

SOME CYTOLOGICAL OBSERVATIONS IN THE GENUS *CAMPANULA*

BY

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INTRODUCTION

A. DE CANDOLLE's (1830) treatment of the genus *Campanula* lists 137 species. Many new species were described since, so that the total number of species should be estimated to be at least twice that number. A new monograph of the genus is, therefore, highly desirable (CLIFFORD CROOK, 1951).

Any classification into subgenera and sections, based on herbarium studies, is bound to meet considerable difficulties on account of the great uniformity among many floral characters of the various species. Cytological information may prove very valuable in order to arrive at a modern classification of the species within the genus.

Cytological investigations, conducted by MARCHAL (1920) and SUGIURA (1942), among others, so far have yielded some contradictory results, partly due to incorrect identification of the plant material concerned. SUGIURA (1942), who studied most of the species, only counted the haploid numbers, so that several morphological aspects concerning the chromosomes of the species studied by him are hitherto unknown.

The main purpose of the current investigations is to arrive at a more natural classification of the genus *Campanula*, using cytotaxonomical data. Secondly, more detailed experimental taxonomic research will be done in several parts of the genus. This paper deals with the chromosome numbers of 31 species, with indication of the origin of the material used. Further investigations are in progress.

MATERIAL AND METHODS

Seeds and living plants, collected in nature and in gardens as well, were obtained from different botanical gardens. Moreover, living material and seeds were collected in nature by the author. The plants are cultivated in Baarn in the botanical garden "Cantonspark".

Roottips were fixed in Karpechenko, embedded in paraffin, sectioned at 15μ and stained according to Heidenhain's haematoxylin method. Herbarium vouchers are deposited in the Utrecht Herbarium.

RESULTS

The chromosome numbers as found by previous authors and by myself are summarized in the table.

All chromosome numbers published by others are indicated by the author's name in the fourth column.

TABLE

| Species | 2n | Origin | Chromosome numbers counted by other authors |
|---------------------------------------------|---------|---------------------------------------------|---------------------------------------------|
| <i>Campanula alliarifolia</i> Willd. | 34 | Italy: Siena *) | |
| | 34 | unknown | Marchal (1920) |
| | 96 | unknown | Matsuura and Suto (1935) |
| | 68 | U.S.S.R.: Caucasus | Sugiura (1942) |
| <i>C. barbata</i> L. | 34 | France: Col du Lautaret, 2000 m. | |
| | 34 | unknown | Marchal (1920) |
| | 34 | Sweden: Lund *) | A. and D. Löve (1944) |
| <i>C. bononiensis</i> L. | 34 | U.S.S.R.: Moskva, seeds collected in nature | |
| | 34 | unknown | Marchal (1920) |
| | 34 | unknown | Rosén (1931) |
| | 34 | unknown | Sugiura (1942) |
| <i>C. carpatica</i> Jacq. | 34 | Czecho-Slovakia: seeds collected in nature | |
| | 34 | Czecho-Slovakia: Dobinska | |
| | 34 | Czecho-Slovakia: Drevenik | |
| | 34 | Austria: Frohnleiten *) | |
| | 34 | Austria: Vienna *) | |
| | 34 | Belgium: Antwerpen *) | |
| | 34 | England: London *) | |
| | 34 | Germany: Göttingen *) | |
| | 34 | Holland: Amsterdam *) | |
| | 34 | Holland: Rotterdam *) | |
| | 34 | Romania: Cluj *) | |
| | 34 | Sweden: Göteborg *) | |
| | 34 | unknown | Marchal (1920) |
| | 34 | Carpathian mountains | Sugiura (1942) |
| 32 | unknown | Koller (1945) (see Darlington and Wylie) | |
| <i>C. cochlearifolia</i> Lam. | 34 | France: Mont Cenis 1900 m. | |
| | 34 | Switzerland: collected in nature | |
| | 34 | unknown | Marchal (1920) |
| | 68 | unknown | Sugiura (1942) |
| <i>C. colorata</i> Wall. | 28 | Denmark: Copenhagen *) | |
| | 24 | India: environment of Simla | Kishore (1951) |

