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Karyology of *Allium* species from the Iberian Peninsula

By

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With 33 Figures (32 Figs. on 8 Plates)

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Summary

PASTOR J. 1982. Karyology of *Allium* species from the Iberian Peninsula. — Phyton (Austria) 22 (2): 171—200, 33 figures. — English with German summary.

A karyological study of 27 taxa of *Allium* L. from the Iberian Peninsula has been made. The chromosome numbers of *A. pardoi* LOSCOS (2n = 6x = 48), *A. melananthum* COINCY (2n = 2x = 16) and *A. oleraceum* L. var. *complanatum* FRIES (2n = 4x = 32, 2n = 6x = 48), are reported for the first time. The following ploidy levels are presumably new: *A. pyrenaicum* COSTA & VAYR. (2n = 4x = 32), *A. guttatum* STEVEN subsp. *sardoum* (MORIS) STEARN (2n = 5x = 40), *A. scorodoprasum* L. subsp. *rotundum* (L.) STEARN (2n = 6x = 48), *A. scorzonerifolium* DESF. ex DC. (2n = 3x = 21) and *A. schmitzii* COUTINHO (2n = 4x = 32). In *A. chamaemoly* L. a new chromosome number (n = 14) has been found.

The study of karyotypes allows to conclude that they are highly symmetrical and that the polyploidy, so frequent in *Allium* has been produced by autopolyploidy. It seems to be a relationship between increase of polyploidy and

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presence of bulbils in the inflorescence. The chromosome basic number x = 7 is supposed to be the most primitive within the genus; the other basic numbers (x = 8, x = 9, x = 10 and x = 14), should be derived from it by fragmentation.

Zusammenfassung

PASTOR J. 1982. Karyologie von *Allium*-Arten der Iberischen Halbinsel. — Phyton (Austria) 22 (2): 171—200, 33 Abbildungen. — Englisch mit deutscher Zusammenfassung.

In einer karyologischen Studie wurden aus der Gattung *Allium* L. 27 Taxa von der Iberischen Halbinsel erfaßt. Die Chromosomenzahlen von *A. pardoi* LOSCOS (2n = 6x = 48), *A. melananthum* COINCY (2n = 2x = 16) und *A. oleraceum* L. var. *complanatum* FRIES (2n = 4x = 32, 2n = 6x = 48) werden erstmals mitgeteilt. Für die folgenden Taxa wurden offensichtlich neue Ploidiestufen ermittelt: *A. pyrenaicum* COSTA & VAYR. (2n = 4x = 32), *A. guttatum* STEVEN subsp. *sardoum* (MORIS) STEARN (2n = 5x = 40), *A. scorodoprasum* L. subsp. *rotundum* (L.) STEARN (2n = 6x = 48), *A. scorzonerifolium* DESF. ex DC. (2n = 3x = 21) und *A. schmitzii* COUTINHO (2n = 4x = 32). Für *A. chamaemoly* L. ergab sich eine neue Chromosomenzahl (n = 14).

Die Karyotypen sind größtenteils sehr symmetrisch, ihr Vergleich führt zu dem Schluß, daß es sich bei der, bei *Allium*-Arten so häufigen Polyploidie im Wesentlichen um Autopolyploidie handelt. Im allgemeinen dürfte eine Korrelation zwischen der Zunahme der Ploidiestufe und dem Auftreten von Bulbillen im Blütenstand bestehen. Die Chromosomengrundzahl x = 7 wird als die ursprünglichste angesehen. Die übrigen Grundzahlen (x = 8, x = 9, x = 10 und x = 14) dürften daraus durch Fragmentation von Chromosomen entstanden sein.

Introduction

This karyological study has been carried out as a part of a taxonomical revision of the genus *Allium* L. in the Iberian Peninsula and Balearic islands.

For the Iberian Peninsula, A. FERNANDES & al. 1948, A. FERNANDES 1950, R. FERNANDES 1953, A. FERNANDES & M. QUEIRÓS 1970—1971 and BARROS NEVES 1973, studied most of the taxa from Portugal. LÖVE & KJELLQVIST 1973, RUIZ REJÓN & SAÑUDO 1976, FERNÁNDEZ CASAS & al. 1977—1978, ARENDS & LAAN 1979 and RUIZ REJÓN & al., 1980, studied some Spanish taxa.

Material and Methods

In order to study the chromosomes in meiosis, flower buds fixed in ethylic alcohol-acetic acid (3 : 1) have been used with iron as mordant, and stained with alcoholic hydrochloric acid-carmin (SNOW 1963).

Root tips of bulbs have been used for the study of chromosomes in mitosis. The roots were treated with 8-hydroxiquinoline for 3—4 hours. Because this treatment was insufficient for the *A.* sect. *Allium*, their species were treated during 6—8 hours. Alcoholic hydrochloric acid-carmin was used as a stain.

The samples investigated are listed individually by the sheet number of the vouchers kept in the herbarium of the Botanic Department, Faculty of Biology, Sevilla (SEV).

For chromosome morphology, the classification of LEVAN & al. 1964 has been followed. STEBBINS 1939: 193 has been followed for the size with some modifications in classifying chromosome size. Chromosomes between 2 and 5 μm are considered as small; between 5 and 9 μm as medium, and over 9 μm as large. This denomination change is owed to the relatively large chromosome size in *Allium*. The symmetry conditions of the karyotypes are indicated following STEBBINS 1971: 88.

In the species of sect. *Allium* secondary constrictions usually appear in the shortest arm of some metacentric chromosomes (m). In some cases, this secondary constriction divides the arm in almost equal parts; KOLLMANN 1971: 19 called this types of constriction "type a" (type scorodoprasum, BRAT 1965a: 492). In other cases the secondary constriction divides the shortest arm in two very unequal parts, and the distal portion is longer than the one nearest to the centromere; KOLLMANN l. c. called this constriction "type b" (type sativum, BRAT l. c.). In other cases the secondary constriction divides the arm in two unequal parts, and the distal portion is a little longer than the proximal one; this constriction is called „type c". Finally, in *A. melananthum* appears a fourth constriction type, called "type d" that divides the shortest arm in two unequal parts, of which the distal portion is shorter than the proximal one.

The lenght of chromosomes, which is indicated in the descriptions, gives the size of chromosomes in the mitotic metaphase, under the conditions of pretreatment mentioned above. The figures are reproduced at different magnifications. Therefore to compare the size the magnifications indicated in the legends are to be considered.

Subgenus *Allium*

Allium sect. *Allium*

A. ampeloprasum L.

Material: Alicante. Cocentaina, 1. VI. 1978, DEVESA, PASTOR & VALDÉS (SEV 42346), 2n = 32. Almeria. Between Huecar Olvera and Pulpi, 30. V. 1978, DEVESA, PASTOR & VALDÉS (SEV 42343), 2n = 32. Between Cantoria and Las Menas, 30. V. 1978, DEVESA, PASTOR & VALDÉS (SEV 42348), 2n = 32. Cádiz. Jerez de la Frontera, 11. V. 1978, DEVESA, PASTOR & TALAVERA (SEV 42345), 2n = 48. Between Cádiz and San Fernando, 11. V. 1978, DEVESA, PASTOR & TALAVERA (SEV 42344), 2n = 48. Granada. Durcal, 26. VII. 1977, PASTOR (SEV 42352), 2n = 32. Jaen, Hornos, 7. VI. 1979, DÍEZ, UBERA & VALDÉS (SEV 42358), 2n = 40, Murcia. Cartagena, 31. V. 1978, DEVESA, PASTOR & VALDÉS (SEV 42347). 2n = 32. Valencia. Between Onteniente and Almansa, 2. VI. 1978, DEVESA, PASTOR & VALDÉS (SEV 42351), 2n = 32. Tarragona. Reus, 7. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42350), 2n = 32. Portugal. Algarve. Burgao, 26. V. 1978, DEVESA, PASTOR & TALAVERA (SEV 42341), 2n = 40.

The numbers 2n = 32, 2n = 40 and 2n = 48 have been found during this study. MAUDE 1940: 18 recorded 2n = 32 for material from England. BRAT 1965a: 487, 1965b: 326 and KOUL & GOHIL 1970: 13 recorded 2n =32 for cultivated plants. BOTHMER 1970: 533 found 2n = 32, 2n = 40 and 2n = 48 in material from Greece and Turkey. KOLLMANN 1971: 16 recorded 2n = 16, 2n = 24, 2n = 32, 2n = 40 and 2n = 48 from Israel. LÖVE & KJELLQVIST 1973: 171 recorded 2n = 32 from Jaen: Sierra Cazorla. BARROS NEVES 1973: 168 found 2n = 40, 2n = 48 in portuguese material from Povoa da Lomba and Cabo S. Vicente, respectively. BOTHMER 1975: 277 recorded 2n = 32, 2n = 40,2 n = 48 and 2n = 56 from Crete, MEHRA & PANDITA 1978: 387 2n = 48 from India and ARENDS & LAAN 1979: 637 2n = 16 for portuguese material from Praha da Rocha.

