within the chloroplast, not the cell nucleus. If there are too many white ones, the plant will be in danger of dying, as the white tissue is dependent upon the green tissue for its food. So some cells will have mixed populations, and some will be entirely white or green. This is usually an unstable process, and this causes the variegations to fluctuate as the plant grows. As the leaf is growing rapidly vertically, and slowly in width, the variegations appear as stripes.

I am not certain what Mr Nakamura's "peace" variegation is, but mine start in a young leaf and have all grown out by the time the leaf matures. Perhaps it is a sectorial variegation which is very unstable.

Mr Nakamura's variegated plants have been developed by him from an original Japanese clone which has been in Japan for a long time. He traded plants with Bill Morris and Kevin Walters, and developed his clones further. I got Mrs Dobson to write him a letter, as I was certain that the article which appeared in Clivia Club's newsletter of January 1998 gave the wrong information when it inferred that his variegated plants were developed from x-rayed or y-rayed seeds. The seed that was treated to a dose of cobalt -60 were done a long time ago by Mr Nakamura in an attempt to emulate an experiment on hemerocallis seeds. The idea of this experiment was that colour changes would appear in the fourth or fifth generation. This is also based on the apical meristem, where a gene may be displaced or altered by a ray, it then starts to grow in a new form, but the alteration is so small that it cannot be seen by eye. If it continues to develop, by the fourth or fifth generation or more, it will have started to become visible. Mr Nakamura's plants are designed for indoors. I have many fine specimens of them, but they suffered badly from a fungal disease that I have only recently come to terms with. I believe that they can be hardened up and grown outdoors. I will have some flowering specimens next season, I am certain. Much the same goes for the samples I have from Bill Morris and Kevin Walters. The one local variegated specimen that I know well is that of Bertie Guillaume. This is a strong and vigorous plant that makes offsets like crazy. The flower needs improving, and I'm certain I will get that right before long. The vigour of this plant is amazing. I have never seen a more vigorous clivia of any type. It has produced many vigorous seedlings with a wide variety of leaf forms, and mostly variegated. Very few are all green or all white. I have seen quite a few others around, and have even acquired a few more, but have not been able to accumulate any knowledge on these specimens. I know Jim Holmes has some successful clones, but know little about them. I will welcome any further information from anyone about any successful forms of variegated clivia.

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RESEARCH IN CLIVIA CHROMOSOMES

Yidong Ran, B.G. Murray and K.R.W. Hammett

Presented by

DR KEITH HAMMETT

DR KEITH HAMMETT trained in botany and plant pathology and went to New Zealand 31 years ago. Gradually he changed his career and became a breeder Today he is a private breeder but he retains his scientific link with a series of MSc and PhD students at Auckland and Massey Universities.

Abstract:

Various staining techniques have confirmed that all four species of *Clivia* have 22 chromosome sets, and that the chromosome sets (karyotype) of each species can be distinguished. This information is being used to investigate the phylogenetic relationships between species and the development of the plant in cultivation.

To start with I would like to say what a privilege it is to speak immediately after Nick Primich who founded this Club. I had the privilege to attend the first International Clivia Conference in Pretoria four years ago. In my estimation about 75% of the people who are currently members were not involved in the Clivia Club four years ago. It must be an enormous thrill for Nick to see the small group that he started having grown into what it is today. What I'm going to talk about today would not have been possible if it wasn't for the formation of the Clivia Club.

Four years ago Nick took me in a car for a week or so and we went up and had a look at *C. caulescens* growing up in the northern part of the country and then we came down through the Transkei and ended up in the Eastern Cape. I remember the Transkei particularly. This year Connie and James Abel took me around for a couple of weeks and we made much the same trip. This is important to me because I live on the other side of the world where we do not have clivia. They all grow here!

In order to work on a plant as a breeder, you have to have a lot of plant material. So it is very important for me to understand what the species are doing in the wild. On the last trip I saw two populations of C. *nobilis* in absolutely pristine condition. This was the first time I had seen C. *nobilis* not growing in a pot. In fact it was the first time I saw *Streptocarpus* and *Strelitzia* growing in the wild. It was close to a religious experience for me to get to stand and look at these magnificent plants and to realise that I was looking at plants that I had only ever seen growing in pots. This time two of these sites were almost totally decimated, one of them had chalets built on top of them, and the other property had goats grazing on the land. It made me very sad indeed.

So, do you understand how fragile the resource that you have is? The other thing that I came away with was people like Nick Primich saying, "We haven't done as much with our flower as people elsewhere in the rest of the world". At the end of my first trip I was not sure that this was true. After this trip however, from what I have seen, I am absolutely certain that no one has done more with your flower than you have and

you can be very proud that the Clivia Club is here in South Africa. What is happening is that you have become aware of each other, you are networking. There are the most wonderful collections here in this country, the most wonderful gardens. So, all you South Africans, can be proud.

First of all, as a breeder I am very interested in the relationship of the Clivia species. We've got three species which are pendulous - *C. caulescens, C. nobilis* and C. *gardenii,* and then we have one upright flower, *C. miniata.*

We had very little material in New Zealand to start with. In New Zealand we had one accession of *C. miniata* species. We know from old catalogues that its been in New Zealand and Australia for over 100 years. Its been disseminated quite widely and it represents one accession. I have seen in the wild here in South Africa, in an area no greater than the corner of this room, more variation than existed in the whole of Australasia. I have been absolutely amazed at the form and quality of some of the naturally occurring C. *miniata* and other species that you have. You have an absolute need and responsibility to maintain that diversity. If it can not be done in the wild, then it is very important to do what John Winter and Mick Dower are doing, and that is to go out and get this material and bring it to safety. I can not emphasise the importance of this too much.

