THE CHROMOSOME NUMBER IN GLADIOLUS [1]

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INTRODUCTION

The genus *Gladiolus* is known best by its many summer-flowering varieties. The exact origin of these types in many cases is uncertain, but it is generally agreed (*2, 3, 6, 11, 12, 13*)[2] that interspecific hybridization followed by rigorous selection has played an important part in their development. It appears that such hybrids have often arisen from crosses between very different species and that eventually not only 2, but sometimes 3 and even 4 species have been involved. The high degree of fertility in the commercial varieties, in view of their supposed origin, is surprising.

It was the purpose of this study to determine the chromosome number of many of the species and some of the representative types of the commercial varieties, and, if possible, to establish the relation between the two groups. Subsequent studies will deal with chromosome behavior in interspecific and intervarietal hybrids.

PREVIOUS REPORTS

The literature on chromosome number in *Gladiolus* is not abundant. Most of the reports have given the chromosome number for only a few species or varieties. These are listed in table 1, along with the list of Ernst-Schwarzenbach (*5*), who has approached this problem along lines similar to those followed in the present investigation.

Table 1.—*Chromosome numbers previously reported for Gladiolus*

Species or variety	*n*	2*n*	Reported by
G. primulinus Baker:			
var. *La Meurthe*	30	--------	De Vilmorin and Simonet (14).
var. *Priority*	14	--------	McLean (*10*).
G. quartinianus A. Rich	14	--------	Do.
G. quartinianus var. *Halloween*	14	--------	Do.
G. tristis L	14	--------	Do.
G. tristis L. var. *concolor*	--------	30	Ernst-Schwarzenbach (*5*).
G. cardinalis Curt	--------	30	Do.
G. Colvillei Sweet var. *roseus*	15	30	Ernst-Schwarzenbach and Brittingham (*3*).
G. ramosus Paxt	--------	46	Ernst-Schwarzenbach (*5*).
G. cuspidatus Jacq	15	--------	Do.
G. byzantinus Mill	30	--------	Do.
G. primulinus var. *Souvenir*	30	--------	Do.
Gladiolus varieties	--------	30	Kinoshita (Kihara et al.) (*7*).
Do	--------	60	Wakakuwa (Kihara et al.) (*7*).
G. gandavensis Van Houtte:			
var. *Pompée*	30	--------	Ernst-Schwarzenbach (*5*).
var. *Alexandre*	--------	60	Do.
var. *Red Canna*	--------	60	Do.
G. lemoinei Hort.:			
var. *Catharina*	30	--------	Do.
var. *Don Salluste*	--------	60	Do.
var. *Mrs. Frank Pendleton*	--------	60	Do.
G. nanceianus Hort. var. *desdémone*	30	--------	Do.

[1] Received for publication July 1, 1935; issued February 1936.

[2] Reference is made by number (italic) to Literature Cited, p. 950.

It appears from table 1 that the larger summer-flowering forms are tetraploid and have a chromosome number of $60=2n$, whereas the smaller winter- or spring-flowering types, both species and varieties, are diploid and have a chromosome number of $30=2n$. One exception is *Gladiolus ramosus* (considered to be a group of hybrids) which has $46=3X+1$ chromosomes and which Ernst-Schwarzenbach (*5*) considers to be a hypertriploid.

MATERIALS AND METHODS

Seeds and corms were secured from many commercial dealers in South Africa, Europe, and the United States and, whenever possible, duplicate material was used. Some critical material was available through the kindness of Dr. F. T. McLean, of the New York Botanical Garden, and B. Y. Morrison, of the Bureau of Plant Industry, United States Department of Agriculture. Identification was made by resorting to a variety of sources, particularly to the work of Beal (*2*) and Baker (*1*). However, the ease of hybridization in *Gladiolus* makes the problem of identification a difficult one, especially where any species has been crossed with a commercial variety. McLean (*9*) reports that most of the progeny look like the species parent.