This species represents a polyploid series with all the levels between diploid (2n = 16) and heptaploid (2n = 56). Except triploids and heptaploids all these levels are known from the Iberian Peninsula.

The asymmetry is of the type 2A for all the populations studied and the idiogrammatic formula is xM + 6xm + xsm, with x = 4, 5 or 6 for tetraploid, pentaploid or hexaploid (figs. 1—3). The length of the chromosomes ranges from 9,5 to 18,9 μm.

On comparing karyograms of the three levels, it can be seen that some groups, for instance number 5, which is formed by metacentric chromosomes (m) with "type a" secondary constriction, present 4, 5 and 6 chromosomes in the tetraploid, pentaploid and hexaploid levels respectively. It has not been possible to observe morphological differences which should enable us to distinguish the plants belonging to different ploidy levels, so it could be assumed that an autopolyploid origin exists for the three levels.

A. baeticum BOISS.

Material: Cádiz. Ubrique, 17. II. 1978, CABEZUDO, PASTOR, TALAVERA & VALDÉS (SEV 42338), 2n = 32. Granada. Between Loja and Lachar, 29. V. 1978, DEVESA, PASTOR & VALDÉS (SEV 42337), 2n = 32. Málaga. Between Ronda and Jimena, 10. VII. 1978, CANDAU, LUQUE & DIEZ (SEV 42239), 2n = 32.

The chromosome number found, 2n = 32, coincides with the number indicated by BARROS NEVES 1973: 171 for portuguese material from Cobagos.

In the populations studied, the asymmetry is of the type 2A, and the idiogrammatic formula is 4M + 24m + 4sm (fig. 4). The length of the chromosomes ranges from 7,5 to 19,5 μm.

In spite of the tetraploid level, the chromosomes have been assembled in pairs in the karyogram of this species, because diploids are not known. The most characteristic chromosomes of the karyogram are the submetacentrics (sm) formed by the pairs 13 and 15, and the chromosomes having type b secondary constriction, formed by the pairs 11 and 12. One can clearly see that chromosomes of those types are not present in groups of four.

A. pardoi Loscos

Material: Teruel. Castelserás, 7. VIII. 1978, Devesa, Pastor & Talavera (SEV 42317), 2n = 48.

The number found (2n = 48) corresponds to the hexaploid level. This number has been recorded presumably for the first time.

The population studied shows a type 2A asymmetry, and its idiogrammatic formula is 6M + 34m + 8sm (fig. 5). The length of the chromosomes ranges from 8,2 to 12,7 μm.

In the karyogram of this species the chromosomes have been assembled in pairs, for the same reason as in the former species, and owing to the fact that no other chromosomic level is known; so, the chromosomes that present secondary constriction type b, forming the pairs 10, 14 and 15, and the submetacentrics that form the pairs 11, 12 and 20, are not to homologize as groups of 6.

A. pyrenaicum Costa & Vayr.

Material: Huesca. Valle de Ansó, 2. VIII. 1978, Devesa, Pastor & Talavera (SEV 42319), 2n = 32.

The population studied possesses 2n = 32. Ono 1935 found 2n = 16 in material from the Pyrenees. Therefore two ploidy levels exist: diploid and tetraploid.

In the population studied the asymmetry is of the type 2A, and the idiogrammatic formula is 4M + 24m + 4sm (fig. 6). The length of the chromosomes ranges from 11,4 to 21,3 μm.

The study of the karyotype for this population allows us to say that it is autotetraploid, because its chromosomes can clearly be grouped in fours. This can be seen in the groups 1, 3 and 7. The group 1 is formed by the metacentric chromosomes of the largest size (m). The group 3 is formed by metacentrics (M); the group 7 is formed by the metacentric chromosomes (m) with type b secondary constriction.

There are no appreciable morphological differences between the populations from Eastern Pyrenees (2x) and Huesca (4x).

A. scorodoprasum L. subsp. *rotundum* (L.) STEARN

Material: Guadalajara. Alcolea del Pinar, 7. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42334), 2n = 64. Alicante. Sierra de Aitana, 1. VI. 1978, DEVESA, PASTOR & VALDÉS (SEV 42333), 2n = 64.

The number found in both populations have been 2n = 64, this corresponds to the octoploid level. LEVAN 1931: 349 indicated n = 16, DIETRICH 1967: 24 n = 8 and 2n = 16 for cultivated material. CHESHMEDJIEV 1973: 867 observed n = 16 and 2n = 32 and later (CHESHMEDJIEV 1976: 624) 2n = 16+2B in material from Bulgaria. RUIZ REJÓN & SAÑUDO 1976: 227 recorded 2n = 32 from Granada (Padul), GARBARI & SENATORI 1975: 21 2n = 32 from Italy and JACOBSEN & OWNBEY 1977: 271 2n = 32 from New Jersey.

This species presents the polyploid series 2n = 2x = 16, 2n = 4x = 32 and 2n = 8x = 64; in the Iberian Peninsula, the 4x and 8x levels have been found.

It can be thougth that the studied plants are autopolyploid, because one of the more characteristic chromosomes, with "type b" secondary constriction, is repeated eight times. Nevertheless, in the populations studied it was not possible to find 8 chromosomes with "type a" constriction, finding 4 in the population from Alicante (SEV 42333), and only 3 in the population from Guadalajara (SEV 42334).

Although RUIZ REJÓN & SAÑUDO 1976: 227 indicated the presence of heterobrachial chromosomes in the tetraploid, all the samples studied have metacentric chromosomes.

A. sphaerocephalon L.

Material: Avila. Puerto de Mesiga, 28. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42307), 2n = 16+1B. Granada. Ascent to Trebenque, 20. VII. 1978, CABEZUDO, PASTOR & TALAVERA (SEV 42314), 2n = 16. Leon. Between Portilla de la Reina and Llanavés, 31. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42309), 2n = 16. Lérida. Between Garés and Artiés, 5. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42311), 2n = 16. Portugal. Beira Alta. Between Vila Nova de Foscoa and Pocinho, 17. VI. 1978, DEVESA & PASTOR (SEV 42308), 2n = 16.

The number found has been 2n = 16+0—1B. Previously LEVAN 1931: 348 found n = 8 in cultivated material. FERNANDES A. 1950: 561 observed n = 8 and 2n = 16 in material from Portugal: Sierra of Gerêz. LEVAN 1935: 313 indicated 2n = 16 for cultivated material, MARTINOLI 1955: 151 2n = 32 from Sardinia, KURITA 1956: 240 n = 9 from Portugal, DIETRICH 1967: 24 n = 8 and 2n = 16 for cultivated material, BARROS NEVES 1973: 162 2n = 16 from Portugal: Buçao and Livrairia do Mondego. BOTHMER 1970: 532 indicated 2n = 16+0—1B from Greece and Turkey. RENZONI & GARBARI 1971: 103 recorded 2n = 16 from Italy, RUIZ REJÓN &

SAÑUDO 1976: 228 2n = 16+2B from Granada, ARENDS & LAAN 1979: 637 2n = 16 from France and FERNANDEZ CASAS & al. 1980: 200 2n = 16 from Burgos.

In all the populations studied without supernumeraries, the asymmetry is of the 1A type, and the idiogrammatic formula is 4M + 10m + 2sm (fig. 8). In the population with supernumerary chromosome, the asymmetry is of the type 2A and the idiogrammatic formula is 4M + 8m + 2m — sm + 2sm + 1Bsm (fig. 7). The length of the chromosomes ranges from 10,4 to 17,5 μm.

The fact that in the karyogram fig. 8 in the pairs 5 and 7 the secondary constriction of type a and c, respectively, can not be observed, and that in the pair 8 the constrictions "a", in the short arm, and "c", in the long one, can only be assumed, is a problem caused by the quality of the slide, because in the rest of the population studied those constrictions can be observed in the respective pairs.

Group 1 of chromosomes in the karyogram represented in fig. 7, is formed by two unequal chromosomes, as one has undergone a process of structural heterozygosity. However, in the karyogram in fig. 8, the chromosomes that form pair 1, are perfectly similar. This phenomenon of structural heterozygosity was observed in *Allium* by KURITA 1953, 1958, LEVAN 1935, EID 1956, KHOSHOO & SHARMA 1959b, GIMENEZ-MARTIN 1961 and BRAT 1965a, 1966.

A. FERNANDES 1950: 561 indicated the presence of two pairs of satellited chromosomes, which correspond to the two pairs with type a secondary constriction.

BOTHMER 1970: 535 found in one out of 10 populations studied 2n = 16+1B. RUIZ REJÓN & SAÑUDO 1976: 228 found in the only population studied 2n = 16+2B. Among 5 populations studied in this work, one contained one B-chromosome.

The number indicated by KURITA 1956: 240 (n = 9) should be taken with reservations, because in all the other investigations of this species only n = 8 and 2n = 16 have been found.

A. melananthum COINCY

Material: Almeria. San Juan de los Terreros, 30. V. 1978, DEVESA, PASTOR & VALDÉS (SEV 42336), 2n = 16. Murcia. Between Puerto de Mazarrón and Cartagena, Sierra de la Muela, 31. V. 1978, DEVESA, PASTOR & VALDÉS (SEV 42335), 2n = 16.