The other plant which is reasonably widely disseminated in Australasia, more particularly in Australia than in New Zealand, is the first known hybrid, namely *C. cyrtanthiflora* which is made between *C. nobilis* and *C. miniata.* This was developed in Belgium in the middle of the last century and has been divided and disseminated throughout Australasia.

The other species we have in New Zealand is *C. gardenii.*

Any pendulous clivia in New Zealand has been referred to as *C. nobilis,* but without exception I have found that this has always been *C. gardenii!* It is only since I have been associated with the Clivia Club and have been able to access genuine *C. nobilis,* that I am quite certain that *C. nobilis* has not existed in Australasia until quite recently.

What first got me started on clivia, was a plant of *C. miniata* which I found growing in the conservatory at Southampton University. I had it in a pot and showed it at the local flower shows in England. My interest was reawakened 18 years ago when I read an article by Kevin Walters which had a picture of a yellow clivia and which absolutely blew me away! So I wrote to Kevin who was very kind and he sent me seed. I duly waited for 4-5 years and then I was able to start crossing with what we had in New Zealand, which was very little.

We then have one or two of the European hybrids which have come either from Belgium or German seed. Understand how limited our resources were. We now have *C. nobilis.* Yoshikazu gave me one when I visited him some years ago in Chiba, and it is the same form as we saw recently in the wild in Grahamstown. We now have *C. caulescens.*

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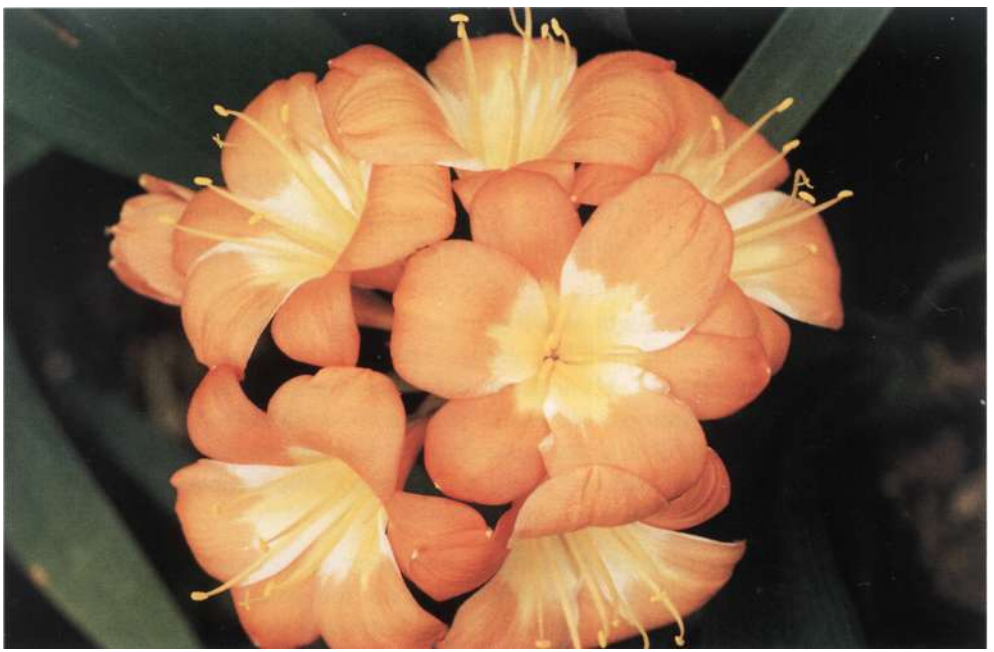

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Tino Ferero: "Yellow Greengirl" 46

Gert Wiese: Best on Show, Cape Town 1998 47

What you find now is that if you take open pollinated seed of *C. cyrtanthiflora* you get a whole range of hybrids and these range from ones that look remarkably like *C. nobilis* and grow as slowly as *C. nobilis,* while others look remarkably like *C. miniata.* I think that this often leads to confusion when people try to identify such plants. Thanks to Yoshikazu we also now have hybrids between *C. caulescens* and *C. miniata,* and *C. miniata* and *C. gardenii.*

I have drawn a rough map of the distribution of clivia in this country. As most of you would realise, the locations are separated by several hundred kilometers and can be separated by several hundreds of metres in altitude. Most of the dots on my map come from herbarium specimens. Taxonomists most frequently work with dead plants. Gardeners and field botanists work on live plants. That influences their thinking.

I have been tremendously fascinated by the importance that clivia plays in the Oriental culture. South African plants can not have been there for more than a couple of hundred years. When I visited China 15 years ago, it was the only plant I found growing in barbed wire cages and this says to me that this plant is important to the Chinese. I am curious to understand how they got clivia and why it assumes such significance.

The work I am presenting this afternoon in many ways is not mine. I initiated it but it is the work of a student from China called Yidong Ran, and my colleague Professor Brian Murray.

We know that the plant went from South Africa to England. We heard this morning about its development on the continent in Belgium and Germany. We are pretty sure that the plants that first came to Australia and New Zealand would have come from Britain. However I am curious to know how the material got to China, Japan and to Korea where, I understand from Kees Sahin, that Clivia is also held in high esteem.

How did clivia get to China? Did it go directly from South Africa? Did it go to Europe and then across to China? Although I urge my Chinese students to chase people in China who might know, the only thing we have found out so far is that the plant was introduced into north-east China, a pretty cold place, by a German priest about 100 years ago. We still do not know for sure but I think it is most likely that clivia went to China via Europe.

