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Colour and contemporary digital botanical illustration

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ABSTRACT

Colour can simply be an attribute of a plant, but for scientific identification purposes, colour can also be diagnostic, distinguishing, or helping to distinguish, a plant from an otherwise similar species or cultivar. Hence the accurate recording of colour has been a feature of botanical illustration since its beginnings. New digital composite botanical illustrations, based largely on photography, can include far more colour information about a plant, both in terms of quantity and quality, than is possible by more traditional methods of colour description. Furthermore such digital composite illustrations allow a significant advance in the communication of such colour data.

1. Introduction

Colour is a notable feature of plants. Indeed colouring is often the first characteristic that we are aware of on seeing a plant for the first time, but for scientific purposes, colour has traditionally been considered by botanists to be secondary as a distinguishing feature. Plant structure has always come first for the purpose of identifying plants. This view dates back at least to the Swedish botanist, Carl Linnaeus, who in his *Philosophia Botanica* of 1751 [1], wrote that "*colour within the same species is remarkably sportive, and so is of no value in definitions*" and so warns his readers "*not to put too much trust in colour*". However, it is precisely this variation in colour that is often of value in ornamental plants, and where flower, foliage and fruit colour can be diagnostic, and even quite subtle colour differences may distinguish one cultivated variety, or 'cultivar', from another.

Where wild plants are concerned, colour can be a useful supplementary identification aid; for example in the identification of winter stems of deciduous trees and shrubs. Indeed some field guides are arranged by colour. When new species are found, named and described, a sample of the plant is preserved to create a permanent reference. The preservation of such 'herbarium specimens' is achieved by pressing and drying. Unfortunately living colour is usually lost on such treatment (see Figs. 1 and 2) and consequently herbarium specimens do not create a permanent reference for colour features.

Even when plant material is not cut or picked, the living colour of a plant part can be a transient feature. Flower and fruit colour are by definition short-lived. Such colour has evolved for the purposes of attracting suitable pollinators and predators to effect fertilisation and seed dispersal, respectively, and also to warn of toxicity to deter unsuitable predators. Once these purposes have been achieved, colour is no longer necessary. The dramatic changes in foliage colour of deciduous trees during the autumn prior to leaf fall, as pigments are moved around the plant are also short-lived, and while not diagnostic, are often fairly characteristic within a species.

For all these reasons, any comprehensive scientific illustration of a plant should therefore not only depict colour accurately but also ideally show all notable colouring exhibited by the plant throughout the entire year. As a result, when creating new digital composite botanical illustrations, Simpson [2] trialled the use of a 'colour key' as an integral part of the illustration. In arriving at such a colour key, traditional methods of describing (both recording and depicting) plant colour were considered.

2. Traditional methods of describing plant colour

2.1. Words

Written descriptions of plant colours can range from a single word, to a descriptive phrase, and are found in both common names, like 'red campion' and 'blackthorn', and in scientific Latin plant names, where the species name, or 'specific epithet', can be a colour or description of a coloured part, for example, *rubra*, meaning 'red,' or *rubricaulis*, meaning 'red-stemmed'. In horticultural descriptions, more complex plant colour is often described as a phrase, for example 'pink fading to white', 'pale pink marked with bright red', or even 'creamy yellow-orange overlain with pale

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[1] During the 2 day conference, 20 digital composite illustrations by the author were on display in the library at the Linnean Society; 10 were of deciduous trees displaying autumn colour and 10 were of various poisonous plants.

[2] For copies of the *RHS Colour Chart*, see http://www.rhs.org.uk/Learning/publications/pubs_library_colourchart.asp

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Fig. 1. Herbarium specimen of *Acca sellowiana* one year after pressing. Many specimens fade to completely brown after a couple of years.

Fig. 2. Photograph of *Acca sellowiana* showing living colour.

pink flush with a central stripe of deep yellowish-pink and speckled with light greenish-yellow, maturing to deep yellowish-pink'. In general though, word colour descriptions are subjective, limited and imprecise, due to our inadequate everyday vocabulary of colours, differing colour memories and our inconsistency and lack of precision in using them. Wang and Rydeheard [3] also point out that in word descriptions the emphasis is only on the hue component of colour.