The number found in both populations has been 2n = 16. Presumably, this is the first caryological study on this species.

In the population studied the asymmetry is of the 1A type, and the idiogrammatic formula is 4M + 12m (fig. 13). The pair 4 has a secondary constriction of the type d. The size of the chromosomes ranges from 12,5 to 18,4 μm.

A. guttatum STEVEN subsp. *sardoum* (MORIS) STEARN

Material: Badajoz. Fuente de Castro, 8. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42328), 2n = 32. Cáceres. Retamosa, 4. VII. 1978, DEVESA & PASTOR (SEV 42331), 2n = 40. Córdoba. Cruce de Trasierra, 16. VII. 1978, PASTOR (SEV 42330), 2n = 32. León. Santa Eulalia, Rebollal, 18. VIII. 1979, DÍEZ (SEV 42332), 2n = 32.

The numbers found have been 2n = 32 and 2n = 40. MENSINKAI 1939: 15 indicated 2n = 32 for material from Asia, BRAT 1965a: 487 n = 8 and 2n = 16 for cultivated material. CHESHMEDJIEV 1973: 868 oberserved n = 8 and 2n = 16+0—3B in Russian, and 1974: 1109 2n = 16 in Bulgarian material. BARROS NEVES 1973: 164 indicated 2n = 32 and 2n = 48 fiom Portugal (Ribeira de Asseca, Caldirao and Lajeosa do Mondego), DIETRICH 1972: 17 n = 8 in cultivated material and ARENDS & LAAN 1979: 637 2n = 16 from Algeria.

In this species a polyploidy series with 2n = 16, 2n = 32, 2n = 40 and 2n = 48 is present. In the Iberian Peninsula the 4x, 5x and 6x levels have been found.

The populations studied have an asymmetry of the type 1A and an idiogrammatic formula of 2xM + 6xm, being x = 4 or 5, according to the tetraploids or pentaploids (figs. 9 & 10). The size of the chromosomes ranges from 8,4 to 12,9 μm.

The study of karyograms of both populations allows us to assume an autopolyploid origin for both levels. Looking at the chromosome morphology one can clearly see this in the tetraploids in the groups 1,5 and 6 and in the pentaploids in the groups 1 and 6: the group 1 is formed by the largest chromosomes (M); the group 5 is formed by metacentric chromosomes (m) with type b secondary constriction, and the group 6 is formed by the smallest metacentric chromosomes (M). The chromosomes of the group 5 of the pentaploid are not exactly similar, but are separated in 2 subgroups, each one with 3 and 2 chromosomes respectively.

There are no morphological differences between plants of both ploidy levels.

A. vineale L.

Material: León. Vegalamosa, Puerto de Pajares, 29. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42320), 2n = 48. Salamanca. Sierra de Béjar, 11. VII. 1978, DEVESA & PASTOR (SEV 42324), 2n = 40. Portugal. Beira Alta. Between Meda and Vila Nova de Foscoa, 17. VII. 1978, DEVESA & PASTOR (SEV 42325), 2n = 40.

The numbers found have been 2n = 40 and 2n = 48. LEVAN 1931: 349 found n = 16 and 2n = 32 in cultivated material. The same numbers were found by CHESHMEDJIEV 1973: 864 in material from Bulgaria. A. FERNANDES & al. 1948: 35 indicated 2n = 40 from Portugal (Braganca), KURITA 1956: 241 2n = 32 and BRAT 1965a: 488 2n = 40 for cultivated material, GADELLA & KLIPHUIS 1967: 15 2n = 32 from Holland, DIETRICH 1967: 24 2n = 32 for cultivated material, BARROS NEVES 1973: 166 2n = 40 and 2n = 48 from Portugal Vila Viçosa, Figueira da Foz and Azeitao, MARCHI & al. 1974: 303 2n = 32 from Rome and ARENDS & LAAN 1979: 637 2n = 48 from Morocco. One can point out the record by CHESHMEDJIEV 1974: 1111 on material from Bulgaria (specimens without bulbils in the inflorescence) in which he found n = 8 and 2n = 16.

This species represents the polyploid series 2n = 16, 2n = 32, 2n = 40 and 2n = 48. In the Iberian Peninsula, the 5x and 6x levels have been found.

The populations studied have an 1A type asymmetry and the idiogrammatic formula is 3xM + 4xm + xsm, being x = 5 or 6 (pentaploid or hexaploid) (figs. 11 & 12). The chromosome size ranges from 9,1 to 13,2 μm.

The samples from León (SEV 42320), 2n = 48, and from Portugal (SEV 42325), 2n = 40, belong to populations with flowers completely substituted by bulbils. The sample from Salamanca (SEV 42324), 2n = 40, has an inflorescence with bulbils and flowers.

An autopolyploid origin for both ploidy levels can be assumed. In the pentaploid this statement is based on group 8, which is formed by the smallest metacentric chromosomes (M), which appear clearly in number of 5. In the hexaploid it is based on group 1 and 6; the group 1 is formed by the largest metacentric chromosomes (M) and the group 6 is formed by the metacentric (m) with type b secondary constriction. On the other hand no relation between polyploidy and morphological characters has been observed.

Allium sect. *Codonoprasum* REICHENB.

A. oleraceum L. var. *oleraceum*

Material: Gerona. Puerto de las Tosas, 7. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42238), 2n = 32. Huesca. Valle de Ansó, 2. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42240), 2n = 32. León. Oseja de Sajambre, 30. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42237), 2n = 40. Villanueva de la Tercia, 29. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42242), 2n = 48. Between Salas and Crémenes, 31. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42241), 2n = 48. Puerto del Pontón, 30. VII. 1978 DEVESA, PASTOR & TALAVERA (SEV 42243), 2n = 48.

The numbers found have been 2n = 32, 2n = 40 and 2n = 48. The various records in the literature do not indicate the variety, so they are quoted here for the typical one. LEVAN 1931: 349; 1933: 104 and 1937: 346 found 2n = 32 in cultivated and wild material. TSCHERMAK-WOESS 1947:

79 observed 2n = 40. DIETRICH 1967: 24 indicated n = 16 and 2n = 32 for cultivated material, GADELLA & KLIPHUIS 1970b: 369 2n = 40 from Holland, VACHOVA & FERAKOVA 1978: 382 2n = 32 from Czechoslovakia and FERNANDEZ CASAS & al. 1980: 200 2n = 40 from Burgos (Spain).

This species presents the polyploid series 2n = 32, 2n = 40 and 2n = 48. The existence of the three levels (4x, 5x, 6x) has been demonstrated in the Iberian Peninsula for the var. *oleraceum.*

In the populations studied for chromosome morphology the asymmetry is of the 2A type, and the idiogrammatic formula is xM + 6xm + xsm, being x = 5 or 6 for the pentaploid or hexaploid (figs. 14 & 15). The size of the chromosomes ranges from 9,2 to 15,3 μm.

In the hexaploid karyogram the group 3 of chromosomes is heterogenous, it consists of three different pairs, probably this is due to the existence of a process of structural alterations. All the chromosomes from this group are the only submetacentric chromosomes of the karyogram. The fact that it occupys the position 3, as in the pentaploid, is owed to the relative size of chromosomes in this metaphasic plate.

Taking as a basis the group 8, corresponding to the smallest metacentrics (m), the most distinct chromosomes, an autopolyploid origin for the different ploidy levels can be assumed. So, 5 and 6 chromosomes of this type appear in the pentaploids and hexaploids. LEVAN 1933: 104 observed the presence of tetravalents, trivalents and some univalents and bivalents, during the meiosis of tetraploid plants. There are nor morphological differences between the plants of the two ploidy levels.

A. oleraceum L. var. *complanatum* FRIES

Material: Lérida. Valencia de Areo, 6. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42239), 2n = 32. Santander. Fuente Dé, 1. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42244), 2n = 48.

Only two populations have been studied (tetraploid and hexaploid); we presume that a wider range of samples would allow to find the pentaploid level.

The populations studied present an asymmetry of the 2Atype, and the size of chromosomes ranges from 11,1 to 16,3 μm, The karyotype of the tetraploid population has a idiogrammatic formula 4M + 24m + 4sm (fig. 16).

A. paniculatum L.

Material: Alicante. Playa de Albir, 4. VI. 1978, DEVESA, PASTOR & VALDÉS (SEV 42254), 2n = 16. Tarragona. Falset, 7. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42255), 2n = 16.

The number found has been 2n = 16. Previously, LEVAN 1931: 348, 1935: 306, 1937: 346 observed n = 8 and 2n = 16, BRAT 1965a: 487, 1965b: 326, 1966: 387 n = 8, 2n = 16 and 2n = 16+1B and DIETRICH

1967: 24 2n = 40 in cultivated material. KOLLMANN 1973b: 113 indicated 2n = 16 and 2n = 24 from Israel, MARCHI & al. 1974: 304 2n = 40 from Italy, RUIZ REJÓN & SAÑUDO 1976: 226 2n = 16 from Granada, ARENDS & LAAN 1979: 637 2n = 16 from Algeria and LOON & SNELDERS 1979: 632 2n = 16 from Greece.