That is one question that interested me and I posed my students.
The other question was the relationship between the species right here in South Africa.

Chromosomes, when I studied biology, were represented as sausages floating around in a jelly. The science of cytogenetics and the whole area of genetic engineering and DNA have exploded in the last 25 years in exactly the same way as computer science and it is difficult to keep up with it even if you are involved in the field as I am as a breeder.

Chromosomes most of the time, do not occur like sausages in a jelly. The DNA is spread out in huge chains associated with proteins while genes are essentially specific areas along those chains. At a particular stage in the division of the cells and meiosis, they condense and by chemical treatment they can be condensed further. They are attached to the spindle by the centromere. You can stain different chromosomes so that they develop bands or stripes. It is rather like a football team, the different teams have different stripes. It is possible to stain the chromosomes of different species of clivia. What you do is to take photographs and recognise different chromosomes by their length and by where the centromere occurs. Then you cut them out and mount them in a nice straight line and see what's happening.

In clivia there are 22 chromosomes. This has been universally reported in literature. These 22 chromosomes are arranged in 11 pairs and are quite remarkably uniform. In essence what this banding shows is that the chromosomes of C. *miniata* and *C. gardenii* are quite closely related and they have bands at their centromeres. In contrast those of *C. caulescens* do not have any bands at their centromeres any more than does *C. nobilis.* So on that criterion, the chromosomes of *C. caulescens* which occurs up in the north is most similar to *C. nobilis* which occurs in the south. It is kind of perverse. At the same time *C. miniata* and *C. gardenii* which grow in much the same area have chromosomes that are similar.

The important thing is that the species appear to be quite recognisable at the chromosome level.

When you have a hybrid between *C. nobilis* and *C. miniata,* you can clearly see chromosomes from the two specific partners. Remember that we tend to classify the species by certain morphological characteristics.

If you think about it, the stripes of a chromosome have no greater or lesser importance. It is just another characteristic. So bear that in mind. You can look at different things on chromosomes as well as banding. One of the things we are interested in is NOR region which occurs on some choromsomes. This is quite important in the physiology of the cells. The NOR region can be recognised by a different staining techniques. What happens when you look at that characteristic is that the relationship between the species appears to change.

C.g*ardenii* has only one pair with NORs, C. *nobilis* in contrast has three, while *C. miniata* and *C. caulescens* have two each.

On that criterion, *C. miniata* and *C. caulescens* appear to be more closely related than the other two species. So the two pieces of information we have from the chromosomes appear to be in conflict.

We are bringing together a range of techniques which at the moment appear to be producing conflicting results and certainly one of the reasons why I am here is because I want to get a better understanding of how the plant has evolved here in South Africa. What was the ancestral climate, what are the other factors that caused them to be isolated and widely separated in different parts of the country? This is

where I need your help and I am really excited that you are going out and bringing material together and I think we can work together cooperatively. We need to talk to climatologists to discover what happened with the climate in the past.

There are so many questions; what are the pollinators, bird or insect? What is the difference in the anatomy of C. *caulescens* and C. *miniata?* Is *C.miniata* just a compressed *C. caulescens?*

While various pieces of information seem conflicting now, maybe it is only contradictory because we have a perception of what a species should be like.

The tendency of humans is to put things into boxes, and to make things linear.

But when you look at nature the only things that are straight are the things that we build.

It has been said that nature made a continuum and man tried to make the divisions.

I find it much more useful instead of thinking of a genus as being made up of species allocated to rigid pigeon holes, to think of a genus as a cloud which has a range of characteristics. Species will have many of these characteristics in common but may be distinguished by some differences. A cloud moving across the sky changes shape. Similarly a genus moving through time changes shape. With this paradigm it should not be surprising to find that characteristics do not occur in neat boxes but come together in somewhat confusing combinations.

It also explains why it is very important that if you are working with a plant you do not just take one accession of a species from one location. Unfortunately this is what has happened to many of our garden plants. Often they are founded on a very narrow genetic base. Almost invariably one plant has been collected and taken into cultivation and then all variations that we have got are derived from that one plant. It is important to have as many accessions within a species as is possible.

The work of the Clivia Club in going out and tracing the source of the various variations within the genus is very important.

CLIVIA IN AUSTRALIA

Kenneth R.Smith1 and Pen Henry2

Presented by

PEN HENRY

Abstract:

This paper deals with the past and present use of clivia in Australia. The writers have gleaned information from various sources to present a picture of the history of clivias in the landscape, as well as giving an insight to the present work being carried out by enthusiasts today. Documented cases of introductions to Australian horticulture are cited. Reference to current work is by journal article or personal correspondence. The future direction for clivias is given.

The paper will be presented at the conference by Pen Henry, principal of Clivia Garden Nursery, Western Australia, the first specialist Clivia nursery in Australia.

Introduction.

When asked to present an account of clivia cultivation in Australia, it is easy to recall the past ten years of seed and information exchange. So much has been learnt by corresponding with new friends worldwide and the growing of new material in our shadehouses around Australia. The Clivia Club has seen to that.

But I would like to take a look at the "development" of clivia in Australia from a much earlier perspective. We are certainly blessed in Australia when it comes to growing clivia. The plant is so accommodating in a shady garden that mass plantings have been extensively utilised, the reward being a bright flower display in spring.

The details of the early introductions and plantings are sketchy to say the least and are proving to be quite a puzzle to solve. One reference indicates clivia being grown during the period 1850 - 1900 with a diagram indicating a large flower form. Likewise, the catalogue of Arthur Yates & Co Ltd, 1923 lists, and I quote

> "Veitchs New Hybrids. A magnificent strain, and a great improvement on the old type. They are recognised as the finest strain of clivias in existence."