Word descriptions are quick and straightforward for most people to write and do give an instant mental impression of colour, if only generally a basic one. From an illustration perspective though, written descriptions are non-visual and so are not suited to inclusion within a botanical plate. A lengthy description would take up valuable space and, in addition, words have the distinct disadvantage of being language-dependent.

2.2. Paintings

Visual descriptions of plant colour have generally taken the form of detailed painted botanical illustrations, typically in watercolour, or of such work reproduced, either in black and white and later hand-coloured, or directly by colour printing. That colour in published botanical work was considered of great importance is evident from the fact that *Curtis's Botanical Magazine* employed coloured illustrations from its establishment in 1787, and continued to be hand-coloured right up until 1949, despite the considerable expense involved.

For artists, pressure of time led to the development of kinds of shorthand for colour recording. At the height of plant exploration in the late eighteenth century, when there was often only time to draw and not paint, it became the practice of botanical artists like Sydney Parkinson, to make colour notes on a preliminary pencil drawing. These could be in the form of written descriptions or annotated notes of coloured parts, but often a small part of each colouring was painted, just enough to act as a reference for full colour to be added at a later date. Some artists make written notes, not only on the observed colour of plant parts, but also on which pigments were mixed in order to achieve a particular colour, together with a painted colour "patch" to act as a visual *aide-memoire,* in order that a particular colour can be remixed at a later date, when time is available to create the full colour painting.

Highly complex colouring, which would take the reading of several paragraphs to visualise, can be conveyed instantaneously by an image where no such visualisation is required. Of course, whereas it would take only minutes to write a description, a watercolour painting complete with diagnostic sections and dissections, would take a considerable length of time—often weeks. Describing colour by painting is much more difficult to accomplish than writing a description in words, and is obviously a completely different skill; one that requires training and practice to achieve. For colour accuracy and detail, painting does of course rely on the eye and ability of the artist and even when trained in observation, the human eye simply cannot see the amount of colour information that photographic sensors and film can capture in an instant and be later revealed on magnification. The depiction of highly complex information can present problems for the artist, for instance, where a plant part is complicated by veining and hairs, often he or she has to make a

decision to concentrate on certain of the elements—and convention has it that this will be the structural elements at the expense of colour.

Other drawbacks of recording colour by painting are that space is limited in the traditional botanical plate which means that not all colour features are always recorded and that the length of time taken, and hence cost, to produce a painting can be a deterrent to including any supplementary colour detail. While painted images have some limitations with regard to colour accuracy and detail, they are a most powerful and instant means of communicating colour, as well as form, to the viewer, and are of course, independent of language.

2.3. Traditional colour photographs

Photography came into its own for botanical purposes with the advent of colour photography in the early 1900s [4] and many botanical artists have used colour photographs not only as visual aids but also as a back-up record; a precaution against the plant colours fading after cutting. Unlike completing a painting at a later date from notes, codes or colour patches, and to a degree from memory, photographs can fairly objectively capture the entire colour information on the spot. For outdoor horticultural recording and botanical field work, photography is excellent at recording and depicting *general* colour in habit and habitat shots of plants, although sunlight, early morning light and late afternoon light can all affect colour. The use of macro-photography and photomicrography enables more detailed colour data capture. However, photographs can lack clarity, with shadows often obscuring or confusing colour detail, while achieving the correct focus of all the relevant plant parts within the frame has always been noted as a problem for illustration purposes. When using traditional silver halide film, photographic results can be variable, with different makes of film giving noticeably differing colour and saturation.

Regardless of the limitations, the instant and fairly objective capture of complex colour data, are some of the great advantages of photography for botanical recording. Traditional photography therefore has had considerable potential for botanical illustration work, but technical problems, such as isolation of parts, achieving all parts in focus, have largely precluded its use up to now. For any accurate colour recording of plants using traditional photography, the inclusion within the shot of a printed colour reference chart, a *Kodak Color Control Patch* or similar, alongside the plant material, has been necessary.

