INTERSPECIFIC RELATIONSHIPS AND INTRASPECIFIC VARIATION OF *CHENOPODIUM ALBUM* L. IN BRITAIN

II. THE CHROMOSOME NUMBERS OF *C. ALBUM* L. AND OTHER SPECIES

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ABSTRACT

A survey of the chromosome number of *Chenopodium album* L. in Britain and abroad has, contrary to the previous reports, shown that intraspecific polyploidy is probably absent, all determinations giving only the hexaploid, $2n = 54$. Counts from *C. reticulatum* ($2n = 54$) and *C. viride* ($2n = 18$) confirm respectively the integration into and separation from the *C. album* complex of these two taxa. Ten additional species have also been counted, seven of these being first records for this country and three, new determinations for the genus.

1. INTRODUCTION

In the first paper of this series (Cole, 1961) reference was made to the possible part played by intraspecific chromosome races in determining the variation pattern of *C. album*. The survey presented below is based primarily upon counts of *C. album* and aims to assess how significant this putative variable may be. Counts on the additional species are included so that an overall picture of the chromosome numbers of the genus from British material is available, data which are invaluable in an investigation into the hybridisation-potential of *C. album* to be presented in a later paper in this series.

Three chromosome races have been reported in the literature from material identified as *C. album* L. : a diploid $2n = 18$ (Winge, 1917; Löve & Löve, 1944; Maude, 1940) : a tetraploid, $2n = 36$ (Cooper, 1935; Bhargava, 1936; Witte, 1947) : and a hexaploid, $2n = 54$ (Kjellmark, 1934). In addition Kawatani & Ohno (1950) reported a tetraploid with a basic number of $x = 8$, i.e. $2n = 32$. Since this is the only report of a basic number of $x = 8$ from the species it should be accepted with reserve.

This paper aims to reconcile these various reports in the literature which are summarised, together with counts of additional species of *Chenopodium*, in Cole (1957).

2. METHODS

Satisfactory counts were made either from actively growing root meristems or from P.M.C. preparations. Root tip squashes were prepared either from primary radicles or, often with better results, from the more vigorous secondary roots from larger plants growing in pots, in soil or sand, in a greenhouse. Excised roots were pretreated in a saturated solution of α-bromo-napthalene for 2-4 hours at room temperature (c. 20°C) and then fixed overnight in acetic-alcohol (1 : 3). The material was then softened in N/1 HCl at 60°C for 4 minutes and the apices severed and teased in 1–2% acetic orcein in 45% acetic acid (Omara, 1948). This method gave deeply staining chromosomes against a clear cytoplasm. The preparations were dehydrated using the freeze-dry method of Conger and Fairchild (1953) and finally were made permanent in 'Deepex' through xylol. Alternatively, by sectioning at 10 μ young inflorescences, which were fixed in acetic alcohol, embedded in paraffin wax, and stained in either Feulgen or Heidenhain's haematoxylin, most stages of microsporogenesis were found.

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Herbarium specimens of all material used for cytological preparations have been sent to either Dr. Paul Aellen, Basle, Switzerland, or Mr. J. P. M. Brenan, Royal Botanic Gardens, Kew, for confirmation of identification. These specimens have now been deposited in the Herbarium of the University of Southampton.

3. Results

(*a*) Chenopodium album

(*i*) *British material.*

During 1954 and 1955 seed was collected from over 100 widespread localities in Great Britain. From this collection 27 chromosome determinations were made representing 18 vice-counties. Table 1 shows that without exception only the hexaploid ($2n = 54$) (Fig. 1) was found, suggesting that in this country at least intraspecific polyploidy appears to be absent in *C. album* L. It is also pertinent to note that identical counts were obtained for *C. reticulatum* Aell. and *C. album* throughout. This evidence was cited in the first paper of this series (Cole, 1961) where it was suggested that *C. reticulatum* does not deserve separate taxonomic recognition from *C. album*.

