CCXV. A SURVEY OF ANTHOCYANINS. V

BY WILLIAM JOHN COOPER LAWRENCE, JAMES ROBERT PRICE,
(MRS) GERTRUDE MAUD ROBINSON AND ROBERT ROBINSON

*From the Dyson Perrins Laboratory, Oxford, and the John Innes Horticultural
Institution, Merton Park, London, S.W. 19*

(Received 13 July 1938)

EMPLOYING the methods previously described [Robinson & Robinson, 1931; 1932; 1933; 1934], further flower petals and permanently pigmented leaves have been examined in order to determine the anthocyanin type. Comments on these results together with those previously recorded will be submitted later. The only new points of technique are the following.

A characteristic property of peonin is that solutions in aqueous sodium carbonate are blue by transmitted daylight and reddish violet by transmitted artificial light. A number of cases have been encountered in which the presence of anthoxanthin and other substances have seriously modified the colour reactions and the distribution properties of anthocyanins, occasionally also of the derived anthocyanidins.

Repeated extraction with hot ethyl acetate or ethyl acetate after the addition of sodium chloride (free from magnesium chloride), or amyl alcohol in the case of diglycosides usually served to remove the interfering substances to a sufficient degree. Such processes must be followed by repeated extraction with benzene, or ether and then benzene, or exposure in a vacuum, in order to remove alcohol.

The autumnal colouring of leaves has been examined with the result that cyanidin saccharides are found to preponderate to a very large extent. The extracts were often contaminated with relatively large quantities of tannins and anthoxanthins and it was particularly difficult to determine the glucoside type. Moreover, it appeared that in a large number of the cases, a mixture of anthocyanins based on one anthocyanidin was present. In the presence of so much foreign material a rhamnoglucoside may simulate a diglucoside and a monoglucoside may behave like a rhamnoglucoside. Although the solutions were purified as far as possible, the results in the series of the autumn leaves are not so conclusive in regard to sugar type as those obtained with flower petals. Most of the anthocyanins produced in autumnal colouring are cyanidin 3-saccharides of various types. In this section the material is classified botanically, using Dr Hutchinson's system reversed so that the more highly developed plants are mentioned first in order; the first number indicates the order and the second the family [Hutchinson, 1926].

SUMMARY OF RESULTS

Flowers		Comments
<i>Abutilon</i> , hybrid, <i>Firefly</i>	e	
<i>Agapanthus umbellatus</i>	x	
<i>Allium cyaneum</i>	x	
<i>Anagallis arvensis</i> , scarlet	i	
<i>A. arvensis</i> , blue var.	y	
<i>A. coerulea</i>	z	
<i>A. collina</i>	i	
<i>Anemone coronaria</i> , blue violet var.	x	Partly methylated or mixed with cyanidin derivatives