The chromosome numbers were determined chiefly from root-tip material, and some were checked in flower buds. Both were fixed with Navaschin's fluid, followed by the usual xylol-paraffin method, and stained in iron-alum haematoxylin after sectioning. Other fixing agents yielded very poor results, particularly when the chromosomes were numerous. Regardless of number, the fixation of the anthers is uncertain, a confirmation of the condition reported by Ernst-Schwarzenbach (*5*).

All drawings were made with the aid of a camera lucida and the the use of a 15× compensating ocular with a 90× 1.3 apochromatic objective.

RESULTS AND DISCUSSION

The chromosome number found in species, species hybrids, and various commercial varieties of *Gladiolus* is shown in table 2, and illustrations of the chromosomes of some representative types are presented in figure 1.

It is apparent from table 2 that the genus *Gladiolus* is heteroploid and has a basic chromosome number of 15. The majority of the species are diploid, the only exceptions being the members of the subsection Dracocephali and the European-Asiatic group. The former contains the major portion of the species involved in the supposed origin of the summer-flowering commercial varieties. The latter group has always been considered a very distinct one, and this is further indicated by the chromosome number.

The size of the chromosomes, regardless of the number, is almost the same. In fact, any variation might well be covered in one root tip. It is possible at times to detect 2 or 4 large chromosomes but the results are not consistent. Brittingham (*3*) has also called attention to this fact, and it seems probable that it may account for the counts of 31 found in occasional cells by Ernst-Schwarzenbach (*5*).