*) cultivated material

| Species | 2n | Origin | Chromosome numbers counted by other authors |
|--------------------------------|---------|----------------------------------------|----------------------------------------------------------------|
| <i>C. dichotoma</i> L. | 24 | Italy: Palermo *) | |
| <i>C. divaricata</i> Michx. | 34 | U.S.A.: West Virginia | La Cour (1945) (see Darlington and Wylie) |
| | 40 | unknown | |
| <i>C. erinus</i> L. | 28 | Portugal: environment of Coimbra | Koller (1945, see Darlington and Wylie) Larsen (1956) |
| | 28 | Portugal: Lisboa *) | |
| | 28 | Portugal: Sacavem, collected in nature | |
| | 28 | Portugal: prov. Estramadura | |
| | 28 | unknown | |
| <i>C. glomerata</i> L. | 28 | Italy: Minuto | |
| | 30 | Estonia: Annemois | Marchal (1920) Griesinger (1937) Sugiura (1942) |
| | 30 | Estonia: Sörve | |
| | 30 | France: collines de Balbronn, Obernai | |
| | 30 | France: Côte d'or, Fixin | |
| | 30 | France: Languedoc méditerr. | |
| | 30 | Scotland: St. Cyrus, Kincardineshire | |
| | 30 | USSR: Pulkoro near Leningrad | |
| | 30 | USSR: near Pskov | |
| | 30 | Austria: Graz *) | |
| | 30 | Austria: Graz *) | |
| | 30 | Bulgaria: Sofia *) | |
| | 30 | England: London *) | |
| | 30 | England: London *) | |
| | 30 | France: Toulouse *) | |
| | 30 | Germany: Berlin *) | |
| | 30 | Germany: Hamburg *) | |
| | 30 | Switzerland: Champex *) | |
| | 34 | unknown | |
| | 30 | Austria, N. Tirol, Trins | |
| 68 | unknown | | |
| <i>C. grossekii</i> Heuff. | 34 | Italy: Siena *) | Sugiura (1942) |
| | 34 | Hungary: without precise locality | |
| <i>C. isophylla</i> Morett. | 32 | Holland: Baarn *) | de Vilmorin and Simonet (1927) |
| | 32 | unknown | |
| <i>C. loeflingii</i> Brot. | 18 | Portugal: environment of Coimbra | Larsen (1954) |
| | 18 | Portugal: Lisboa *) | |
| | 18 | Portugal, environment of Coimbra | |
| <i>C. lactiflora</i> Bieb. | 34 | Germany: Berlin *) | Sugiura (1942) |
| | 34 | unknown | |

*) cultivated material

| Species | 2n | Origin | Chromosome numbers counted by other authors |
|------------------------------------------|------------------------|--------------------------------------------------------------------|---------------------------------------------|
| <i>C. latifolia</i> L. | 34 | Holland: Amsterdam *) | |
| | 34 | unknown | Marchal (1920) |
| | 34 | unknown | de Vilmorin and Simonet (1927) |
| | 34 | unknown | Sugiura (1942) |
| | 34 | Sweden: Lund, coll. in nature? | A. and D. Löve (1944) |
| <i>C. medium</i> L. | 34 | Portugal, Lisboa *) | |
| | 34 | USSR: Ashkabad *) | |
| | 34 | unknown | Marchal (1920) |
| | 34 | S. Europe, without precise locality | Sugiura (1942) |
| <i>C. persicifolia</i> L. | 16 | Estonia, Saarema, Sörve | |
| | 16 | Sweden, Ivetofta | |
| | 16 | Czecho-Slovakia, environment of Bratislava | |
| | 16 | USSR: Moskwa, coll. in nature | |
| | 16 | Belgium: Antwerpen *) | |
| | 16 | unknown | Marchal (1920) |
| | 16 | unknown | Gairdner (1926) |
| | 16 | Belgium, Louvain *) | de Souza Violante (1929) |
| | 16 | Austria: Gmunden | Gairdner and Darlington (1930 and 1932) |
| | 16 | Austria: Innsbrück | idem |
| | 16 | Bulgaria: Varna | idem |
| | 16 | France: Auvergne, Murols | idem |
| | 16 | Sweden: Mälär | idem |
| | 32 | unknown | Gairdner and Darlington (1930 and 1932) |
| | 16 | unknown | Straub (1936, 1937) |
| 16 | unknown | Sugiura (1942) | |
| <i>C. portenschlagiana</i> Roem. et Sch. | 34 | England; London *) | |
| | 34 | unknown | Marchal (1920) |
| | 102 | Jugoslavia, Dalmatia | Sugiura (1942) |
| <i>C. poscharekyana</i> Degen. | 34 | England: London *) | |
| | 34 | Holland: Baarn *) | |
| <i>C. prenanthoides</i> Dur. | 34 | U.S.A.: California, South of Richardson Redwoods, Mendocino County | |
| <i>C. rapunculus</i> L. | 20 | France: in the environment of Nantes | |
| | 20 | Portugal: without precise locality | |
| | 20 | Portugal: Estremadura, Algueciras | |
| | 20 | Portugal: without precise locality | |
| | 20 | unknown | Armand (1912) |
| | 20 | unknown | Marchal (1920) |
| 20 | France: Meun sur Loire | Larsen (1956) | |