Flowers		Comments
<i>Anemone coronaria</i> , red violet var.	h	With some delphinidin derivatives. The pigments of the anthers are monoglycosidic or pentoseglycosidic
<i>Aphelandra nitens</i>	i	With some pelargonidin diglycoside
<i>Aubretia deltoidea</i> , var. E. M. Crosfield	e	
<i>Begonia socotrana</i>	h	Acylated, colour reactions before alkaline hydrolysis were correct for 3:5-dimonoside
<i>Beloperone guttata</i>	c	In petals and bracts
<i>Billbergia Sanderiana</i> , blue petals	x	With trace of anthocyanin derived from cyanidin
<i>B. Sanderiana</i> , scarlet bracts	A	
<i>Brachycombe iberidifolia</i>	x	Much anthoxanthin
<i>Browallia elata</i>	B	Complex
<i>Brunella grandiflora</i> , violet red var.	e	Complex
<i>B. grandiflora</i> , violet var.	x	Complex
<i>Buddleia Davidii</i> , var. <i>superba</i>	C	
<i>B. Davidii</i> , var. <i>magnifica</i>	D	
<i>Camellia japonica</i> , var. Lady Clare	a	Very high distribution, almost certainly a cyanidin complex 3-monoglycoside and would doubtless repay detailed investigation. Although the results were not entirely satisfactory, hydrolysis with alkalis gave an anthocyanin of lower distribution and hence the substance is probably an acylated cyanidin glycoside rather than a derivative in which the sugar is attached to the acyl group
<i>C. sasnqua</i>	a	Complex, probably identical with <i>C. japonica</i>
<i>Campanula Portenschlagiana</i>	B	
<i>Cistus purpureus</i>	E	Or complex anthocyanin resistant to hydrolysis
<i>Correa speciosa</i> , var. <i>ventricosa</i>	c	
<i>Crocus asturicus</i>	x	Kaempferol separated from the acid extracts
<i>C. hadriaticus</i>	x	
<i>C. longiflorus</i>	x	
<i>C. nudiflorus</i>	x	
<i>C. pulchellus</i>	z	
<i>C. sativus</i>	x	With a little complex diglycoside
<i>C. speciosus</i>	z	Extracts contained kaempferol
<i>Dimorphotheca aurantiaca</i>	k	Possibly pentoseglycoside carotenoids are present
<i>Erica hyemalis</i>	a	Much ivory anthoxanthin
<i>Erodium macradenum</i>	x	Methylated. The anthocyanidin is completely extracted by the delphinidin reagent, and not at all by the cyanidin reagent; but it is easily oxidized in strongly alkaline solution. Therefore it may be a new delphinidin derivative, unless a catalyst is present which facilitates the oxidation of malvidin. As this has never previously been observed, it seems more probable that we are dealing here with a new type of delphinidin derivative
<i>E. Reichardii</i> , var. <i>roseum</i>	x	
<i>Escallonia edinensis</i>	a	
<i>Eschscholtzia californica</i> , var. <i>The Mikado</i>	g	With anthoxanthin
<i>Euphorbia fulgens</i>	a	Much yellow anthoxanthin
<i>Gentiana Lagodechiana</i>	x	
<i>Geranium Endressi</i>	z	
<i>Gilia capitata</i>	x	
<i>Godetia grandiflora</i> , var. <i>Crimson Glow</i>	F	
<i>Helianthemum nummularium</i> , a var. with brick red double flowers	a	Much anthoxanthin
<i>Hippeastrum aulicum</i>	j	Co-pigmented
<i>H. equestre</i>	j	
<i>Hydrangea macrophylla</i> vars.	k	After careful purification the reactions and distribution ratios tallied with synthetic delphinidin 3-glucoside. The anthocyanins of red, blue, and violet flowers were found to be identical (correction of Part I)