The three ploidy levels in this species are 2n = 16, 2n = 24 and 2n = 40. In the Iberian Peninsula only the diploid level has been found. In the populations studied the asymmetry is of the 1A type and the idiogrammatic formula is 2M + 12m + 2sm. The size of the chromosomes ranges from 10,5 to 17,1 μm. Supernumerary chromosomes have not been found.

A. pallens L.

Material. Avila. Between Mota del Marqués and Villardefrades, 28. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42253), 2n = 16. Cáceres. Sierra de las Villuercas, 21. VI. 1978, DEVESA & PASTOR (SEV 42252), 2n = 16. Salamanca. Béjar, 21. VI. 1978, DEVESA & PASTOR (SEV 42249), 2n = 16. Portugal. Alto Alentejo. Between Alphalao and Nisa, 16. VI. 1978, DEVESA & PASTOR (SEV 42251), 2n = 16.

The number found has been 2n = 16. Previously, CONTANDRIOPOULOS 1957: 534 recorded 2n = 32 from France, BRAT 1965a: 487 n = 8 and 2n = 16 from Turkey, BRAT 1965b: 326 2n = 16 for cultivated material, DIETRICH 1967: 24 n = 8 and 2n = 16 for cultivated material, A. FERNANDES & QUEIRÓS 1970: 368 2n = 16 from Portugal, MARCHI & al. 1974: 305 2n = 32 from Rome and RUIZ REJÓN & al. 1980: 252 indicated 2n =16 from Granada.

There are two ploidy levels: 2n = 16 and 2n = 32. In the Iberian Peninsula only the diploids have been found.

The populations studied have an 1A type asymmetry and its idiogrammatic formula is 2M + 2(M—m) + 10m + 2sm. The size of the chromosomes ranges from 8,8 to 14,1 μm.

It is possible that many counts indicated for *A. pallens*, belong to *A. paniculatum* and viceversa, because both species are very closely related and have been frequently mistaken for each other.

Allium sect. *Molium* G. DON ex KOCH

A. roseum L.

Material: Alicante. Between Benilloba and Benasau, 1. VI. 1978, DEVESA, PASTOR & VALDÉS (SEV 42295), 2n = 32. Cocentaina, Sierra de Mariola, 1. VI. 1978, DEVESA, PASTOR & VALDÉS (SEV 42294), 2n = 32. Between Jijona and Alcoy, 1. VI. 1978, DEVESA, PASTOR & VALDés (SEV 42304), 2n = 32. Cádiz. Chiclana de la Frontera, 16. II. 1979, PASTOR, SILVESTRE & UBERA (SEV 42300), 2n = 32. Córdoba. Las Ermitas,

1. V. 1978, PASTOR (SEV 42297), 2n = 32. Sevilla. Morón de la Frontera, Pico Espartero, 4. V. 1979, CANDAU & FERNÁNDEZ (SEV 44990), 2n = 32.

In all populations studied 2n = 32 has been found. TELEZINSKY 1930 (sec. BARROS NEVES 1973: 174) indicated 2n = 16, MESSERI 1930: 276, 1931: 436 2n = 48 from Italy, LEVAN 1931: 349 2n = 32 for cultivated material, DIETRICH 1967: 24 n = 20 and 2n = 40 and later (DIETRICH 1969: 33) n = 16, both for cultivated material, BARROS NEVES 1973: 175 2n = 32 from Sierra de Monsanto, LÖVE & KJELLQVIST 1973: 170 2n = 32 from Sierra Cazorla (Jaén) and RUIZ REJÓN & SAÑUDO 1976: 230 observed 2n = 32 in material from Padul (Granada). BORGEN 1969, 1975: 75 indicated n = 14 and 2n = 28 from Gran Canaria and Gomera, but these numbers differ from all the others, and must be accepted with reservation.

From the polyploid series 2n = 16, 2n = 32, 2n = 40 and 2n = 48, in the Iberian Peninsula only the tetraploid level (2n = 32) has been found.

The populations studied have a karyotype asymmetry of the 2A type and the idiogrammatic formula is 24 m + 4sm + $4T^{sat}$ (fig. 17). The size of the chromosomes ranges from 8,8 to 17,4 μm.

The records of MESSERI 1930, 1931 (2n = 48), DIETRICH 1967 (2n = 40) and LÖVE & KJELLQVIST 1973 (2n = 32) belong to populations with bulbils and flowers in the inflorescences. Among the populations studied, only those from Alicante (SEV 42245 & 42304) have flowers and bulbils in the inflorescences and the number found has been 2n = 32. The other plants studied have inflorescences only with flowers and they have also 2n = 32 chromosomes.

A. negevense and *A. erdelii* (x = 10 and x = 8, respectively, sec. KOLLMANN 1969), *A. zebdanense* (x = 9, EID 1963, sec. BRAT 1965a.: 496) and *A. roseum* (x = 8) are the only species from *A.* sect. *Molium* with chromosome basic numbers different from x = 7.

Most of species from *A.* sect. *Molium* possess metacentric chromosomes, but *A. negevense*, *A. erdelii*, *A. zebdanense* and *A. roseum* have telocentric chromosomes.

The tetraploid karyogram of *A. roseum* contains 4 telocentric chromosomes. The study of the karyogram shows that the chromosomes 7 (m,) and 8 (T^{sat}) have a size equivalent to half of that of group 1, 2 and 3. If a chromosome 8 joins a chromosome 7, a submetacentric chromosome similar to those of group 3 is obtained. It could be supposed that by division of chromosomes similar to group 3 of *A. roseum*, the smallest metacentric (m) and the telocentric (T^{sat}) chromosomes have originated.

A. chamaemoly L.

Material: Córdoba. Aldea Quintana, 11. XII. 1978, PASTOR (SEV 42257), n = 14. Sevilla. Universidad Laboral, 28. XI. 1979, PASTOR

(SEV 42359), n = 14. La Puebla del Río, 20. XII. 1979, PASTOR (SEV 42360), n = 14.

In meiosis of 8 specimens from the three populations studied, n = 14 has been found. In prophase I 14 bivalents are formed. In mitosis of pollen grains n = 14 has been seen too. These results are not in agreement with the records of MARCHI & al. 1974: 306 and GARBARI 1975: 541 (2n = 22) from Italy.

The populations studied have an asymmetry of the 3A type. The size of the chromosomes varies from 6 to 9,5 μm.

In the meiosis bivalents are always formed (fig. 18). Mitosis has been studied only in pollen grains (fig. 18), but there is a high proportion of telocentrics (12) in relation to metacentrics (2). Probably this 2n = 28 has been formed by the division of metacentric chromosomes. These populations can not be considered as tetraploid because their chromosome complement has not been formed by duplication. MARCHI & al. 1974: 306 indicated for this species 2n = 22, with a karyotype of 8 metacentrics (m) and 14 telocentrics (t). It could be supposed that the 8 m and 14 t indicated by those authors derives from 14 original metacentrics (m), by division of 8 metacentrics (m) in 16 chromosomes, 14 telocentrics (t) and 2 metacentrics (m) of almost half the size of that of the rest.

A. subvillosum SALZM. ex SCHULTES & SCHULTES fil.

Material: Cádiz. Puerto de Santa María, 16. II. 1979, PASTOR, SILVESTRE & UBERA (SEV 42270), n = 14 and 2n = 28. Jerez de la Frontera, 16. II. 1979, PASTOR, SILVESTRE & UBERA (SEV 42271), n = 14 and 2n = 28.

The number 2n = 28 has been found; this is in agreement with the number found by RUIZ REJÓN & SAÑUDO 1976: 228 for material from Granada. ARENDS & LAAN 1979: 636 observed 2n = 21 in material from Algeria. The haploid number n = 14 has been observed in the meiosis for both populations.

In this species two ploidy levels must occur: 2n = 3x = 21 and 2n = 4x = 28. As this species has been mistaken with *A. subhirsutum*, it is possible that some records of 2n = 14 indicated for *A. subhirsutum* belong to *A. subvillosum*. In the Iberian Peninsula only the tetraploid level has been observed.

The populations studied present an asymmetry of the 3B type and the idiogrammatic formula is $4m + 4sm + 18st + 2st^{sat}$ (fig. 19). The size of the chromosomes ranges from 5,8 to 12,4 μm.

It is necessary to emphasize that this karyogram is anomalous in *A.* sect. *Molium*. The species of this section shows karyograms with a high level of symmetry; they are formed by large size metacentric chromosomes (M or m), whereas in *A. subvillosum* the karyogram, absolutely asymmetrical, is formed by subtelocentric chromosomes (st), almost half the size than that of the rest.

It is possible to suppose that 28 telocentric chromosomes have been formed by division of 14 metacentrics. In this species bivalents are always formed in the meiosis. Probably this species must not be considered as a real tetraploid as its chromosomic complement has not been formed by duplication (RUIZ REJÓN & SAÑUDO 1976: 236).