*) cultivated material

| Species | 2n | Origin | Chromosome numbers counted by other authors |
|-------------------------------------------|-----|-------------------------------------------------|---------------------------------------------------|
| | 20 | France: Roque Houte near Béziers | Larsen (1956) |
| | 20 | Italy: Campidoglio | Larsen (1956) |
| <i>C. rapunculoides</i> L. | 102 | Estonia: near Tartu | |
| | 102 | France: Savoie, Termignon | |
| | 102 | Germany: environment of Münster | |
| | 102 | Holland: Oostvoorne | |
| | 102 | Holland: Oostvoorne | |
| | 102 | Switzerland: without precise locality | |
| | 102 | Germany: Freiburg i. Br. *) | |
| | 102 | Italy: Siena *) | |
| | 102 | Italy: Siena *) | |
| | 102 | Poland: Warszawa *) | |
| | 102 | Portugal: Lisboa *) | |
| | 102 | Sweden: Lund *) | |
| | 102 | USSR: Alma Ata *) | |
| | 102 | unknown | Marchal (1920) |
| | 102 | unknown | de Vilmorin and Simonet (1927) |
| | 102 | Sweden: Lund | A. and D. Löve (1944) |
| | 102 | unknown | Sugiura (1942) |
| <i>C. rotundifolia</i> L. (sensu lato) | 34 | Germany: Oberfranken, Hazelbrünn | |
| | 34 | Germany: Oberfranken, Pütlarktal | |
| | 34 | Germany: Berlin-Tegel, Bannbergen | |
| | 34 | Sweden: Granhogen | |
| | 34 | Austria: Frohnleiten *) | |
| | 68 | Belgium: la Calamine (Neu-Moresnet) | |
| | 68 | Belgium: idem | |
| | 68 | Czecho-Slovakia: E. Slovakia near Dre- venik | |
| | 68 | Czecho-Slovakia: E. Slovakia, Simonov | |
| | 68 | Denmark: W. Jutland near Egtved | |
| | 68 | Denmark: N. Sjaland, Mellg | |
| | 68 | Denmark: Milby Nordfell | |
| | 68 | Denmark: W. Jutland near Tarn | |
| | 68 | Denmark: N. Seeland near Tømmerup | |
| | 68 | Denmark: N. Jutland near Ulfborg | |
| | 68 | England: Norfolk, Hunstanton | |
| | 68 | Estonia: Sörve | |
| | 68 | France: Côte d'Or, Fixin | |
| | 68 | France: S. Mar.: Isneauville | |
| | 68 | France: environment of Nancy | |
| | 68 | France: Vosges, Niederbronn | |
| | 68 | France: environment of Paris | |
| | 68 | France: environment of Rouen | |
| | 68 | Germany: Eiffel near Heimbach | |
| | 68 | Germany: environment of Lübeck | |