Flowers		Comments
<i>Hypoestes aristata</i>	e	
<i>Ipomoea Learii</i>	z	
<i>Iris unguicularis</i>	B	
<i>Ixora</i> , hybrid, Lord Williamson	g	
<i>Lapageria rosea</i>	a	
<i>Lilium ochraceum</i>	c	
<i>Linaria purpurea</i>	x	
<i>Luculia gratissima</i>	z	Much anthoxanthin
<i>Lychnis viscaria</i> , var. <i>Blue Bouquet</i>	B	Indication of partial methylation
<i>Lythrum salicaria</i> , var. <i>superbum</i> , pink flowers	z	Strongly co-pigmented
<i>L. salicaria</i> , var. <i>superbum</i> , purple flowers	z	Strongly co-pigmented
<i>L. salicaria</i> , var. <i>Crimson Dwarf</i>	z	
<i>Macleania punctata</i>	i	
<i>Malvaviscus conjatii</i>	G	
<i>Mesembryanthemum truncatum</i> , var. <i>roseum</i>	K	
<i>Monarda didyma</i> , var. <i>Cambridge Scarlet</i>	H	Complex
<i>Musa basjoo</i> , bracts	c	
<i>Naegelia cinnabarina</i>	i	
<i>Nemesia strumosa</i> , scarlet var.	a	
<i>Nierembergia coerulea</i>	x	
<i>N. frutescens</i>	x	
<i>Papaver Argemone</i> , spots	g	With a little 3-monoside
<i>P. Argemone</i> , remainder of petals	G	With some pelargonidin 3-saccharide of higher distribution number
<i>P. atlanticum</i>	G	
<i>P. commutatum</i> , spots	g	
<i>P. commutatum</i> , remainder of petals	g	With little of pelargonidin or peonidin derivative
<i>P. somniferum</i> , spots	g	
<i>P. somniferum</i> , remainder of petal	g	As <i>P. commutatum</i>
<i>Pelargonium inquinans</i>	i	Noteworthy in a <i>P. species</i>
<i>P. saniculaefolium</i>	H	
<i>Penstemon cordifolius</i>	e	With anthoxanthin
<i>Peristrophe speciosa</i>	e	
<i>Phacelia whillavia</i>	z	
<i>Pisum sativum</i> , purple var.	C	May contain delphinidin but no malvidin derivatives
<i>P. sativum</i> , violet var.	C	With a little malvidin derivative. In both vars. the outer parts of the flower are highly co-pigmented, the inner very little
<i>Platycodon grandiflorum</i> , var. <i>Mariesii</i>	x	Much anthoxanthin
<i>Plumbago capensis</i>	h	Much anthoxanthin obscures colour reactions, but the anthocyanin is probably a 3:5-dimonoside
<i>Portulaca grandiflora</i>	K	
<i>Potentilla nepalensis</i>		Acylated cyanidin saccharide. The colour reactions were those of 3-substituted cyanidin derivatives. On hydrolysis an acylated cyanidin was obtained
<i>Pycnostachys Dawei</i>	x	Acylated. Contains a trace of a cyanidin derivative
<i>Raphiolepis Delacourii</i>	a	Much anthoxanthin
<i>Rhodochiton volubile</i> , bracts	f	
<i>Salvia Grahamii</i>	J	Acylated, differing from salvin in that the solution in aqueous Na ₂ CO ₃ is almost pure blue
<i>S. neurepia</i>	J	Acylated. Colour reactions tallied with those of salvin and monardin and differed from those of the anthocyanin of <i>S. Grahamii</i>
<i>Silene Schafta</i>	e	
<i>Solanum crispum</i>		Diglycoside of petunidin or delphinidin; the presence of cyanidin is not excluded if an oxidizing catalyst effective in alkaline solution is present
<i>Sollya heterophylla</i>	x	