Table 1

Chromosome counts of *C. album* L. (incl. *C. reticulatum* Aell.) and the localities of the British material

v.c.	*Locality*	*Seed marking**	*Root tip or Pollen mother cell preparation*	*Diploid Chromosome No.* $2n$
1	Penzance, Cornwall	A	R.T.	54
11	Romsey, Hants.	A	R.T.	54
11	Southampton, Hants.	A	R.T.	54
11	Southampton, Hants.	A	R.T.	54
11	Southampton, Hants.	A	P.M.C.	54
15	Sandwich, Kent	A	R.T.	54
20	Bayfordbury, Herts.	A	R.T.	54
30	Luton, Beds.	A	R.T.	54
31	St. Neots, Hunts.	A	R.T.	54
35	Newport, Mon.	A	R.T.	54
36	Hereford	A	R.T.	54
36	Hereford	A	R.T.	54
45	Dale Fort, Pembs.	A	R.T.	54
60	St. Annes on Sea, Lancs.	A	R.T.	54
67	Newcastle, Northumberland	A	R.T.	54
70	Penrith, Cumberland	A	R.T.	54
72	Gretna, Dumfries.	A	R.T.	54
72	Dumfries, Dumfries.	A	R.T.	54
92	Inverurie, Aberdeenshire	A	R.T.	54
95	Elgin, Moray	A	R.T.	54
11	Southampton, Hants.	R	R.T.	54
11	Southampton, Hants.	R	R.T. & P.M.C.	54
11	Southampton, Hants.	R	P.M.C.	54
12	Winchester, Hants.	R	R.T.	54
15	Sholden, Kent	R	R.T.	54
17	Merton Park, Surrey	R	R.T.	54
25	R. Deben, Suffolk	R	R.T.	54

*A = *C. album* R = *C. reticulatum*

27 counts from 18 vice-counties (no counts from Ireland available); all hexaploid, $2n = 54$.

