SOME CHROMOSOME COUNTS IN THE EUROPEAN CISTACEAE

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The Cistaceae are a small and rather homogeneous family, distributed chiefly in the Mediterranean region. A few, including the four British species, extend into central and northern Europe, and others occur in the west Asian steppes, the Arabian and north African deserts, and the Atlantic islands. In addition a number of species, which will not be considered further here, are confined to the New World. The Linnean genus *Cistus* originally included all the European Cistaceae, but these are now invariably subdivided. Grosser (1903) in his monograph of the family recognises five genera, and I follow most recent authors in adopting them throughout this paper.

A number of chromosome counts of species of Cistaceae exist in the literature, but taken as a whole they are unsatisfactory. Few have been based on wild material of known origin, and some seem certainly to be wrong. The position in *Cistus* itself is clear. Many counts have been made by several workers with the uniform result $2n = 18$ in all the species investigated (Chiarugi, 1925, 1937; Collins in Warburg, 1930; Bowden, 1940; La Cour in Darlington & Janaki Ammal, 1945). The published records for *Helianthemum s.l.* present a much more confused picture, which it is the attempt of the present paper to clarify.

Counts have been made of both mitotic and meiotic chromosomes. Mitosis was examined in root tips obtained either from germinating seeds or from pot-grown plants. The roots were cut off, pre-treated with 0·002 M 8-hydroxy-quinoline for 4-6 hours, and then fixed in Carnoy's fluid. Maceration and staining were combined by heating the roots in a little acetocarmine in a test-tube over a boiling water-bath for 5-10 minutes. Iron was introduced either by standing a needle in the test-tube for a short time or by adding a drop of an iron acetate solution. The root-tips were cut off on a slide, teased in a drop of 45 per cent acetic acid, tapped out and squashed in the usual way. Acetic orcein gave better results with pollen mother cell preparations for meiosis. A few anthers were squashed in a small drop of the stain with a fine pointed scalpel, the anther debris was removed and the preparation covered and squashed. Preparations were made permanent by inverting the slide in a dish of 50 per cent alcohol until the coverslip separated. The slide and coverslip were dehydrated separately, and recombined in a drop of 'Euparal.'

The chromosomes were drawn using a *camera lucida*, at a magnification of about × 1,800. A Leica camera with a microscope adaptor was used for the photographs.

Almost all the plants used were of known wild origin, and documented herbarium specimens of most have been deposited in the Cambridge University Herbarium.

The results are listed in the following table. In general they differ from genus to genus, but within a single genus show a considerable degree of regularity. Some confirm existing counts, but in a number of cases published figures show discrepancies which will be discussed in more detail below.