From early days it appears that we had some selections already being cultivated in our gardens.

Our "common" *C. miniata* is a narrow foliage plant that produces umbels of paler, apricot flowers. The petals are narrower than the improved forms and seed set is generally poor unless hand pollinated, although one garden I know of has a planting of a somewhat better "common" form with wider petals and a good display of fruits each season. Extensive plantings in Botanic Gardens, older estates and private gardens generally prove to be this form. It is easily propagated by division and whilst I know it is also grown by seed, the resultant plants are fairly true to the narrow flower form of pale apricot. Obviously, the result varies if other clivia selections are grown in the same garden bed. It is intriguing that this smaller "common" form abounds. Is it tougher? Does it grow faster?

The Seed/Plant Market.

Clivia miniata forms are certainly the main plants in our gardens. The documents just mentioned show that plant importation occurred. The material was sold through the nurseries to be planted into the gardens where they probably still exist today. For many years though, the clivia being sold in Australian nurseries has invariably been grown from imported seed. Seed companies offer many lines such as - Belgian Hybrids, Dutch Hybrids, French Hybrids, Californian Strain, Santa Barbara Strain, South African Hybrids, European Hybrids as well as just Hybrids! In the late 1980's, Jerd Seeds, based then in Victoria, released several new lines of improved clivia to the market. They were - Twins, Variegated, New Hybrids, Midget and Mammoth. Many thousands of seeds were sold and the resultant plants reached the gardening public. Depending on the nursery involved, plants end up being variously labelled C. *miniata* or *C. miniata* 'Grandiflora'. The mail order nurseries tend to sell the plants as the named strain or seed line. Twins seems to be the main line offered today.

The result of all this importation is a wealth of broader leaf forms showing brighter, deep orange colour in a bolder flower display. Garden plantings put on a good show and it is only when you take a closer look that you see the subtle changes in flower colour, markings and petal width. Also we could go into the fruit colour differences.

A constant supply of plants is required to meet the demand by the gardening public and landscapers. Sales are best when the flowering season is upon us, a potted clivia in flower commands a good price. As a result of the increased awareness of clivia in recent years, the yellow flowered forms of C. *miniata* are in greater demand.

Some People, Past and Present.

Forms sold as *C. miniata* 'Aurea' have been available via mail order for many years. Reference to a Victorian nurseryman, Mr F H Pollard of Caulfield, obtaining plants from the late Mr Dearing, was reported in Your Garden magazine of December 1980. One of the plants obtained was 'Ailsa Dearing', a reputed cross between *C. miniata* 'Aurea' and a common *C. miniata.* I wonder what other clivia plants Mr Dearing produced?

Jean Kent has been selling offsets of her "cream" clivia by mail order from Victoria for many years. Her stock was purchased from "an elderly gentleman" because she liked the flower colour. Maybe that gentleman was Mr Dearing? David Bearlin, of Burwood Nurseries is breeding yellow clivia for sale based on 'Aurea' stock. Several other people in Victoria and South Australia offer offsets from time to time. In a recent article in Gardening Australia, Don Barrett's clivia breeding is mentioned. Allan Clarke, from South Australia, tells me he has been growing a yellow purchased from "an old gentleman in Melbourne" about twenty years ago. Warren Glover wrote about breeding yellows in the early 1980's, in his article in Herbertia.

The clivia breeding endeavours of Kevin Walters, from Queensland, are outlined in a detailed article in The Australian Garden Journal, April/May 1987. Kevin has been growing and developing clivias for nearly thirty-five years and in that time has

produced some splendid, large flowered forms, including yellows. To my knowledge, he has named at least a dozen clones of merit. Work on clivia in Queensland is continuing at the nursery of Kev and Coral Larsen where yellow *C. miniata* figure in their breeding programme.

Members of the Clivia Club will be well aware of the breeding work of Bill Morris. Bill's early breeding goals were to produce improved flowers on plants that were hardy in the garden. This work was carried out in conjunction with his friend, Alan Bull. Plants obtained from a nurseryman in the 1950's formed the basis of this work. Then during the early 1960's, Bill received seed carrying the yellow gene from Les Hannibal in America. Six seedlings formed the start of a yellow breeding programme and through careful selection and improvement, Bill has achieved an excellent, yellow breeding strain of clivia today. He is still busy improving the forms in his collection.

Many others have gone before, or during this same period, and have worked in their own way towards improving clivia. Cliff Grove, from Western Australia, presented a paper on clivia to a Horticulture Conference held in September, 1988. It was based on his experiences with clivia. The collection that Cliff developed now forms the basis of Pen Henry's Clivia Garden Nursery, Australia's first nursery devoted to the genus *Clivia.*

When the work of earlier breeders is documented, information is passed along to those following. I am hopeful of learning more about the plants produced by Mr Sinclair of Waratah Nursery, New South Wales. Clones like 'Salmon Queen' and 'Giant No 3' are in my possession but as to their history, no details of any substance are available. The benefit of a forum like this conference is that someone reading this paper may know more about the history of some of our clivia breeders and will let us know.

Up until now our discussion has been focused on *C. miniata* and the yellow flowered form. It is interesting to note that a paper outlining breeding results of G. Keith Cowlishaw was published in the Herbertia Yearbook of 1935. Several genera were dealt with but the clivia breeding is one of the few documented accounts which allow us to fill in the puzzle. Two points are interesting regarding his development of the plant. Firstly, no yellows were used in his programme even though he states

> "Mr R.W.Finch has raised some very fair varieties, and some very good pale ones, one in particular, almost a white."