*) cultivated material

| Species | 2n | Origin | Chromosome numbers counted by other authors |
|---------|-----|----------------------------------------------------------------|---------------------------------------------------|
| | 68 | Germany: Selent near Kiel | |
| | 68 | Holland: N. Brabant, near Valkenswaard | |
| | 68 | Holland; Drenthe, near Vledder | |
| | 68 | Holland: Friesland, near Aldemirdum | |
| | 68 | Holland: Overijssel, near Denekamp | |
| | 68 | Holland: Overijssel, near Mariënberg | |
| | 68 | Holland: Overijssel, near Mariënberg | |
| | 68 | Holland: Utrecht, near Maarn | |
| | 68 | Italy: Valtellina | |
| | 68 | Italy: Valtellina, Bormio | |
| | 68 | Scotland: Aglionby, Carlisle | |
| | 68 | Scotland: Kincardineshire, St. Cyrus | |
| | 68 | Sweden: Scania, Maglarp, Stavsten | |
| | 68 | Sweden: Scania, without precise loc. | |
| | 68 | Sweden: Västergötland | |
| | 68 | Sweden: without precise locality | |
| | 68 | USSR: near Moskva | |
| | 68 | USSR: Pulkoro, near Leningrad | |
| | 68 | Austria: Klagenfurt *) | |
| | 68 | Austria: Vienna *) | |
| | 68 | Belgium: Bruxelles *) | |
| | 68 | Denmark: Copenhagen *) | |
| | 68 | Germany: Freiburg Brn. *) | |
| | 68 | Holland: Amsterdam *) | |
| | 68 | Switzerland: Genève *) | |
| | 102 | France: (S. Mar.) St. Adrien | |
| | 102 | France: Puy de Dôme, near Clermont-Ferrand | |
| | 102 | Czecho-Slovakia: collected in nature, without precise locality | |
| | 40 | unknown | Armand (1912) |
| | 68 | unknown | Marchal (1920) |
| | 34 | E. Greenland | Böcher (1936) |
| | 68 | E. Greenland; Denmark | idem (1936) |
| | 68 | Norway, Finse | Böcher (1938) |
| | 68 | Norway, Angmagssalik | Böcher (1938) |
| | 68 | unknown | Sugiura (1942) |
| | 34 | France, Alpes maritimes, Roubion | Guinochet (1942) |
| | 55 | } France: Alpes maritimes; (hybrids?) | Guinochet (1942) |
| | 56 | | |
| | 68 | France: 4 localities in the Alps | Guinochet (1942) |
| | 34 | W. Greenland: 7 different localities | Böcher (1960) |
| | 34 | the Pyrenees: 2 different localities | Böcher (1960) |
| | 34 | USSR: near Moskva | Böcher (1960) |
| | 34 | Sweden: Öland | Böcher (1960) |
| | 34 | Denmark: Bornholm | Böcher (1960) |
| | 68 | 25 different localities in Europe | Böcher (1960) |
| | 102 | France, Massif Central, Les Vignes | Hubac (1961) |

*) cultivated material

| Species | 2n | Origin | Chromosome numbers counted by other authors |
|------------------------------------------|-----|---------------------------------|---------------------------------------------|
| <i>C. scheuchzeri</i> Vill. | 68 | Austria: Raxalpe | |
| | 68 | unknown | Böcher (1936) |
| | 68 | unknown | Sugiura (1942) |
| <i>C. sibirica</i> L. | 34 | Austria: Hainburg | |
| | 34 | Czecho-Slovakia: Salka | |
| | 34 | Czecho-Slovakia: Slovensky Kras | |
| | 102 | unknown | Sugiura (1942) |
| <i>C. spathulata</i> Sibth. | 20 | Switzerland: Genève *) | |
| <i>C. spicata</i> L. | 34 | France: Savoie, Termignon | |
| | 34 | France: Col de Lautaret | |
| | 34 | Italy: Cortina (Dolomites) | Larsen (1960) |
| <i>C. thyrsoides</i> L. | 34 | France: Col de Lautaret | |
| | 34 | unknown | Rosén (1931) |
| | 38 | France: Jura | Sugiura (1942) |
| <i>C. trachelium</i> L. | 34 | Holland: S. Limburg, Savelsbos | |
| | 34 | Italy: Peninsula of Portofino | |
| | 34 | USSR: Moskva, coll. in nature | |
| | 34 | unknown | Marchal (1920) |
| | 34 | unknown | Sugiura (1942) |
| | 34 | Sweden: Lund | A. and D. Löve (1944) |
| <i>C. vidalii</i> Watson | 56 | Canar. Isles (cultivated?) | |
| | 56 | Portugal: Lisboa*) | |
| | 56 | Portugal: Coïmbra *) | de Mesquita Rodriguez (1954) |
| <i>C. waldsteiniana</i> Roem. et Sch. | 34 | Austria: Graz *) | |
| | 34 | Austria: Graz *) | |
| | 34 | Germany: Frankfurt M. *) | |