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LIST OF CHROMOSOME NUMBERS DETERMINED	*n*	2*n*
HALIMIUM (Dunal) Willk.		
ocymoides (Lam.) Willk. & Lange		
Sintra, Mercês, Estremadura, Portugal (Estação Agronómica Nacional, Sacavém, Portugal)		18
halimifolium (L.) Willk. & Lange		
Sesimbra, Apostica, Estremadura, Portugal (E.A.N.)		18
umbellatum (L.) Spach		
Almada, Corroios, Estremadura, Portugal (E.A.N.)		18
TUBERARIA (Dunal) Spach		
vulgaris Willk.		
Sintra, Mercês, Estremadura, Portugal (E.A.N.)		14
(Garden origin)		14
guttata (L.) Fourreau		
South Stack, Holyhead, Anglesey (D.E.C.)		c. 36
Three Castles Head, Co. Cork, Ireland (S.M.W.)		36
Baie des Trépassés, Finistère, France (C.D.P.)		36
Sintra, Mercês, Estremadura, Portugal (E.A.N.)		36
HELIANTHEMUM Adans.		
apenninum (L.) Mill.		
Berry Head, Brixham, Devon	10	
Purn Hill, Bleadon, Somerset (S.M.W.)		20
Les Andelys, Eure, France (S.M.W.)		20
St. Adrien, nr. Rouen, Seine-inf., France (S.M.W.)	10	
chamaecistus Mill.		
Hod Hill, Blandford, Dorset		20
Chilham, Kent (C.D.P.)		20
Risby Poors Heath, Suffolk		20
Holywell Mound, Lincs.		20
Millington Pastures, Yorkshire Wolds, E. Yorks. (M.E.B.)		20
Gordale Scar, Malham, W. Yorks.		20
Humphrey Head, Grange, N. Lancs.	10	
Near Aberfeldy, Perthshire (M.E.D.P.)		20
Ballintra, Co. Donegal, Ireland (S.M.W.)		20
Sta. Comba Dão, Beira Alta, Portugal (E.A.N.)		20
Domodossola, N. Italy (C.D.P.)		20
Visp, Wallis, Switzerland (C.D.P.) (*H. grandiflorum* (Scop.) DC.)		20
Donaueschingen, Baden, S.W. Germany (W.K.) (*H. ovatum* (Viv.) Dunal)		20
Bjergsted Bakker, Sjaelland, Denmark (T.W.B.) (*H. ovatum*)	10	
Mt. Trebeviča, nr. Sarajevo, Jugoslavia (W.K.) (*H. tomentosum* (Scop.) Spreng.)	10	
ledifolium (L.) Mill.		
Sintra, Algueirão, Estremadura, Portugal (E.A.N.)		20
canum (L.) Baumg.		
Rhossili, Glamorganshire	11	
Pabo, nr. Llandudno, Caerns. (S.M.W.)	11	
Cronkley Fell, Teesdale, N.W. Yorks. (H.G.)	11	
Scout Scar, Kendal, Westmorland		22
Poulsallagh, Co. Clare, Ireland (S.M.W.)		22
Poulsallagh, Co. Clare, Ireland (C.D.P.)	11	
St. Adrien, nr. Rouen, Seine-inf., France (S.M.W.)	11	
Öland, Sweden (T.G.T.)		22
Nüssenberg, N. of Naumburg, Saxony, Germany (A.H.)		22
oelandicum (L.) Swartz		
Öland, Sweden (T.G.T.)	11	
alpestre (Jacq.) Dunal		
Schynige Platte, Interlaken, Switzerland (T.W.B.)	11	
lunulatum (All.) DC.		
(Garden origin)		22
FUMANA		
laevipes (L.) Spach		
Portinho, Serra d'Arrabida, Portugal (S.M.W.)		32