<i>Sphaeralcea australis</i>	i	
<i>Streptocarpus caulescens</i>	z	Pure, no trace of anthocyanin giving a positive ferric reaction

Flowers		Comments
<i>Streptocarpus Rezii</i>	z	Containing a small amount of cyanidin dimonoside
<i>Suaeda maritima</i>	K	
<i>Tibouchina semidecandra</i>	z	Complex
<i>Tropaeolum majus</i> vars.		The presence of G was confirmed (previously recorded). Deeper coloured vars. contained mixtures in varying proportions of diglycosidic anthocyanins based on cyanidin and delphinidin, ranging from almost pure cyanidin to almost pure delphinidin
<i>Valeriana officinalis</i> , a red var.	c	With a flavone derivative
<i>Veltheimia viridifolia</i>	e	Acylated
<i>Verbena canadensis</i>	e	
<i>V. canadensis</i> , var. <i>Drummondii</i>	e	
<i>V. tenera</i>	e	
<i>V. erinoides</i>	B	With small amount of cyanidin diglycoside
<i>V. venosa</i>	B	
<i>V. radicans</i>	B	
<i>V. peruviana</i>	i	
<i>Veronica maritima</i>	x	Complex
<i>Vriesia Duvaliana</i> , petals	x	
<i>V. Duvaliana</i> , bracts	z	Contaminated with a derivative of an anthocyanidin exhibiting a ferric reaction under the usual conditions. The anthocyanin of the bracts could not be extracted even by boiling 1% HCl until the outer skin was removed, when the pigment was yielded to a cold solvent
<i>Zauschneria californica</i> , var. <i>latifolia</i>	i	
<i>Zygocactus truncatus</i>	K	
Leaves permanently coloured		
<i>Acalypha macrostachya</i>	a	
<i>Alocasia Lowii</i>	g	Pigmented on underside only
<i>Aphelandra nitens</i>	x	May contain some cyanidin derivative and some monoglycoside. Pigment on underside of leaf only
<i>Calathea insignis</i>	L	
<i>Codiaeum</i> , hybrid, <i>Emperor Alexander III</i>	c	
<i>Columnnea Schiedeana</i>	h	Only a trace of anthocyanidin was obtained by hydrolysis under the usual conditions, a sparingly soluble mauve precipitate being thrown down. Pigment on underside of leaf only
<i>Cyanotis Kewensis</i>	g	
<i>Hoffmannia Ghiesbreghtii</i> , var. <i>variegata</i>	f	
<i>Hoya carnosa</i> , var. <i>variegata</i>	c	Pigmented in chlorophyll-free parts only
<i>Iresine Herbstii</i>	K	
<i>I. Lindenii</i>	K	
<i>Perilla nankinensis</i>	e	Complex
<i>Prunus persica</i> , red-leaved var.	a	
<i>Streptocarpus Wendlandii</i>	g	Pigment on underside of leaf only
<i>Strobilanthes Dyerianus</i>	e	
<i>Stromanthe Porteana</i> , var. <i>variegata</i>	c	Strongly co-pigmented
<i>Viburnum tomentosum</i> , var. <i>plicatum</i>	a	With much anthoxanthin
Other organs		
Cacao beans	a	
<i>Cornus mas</i> (Cornelian cherry)	i	In red berries
<i>Euonymus yedoensis</i> , capsules	a	
<i>Pisum sativum</i> , purple pods	x	
<i>P. sativum</i> , salmon pods	e	
<i>Rubus idaeus</i> , fruits	g	A number of varieties were examined and found to be mainly "g" together with smaller amounts of an anthocyanin derived from cyanidin of very high distribution which gave the same colour reactions as cyanidin 3-saccharides