*) cultivated material

DISCUSSION

The table shows that 18 species have the same chromosome number as counted by other authors. These species will not be discussed any more.

The following were not examined previously:

- C. dichotoma* L. (2n=24)
- C. prenanthoides* Dur. (2n=34)
- C. spathulata* Sibth. (2n=20)
- C. Waldsteiniana* Roem. et Sch. (2n=34)

Concerning the following species there is no uniform opinion on the

number of chromosomes, or else the plants have probably been misidentified:

- a** *C. alliariaefolia* Willd.
The number $2n = 34$ was counted by both MARCHAL (1920) and myself. The number $2n = 96$, MATSUURA and SUTO (1935) and $2n = 68$, SUGIURA (1942) may result from misidentification.
- b** *C. carpatica* Jacq.
Like MARCHAL (1920) and SUGIURA (1942), I find $2n = 34$ in plants originating from 15 different sources.
 $2n = 32$ was not found, but plants having this number perhaps do occur.
- c** *C. cochleariifolia* Lam.
Like Marchal (1920) I found $2n = 34$;
 $2n = 68$ (SUGIURA, 1942) may, again, result from wrong determination.
- d** *C. colorata* Wall.
KISHORE (1951) found $2n = 24$, whereas I counted $2n = 28$. In view of the fact that A. DE CANDOLLE (1830) placed *C. colorata* not far from *C. erinus* ($2n = 28$) it seems to me that $2n = 28$ is the more likely.
- e** *C. divaricata* Michx.
Contrary to LA COUR (1945, see DARLINGTON and WYLIE), who counted $2n = 40$, I found $2n = 34$. Further investigations are needed to determine if intraspecific cytological variation exists.
- f** *C. glomerata* L.
Like GRIESINGER (1937) I found $2n = 30$, whereas MARCHAL (1920) and SUGIURA (1942) counted $2n = 34$ and $2n = 68$ respectively.
 $2n = 30$ occurred in material from 18 different sources; therefore this number seems the most likely to me.
The chromosome number is often difficult to determine, possibly due to inadequate fixation.
- g** *C. portenschlagiana* Roem. et Sch.
Again it seems likely that SUGIURA (1942) determined his material incorrectly. Whereas Sugiura found $2n = 102$, both MARCHAL (1920) and I found $2n = 34$.
- h** *C. rotundifolia* L. sensu lato.
The chromosome numbers $2n = 34$ and $2n = 68$ were counted by several authors, although $2n = 68$ seems to be the more common.
The exact distribution of these diploids and tetraploids within Europe and the other parts of the distribution area of the species is not yet known, although GUINOCHET (1942) and especially BÖCHER (1960) made rather extensive investigations.

The numbers $2n=40$ and $2n=55$, 56 were counted respectively by ARMAND (1912) and GUINOCHET (1942) only. Possibly the number $2n=40$ results from misidentification.

HUBAC (1961) counted $2n=102$ in plants from the southern parts of the Massif Central, France.

Although the exact taxonomic position of these plants within the species *C. rotundifolia* s.l. is not yet known, it is possible that they originated from a cross between plants with $2n=34$ and $2n=68$, followed by a chromosome doubling.

In plants originating from three different populations I counted also $2n=102$.

This material will be investigated in Utrecht both morphologically and genetically.

The above mentioned hypothesis will be tested.

i *C. sibirica* L.

Three times I found $2n=34$, the material being from different origin in each case.

Incorrect identification may account for $2n=102$ (Sugiura, 1942)

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