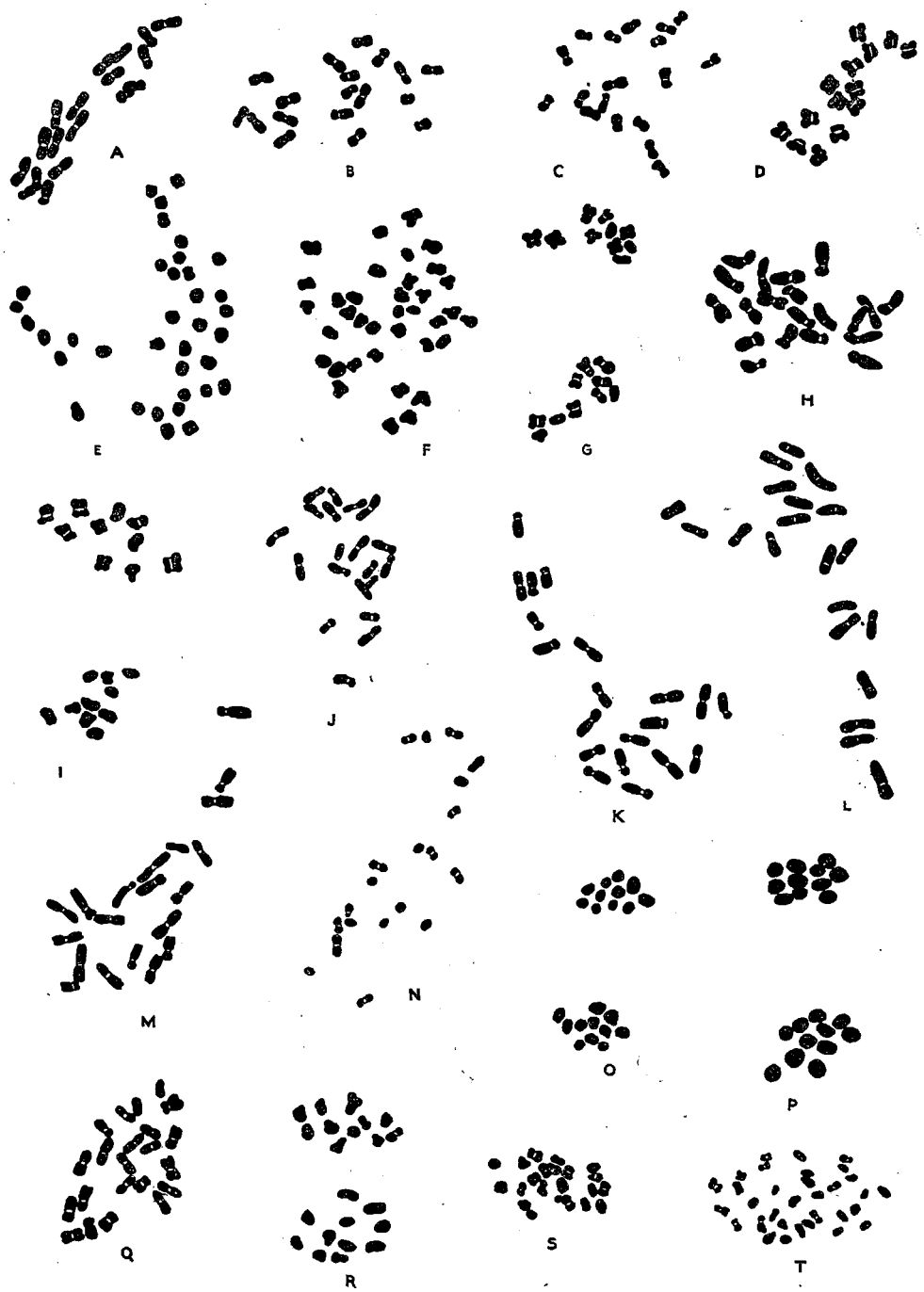

Fig. 1. Chromosomes of Cistaceae (× 1,200) : g, i, o, p, and r are pollen mother cell meiosis; the remainder are from root tip preparations. (a) *Halimium ocymoides*, Sintra, Portugal; (b) *H. halimifolium*, Sesimbra, Portugal; (c) *H. umbellatum*, Almada, Portugal; (d) *Tuberaria vulgaris*, Sintra, Portugal; (e) *T. guttata*, Sintra, Portugal; (*f*) *T. guttata*, Finistère, France; (g) *Helianthemum apenninum*, Berry Head, Devon; (h) *H. apenninum*, Les Andelys, France; (i) *H. chamaecistus*, Humphrey Head, Lancs.; (j) *H. chamaecistus*, Risby, Suffolk; (k) *H. chamaecistus*, Yorkshire Wolds; (l) *H. chamaecistus*, Perthshire; (m) *H. chamaecistus*, Visp, Switzerland; (n) *H. ledifolium*, Sintra, Portugal; (o) *H. canum*, Teesdale, Yorks.; (p) *H. canum*, Rhossili, Glamorganshire; (q) *H. canum*, Kendal, Westmorland; (r) *H. oelandicum*, Öland, Sweden; (s) *H. lunulatum*; (t) *Fumana laevipes*, Portinho, Portugal.

(a) *Halimium*

The three species counted all have a diploid number of 18, which agrees with the counts of n = 9 in *H. halimifolium* and 2n = 18 in *H. atriplicifolium* (Lam.) Spach given by Chiarugi (1925, 1937).