ANTHOCYANINS FOUND IN LEAVES AFTER AUTUMNAL COLORATION

Species and varieties

76-264.	<i>Elsholtzia Stauntonii</i>	b	57-200.	<i>Acer circinatum</i>	a
76-263.	<i>Callicarpa Giraladiana</i>	e		<i>A. dasycarpum</i>	a
	<i>C. japonica</i>	e		<i>A. Davidii</i>	c
	<i>C. koreana</i>	e		<i>A. Ginnala</i>	b
69-241.	<i>Ceratostigma plumbaginoides</i>	b		<i>A. griseum</i>	c
	<i>Limonium latifolium</i>	b		<i>A. palmatum</i>	a
69-240.	<i>Steironema ciliatum</i>	k		<i>A. pseudoplatanus</i>	b
68-239.	<i>Swertia koreana</i>	b, o		<i>A. rubrum</i>	a
66-233.	<i>Diervilla Lonicera</i>	c		<i>A. rufinerve</i>	a
	<i>Kolkwitzia amabilis</i>	c		<i>A. Tschonoskii</i>	d
	<i>Viburnum bithchieuense</i>	b		<i>A. palmatum dissectum</i>	b
	<i>V. dentatum</i>	b		<i>A. palmatum septemlobum</i>	b
	<i>V. dilatatum</i>	a		<i>A. palmatum septemlobum elegans</i>	a
	<i>V. fragrans</i>	a		<i>A. palmatum roseo-marginatum</i>	b
	<i>V. Lantana</i>	d		<i>A. platanoides Reitenbachii</i>	d
	<i>V. Lentago</i>	d	57-205.	<i>Rhus canadensis</i>	b
	<i>V. lobophyllum</i>	a		<i>R. cotinoides</i>	a
	<i>V. opulus</i>	q		<i>R. cotinus</i>	a
	<i>V. opulus sterile</i>	a, n		<i>R. cotinus atropurpurea</i>	b
	<i>V. orientale</i>	a		<i>R. glabra laciniata</i>	b
	<i>V. Sargentii</i>	f		<i>R. Potaninii</i>	b
	<i>V. setigerum</i>	a		<i>R. toxicodendron</i>	k
	<i>V. theiferum</i>	a		<i>R. trichocarpa</i>	d
64-229.	<i>Frazinus Ornus</i>	a, n		<i>R. typhina</i>	a
	<i>Ligustrum obtusifolium</i>	c		<i>R. typhina laciniata</i>	a
60-215.	<i>Enkianthus campanulatus</i>	a		<i>R. verniciflua</i>	a
	<i>E. deflexus</i>	f	55-194.	<i>Aegle sepiaria</i>	g
	<i>E. perulatus</i>	b	54-193.	<i>Vitis Coignetiae</i>	a
	<i>Gaultheria procumbens</i>	a		<i>V. Englemannii</i>	b
	<i>Leucothoe Keiskei</i>	b		<i>V. Henryana</i>	a
	<i>Oxydendrum arboreum</i>	f, t		<i>V. inconstans</i>	a
	<i>Pieris Mariana</i>	a		<i>V. pulchra</i>	e
	<i>Rhododendron calendulaceum</i>	b		<i>V. quinquefolia</i> , var. <i>Engelmannii</i>	a, n
	<i>R. canadense</i>	a	51-173.	<i>Euonymus alata</i>	b
	<i>R. mucronulatum</i>	b		<i>E. americanus</i>	a
	<i>R. occidentale</i>	b		<i>E. Bungeanus</i>	a
	<i>R. occidentale exqu岸ita</i>	a		<i>E. europaeus</i>	a
	<i>R. pentaphyllum</i>	b		<i>E. Maackii</i>	a
	<i>R. ponticum</i>	b		<i>E. nikoensis</i>	b
	<i>R. reticulatum</i>	a		<i>E. oxyphyllum</i>	b
	<i>R. Schlippenbachii</i>	b		<i>E. planipes</i>	a, n
	<i>R. Vaseyi</i>	a, n		<i>E. radicans</i>	b
	<i>R. yunnanense</i>	a		<i>E. sanguineus</i>	a
60-216.	<i>Gaylussacia baccata</i>	a		<i>E. verrucosus</i>	b, n
	<i>G. dumosa</i>	a		<i>E. Wilsonii</i>	b, n
	<i>Vaccinium caespitosum</i>	b		<i>E. yedoensis</i>	b
	<i>V. corymbosum</i>	a	48-162.	<i>Carpinus caroliniana</i>	b
	<i>V. myrtillus</i>	a		<i>Corylus americana</i>	b
	<i>V. ovalifolium</i>	a	48-163.	<i>Quercus alba</i>	b
	<i>V. pennsylvanicum</i>	b		<i>Q. coccinea</i>	f
	<i>V. uliginosum</i>	b		<i>Q. coccinea splendens</i>	b
	<i>V. virgatum</i>	b		<i>Q. glandulifera</i>	a
59-212.	<i>Aralia chinensis Mandschurica</i>	h, u	42-151.	<i>Corylopsis yunnanensis</i>	e
59-209.	<i>Cornus alba</i>	b		<i>Disanthus cercidifolius</i>	a
	<i>C. alba Spaethii</i>	h		<i>Fothergilla Gardenii</i>	h
	<i>C. Amomum</i>	f		<i>F. monticola</i>	g
	<i>C. Baileyi</i>	c		<i>Hamamelis japonica flavopurpurea</i>	v
	<i>C. florida</i>	b		<i>H. japonica Zuccariniana</i>	w
	<i>C. glabrata</i>	b		<i>Liquidambar styraciflua</i>	a
	<i>C. Koenigii</i>	a		<i>Parrotia persica</i>	l
	<i>C. Kousa</i>	a	40-143.	<i>Amelanchier canadensis</i>	b
	<i>C. Nuttallii</i>	c		<i>A. florida</i>	b
	<i>C. obliqua</i>	c		<i>A. oblongifolia micropetala</i>	a
	<i>C. Walteri</i>	a			
59-211.	<i>Nyssa sylvatica</i>	a, n			