Several other breeders' names are included, as well as the statement that

> "a number of hybrid forms were imported from England."

Alas, no names of the forms are given. It makes the search very awkward and time consuming, but fascinating none the less.

The second point of interest regarding clivia is the mention of *C. nobilis* and C. *cyrthanthiflorum* (sic). The Cowlishaw plants growing in my collection today do not show any evidence of pendulous forms in their breeding. A critical reading of the

complete article suggests that perhaps improved forms were crossed with a plant of the "common" C. m*iniata* that was labelled *C. nobilis.* Further evidence that *C. nobilis* was incorrectly represented on the marketplace is shown in advertisements as late as 1974 in Your Garden. A picture of *C. miniata* is labelled *Clivia nobilis.* The 1996 Gardening Australia article makes the same mistake! How long did this situation exist? Bill Morris has written a more detailed critique of the Cowlishaw clivia breeding for a new issue of Herbertia.

C. nobilis, or at least the pendulous flowering form that we know in Australian horticulture, is found in old garden plantings. It is certainly not commonly offered in nurseries, except the few that specialise in bulbous plants by mail order. Flower colour varies somewhat but tends to be darker, orange-red. Plants are found that may have a pale shade inside the floral tube and darker outside. Perhaps the form we grow segregates to its parents? Who knows? The Western Australian form tends towards larger plants and flowers, with a lighter flower colour. Foliage has the blunt leaf tip shape and the rough leaf edges, but the green tipped flowers as described in the texts is not as pronounced. This is particularly so when comparing photographs of the true *C. nobilis* from overseas growers.

Plants labelled *Clivia x cyrtanthiflora* in the Sydney Botanic Gardens are larger growing clumps than *C. miniata* or our Australian *C. nobilis.* Like the other pendulous flowering type, this plant is found in older gardens and is not common in nurseries. It is often referred to as *C. nobilis.* The flowers flare at the mouth a bit more and the colour is a pale apricot.

C. gardenii is represented as large plantings in Sydney Botanic Gardens. Other Botanic Gardens would have similar plantings yet it is not common in nurseries or private gardens. It appears to be more widespread in Western Australia than on the East Coast. Only now are the specialist growers offering this species. As a flower display in the garden it is not as showy as the selections of *C. miniata* and perhaps that is why it is less widespread? Growth is vigorous due to the rhizomes, but seed set is not great in a garden situation unless hand pollinated. It is worth growing for the bright pink fruits.

The least known species of clivia would have to be *C. caulescens.* This would only be in the collections of a few enthusiasts. I have not come across any reference to it in gardens or nurseries. Hybrids including this species are now in Australia.

A Summary

There is a strong association with clivia as a garden plant in Australia. Their use may have gone in and out of fashion over the years. Clivia has certainly been used extensively in the landscape and the documented evidence found so far points to early introductions of improved forms, a situation that continues today. The "renewed" interest in the past ten years will only enhance the cultivation of many clivia types in Australia. The plants will grace our gardens and the search for answers to the early introductions will stimulate our minds.

The Future

For those who love clivia, the future is bright indeed. The dissemination of diverse genetic material of clivia species and selections to the members of the Clivia Club in Australia can only advance the standing of clivia as a desirable ornamental plant. Its role as an outstanding shaded garden plant is well known. Large flowers, small flowers, pendulous flowering types, flower colours of varied intensity and pattern, multiple petal forms and variegated foliage all add up to an exciting future. I know that Pen and I find it very exciting.

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CLIVIA MINIATA FORMS FROM THE TRANSKEI,
EASTERN CAPE PROVINCE, SOUTH AFRICA

Pastel form 48

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"Chubb's Peach" 53

CLIVIA MUTATIONS AND COLOUR VARIATIONS

by

WESSEL LOTTER

Abstract:

For many years clivia breeders were puzzled by the strange phenomenon of orange progeny, when Natal yellow was crossed with another yellow known to be true breeding. Not surprisingly Natal yellow was blamed for this odd breeding behaviour.

During 1996 a second clone related to Natal yellow was identified. Test breeding has proved that these "Natal yellows" are as true breeding as any other yellow strains. Unlike the true yellows which show no signs of anthocyanin (red pigment), the Natal yellow sometimes displays red spots or streaks on it's flowers and/or berries. As the latter can now be produced in significant numbers, a name had to be found to differentiate it from the true yellows. The name par-yellow was suggested as its breeding behaviour is on a par with that of the true yellows. Furthermore, it is just a matter of two different genes responsible for the production of anthocyanin, being non-functional which gave rise to true yellow and par-yellow. No doubt these F1 orange progeny from true yellow x par-yellow if selfed or crossed with true yellow will give rise to yellows of different genotypes. These yellows in turn were crossed with true yellows again with the result that yellow x yellow might produce certain percentages of orange progeny. It now appears that there is a third yellow produced by a plant with normal functioning anthocyanin but for some reason does not distribute it to its flowers.

Another phenotype which is closely related to the yellows is called a dilute or peach. Test breeding has proved that it is recessive to orange but dominant over true yellow. The orange colour of the flowers is the combined effect of the presence of anthocyanin (red pigment) in the epidermis and xanthophylls (yellow pigments) in the underlying tissues. The different shades from pastels to red are due to the ratio of cells containing leucoplasts, that are colourless, chromoplasts that contain yellow xanthophylls and the concentration of anthocyanin. Chromoplasts are not only present in the flowers, but also in the leaves where they fulfil a vital function together with the chlorophyll. The elusive white will therefore not appear as a sudden mutation of the yellow pigments, but may be achieved by selecting and breeding from the palest yellows.