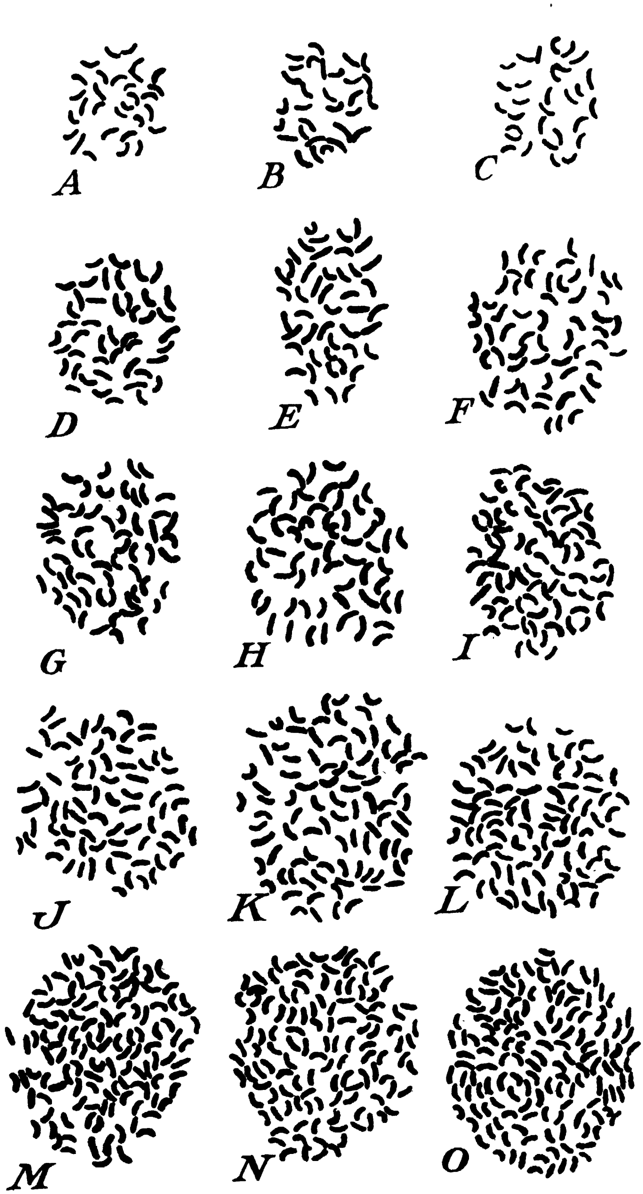

FIGURE 1.—Somatic chromosome plates from root-tip cells of *Gladiolus: A, G. cardinalis*, $2n=30$; *B, G. oppositiflorus*, $2n=30$; *C, G. saundersii*, $2n=30$; *D, G. saundersii* hybrid, $2n=45$; *E, Gladiolus* var. Nymph, $2n=45$; *F, G. primulinus*, $2n=60$; *G, G. platyphyllus*, $2n=60$; *H, Gladiolus* var. Mr. W. H. Phipps, $2n=60$; *I, G. dracocephalus* hybrid, $2n=75$; *J, G. quartinianus* hybrid, $2n=75$; *K, G. psittacinus*, $2n=90$; *L, G. byzantinus*, $2n=90$; *M, G. segetum*, $2n=120$; *N, G. anatolicus*, $2n=120$; *O, G. communis*, $2n=138\pm$. $\times$2,150.

TABLE 2.—*Chromosome numbers determined for gladiolus species, species hybrids and various commercial varieties*

SPECIES AND SPECIES HYBRIDS

Name	n	2n
Eugladiolus:		
Species of Europe and western Asia:		
G. byzantinus Mill		90
G. communis L. variety		138±
G. segetum Ker		120
G. atroviolaceous Boiss	45	90
G. anatolicus Van Tub		120
G. ———		60
Species of Cape and tropical Africa:		
G. tristis L	15	30
G. tristis var. *concolor* Salis	15	30
G. grandis Thunb		30
G. recurvus L		30
G. recurvus hybrid		30
G. gracilis Jacq		30
G. angustus L		30
G. cuspidatus Jacq	15	30
G. trichonemifolius Ker		30
G. brevifolius Jacq		30
G. debilis Ker		30
G. pappei Baker		30
G. villosus Ker		30
Parviflori:		
G. crassifolius Baker		30
G. papilio Baker hybrid		75
Eugladiolus—Continued		
Blandi:		
G. blandus Aiton		30
G. hirsutus Jacq		30
G. oppositiflorus Herb		30
G. undulatus Jacq	15	30
G. odoratus L. Bolus		30
G. callistus F. Bolus		30
Cardinales:		
G. cardinalis Curt		30
G. splendens Baker		30
G. carmineus Wright		30
Dracocephali:		
G. dracocephalus Hook		90
G. dracocephalus hybrid		75
G. psittacinus Hook	45	90
G. psittacinus hybrid		75
G. primulinus Baker	30	60
G. platyphyllus Baker		60
G. coccineus L. Bolus		60
G. quartinianus A. Rich. hybrid		75
G. saundersii Hook		30
G. saundersii hybrid		45
Hebea:		
G. alatus L	15	30
G. alatus hybrid		45
G. orchidiflorus Andr. hybrid		45
G. formosus Klatt hybrid		45
G. permeabilis De la Roche		30

COMMERCIAL VARIETIES, WINTER-FLOWERING TYPES

Name	2n
Gladiolus colvillei Hort.:	
var. *alba*	30
var. *roseus*	30
var. *rubra*	30
G. tuberginii Hort.:	
var. Charm	45
var. Prunella	45
G. nanus Hort.:	
var. Siren	30
var. Spitfire	30
var. *cardinalis elegans*	30
var. Ackermanni	30
var. Peach Blossom	30
Gladiolus nanus Hort.—Continued.	
var. Robinhood	30
var. Blushing Bride	30
var. Nymph	45
var. Liberty	45
var. Groenendaal	60
var. Roos van Dekama	60
Herald gladiolus:	
var. Dillenberg	60
var. Joost v. d. Vondel	60
var. P. C. Hooft	60
var. Prof. Donders	60
var. Leeuwenhoek	45

COMMERCIAL VARIETIES, SUMMER-FLOWERING TYPES, ($2n=60$)