40-143.	<i>Aronia arbutifolia</i>	a		<i>Sorbus Folgneri</i>	d
	<i>A. arbutifolia macrocarpa</i>	d		<i>S. hupehensis</i>	a
	<i>A. melanocarpa</i>	a		<i>S. Sargentiana</i>	a
	<i>A. melanocarpa elata</i>	b		<i>S. serotina</i>	d
	<i>Cotoneaster acutifolia</i>	b		<i>Spiraea japonica ruberrima</i>	a
	<i>C. Franchetii</i>	b		<i>S. nipponica</i>	d, p
	<i>C. frigida</i>	a		<i>S. Sargentiana</i>	a, n
	<i>C. Henryana</i>	b		<i>Stephanandra incisa</i>	a
	<i>C. horizontalis</i>	a		<i>Stranvaesia salicifolia</i>	i
	<i>C. rotundifolia</i>	a		<i>S. undulata</i>	a
	<i>Crataegus acutiloba</i>	b	39-139.	<i>Itea virginica</i>	a
	<i>C. Boyntoni</i>	b, r	39-141.	<i>Ribes americanum</i>	j
	<i>C. collina</i>	b		<i>R. cynosbati</i>	b
	<i>C. Downingii</i>	d, r		<i>R. odoratum</i>	a
	<i>C. opposita</i>	a	39-142.	<i>Deutzia gracilis carminea</i>	d
	<i>C. prunifolia</i>	a		<i>D. scabra</i>	h
	<i>Fragaria indica</i>	a		<i>Hydrangea quercifolia</i>	c
	<i>Malus coronaria elongata</i>	b	34-124.	<i>Eucryphia glutinosa</i>	a
	<i>M. ioensis plena</i>	b	34-123.	<i>Hypericum patulum</i>	b
	<i>M. Tschonoskii</i>	b		<i>H. patulum Forrestii</i>	b
	<i>Neillia longiracemosa</i>	d	32-108.	<i>Stewartia pentagyna</i>	b, o
	<i>Nuttallia cerasiformis</i>	b		<i>S. Pseudo-Camellia</i>	b, o
	<i>Photinia serrulata</i>	a	21-75.	<i>Punica Granatum</i>	a
	<i>Prunus Davidiana</i>	a	14-47.	<i>Bergenia cordifolia</i>	a
	<i>P. glandulosa albo-plena</i>	a	5-19.	<i>Berberis acuminata</i>	b, o
	<i>P. incisa serrata</i>	b		<i>B. aemulans</i>	a
	<i>P. pennsylvanica</i>	h		<i>B. angulosa</i>	a
	<i>P. Sargentii</i>	a		<i>B. Beaneana</i>	a
	<i>P. Sieboldii</i>	b, s		<i>B. consimilis</i>	b
	<i>P. subhirtella</i>	a		<i>B. dictyophylla</i>	a
	<i>P. thibetica</i>	b		<i>B. Ferdinandi-Coburgii</i>	f
	<i>P. yedoensis</i>	d, o		<i>B. Jamesiana</i>	a
	<i>Pyrus Calleryana</i>	a		<i>B. Julianae</i>	a
	<i>P. Pashia</i>	a		<i>B. replicata</i>	b
	<i>Rosa blanda</i>	a		<i>B. Sargentiana</i>	b
	<i>R. nitida</i>	a		<i>B. Thunbergii</i>	b
	<i>R. rugosa</i>	b		<i>B. Tischleri</i>	b
	<i>R. smoleschina</i>	b		<i>B. Veitchii</i>	d
	<i>R. spinosissima</i>	a		<i>B. virescens</i>	a
	<i>R. virginiana</i>	b		<i>B. yunnanensis</i>	b
	<i>Rubus allegheniensis</i>	a		<i>Mahonia japonica</i>	b
	<i>R. chroosepalus</i>	b		<i>Podophyllum Emodi</i>	a
	<i>R. cinnamomeus</i>	a	1-7.	<i>Cercidiphyllum japonicum</i>	h

Species hybrids

60-215.	<i>Rhododendron altuclarense</i>	b	48-163.	<i>Quercus Leana</i> (= <i>Q. imbricaria</i> × <i>Q. velutina</i>)	f
	<i>R. viscosipala</i>	b			
	<i>R. occidentale</i> × <i>calendulaceum</i>	b	40-143.	<i>Rosa calocarpa</i> (= <i>R. rugosa</i> + <i>indica</i>)	a
	<i>R. malvatica</i> × <i>Kaempferii</i>	b			
	"Jeannette"				