The colour of the berries is effected in much the same way as the flowers. The only difference is that in some berries the pulp remains green when ripe. These berries when containing anthocyanin in the epidermis will appear purple.

1. DEFINITIONS AND TERMINOLOGY

Flavonoids

Pigments dissolved in the cell sap, such as anthocyanidins, which are red or blue, betaxanthins, which are yellow and anthoxanthins which are yellow or cream. Unrelated compounds are betacyanins of which betanidin found in beet is an example.

Carotenoids

Pigments in plastids within the plant cell, namely carotenes, which are orange and xanthophylls, which are yellow.

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True yellow

For the purpose of this article, true yellow shall be a clivia which displays a complete lack of anthocyanin in its flowers, berries and seedlings.

Par-yellow

This plant is still able to produce very little anthocyanin, which sometimes shows up as spots or streaks on the flowers and/or berries. The seedlings however are unpigmented. It has only recently been identified as a second mutation. The term "par" is not my creation but an already established term in some bird mutations, e.g. blue and par-blue, which are not equal in colour but equal in its inheritance (recessive over the normal green colour). Further in birds where the colour is equal and the inheritance differs, the mode of inheritance is used to differentiate between the two, e.g. sex-linked yellow and recessive yellow. The par-yellow clivias are definitely not freaks or rogues but merely a mutation of another gene in the anthocyanin pathway (Figure 1). Natal Yellow A and B are examples.

True breeding

A phenotype can only be true breeding if it is homozygous. This means that a true yellow of the genotype aaJJ or a par-yellow of the genotype AAjj will be true breeding if selfed or crossed with its own genotype. A true yellow of the genotype aaJj is heterozygous (carrying factor for par-yellow), and if selfed will produce three different genotypes. Genetically it will not be regarded as true breeding even if its phenotype remains unaltered. The three different genotypes are aaJJ, aaJj and aajj. The latter can be crossed with true yellow or par-yellow producing 100% yellow progeny, true yellow or par-yellow, as the case may be of the genotypes aaJj and Aajj respectively. If these two genotypes are crossed 25% orange will be produced as will be demonstrated in the concluding section of this article. The term true

2. COMBINED MUTATIONS

At the meeting on 14 February 1998, I demonstrated three different methods to indicate how I arrived at my prediction as set out in item 10 of my article (Newsletter vol. 7, Jan. 1998, p. 13)). I was asked to do an article on this for the newsletter, but I was reluctant to do so, as I had no literature to substantiate my views. I was fortunate enough to receive an article by R.J. Griesbach of the United States Department of Agricultural Research Service, Beltsville, Maryland, 20705, under the heading "Genetics and Biochemistry of Anthocyanin Albinism in *Paphiopedilums"* and I quote: *"Most plants are diploid and have two copies of every gene. For discussion purposes, Paph. faireanum fma. Alba's genotype could be designated AABBCCDDEEFFGGHHjj.*

The two copies of the "j" anthocyanin gene are non-functional and anthocyanin is not produced. On the other hand one could designate Paph. bellatum fma. Alba's geneotype as aaBBCCDDEEFFGGHHIIJJ. In this case, the two copies of the "a" anthocyanin gene are non-functional. The hybrid Paph. x Iona, would have one gene from each parent and would be designated AaBBCCDDEEFFGGHHIIJj. In Iona, there would be at least one functional copy of each anthocyanin gene, which would result in red flowers. Two copies of each gene are not needed for anthocyanin production. When Paph. x Iona is selfed, one would find that 7/16 or 44% of the progeny are alba (Table I).

Table I Genetics of diploid Paph. x lona (AaJj) = Paph. faireanum alba (AAjj) x bellatum alba (aaJJ).

Parents Fl	AaJj	x	AaJj
Sex cells	25% AJ		25% AJ
	25% Aj		25% Aj
	25% aJ		25% aJ
	25% aj		25% aj

Progeny F2:	AJ	Aj	aJ	aj
AJ	AAJJ	AAJj	AaJJ	AaJj
Aj	AAJj	AAjj	AaJj	Aajj
aJ	AaJJ	AaJj	aaJJ	aaJj
aj	AaJj	Aajj	aaJj	aajj

Alba genotypes = AAjj, Aajj, aaJJ, aaJj, aajj.

Figure 1 Anthocyanin biosynthetic pathway showing the action of ten genes (G. Stotz, et al, 1985. Theor. Appl Genet. 70:300)

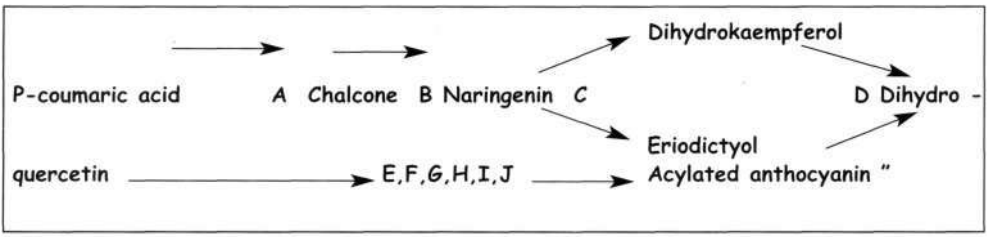

Table 1 by Griesbach as set out above was one of the methods demonstrated by me at the meeting on 14 February 1998, the only difference being the symbols I used. Apart from the 7/16 or 44% (to the nearest) albino progeny, Griesbach did not give a full analysis of all the genotypes and their percentages. For convenience I shall use his symbols for our yellow clivias, i.e.