2.4. Codes to personal colour charts for painting

Certain botanical artists, notably Ferdinand Bauer, have created their own personal "painting by numbers" colour systems, using abbreviations, numbers or codes to refer to particular colours on a chart. Lack and Ibáñez [5] give details on Ferdinand Bauer's colour chart made up of 140 colour codes and note that there is evidence that Bauer later created a far more comprehensive chart of around 1000 colours, which, however, has not survived. While Bauer was by no means the first to use a colour chart, the sheer quantity and outstanding quality of his artwork is proof of the considerable value of the colour chart as a colour recording tool for the botanical artist. Mabberley et al. [6] have published of one of Bauer's expedition outline pencil sketches now reconstructed as a colour painting, following the cracking of Bauer's coding, which demonstrates how a personal colour chart can be used not only by the artist themselves, but by anyone who has the key to the codes and at any time. Contemporary artists have also used personal colour codes and Christabel King [7] has documented her experience of using a personal chart of 240 colours.

2.5. Codes to standard colour charts

Proprietary colour matching systems have been available for colour recording. The systems comprise a printed set of standard colours, each colour patch being marked with a unique number or code, to act as a standard reference against which coloured materials can be viewed for matching. The need for standardised colour descriptions for recording the colour of cultivated plants was recognised and the British Colour Council, in collaboration with the Royal Horticultural Society, developed a standard colour reference system for horticultural use, known as the *RHS Colour Chart,* [8] as a result. Elliott [9] gives a short history of the *RHS Colour Chart*. For ease of use with plant material, the format of the RHS chart changed from loose pages to a boxed set of four fans in the 1966 edition, and later editions have a viewing hole through each colour patch. (See Fig. 3.) Published by the Royal Horticultural Society, which describes it as "*Used by the Royal Horticultural Society, growers, plant registration authorities and specialist organizations such as the International Union for the Protection of new Varieties of Plants (UPOV) to identify and describe plant colour accurately*", the revised 2007 edition [10] contains 896 colours in total, and comes with instructions in six languages—English, French, Dutch, German, Russian and Japanese.

Colour perception varies between individuals and so colour matching is inevitably somewhat subjective. The viewing of plant colours against a colour chart is affected by daylight lighting conditions, which are not consistent, and colour viewing is further influenced by the immediate surroundings and even viewing angle. Artificial light is not suitable and optimal viewing conditions of natural north light are not always available in all recording situations, though this can largely be overcome by the use of indirect daylight or by the use of an artificial daylight simulation bulb.

A single colour, or even two colours, is frequently an over-simplification; often a plant part displays many more. For example, the leaf photograph in Fig. 4 shows how numerous

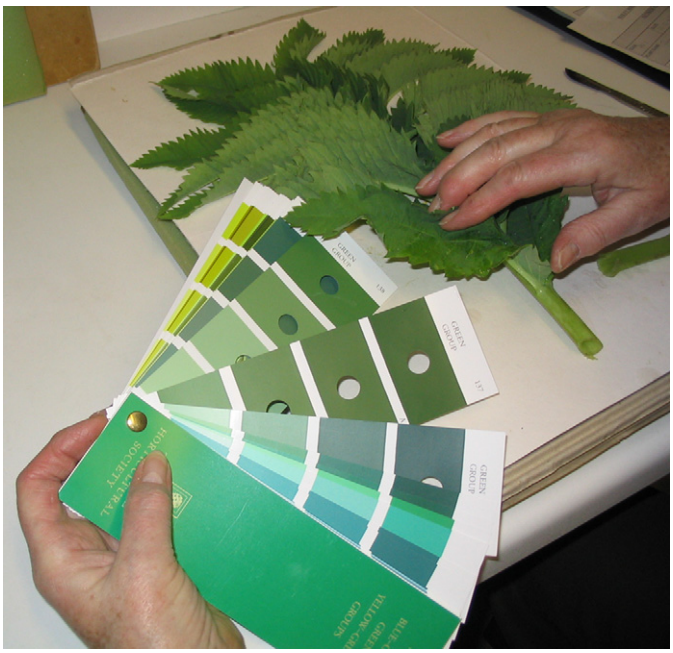

Fig. 3. Recording foliage colour using the *RHS Colour Chart* as a reference. (Image reproduced courtesy of the RHS Herbarium Image Collection.)