A. neapolitanum CYR.

Material: Cádiz. El Bosque, 16. II. 1978, PASTOR (SEV 45015), n = 17, 18. Córdoba. Córdoba, 16. IV. 1977, PASTOR (SEV 44976), n = 17, 18. Las Ermitas, 12. II. 1979, PASTOR (SEV 44979), n = 16, 19. Los Villares, 13. II. 1978, PASTOR (SEV 42273), 2n = 35. Huelva. La Palma del Condado, 2. III. 1978, TALAVERA & VALDÉS (SEV 42776), n = 16, 19. Jaen. Cazorla, 10. V. 1979, GARCÍA, LUQUE & VALDÉS (SEV 44968), n = 17, 18. Málaga. Between Zahara de la Frontera and Montejaque, 18. III. 1977, TALAVERA & VALDÉS (SEV 44982), n = 17, 18.

The number 2n = 35 has been found and the haploid numbers observed let us conclude, that all plants were pentaploid with 2n = 35. The following chromosome numbers have been indicated for cultivated material: 2n = 28 (LEVAN 1931: 349); 2n = 14 and 2n = 28 (LEVAN 1935: 293); 2n = 24, 21, 28 and 35 (KEFALLINOV 1956: 272); 2n = 35 (KHOSHOO & SHARMA 1959a: 305); 2n = 35 (BRAT 1967: 387); 2n = 35 (DIETRICH 1967: 24).

For wild material, the following numbers are known: BARROS NEVES 1973: 176 indicated 2n = 31, 32, 33, 34, 35, 36 from Coimbra, KOLLMANN 1973a: 96 2n = 14, 21 and 28 from Israel, RUIZ REJÓN & SAÑUDO 1976: 231 2n = 35 from Granada, KOLLMANN 1977: 156 2n = 14 from Israel (Mountain Hermon) and LOON & JONG 1978: 57 2n = 28 from Canarias.

From the polyploid series 2n = 14, 2n = 21, 2n = 28, 2n = 35 in the Iberian Peninsula only the 5x level with 2n = 35 and the aneuploids with 2n = 31, 32, 33, 34 and 36 have been found.

The study of meiosis shows the formation of univalents to pentavalents, the higher proportion corresponding to the trivalents. The figure 21A show 1 univalent, 2 bivalents, 4 trivalents and 2 tetravalents. Probably this pentaploid has originated by fusion of unreduced gametes of triploid plants with normal gametes of tetraploids.

KHOSHOO & SHARMA l. c. and RUIZ REJÓN & SAÑUDO l. c. suppose that pentaploid plants of this species are segmental allopolyploids. The formation of some pentavalents in meiosis speaks for the idea that the pentaploid is truly an autopolyploid or hemi-autopolyploid sensu LÖVE & LÖVE 1975: 13 originated from triploids and tetraploids or tetraploids and hexaploids with the same genomes.

An irregular distribution of chromosomes in the first anaphase is observed, with frequent segregation of 17 or 18 chromosomes (fig. 21B), although groups of 16 and 19 chromosomes could also segregate (fig. 21C). The fact that the plants studied for this paper always present 5x = 35 chromosomes allows to suppose that the zygotes with 35 chromosomes hold a higher viability. Nevertheless, BARROS NEVES 1973: 176 studied pentaploid plants with 2n = 31, 32, 33, 34, 35 and 36 chromosomes, which means that other gametic combinations are possible. Another interpretation, perhaps more accurate, is that the pentaploids are sterile and only maintained by vegetative multiplication. However, a population from Coimbra had a fertile F_1 (BARROS NEVES l. c.).

A. moly L.

Material: Cuenca. Tragacete, San Blás, 6. VII. 1979, CABEZUDO, LUQUE & UBERA (SEV 42283), 2n = 14. Hoz de Beteta, 6. VII. 1979, CABEZUDO, LUQUE & UBERA (SEV 42286), 2n = 14. Jaén. Sierra de Cazorla, río Borosa, 20. V. 1978, UBERA (SEV 42269), 2n = 14. Navarra. Paso de dos Hermanas, VII. 1979, J. MONSERRAT (SEV 42384), 2n = 14.

The number 2n = 14 has been found. LEVAN 1931: 348, 1932: 262 observed n = 7 in cultivated material. SATO 1934: 155 indicated n = 7 and 2n = 14, LÖVE & KJELLQVIST 1973: 171 2n = 14 from Sierra Cazorla (Jaen) and DIETRICH 1969: 33 indicated n = 7 for cultivated material with bulbils and flowers in the inflorescence.

The populations studied show an asymmetry of the 1A type and the idiogrammatic formula is 14m (fig. 20). The size of the chromosomes ranges from 16,3 to 26,8 μm.

A. scorzonerifolium DESF. ex DC.

Material. Cádiz. Alcalá de los Gazules, 23. IV. 1979, CABEZUDO, GARCÍA & RIVERA (SEV 42266), 2n = 14. Between Alcalá de los Gazules and Algeciras, 23. IV. 1979, CABEZUDO, GARCÍA & RIVERA (SEV 42267), 2n = 14. Arcos de la Frontera, 23. IV. 1979, CABEZUDO, GARCÍA & RIVERA (SEV 42265), 2n = 14. Orense. Sierra del Invernadero, 20. VI. 1978, DEVESA & PASTOR (SEV 42264), 2n = 21.

Figures 1–32. Karyograms of *Allium* species. In some cases meiotic chromosomes and mitosis in pollen grains are also figured.

Fig. 1. *A. ampeloprasum* (4x). Valencia, between Onteniente and Almansa (SEV 42351), ×900.

Fig. 2. *A. ampeloprasum* (5x). Portugal, Algarve, Burgao (SEV 42341), ×800.

Fig. 3. *A. ampeloprasum* (6x). Cadiz, Jerez de la Frontera (SEV 42345), ×600.

Fig. 4. *A. baeticum* (4x). Málaga. Between Ronda and Jimena (SEV 42239), ×900.

Fig. 5. *A. pardoi* (6x). Teruel, Castelserás (SEV 42317), ×600.

Fig. 6. *A. pyrenaicum* (4x). Huesca, Valle de Ansó (SEV 42319), ×700.

Fig. 7. *A. sphaerocephalon* (2x), with 1 accessory chromosome. Avila, Puerto de Mesiga (SEV 42307), ×1000.

Fig. 8. *A. sphaerocephalon* (2x). Granada, Ascent to Trevenque (SEV 42314), ×1000.

Fig. 9. *A. guttatum* (4x). Cáceres, Retamosa (SEV 42230), ×900.

Fig. 10. *A. guttatum* (5x). Córdoba, Trasierra (SEV 42331), ×900.

Fig. 11. *A. vineale* (5x). Portugal, Beira Alta, between Meda and Vila Nova de Foscoa (SEV 42325), ×900.

Fig. 12. *A. vineale* (6x). León, Vegalamosa (SEV 42320), ×900.

Fig. 13. *A. melananthum* (2x). Almería, San Juan de los Terreros (SEV 42336), ×900.

Fig. 14. *A. oleraceum* var. *oleraceum* (5x). León Oseja de Sajambre (SEV 42237), ×800.

Fig. 15. *A. oleraceum* var. *oleraceum* (6x). León Villanueva de la Tercia (SEV 42242), ×500.

Fig. 16. *A. oleraceum* var. *complanatum* (4x). Lérida, Valencia de Areo (SEV 42239), ×800.

Fig. 17. *A. roseum* (4x). Alicante, Sierra de Mariola (SEV 42249), ×800.

Fig. 18. *A. chamaemoly* (2x). Metaphase in a pollen grain and Diakinesis in a PMC. Sevilla, La Puebla del Rio (SEV 42360), ×600.

Fig. 19. *A. subvillosum* (2x). Cádiz, Puerto de Santa María (SEV 42270), ×1000.

Fig. 20. *A. moly* (2x). Jaén, Sierra de Cazorla (SEV 42269), ×800.

Fig. 21. *A. neapolitanum* (5x). A, prophase I with 2_{II}, 4_{III}, 2_{IV} and 1_{I}. — B, anaphase I, plates with 17 and 18 chromosomes. Cádiz, El Bosque (SEV 45015). — C. anaphase I, plates with 16 and 19 chromosomes. Córdoba, Las Ermitas (SEV 44979), ×300.

Fig. 22. *A. massaessylum* (2x). Portugal, Alto Alentejo, between Marvao and Castelo da Vide (SEV 43307), ×1000.

Fig. 23. *A. scorzonerifolium* (2x). Cádiz, Alcalá de los Gazules (SEV 42266), ×1000.

Fig. 24. *A. scorzonerifolium* (3x). Orense, Sierra del Invernadero (SEV 42264), ×900.

Fig. 25. *A. triquetrum* (2x). Cádiz, Algeciras (SEV 42261), ×900.

Fig. 26. *A. ursinum* (2x). Metaphase in a pollen grain and karyogram. León, Geras (SEV 42256), ×900.

Fig. 27. *A. victorialis* (2x). León, Foncebadón (SEV 42281), ×800.

Fig. 28. *A. nigrum* (2x). Málaga, Casares (SEV 42353), ×800.