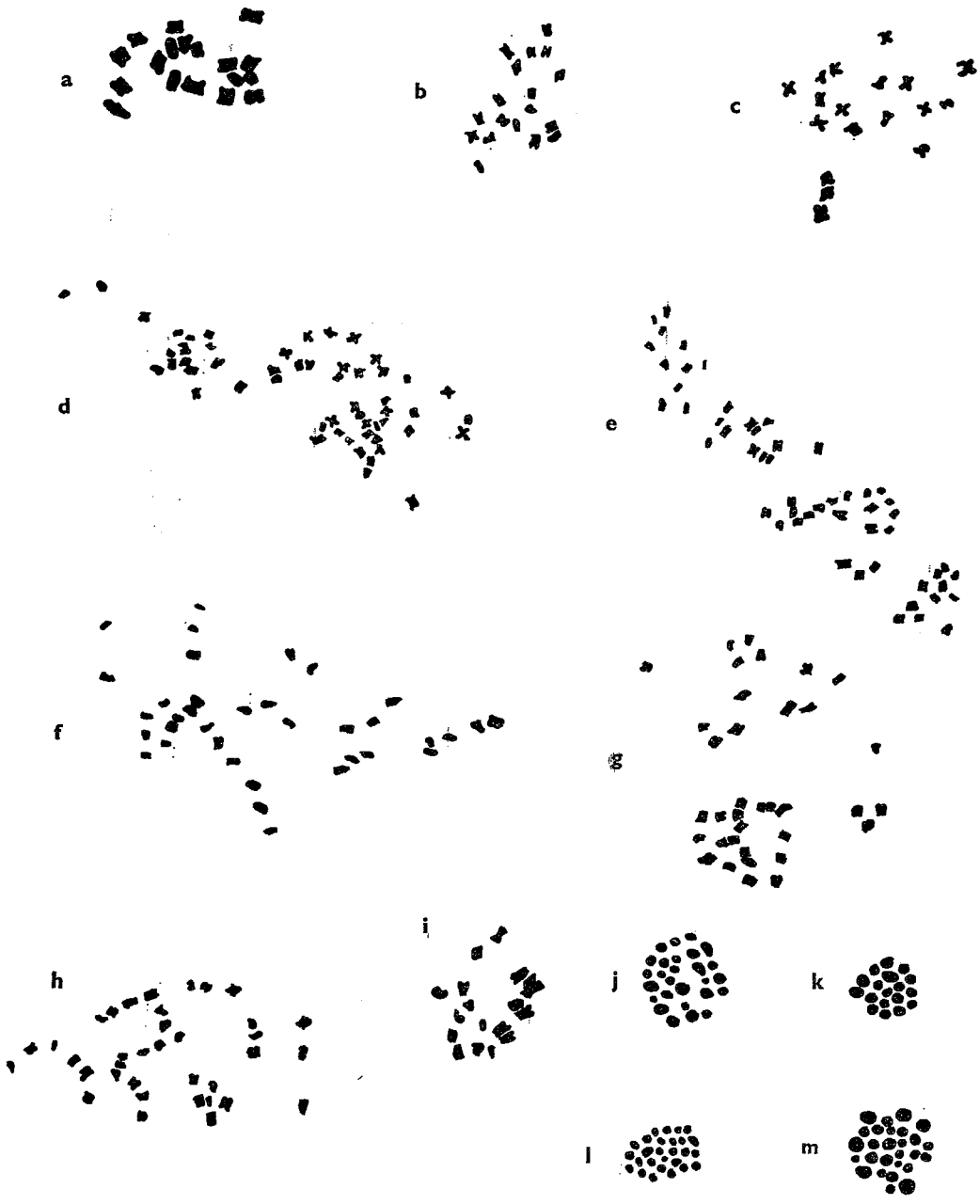

Fig. 1. Chromosomes from the genus *Chenopodium.*

a. *C. viride* L. ($2n = 18$) Oslo, Norway; b. *C. ficifolium* Sm. ($2n = 18$) Southampton; c. *C. murale* L. ($2n = 18$) Southampton; d. *C. album* L. ($2n = 54$) Southampton; e. *C. reticulatum* Aell. ($2n = 54$) Southampton; f. *C. urbicum* L. ($2n = 36$) Holbury, Hants; g. *C. bonus-henricus* L. ($2n = 36$) Southampton; h. *C. berlandieri* Moq. subsp. *zschackei*, (J. Murr) Zob. ($2n = 36$) Southampton; i. *C. polyspermum* L. ($2n = 18$) Southampton; j. *C. opulifolium* Schrad. ex Koch & Ziz ($n = 27$) Southampton; k. *C. variabile* Aell. ($n = 18$) Romsey, Hants; l. *C. album* L. ($n = 27$) Saskatchewan, Canada; m. *C. reticulatum* Aell. ($n = 27$) Southampton. a–i, root tip mitoses × *c.* 1000. j–m, PMC metaphases × *c.* 1350. All drawings are either by camera lucida or are tracings from photographs.

TABLE 2

Chromosome counts of *C. album* L. (incl. *C. reticulatum* Aell.) and the localities of the foreign material

Locality	*Seed marking*	*R.T./P.M.C.*	*2n*
Saskatchewan, Canada	A	P.M.C.	54
Ottawa, Canada	A	R.T.	54
Minnesota, U.S.A.	A	R.T.	54
Carenac, France	A	R.T.	54
Neuchâtel, Switzerland	A	R.T.	54
Coburg, Germany	A	R.T.	54
Bremen, Germany	A	R.T.	54
Copenhagen, Denmark	A	R.T.	54
Pavia, Italy	A	R.T.	54
Christchurch, New Zealand	A	R.T.	54
Rouen, France	R	R.T.	54
Vienne, France	R	R.T.	54
Dandenong, Australia	R	R.T.	54

13 Counts from America, Europe and Australasia; all hexaploid, $2n = 54$.

TABLE 3

Chromosome counts of *Chenopodium* spp. excl. *C. album* L. Localities of British material

Species	*Locality*	*v.c.*	*R.T/P.M.C.*	*2n*
C. ficifolium Sm.	Southampton, Hants.	11	R.T.	18
C. murale L.	Southampton, Hants.	11	R.T.	18
C. polyspermum L.	Romsey, Hants.	11	R.T.	18
C. viride L. (*C. suecicum* J. Murr)	Enfield, Middx.	21	R.T.	18
C. viride L. (*C. suecicum* J. Murr)	Newark, Notts.	56	R.T.	18
C. viride L. (*C. suecicum* J. Murr)	Dumfries, Dumfries.	72	P.M.C.	18
C. bonus-henricus L.	Southampton, Hants.	11	R.T.	36
C. rubrum. L.	Southampton, Hants.	11	R.T.	36
†*C. opulifolium* Schrad.	Southampton, Hants.	11	P.M.C. & R.T.	54
**C. berlandieri* Moq. ssp. *zschackei* (J. Murr) Zob.	Southampton, Hants.	11	R.T.	36
**C. urbicum* L.	Holbury, Hants.	11	R.T.	36
**C. variabile* Aell.	Romsey, Hants.	11	P.M.C. & R.T.	36

*New determinations.