P-generation: aaJJ for true yellow x AAjj for par-yellow

F1-generation: AaJj F1-orange

These Fl-orange parents will give rise to the following genotypes in the F2-generation:

F2-generation:

1.	AAJJ	1/16	6.25%	Orange
2.	AAJj	2/16	12.5%	Orange split par-yellow
3.	AaJJ	2/16	12.5%	Orange split true yellows
4.	AaJj	4/16	25%	Orange split true and par-yellow
5.	AAjj	1/16	6.25%	Par-yellow
6.	Aajj	2/16	12.5%	Par-yellow split true yellow
7.	aaJJ	1/16	6.25%	True yellow
8.	aaJj	2/16	12.5%	True yellow split par-yellow
9.	aajj	1/16	6.25%	True yellow and par-yellow combined

Genotypes 1-4 are orange and represent a total of 56.25%
Genotypes 5-9 are yellow and represent a total of 43.75% in total

Phenotypic ratio of 9:7

Please note that 12.5% as stated in item 10(d) of my article in the January 1998 issue of the newsletter is a typing error and should read 25%.

The genotype in item 9 above is true yellow as well as par-yellow, but its phenotype is true yellow only. The reason for this is that the anthocyanin pathway is totally blocked by the genes responsible for true yellow and thus the phenotypic expression of the genes responsible for par-yellow is suppressed. This is called epistasis or masking. There are several forms of epistasis. They have one thing in common and that is that they change the normal expected phenotypic ratio of breeding results considerably. The British geneticist Bateson discovered this particular form involving the inter-action of two different recessive gene pairs early in the 20th century. He crossed two true breeding sweet peas with white flowers. To his surprise this resulted in purple flowers only. This Fl-generation was allowed to self and out of a total of 651 F2-plants, 382 produced purple flowers and 269 white flowers, a ratio of 9:7. The following table was used to demonstrate the interaction of the genes and the 9:7 ratio.

P-generation aaBB (White) x AAbb (White)

Or alternatively AABB (Purple) x aabb (White)

Gametes : (sex **cells)** aB and Ab

Fl-generation: AaBb (Purple)

F2-generation AaBb x AaBb

Gametes	AB	Ab	AB	ab
AB	AABB	AABb	AaBB	AaBb
Ab	AABb	AAbb	AaBb	Aabb
aB	AaBB	AaBb	aaBB	aaBb
ab	AaBb	Aabb	aaBb	aabb

Genotypes shaded are purple

F2-generation : Phenotypic ratio of 9 purple and 7 white.

This deviates from the normal expected phenotypic ratio of 3:1 in the F2-generation when a single recessive gene pair is involved.

Example (as for Clivias)

AA (orange) x aa (yellow) =100% AaF1 -orange

Aa x Aa =25% AA (orange), 50% Aa (orange) and 25% aa (yellow)

F2-generation = 75% orange and 25% yellow, a ratio of 3:1

3. ABERRANT YELLOW FORMS

A clivia is variable in many respects and colour is no exception. For example it may be able to produce anthocyanin in the normal way, but the intensity of the colour as well as the extension thereof, wherever it may occur in the plant, may vary considerably. In Mirian Meltzer's vast collection of some 50,000 orange clivias, mostly grown from seed, there are two or three with orange flowers and yellow berries. It is not surprising that in this vast collection three yellows arose, but with a difference. The one has orange midribs on the outside of its petals, the other one is the picotee as illustrated in the Clivia Review 1998. The third one is a clear yellow with orange berries. Further more Nick Primich produced a yellow from a normal orange plant. He selfed this yellow and I know he does this meticulously, but the seedlings were all pigmented. Hopefully we will now be able to see whether some of these pigmented seedlings will produce yellow flowers. Mirian Meltzer's seedlings from her yellow are also all pigmented. I myself used the pollen of the picotee on a yellow with faint red tips to its petals, but the progeny are all pigmented. I am now more than ever before convinced that a plant with normal functioning anthocyanin can produce yellow flowers in as much as an orange flowering plant can produce yellow berries.

4. DILUTE

This is another phenotype, which is closely related to our yellow mutations. In a dilute the intensity of the pigmentation is so diluted that very pale flowers result. Chubb's peach is a good example of this. By analysing the breeding behaviour of a plant, its genotype can be deduced. The following breeding results were obtained from Chubb's peach:

(a) Natal Yellow B x Chubb's peach = 100% orange flowering plants

(b) True Yellow x Chubb's peach = 100% unpigmented seedlings

This implies that the defect, which is responsible for Chubb's peach, acts on the same gene as that which is responsible for true yellow. Experience with other genera of plants has proved that a normal plant is dominant over both dilute and albino, but that dilute in turn is dominant over albino. As Chubb's peach originated in an orange flowering population where no yellows occur, the genotype **A'A'** could be designated to it. **A'A** would be orange flowering as orange is dominant over dilute.

The genotype of the progeny in (a) above would therefore be **A'AJj (Orange).** The genotype of the progeny in (b) would be **A'a**, and therefore all dilutes, as **A' (dilute)** is dominant over **a (true yellow).** If the dilute of the genotype A'a, is crossed with a true yellow (**aa**), 50% dilute and 50% true yellow would be produced.