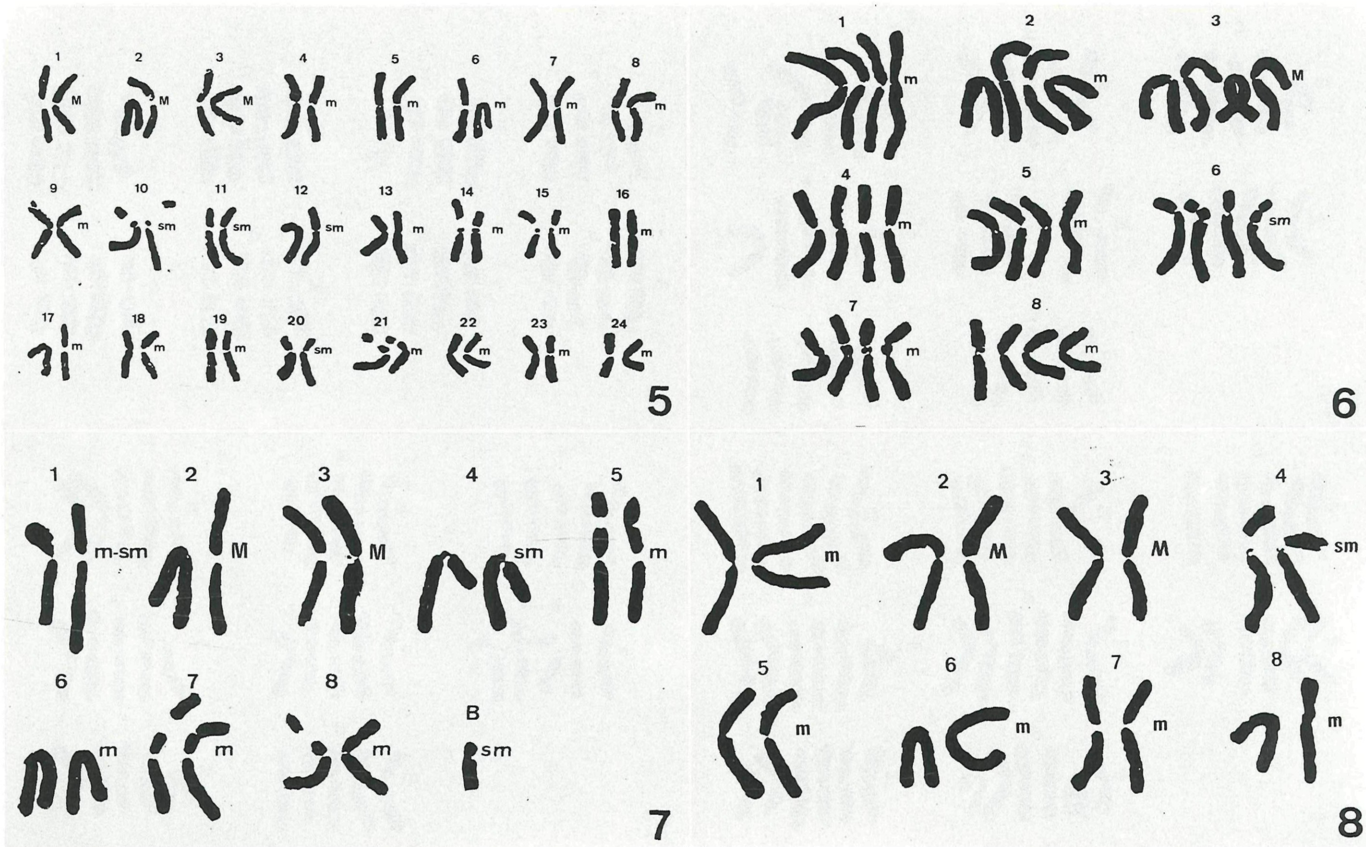
Fig. 29. *A. senescens* subsp. *montanum* (2x). Lérida, Puerto de la Bonaigua (SEV 42291), ×900.

Fig. 30. *A. senescens* subsp. *montanum* (4x). León, Oseja de Sajambre (SEV 42289), ×600.

Fig. 31. *A. schoenoprasum* (4x). Avila, Circo de Gredos (SEV 42285), ×800.

Fig. 32. *A. schmitzii* (4x). Navarra, Pena Izaga (SEV 42292), ×800.