(b) *Tuberaria*

This genus provided two rather surprising diploid counts of 14 and 36, both, I believe, not previously recorded. Of the published figures for *T. guttata*, Bowden's 2n = 20 (1940) is almost certainly an error due to wrongly named material. Chiarugi (1925) found n = 24, and this count deserves more consideration. The occurrence of as low a number as 2n = 14 in *T. vulgaris* suggests that *T. guttata* with 2n = 36 must have arisen as a polyploid. It seems most likely that it is a hexaploid on a basic number of 6, so that, whatever its exact mode of origin, plants with other multiples of this number, especially 12 and 24, should be sought. The four counts published here are from only a small part of the area of the *T. guttata* complex, and it is quite likely that other numbers may occur in other parts of the range. Cytological investigation both of other *T. guttata* forms, and of the remaining perennial species, *T. globulariifolia* (Lam.) Willk., would be well worth while.

(c) *Helianthemum*

Two differing chromosome numbers occur in this genus as in the last. In the species investigated, those of the subgenus *Helianthemum* have 2n = 20, while those of *Plectolobum* have 2n = 22. However the genus is a large one, and more counts would be needed to establish that this represents the full variation, especially as the material studied leaves several sections unrepresented. Most of the more recent published work is consistent with these results, but Bowden (1940) obtained diploid counts of 32 in *H. apenninum* and *H. chamaecistus*, and Mattick (in Tischler, 1950) 32 in *H. chamaecistus* which agree with the earlier determinations of Chiarugi (1925). It is difficult to see how a mistake can have occurred, though the triploid garden forms of *Helianthemum* reported by Snoad (1954) with a somatic chromosome number of 30 suggest one possibility. On the evidence now presented, appears to be cytologically uniform over a wide area with 2n = 20 (Fig. 2). The forms investigated embrace the greater part of its morphological variation, and it semes unlikely that there could actually exist a chromosome race with as unrelated a number as 2n = 32. Apart from my counts, 2n = 20 is quoted by Á. & D. Löve (1948) from Scandinavian material, and it has been determined by K. Larsen (Dr. T. W. Böcher *in litt.*) from the following localities : dry field in *Pinus* wood between Angoulême and Bordeaux, France; dry slope in the valley at Luchon, Pyrenees, France; dry *alvar* on Gotland, Sweden. Bowden's '*H. alpestre*' with 2n = 20 was probably a small form of *H. chamaecistus*. A plant of *H. alpestre* from Interlaken, Switzerland, agreed quite clearly with *H. canum* and *H. oelandicum* in its haploid number of 11, as would be expected from its taxonomic relationships. The counts given here for *H. canum* from Teesdale and Westmorland confirm those published by Tutin (1953) from the same localities.

(d) *Fumana*

Few counts are available for *Fumana* species. Such as there are suggest a uniform diploid number of 32, the number obtained by me for *F. laevipes*, but most are old and need confirmation.

A number of errors have been indicated in the published chromosome numbers of the Cistaceae, and some comment on accuracy in chromosome counts seems called for. Errors may arise in two ways : either through poor technique, or through wrongly named