Horticultural forms of unknown origin

60-215.	<i>Azalea</i> : "Raphael de Smet"	a		<i>A. japonicum aureum filicifolium</i>	b
	"Corneille"	a		<i>A. palmatum reticulatum</i>	a
	"Il Tasso"	a		<i>A. palmatum scolopendrifolium septemlobum</i> Osakozuki	b
	"Joseph Baumann"	a		<i>A. palmatum scolopendrifolium versicolor</i>	b
	KH 101 "Mrs A. Waterer"	a			
	KH 177 "Whitethroat"	a		<i>A. platanoides laciniatum</i>	b
	KH 182	a			
57-200.	<i>Acer Davidii Forrestii</i>	b	40-143.	<i>Pyrus communis</i>	c

a Cyanidin 3-monoside.

b Cyanidin monoside.

c Cyanidin 3-pentoseglycoside.

d Cyanidin pentoseglycoside.

e Cyanidin 3:5-dimonoside.

f Mixed cyanidin saccharides, probably chiefly 3-saccharides.

g Cyanidin 3-bioside.

- h Cyanidin diglycoside.
- i Pelargonidin 3-monoside
- j Pelargonidin 3-pentoseglycoside.
- k Delphinidin 3-monoside.
- l Delphinidin 3:5-dimonoside.
- n These all contained amounts of diglycoside as well as the main anthocyanin.
- o The distribution of the anthocyanins in these cases was intermediate between monoside and pentoseglycoside.
- p The anthocyanin is largely pentoseglycoside, but contains a small amount of diglycoside. The aglycone from the pentoseglycoside fraction consists of cyanidin together with some anthocyanidin, in lesser amount, with a high distribution to the cyanidin reagent.
- q Largely cyanidin monoside containing some diglycoside which on acid hydrolysis gave a mixture of cyanidin and some anthocyanidin based on delphinidin.
- r The anthocyanins were monosides and the aglycones gave reactions indicating mixtures of cyanidin with peonidin. Cyanidin was certainly present, but the constituent with a high distribution to the cyanidin reagent may have been pelargonidin. Peonidin was considered more likely on account of marked blueing on dilution with absolute ethyl alcohol.
- s These two resemble *Spiraea nipponica* in that the aglycone consists of cyanidin containing some anthocyanidin with a high distribution to cyclohexanol-toluene. It may have been an acylated cyanidin, since unlike *Crataegus Boyntonii* and *C. Downingii*, after repeated washing of a cyclohexanol-toluene extract, the ferric reaction was still completely positive.
- t Mixture of cyanidin monoside with a cyanidin 3-saccharide of higher distribution.
- u The anthocyanidin was cyanidin, but the saccharide was of unusual type. The distribution (without salt) was nil, but on saturating with salt the pigment was partly extracted. This behaviour remained unaltered after purification (by repeated extraction with amyl alcohol and returning to 1% HCl and repeating the process). The colour reactions were dirty, but indicated a 3-saccharide.
- v Diglycosidic anthocyanins based mainly on malvidin together with a little cyanidin.
- w Similar to the above variety *flavo-purpurascens*, except that the amount of cyanidin present is greater.
- x Delphinidin diglycoside.
- y Malvidin 3-monoside.
- z Malvidin 3:5-dimonoside.
- A Pelargonidin 3:5-dimonoside and a cyanidin diglycoside in more or less equal proportions.
- B Delphinidin 3:5-dimonoside.
- C Petunidin diglycoside.
- D Petunidin 3-pentoseglycoside.
- E Petunidin 3-monoside.
- F Peonidin diglycoside.
- G Pelargonidin 3-bioside.
- H Pelargonidin 3:5-dimonoside.
- J Pelargonidin diglycoside.
- K Betanin type of pigment.
- L Delphinidin 3-pentoseglycoside.

The authors thank the following for the provision of material: The Royal Botanical Gardens, Kew; The Royal Horticultural Society, Wisley; Mr Lionel de Rothschild; Knap Hill Nursery, Woking; W. C. Slocock, Woking.

REFERENCES

- Hutchinson (1926). *The Families of Flowering Plants*. (London, Macmillan.)
- Robinson, G. M. & Robinson, R. (1931). *Biochem. J.* **25**, 1687.
- — (1932). *Biochem. J.* **26**, 1647.
- — (1933). *Biochem. J.* **27**, 206.
- — (1934). *Biochem. J.* **28**, 1712.