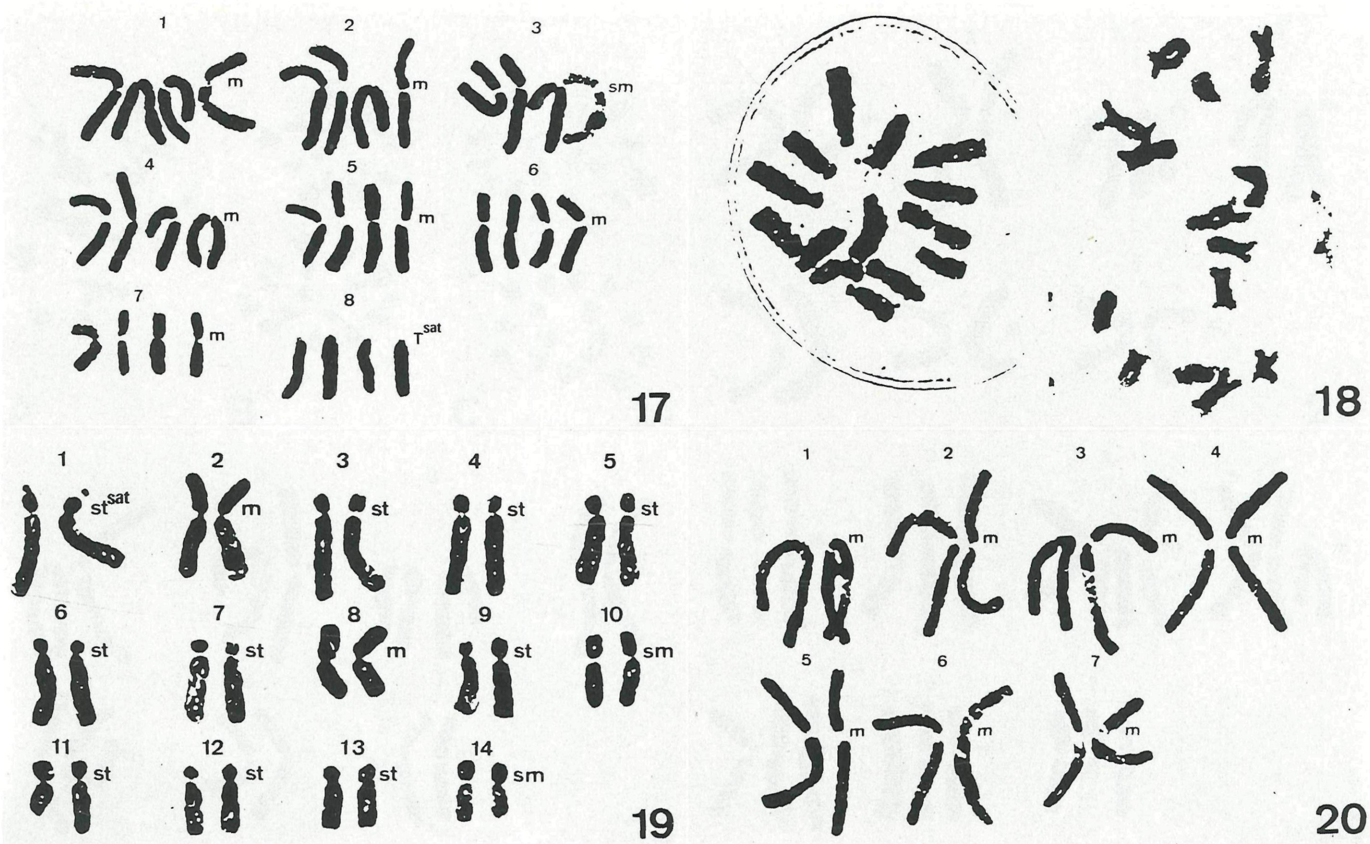
Explanation of Fig. 1—4 on p. 185—186



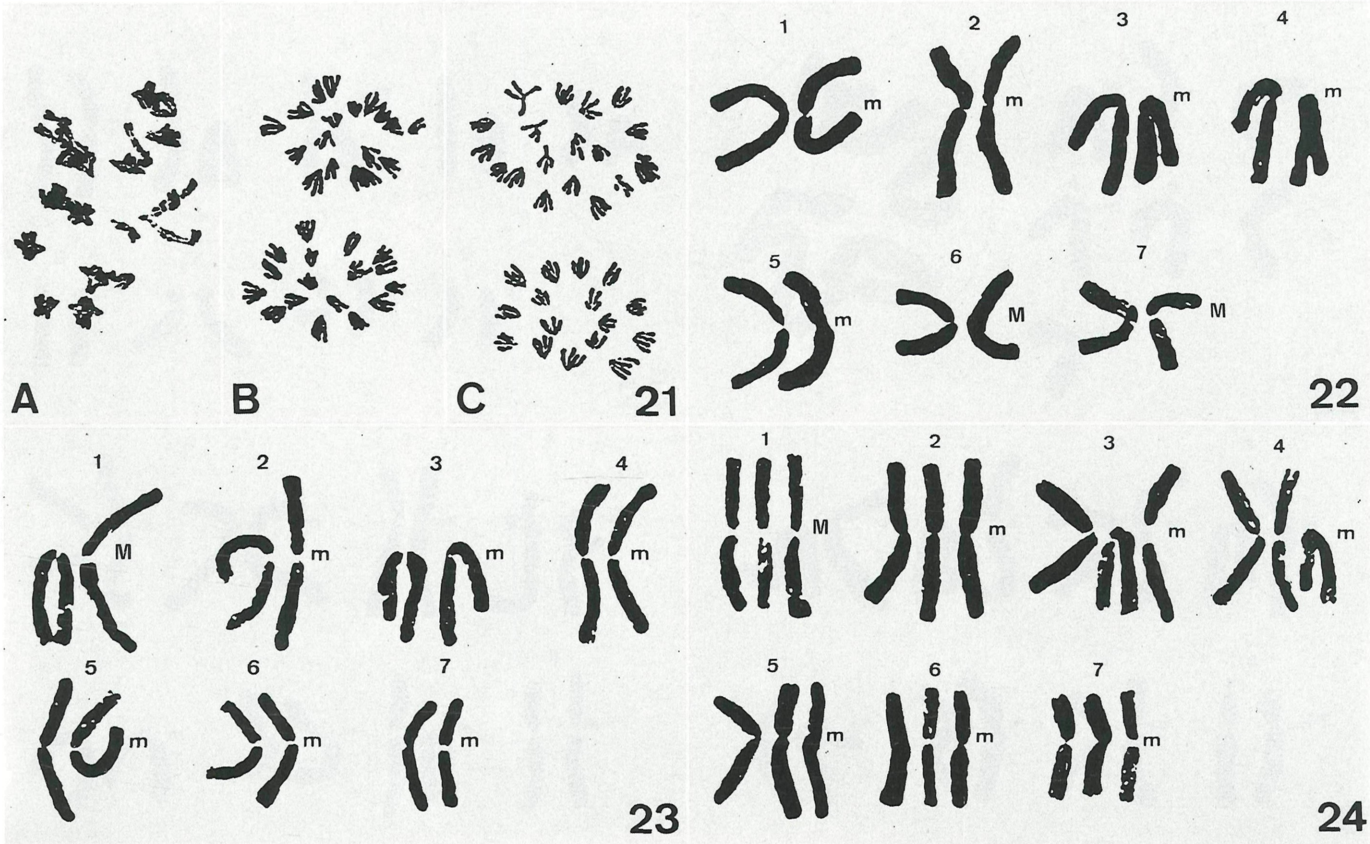
Explanation of Fig. 5—8 on p. 186

Explanation of Fig. 9—12 on p. 186

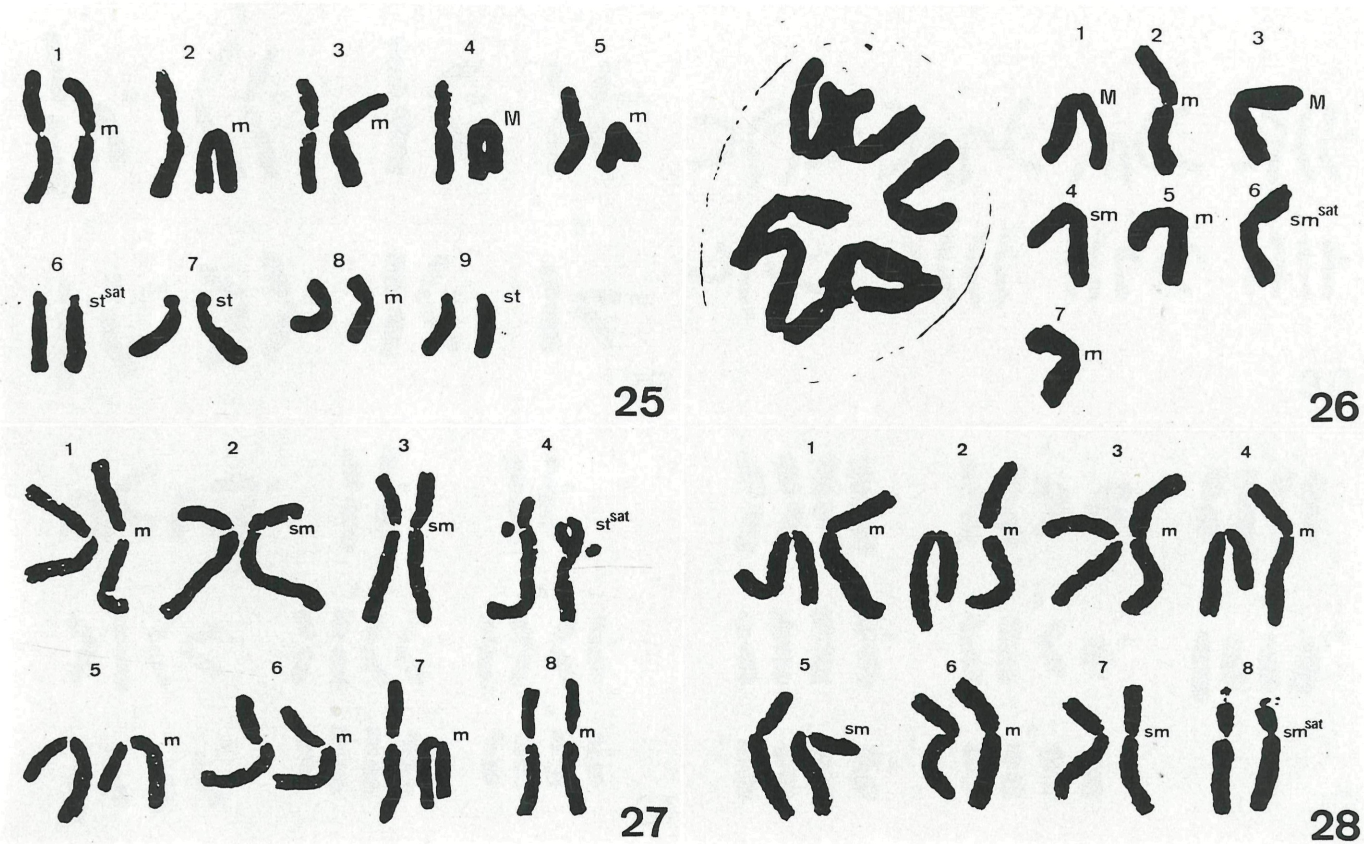
Explanation of Fig. 13–16 on p. 186



Explanation of Fig. 17—20 on p. 186



Explanation of Fig. 21—24 on p. 186



Explanation of Fig. 25—28 on p. 186

Explanation of Fig. 29—32 on p. 186

The numbers 2n = 14 and 2n = 21 have been found. MENSINKAI 1939: 27 observed n = 5 on cultivated material. R. FERNANDES 1953: 188 indicated n = 7 from Portugal (Serra da Estrêla). This species comprehends the diploid and triploid levels.

The populations studied contain a chromosome set with an asymmetry of the 1A type and the idiogrammatic formula is xM + 6xm, being x = 2 or 3 for diploids or triploids (figs. 23 & 24). The size of the chromosomes ranges from 12,2 to 22,1 μm.

By comparing the diploid and triploid karyograms, it can be assumed that in the triploid the chromosomes can be grouped in threes.

A. massaessylum BATT. & TRABUT

Material: Huelva. Aracena, 20. V. 1979, PASTOR (SEV 42287), 2n = 14. Portugal. Alto Alentejo. Between Marvao and Castelo da Vide, 22. V. 1978, DEVESA, PASTOR & TALAVERA (SEV 43307), 2n = 14.

The number 2n = 14 has been found. A. FERNANDES & QUERIÓS 1970: 368 and BARROS NEVES 1973: 175 indicated 2n = 14 for material from Portugal.

The populations studied show an asymmetry of the 1A type and the idiogrammatic formula is 4M + 10m (fig. 22). The size of the chromosomes ranges from 13,1 to 19,3 μm.

Although A. FERNANDES & QUEIRÓS 1970: 368 indicated the presence of two pairs of satellited chromosomes, they have not been detected in the population studied.

Allium sect. *Briseis* (SALISB.) STEARN

A. triquetrum L.

Material: Cádiz. Ubrique, 17. II. 1978, CABEZUDO, PASTOR & VALDÉS (SEV 42262), n = 9. Algeciras, 20. IV. 1978, DEVESA & PASTOR (SEV 42261), 2n = 18. Málaga. Casares, 28. IV. 1978, LUQUE, TALAVERA & VALDÉS (SEV 42260), 2n = 18. Coín, 20. IV. 1978, DEVESA & PASTOR (SEV 42263), 2n = 18.