†First count on British material contradicting a previous Continental record (see text).

Other numbers are first counts on British material confirming previous Continental records.

(*ii*) *Foreign material.*

Seed sent from colleagues abroad enabled counts to be made from other continents. The results (see Table 2) are in agreement with those from Britain : only the hexaploid count was recorded and this from plants with both smooth and reticulate seed coats.

(*b*) *Species of* Chenopodium *other than* C. album

Seed was available from ten additional species and their chromosome numbers were determined (Table 3 and Fig. 1). Of these six are first records for this country and confirm previous counts from abroad, three (*C. urbicum* L., *C. variabile* Aell., and *C. berlandieri* Moq. subsp. *zschackei* (J. Murr) Zob.) are new determinations and one (*C. opulifolium* Schrad. ex Koch & Ziz $2n = 54$) differs from the previous record from Germany (Wulff, 1936) of $2n = 36$.

4. Discussion

The results of this investigation suggest with reasonable certainty that *C. album* L. (incl. *C. reticulatum* Aell.) exists, at least in this country, and probably elsewhere, only as a hexaploid ($2n = 54$). Attempts however should be made to reconcile this result with the previous contradictory reports in the literature, since it was Kjellmark (1934) who alone obtained the hexaploid count.

One possible explanation put forward by Aellen & Just (1943) to account for these divergent counts was that of polysomaty. This phenomenon has been reported extensively from the *Chenopodiaceae* and in particular from *Chenopodium*, (Wulff, 1936; Lorz, 1937; Maude, 1940; Witte, 1947). However, hexaploid cells are unlikely to have arisen as a consequence of simple polysomaty (only tetraploid and octoploid cells would be expected) and it can be assumed that any hexaploid counts reported are probably indicative of a true diploid number and are not of polysomatic origin.

A much more feasible explanation is that these discrepancies are errors arising from the taxonomic misidentification of the original material used, mistakes which are easily made in this critical genus. For example, out of five samples of seed sent as *C. album* L. from four independent sources in Scandinavia, four were suspected on seed characters to be *C. viride* L. Two chromosome numbers were recorded, a diploid ($2n = 18$) from the material suspected to be *C. viride* and a hexaploid ($2n = 54$) from the single specimen of *C. album*.

It is suggested that similar confusion between these two species might easily explain the previously recorded reports of $2n = 18$ for *C. album* of Winge (1917) and Löve & Löve (1944) from Denmark and Sweden respectively : their material was probably *C. viride* L. (*C. suecicum* J. Murr) which is notably abundant in Scandinavia.

From this country also Maude (1940) reports a diploid number of $2n = 18$ for *C. album* which may similarly refer to *C. viride*, known to occur in Merton Park. Certainly material of *C. album* from that locality collected personally in 1954 gave the hexaploid count (see Table 1).

The record of $2n = 36$ from the U.S.A. attributed to *C. album* (Cooper, 1935; Witte, 1947) may also be a consequence of misidentification, this time with *C. berlandieri* Moq. subsp. *zschackei* (J. Murr) Zob. ($2n = 36$). There is ample evidence to show that this last species has been long confused with *C. album* in the U.S.A. (cf. Wahl, 1952) and data from the Kew herbarium, for example, show that, out of 23 specimens from North America initially determined as *C. album*, Aellen redetermines 18 of them as *C. berlandieri* subsp. *zschackei*.

On the basis of these observations it is suggested that taxonomic misidentification is largely responsible for the previous reports of varying chromosome numbers for *C. album*, and whilst this conclusion must remain tentative until further counts have been made, the evidence is sufficiently strong to suggest that in Britain, at least, *C. album* L. (incl. *C. reticulatum* Aell.) exists only as the hexaploid $2n = 54$.

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