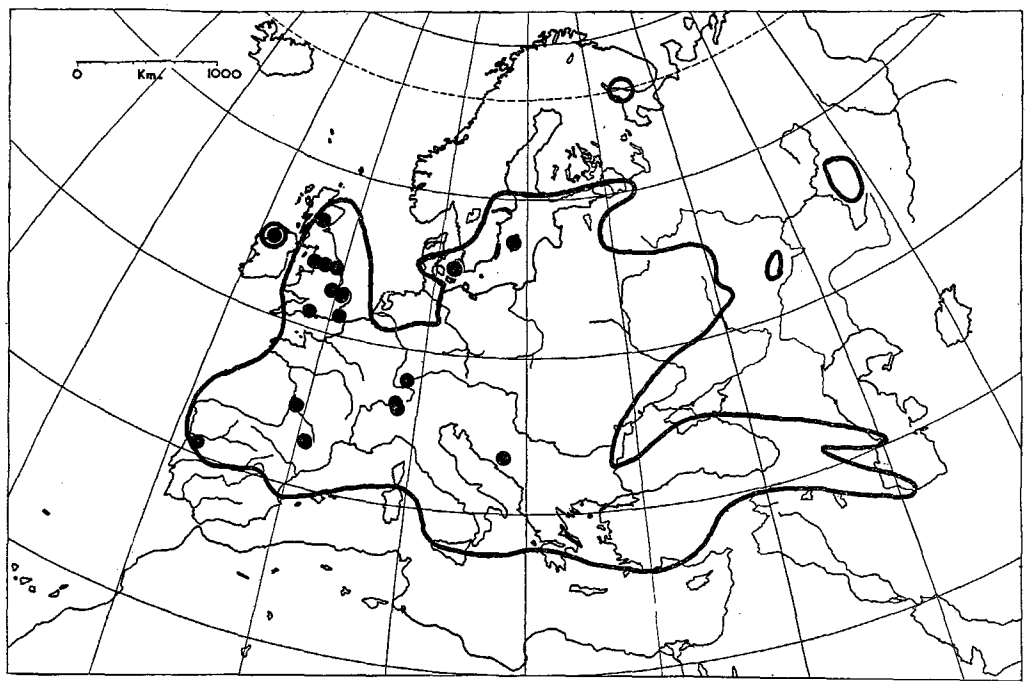

Fig. 2. Map showing the distribution of *Helianthemum chamaecistus* (from Meusel, 1943) and the localities from which chromosome counts are given in the present paper.

material. Cytological methods have advanced greatly in recent years, and for this reason alone too much weight must not be laid on the early counts. With careful use of modern methods there is no reason for serious mistakes to occur. Cytologists are however usually dependent on outside sources, especially botanic gardens, for their material, and this used uncritically can be a fertile source of error. I have received from two very reputable sources seed of an annual species of the *Brachypetalum* section of *Helianthemum* as *Tuberaria guttata*, and plants of *Helianthemum chamaecistus* as *H. alpestre*. Both these might have given rise to incorrectly recorded chromosome counts. The remedy lies partly with the botanic gardens and others distributing plants and seeds, but it is also a responsibility of the cytologist to be sure that his plants are correctly named. It is particularly desirable that seed should be grown on and checked very carefully, and specimens of the plants used preserved.

The distribution of chromosome numbers in the Cistaceae accords quite well with existing classifications. It seems quite clear that the four genera within *Helianthemum s. l.* are natural groups, and that they are not particularly closely related one to another. In particular *Halimium* seems in all respects to be much closer to *Cistus* than to the restricted *Helianthemum*. This is borne out by the occurrence of bigeneric hybrids between *Halimium* and *Cistus* section *Ledonia*. The chromosomes are rather small, so it has not been possible to get much help from their morphology, though a few generalisations can be made. *Halimium* has roughly equal sized chromosomes with median centromeres. The species of *Helianthemum* investigated show two or three pairs of chromosomes with obviously unequal arms, and there is some variation in size. In *Tuberaria* a large proportion of the chromosomes are asymmetrical.

Two conspicuous characteristics of the Cistaceae are the absence of polyploid chromosome races, and the variation in basic number between the genera. Genome

evolution seems to have proceeded largely by aneuploid variation early in the history of the group. Polyploidy probably played a part in the origin of *Tuberaria guttata*, and perhaps of *Fumana*. Bowden (1940) comments on finding a single tetraploid cell in otherwise diploid *H. canum*, and I have found tetraploid cells in root tips of *Tuberaria vulgaris*, *Helianthemum chamaecistus* and *H. ledifolium*. However a woody plant with a limited life-span, and reproducing sexually from seed, may provide conditions hardly more favourable than an annual for polyploid types to arise. Even so, it is surprising that an annual should provide the only instance of polyploidy in a predominantly perennial family.

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SUMMARY:

42 chromosome counts from 13 species of Cistaceae are listed and briefly discussed. The distribution of the chromosome numbers in the family is as follows:

	2n
Halimium	18
Tuberaria sect. *Eu-tuberaria*	14
sect. *Scorpioides*	36
Helianthemum subgen. *Helianthemum*	20
subgen. *Plectolobum*	22
Fumana	32

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