Example

	a	a
A'	A'a	A'a
a	aa	aa

50% dilute and 50% yellow

The origin of Naude's peach is unknown and so is its genotype. Preliminary experiments indicate that it could be of the same genotype as Chubb's peach, but further research is necessary to confirm this. Few of the ten genes in the anthocyanin pathway give rise to viable mutants for reasons as set out in the next section dealing with white. We already have two of the ten genes responsible for clivia mutations, i.e. one for true yellow and Chubb's peach and one for par-yellow. The possibility of a third gene being involved is therefore unlikely. The allelic relationship (being different forms of the same gene) of Naude's peach with par-yellow has been ruled out. The following breeding results confirm this and suggest a relationship between true yellow and Chubb's peach:

(a) Natal yellow x Naude's peach : 100% pigmented seedling

(b) Natal yellow x Chubb's peach (F1-orange) x Naude's peach : 5 seedlings - 3 pigmented and 2 unpigmented.

(c) True yellow x Natal yellow B (F1-orange) x Naude's peach : 18 seedlings - 12 pigmented and 6 unpigmented. This deviation from the expected 50% may be due to the fact that one third of the flowers of the seed plant were already open when pollination with Naude's peach commenced.

Meg Hart unintentionally and without knowing which the parents were, bred three dilutes. Either she must have an orange flowering plant of the genotype **A'A**, which selfed or a peach which is so diluted that it appears yellow.

Dilute should not be confused with pastels, which are very pale orange forms. Pastels can be crossed with any colour within the orange spectrum producing a variety of shades. It is not yet known whether Mayer's Peach is a dilute or a very pale pastel. If pollen can be made available,the necessary experiments will be done to determine its genotype.

5. THE MYTHICAL WHITE

Griesbach defines an albino as follows : "An albino will by definition display a lack of anthocyanin pigmentation, but will contain chlorophyll and carotenoid pigments." Our yellow clivias are therefore already albinos. The yellow colour of the flowers is mainly due to carotenoids, which are also present in the leaves. Without this the plant cannot survive. It not only protects the chlorophyll, but is also involved in the absorption of certain rays of the sun. Furthermore, the vast majority of albinotic mutations are blocked at the same step in the anthocyanin pathway. The reason for this is that the ten genes in the anthocyanin pathway are also involved in other flavanoid pathways, which are essential for growth and protection from the harmful effects of ultra-violet irradiation. Admittedly yellow pigments are not essential in the flower and it may be possible to produce a white by selective breeding.

The clivia with the white and green centre as depicted on page 6 of the Clivia Review 1998, preferably as a mother plant, would be an excellent choice. By crossing this plant with yellow you may get whites or nearly so, with green in the centre in the F2-generation. If I had a choice for a yellow as pollen plant, it would be one which already has green in the centre, like that on page 8 of the Clivia Review 1998. The reason why this breeding should not be done the other way round (yellow as mother plant) is because yellow is said to be maternal and may be a dominating factor if you have white in mind.

6. COLOUR

Colour in the clivia is the combined effect of the presence of anthocyanin in the epidermis and carotenoids in the mesophyll (underlying tissue). Removing the epidermis of an orange flower can prove this. The epidermis will be red and the exposed mesophyll will be yellow. If this red epidermis is placed on any yellow surface, the colour will change to orange. The different shades from pastel to red are the result of the ratio of leucoplasts (transparent cells), chromoplasts (cells containing carotenoids) and the concentration of anthocyanin.

Example

(a) A flower with few chromoplasts and a high concentration of anthocyanin will be red.

(b) A flower with few chromoplasts and a low concentration of anthocyanin will be pink.

(c) A flower with leucoplasts only and no anthocyanin will be white.

(d) A flower with chromoplasts in abundance and a low concentration of anthocyanin is salmon.

(e) The epidermis of a yellow clivia flower contains no anthocyanin and is transparent. The yellow colour is displayed by carotenoids in the mesophyll underneath.
The colour of the berries is influenced by an additional factor, namely chlorophyll which is retained in the mesocarp (pulp) of some plants.

Example

(a) Orange-red berries have yellow pulp and a high concentration of anthocyanin in the epidermis.

(b) Yellow berries have yellow pulp and a transparent epidermis.

(c) Pale green berries have green pulp and a transparent epidermis.

(d) Purple berries have green pulp and a red epidermis. If the epidermis of this berry is removed and thoroughly washed it will be red. Place it on a green surface, press it well down and it will appear purple again.

7. CONCLUSION

This study has proved that there is not a pair of genes for red and a pair of genes for yellow as previously accepted. Yellow is due to a gene, which is responsible for one of the enzymes necessary for the production of anthocyanin, being non-functional. In the case of a dilute the gene is defective. Furthermore the theory of the hidden red gene can now also be explained. We may already have yellows of five different genotypes, namely **aaJJ, aaJj, aajj, AAjj and Aajj.**

Not all of these would produce 100% yellow progeny. We already know that true yellow (aaJJ) x par-yellow (AAjj) produce 100% orange, but aaJJ x Aajj would produce 50% orange and 50% yellow, whereas Aajj x aaJj would produce 25% Orange and 75% yellow progeny.

Example 1

P-generation		aaJJ	x	Aajj
Gametes	aJ	aJ	Aj	aj

Progeny:

	Aj	aj
aJ	AaJj	aaJj
aJ	AaJj	aaJj

50% orange and 50% yellow

Example 2

P-generation		Aajj	x	aaJj
Gametes	Aj	aj	aJ	aj

Progeny:

	aJ	aj
Aj	AaJj	Aajj
aj	aaJj	aajj

Yellow genotypes Aajj, aaJj and aajj = 75%. Orange genotype AaJj = 25%

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Miniature *Clivia miniata* 58

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Front cover: *Clivia nobilis* (emblem of the Cape Province branch)
Back cover: *Clivia miniaia* 'Apple Blossom"

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