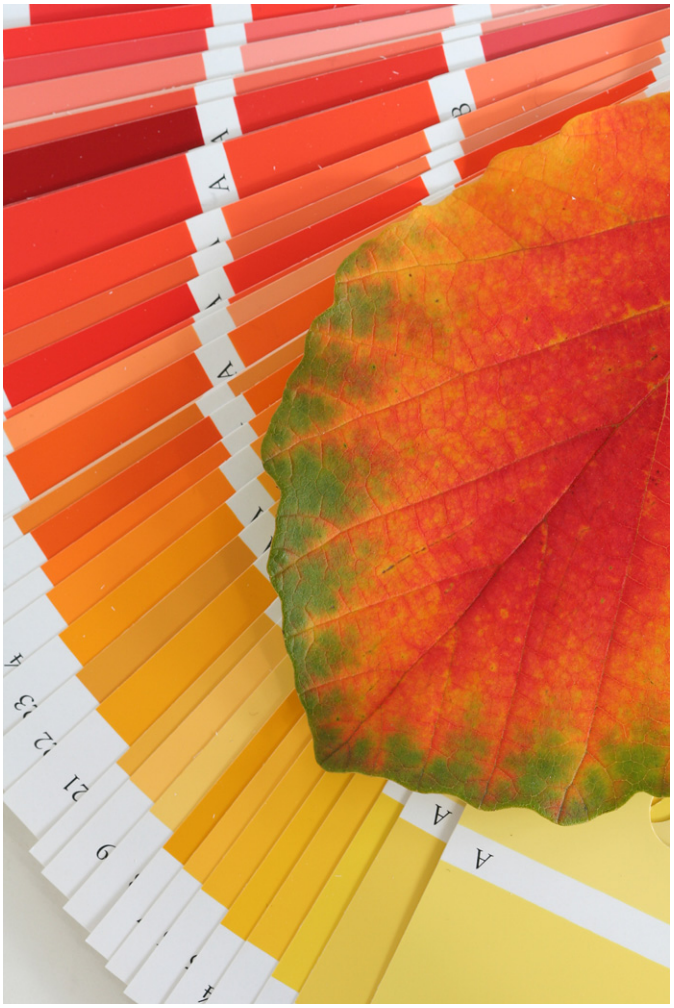

Fig. 4. Complex colouring in a leaf.

colours can be observed and identified by comparison with the colour chart underneath it, even within a small area, and indeed how difficult it can be to decide just which of the gradation of colours observed to record.

While colour charts contain a large range of colours, they are not fully comprehensive and plant colours will be found that cannot be exactly matched, which means that references like "slightly darker than X", or "between X and Y" are needed. The use of a code alone gives the reader no mental picture of the colour. Consequently, in descriptions of plants given awards by the Royal Horticultural Society, the colour chart page heading is usually included, for example, 'Red-Purple Group 76B'. Susan Grayer, practiced in using the *RHS Colour Chart* to describe specimens for the RHS, gives some guidance notes for its use in the *RHS Plant Finder News* [11]. New editions of a colour chart may be produced by different printing processes and can result in minimal shifts between editions, making it a good idea to add the colour chart edition as well as the code in any colour reference. The charts themselves may fade if left out in sunlight and, being paper-based, colour charts are not particularly suited to outdoor use.

Despite these limitations, colour charts are excellent for recording plant colour; they are quick and handy to use with plant specimens, and there is a large range of colours suitable for plant description. Being referenced by numbers or codes, they are not so dependent on language and can be used internationally. Consequently, where precise colour recording of plants is required, internationally recognised standard colour charts are a considerable advance over written descriptions, personal coded systems and traditional photographs as a tool for colour description. They have been in use in horticulture, for the colour description of cultivars since the 1900s, though their use has been confined to textual descriptions. As far as the author is aware, they have not been used by botanical artists within illustrations, but their use in this way has potential for increasing the colour information provided within botanical illustrations.