Name	Name	Name	Name
Abbé Raucourt	Commodore	King of Oranges	Pacha
Aida	Contemplation	L. von Beethoven	Pfitzer's Triumph
Albatross	Desdémone	Los Angeles	Picardy
Alice Tiplady	Dr. F. E. Bennett	Marshal Foch	Pierian
Alsace Lorraine	Encelade	Mary Jane	Porthos
Altar	Enchantress	Meadow Lark	Pride of Wanakah
Anthony Kunderd	Evelyn Kirtland	Minuet	Princeps
Ave Maria	Francis King	Mr. Mark	Prof. E. H. Wilson
Baron Joseph Hulot	Giant Nymph	Mr. W. H. Phipps	Purple Glory
Blue Isle	Gloriana	Mrs. F. C. Peters	Rob Roy
Blue Triumphator	Golden Dream	Mrs. Frank Pendleton	Rose
Break o'Day	Golden Measure	Mrs. Leon Douglas	Syncopation
Cardinal Prince	Hyperion	Mrs. P. W. Sisson	Taurus
Catharina	Impressario	Mrs. Van Konynenburg	Vermillion
Catherine Coleman	Indian Chief	October	
Cattleya Rose	Jane Addams		

While many of the records concerning the development of the commercial varieties of *Gladiolus* may be questionable, there seems to be no doubt that many of the external characters which distinguish some of the species are found in the current commercial types. McLean (*10*) and others, have shown specific cases and listed the probable species concerned. While the list in table 2 does not include all of these species, it does contain many of the key types, namely, *G. cardinalis*, *G. oppositiflorus*, *G. Saundersii*, *G. primulinus*, *G. dracocephalus*, and *G. psittacinus* and their chromosome numbers are given as 30, 60, and 90. If such species, with different chromosome numbers, are parents of the commercial varieties, it is hard to see how all of these hybrids are tetraploids. However, the occasional triploids and pentaploids might form an intermediate step in this development.

Within the past few years the attention of cytologists has been centered on the nature of the chromosomes rather than on the number, and special consideration has been given to the spindle-fiber attachment, to the satellites, and to size differences. These features have been helpful in tracing the ancestry of existing types. This method of tracing ancestry would be exceedingly difficult to apply in the case of *Gladiolus* because of the smallness of the chromosomes, so other methods must be employed. One of these seems to be a careful observation of the behavior of the triploids and pentaploids, in regard to both chromosome number and genetical characters, when they are used in crosses. That such triploids and pentaploids exist has already been pointed out. These are probably diploid-tetraploid and tetraploid-hexaploid hybrids, and recent crosses between forms with known chromosome numbers have shown that such crosses are very readily secured. If such triploids and pentaploids are again used in backcrosses, particularly as the pollen parent, selection by hybridizers from the resulting offspring might tend to be centered around those with a tetraploid number, because of certain desirable qualities which they possess. This would be especially true when a tetraploid is used as the seed parent. That the gametes of triploids and pentaploids which must effect fertilization are likely to be euploid has been shown in *Zea-Euchlaena*, *Triticum*, and *Nicotiana* hybrids and in many other crosses of this type. Longley, who has listed and discussed these hybrids *(8, p. 802)* says:

> Where the chromosome complement of a plant is made up of chromosomes in addition to the two homologous sets [triploids and pentaploids], the tendency of the functioning gametes to have the basic chromosome number or a multiple of this number must lead to the production of plants with chromosome numbers in multiples of the basic number and to the absence of plants with aneuploid chromosome numbers.

No aneuploid *Gladiolus* has yet been found except a variety of *G. communis*, and this group has apparently not entered into the formation of tetraploid summer gladiolus.

A detailed description of meiosis, particularly in the commercial varieties, is omitted from this account because of the confusing trivalents and tetravalents which need further study.

SUMMARY

The basic chromosome number of the genus *Gladiolus* is 15.

Diploid, triploid, tetraploid, pentaploid, hexaploid, octoploid, and hyperenneaploid species and hybrids have been found. The majority of species are diploid and all of the summer-flowering commercial varieties which were studied are tetraploid.

The subsection Dracocephali and the European-Asiatic group contain most of the polyploids.

A brief discussion of the possible origin of the tetraploids, in view of their parentage, is presented.

The chromosomes are small and of approximately the same size.

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