3. Digital images

The arrival and rapid development of digital cameras and digital imaging technology has brought benefits for recording and observing the colour detail of plants. The combination of instant photographic capture of large amounts of colour data, the ability to view and manipulate that data onscreen, together with the ease of enlargement—literally at the touch of a button—enables the ready viewing of magnified plant colour detail (see Fig. 5). Subjectivity in data capture is removed; none of the colour is selected or interpreted by an artist, remembered or decoded from a colour reference chart or written notes. There are limitations however to working with colour digitally from the point of view of botanical illustration.

In digital work, colour can be defined using one of several internationally standardised colour reference systems: RGB (red, green, blue), HSB (hue, saturation, brightness), the similar HSL

Fig. 5. Colour detail of leaf revealed by enlargement of photograph.

(hue, saturation, lightness), CMY (cyan, magenta, yellow), hexadecimal values, Lab colour, as well as proprietary systems, such as Pantone®. Working with colour in the form of light, as in seeing plants and viewing images on a computer monitor, involves a different underlying colour system from when working with colour in the form of paints or printed inks. Simply put, colour cannot be reproduced by printing with light on to a surface; printing colour on to a surface requires pigments and this involves the subtractive colour system, with CMY components. The additive colour system, with RGB components, is based on light and is how we perceive colour around us—including colour in plants.

Even with the addition of black (kohl) as a key colour to CMY for the CMYK or '4-colour' printing process, the number of colours produced by RGB devices still exceeds that possible to reproduce by using CMY pigments, though still not as many as are perceptible to the human eye. The different colour ranges, or gamuts, between the systems means that problems can arise when images are reproduced, as some RGB colours may not be printable. This is of course pertinent to botanical artists, where accurately coloured digital illustrations are created for publication in the printed medium. A further consequence of the two different colour systems is a conflict when matching the plant colour seen between that on a printed colour chart (subtractive colour) and that viewed onscreen (additive colour), the difference being exaggerated by the fact that printed colour charts are optimally viewed in natural daylight, whereas viewing on a computer monitor is most likely to be viewed in non-daylight conditions.

Additionally, the accuracy with which colour is recorded in digital illustrations is dependent on having a fully colour-calibrated system, from the computer used for editing, to the subsequent processes of printing or, indeed, any computer on which the image may be viewed.

3.1. Colour keys for digital botanical illustrations

For these composite illustrations, a 'colour key' was envisaged, rather like the sample colour patches used by artists on their sketches, but with the set of colour boxes being used in conjunction with codes matched to a universal standard colour reference and all being placed *within* a composite illustration as an integral part of it. With this combination of visual colour and colour reference code, it was felt unnecessary to include any word description, other than that contained in a plant's name. Simpson [12] showed the use of such a colour key to give colour references for the dominant or notable colours of a plant.

Fig. 6 shows an example of a digitally created composite botanical illustration with the colour key, in this case, placed in the top left hand corner. The colour information of this illustration can be compared with Figs. 1 and 2, the herbarium specimen and habit photograph, respectively, which are all of the same plant of *Acca sellowiana*.

The series of 41 digital composite illustrations exhibited in the Botanisches Museum Berlin-Dahlem, Germany, in 2007 [13], contained colour keys based on the 1995 edition of the *RHS Colour Chart* [14]. The photography of plant parts was carried out in daylight conditions, avoiding sunlight, to avoid colour bias as far as possible. The colour codes were recorded by matching the plant parts to the printed colour chart in the usual way, while the actual matching colour shown in a box was selected from the photographic image onscreen; the earlier ones 'by eye,' and the later ones using the software's 'eye-dropper' tool. Neither the 3rd edition used, nor the current edition of the *RHS Colour Chart*, includes any conversion to RGB, HSL, HSB, or CMYK and no attempt was made to correlate the printed chart codes to other values, since at the time these images were produced simply to demonstrate that a digital approach to botanical illustration was possible. (Interestingly, the 1966 edition of the *RHS Colour Chart* did include equivalents using the CIE xyY colour model.)

4. Discussion

Having created these images, it has since been possible to give the colour aspect some further consideration, with a view to improving the recording of colour in future digital illustrations.

The use of an eye-dropper on an image, to obtain a precise colour reference, while appearing to remove the subjectivity of using a colour chart, naturally relies for its precision on the accuracy of the source image. The use of the eye-dropper tool is quick and easy to use, but point sampling will give the precise colour values of a single pixel, which is likely to be only one of literally thousands or even millions of colours in the image. The result could be misleading if an atypically coloured pixel happened to be unknowingly selected, and such precision obviously far exceeds that needed for botanical or horticultural description. More useful, though still perhaps excessive, would be area sampling which would give an averaged, more consistent and more representative value for, say a 5×5 pixel or larger square within the image.

The latest *RHS Colour Chart* contains 896 colours thought to be the most useful for horticultural description and it is interesting to note that Bauer extended his later colour chart to a number close to this, presumably because he found fewer colours inadequate. By comparison the 16.77 million colours available to pick from on a monitor screen would seem excessive, to say the least. For the colour description of plants, it is necessary and practical to record only the dominant or notable colour, or colours, and the need to balance precision against requirement and practicality should perhaps be emphasised.

While the human eye remains supreme in terms of the number of colours that can be seen, we cannot begin to either identify this number or reproduce them in paint or print. So for the pragmatic purpose of plant description, a range of approximately 1000 colours would appear to be appropriate. The *RHS Colour Chart* provides such a realistic range with regard to printed colours, but an equivalent digital range would be better suited to digital photography-based illustration work. The use of additive colour offers more available colours, is more accessible and usable for digital work and would be more consistent, especially on a colour-managed system. However, some subtractive printed colours, currently in use within the *RHS Colour Chart,* may not have exact additive equivalents. It might also be questioned whether the differences between non-colour-managed systems would actually be greater than those arising from the subjectivity of using a colour chart.

Further work is needed in this area in order to evaluate the digital colour system most appropriate for use in such digital botanical illustrations. As these digital composite botanical illustrations have been first and foremost designed to be viewed onscreen, it is hoped in future to construct colour keys referenced to similar colour ranges from other (additive) colour models (RGB, HSB).

The advantages of digitally created, photography-based illustrations, from the point of view of colour, are considerable. A far greater amount of colour detail can be captured in the instant the photograph is taken, than is possible for an artist to either observe, or portray in a painting, whether painted at the time or later from a colour chart reference, and such colour recording is done objectively. The use of photography for botanical illustration undoubtedly allows more colour information to be recorded

Fig. 6. Portion of a digitally created composite botanical illustration, or 'image specimen', of *Acca sellowiana* showing living colour and colour key.

within an illustration, this being achieved by combining the objective and detailed colour capture that quality digital photography enables, with the benefits of a colour key which references colours to a universal standard colour reference system. However, this is only revealed and fully appreciated when the zoom or magnification tools of image software are used. Important further benefits arise from the possibilities for interactive use of such images and for global access by a worldwide audience, both of which enable significantly improved communication of colour data.

5. Conclusion

New digital photography and imaging technology has meant that the potential of photography can be developed for illustration work and digitally created composite botanical illustrations, based on photography, can demonstrate a significant advance in colour information content, countering the subjectivity and limitations of traditional methods of colour observation, recording and depiction.

The use of a colour range, appropriate for botanical and horticultural description, in an additive colour model (such as RGB, HSB, Lab colour) which would be more suited to digital illustration, is envisaged for future composite illustrations.

In providing accurate and detailed information on living colour, digital composite botanical illustrations can form valuable supplements to herbarium specimens, in which colour is generally lacking. Transient colour features seen throughout the year can be accurately documented, as can the precise subtleties of the spectrum which may differentiate cultivars.

Furthermore, being designed for onscreen viewing, significant advances in the communication of such botanical colour data are enabled, by way of the possibilities for interactivity and for global access via the internet.

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