The number n = 9 has been found in mitosis of pollen grains and 2n = 18 in somatic mitosis of apical meristems. In the work of previous authors the following numbers are recorded: n = 9 (LEVAN 1932: 270, cultivated material); n = 9 and 2n = 18 (DIETRICH 1967: 24, cultivated material); 2n = 18 (RENZONI & GARBARI, 1970: 66 from Italy; BARROS NEVES 1973: 180, from Portugal: Arrabida, Coimbra; RUIZ REJÓN & SAÑUDO, 1976: 228 from Cádiz; LEAL PÉREZ-CHAO & al., 1980: 271 from Cádiz); 2n = 16 (ARENDS & LAAN, 1979: 636 from Tunisia). This last number probably does not correspond to this species.

All the populations studied have an asymmetry of the type 2B and the idiogrammatic formula 2M + 10m + 4st + $2st^{sat}$ (fig. 25). The size of chromosomes ranges from 7,25 to 15,7 μm.

The secondary constrictions found by LEVAN 1932: 272 in one of the metacentric pairs (m), have not been seen.

Allium sect. *Ophioscorodon* (WALLR.) BUBANI

A. ursinum L.

Material. León. Geras, 12. VI. 1979, DÍEZ, PASTOR & SILVESTRE (SEV 42256), n = 7.

This is in accord with the results (n = 7 and/or 2n = 14) obtained for cultivated plants (LEVAN 1931: 348, 1932: 263; BRAT 1965a: 487, 1965b: 326; DIETRICH 1967: 24) or wild material of European origin (Italy: GADELLA & KLIPHUIS 1963: 196; CESCA 1972: 45; GARBARI & TORNADORE 1972: 64. Czechoslovakia: JACOBSEN & OWNBEY 1977: 271).

The population studied presents an asymmetry of the 1A type, and the idiogrammatic formula is 2(2M + 3m + 1sm + $1sm^{sat}$) (fig. 26). The length of chromosomes ranges from 11,6 to 17,9 μm.

Subgenus *Rhizirideum* (G. DON ex KOCH) WENDELBO

Allium sect. *Rhizirideum* G. DON ex KOCH

A. senescens L. subsp. *montanum* (FRIES) HOLUB

Material: León. Oseja de Sajambre, 30. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42289), 2n = 32. Lérida. Puerto de la Bonaigua. 5. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42291), n = 8, 2n = 16.

In the populations studied, 2n = 16 and 2n = 32 have been found,

MENSINKAI 1939: 36 observed 2n = 48 in cultivated material. BAKSAY 1956: 321 indicated 2n = 24 from Hungary, BRAT 1965b: 326 2n = 32+0—1B for cultivated material, SHOPOVA 1966: 150 2n = 32 from central and east Europe, DIETRICH 1967: 24 n = 16 and 2n = 32 for cultivated material, GADELLA & KLIPHUIS 1970a: 490 2n = 32 from French Alps, HOLUB & al. 1970: 341 2n = 32+0—4B from Czechoslovakia, FERNÁNDEZ CASAS & al. 1978: 110 2n = 16+0—5B from Huesca (Spain), ZABORSKY 1978: 381 2n = 32 from Czechoslovakia and JACOBSEN & OWNBEY 1977: 271 found 2n = 32 in cultivated material.

A polyploid series with 2n = 16, 2n = 24, 2n = 32 and 2n = 48 exist in this species; the diploid and tetraploid levels are represented in the Iberian Peninsula.

All the populations studied give an asymmetry of the type 2A, and the idiogrammatic formula 2xM + 4xm + xsm + xst^{sat}, being x = 2 or 4 for diploid or tetraploid (figs. 29 & 30). The size of chromosomes ranges from 9,9 to 17,6 μm. In meiosis the haploid number is n = 8 and bivalents are formed regularly.

By comparison of diploid and tetraploid karyotypes (fig. 29 & 30), we can say that the 4x level was generated by autopolyploidy. This affirmation is based principally on group 5 of the 4x karyotype, which gather the only satellited subtelocentric chromosomes homologous, with the pair 5 of the diploid karyotype. In the tetraploid karyotype the groups 1 and 7 are formed by metacentric chromosomes (m) of largest and smaller size respectively, they are perfectly homologous with pairs 1 and 7 of the diploids.

Morphologicaly, the 2x and 4x individuals do not show any difference that permits different taxonomical categories. The diploid population was collected at 2070 m. s. m. and tetraploid population at 650 m. s. m.

Allium sect. *Anguinum* G. DON ex KOCH

A. victorialis L.

Material. León. Foncebadón, 12. VI. 1979, DÍEZ, PASTOR & SILVESTRE (SEV 42281), n = 8, 2n = 16. Lago de la Baña, 6. VIII. 1979, DÍEZ (SEV 42284), 2n = 16.

The numbers n = 8 and 2n = 16 have been found in meiosis and mitosis respectively. LEVAN 1931: 348, 1933: 114 reported n = 8 and 2n = 16 for cultivated material, and LOVKA & al. 1971: 788 and SUSNIK & al. 1972: 346 2n = 16 from Yugoslavia, MEHRA & PANDITA 1978: 387 2n = 16 from India. Many japanese authors indicated 2n = 32 on material presumably from Asia.

This species is diploid and tetraploid. In the Iberian Peninsula only diploids have been found so far.

The populations studied have an asymmetry of the type 2A, and the idiogrammatic formula 10m + 4sm + $2st^{sat}$ (fig. 27). The length of the chromosomes ranges from 16,6 to 20,35 μm.

The number n = 8 has been found in meiosis; in metaphase I always bivalents are present.

Allium sect. *Schoenoprasum* DUMORT.

A. schoenoprasum L.

Material. Avila. Circo de Gredos, 27. VII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42285), 2n = 32. Huesca. Sallent del Gállego, 4. VIII. 1978, DEVESA, PASTOR & TALAVERA (SEV 42286), n = 8.

Two populations have been studied; one of them is diploid (n = 8) and the other tetraploid (2n = 32). LEVAN 1931: 348 indicated n = 8 and 2n = 16 for cultivated material, MESSERI 1931: 436 n = 8 and 2n = 16 from Italy, LEVAN 1936: 279 2n = 16 and 2n = 32 on cultivated material, Contandriopoulos 1957: 534 2n = 16 from Corsica. Kurita 1955: 207, 1956: 240 indicated 2n = 16 and 2n = 16+1B, respectively, for material from Japan. Brat 1965a: 487, 1965b: 326 reported n = 8 and 2n = 16 for cultivated material, Turesson 1966: 182 2n = 16 and 2n = 32 from Sweden and Siberia respectively, Dietrich 1967: 24 n = 8 and 2n = 16 for cultivated material, Mosquin 1968: 94 2n = 16 from Canada, Lovka & al. 1972: 337 2n = 16 from Yugoslavia, Bougourd & Parker 1975: 276 2n = 16+0—18B from England, Fernandez casas & Machín santamaría 1977: 206 2n = 16, 24 and 32 from Madrid (Sierra Guadarrama) and Valdés bermejo & Castroviejo 1979: 96 found 2n = 32 in material from Palencia.

In this species the polyploid series with 2n = 16, 2n = 24 and 2n = 32 exists. The three levels have been found also in the Iberian Peninsula.

Of the two populations studied, one is diploid and the other tetraploid. The tetraploid population has an asymmetry of 2A type, and the idiogramatic formula is $4M + 24m + 4t^{sat}$ (fig. 31). The length of the chromosomes ranges from 8,2 to 13,6 μm. In the meiosis of the diploid population normal bivalents are formed.

By considering that chromosomes can be grouped in fours, except group 2 (affected by a phenomenon of structural heterozygosity), and on basis of all the most characteristics [as group 1, formed by largest chromosomes, metacentric (M); the group 6, formed by satellited telocentric chromosomes (t^{sat}), and the group 8, formed by the smaller metacentrics (m)], it is possible to assume an autopolyploid origin for the tetraploid. The comparison of the specimens with different chromosomic levels, brings no useful characteristics to help to distinguish them.

In the populations studied, B-chromosomes have not been found, although Bougourd & Parker 1975: 276 indicated 0—18B.

A. schmitzii Coutinho

Material. Navarra. Peña Izaga, 19. V. 1974, Montserrat & Villar (SEV 42292), 2n = 32.

The number 2n = 32 has been found in the population from cultivated material. In this species only one previous count from Barros neves 1973: 171 2n = 16 on material from Portugal (Xarrama, Vila Velha de Rodao is known. So, there are two ploidy levels: 2n = 16 and 2 = 32.

The population studied presents an asymmetry of 2A type and the idiogrammatic formula is $4M + 24m + 4t^{sat}$ (fig. 32). The length of chromosomes ranges from 6,4 to 12,1 μm.

The chromosomes of this population, with the exception of group 5, can be grouped perfectly in fours. A diploid level is known, so we can suppose that the population studied is autotetraploid.

By comparing the cultivated material with herbarium material from Coimbra (Vila Velha de Rodao), there no appreciable morphological differences between plants of both ploidy levels have been found.

Subgenus *Melanocrommyum* (WEBB & BERTH.) ROUY

Allium sect. *Melanocrommyum* WEBB & BERTH.

A. nigrum L.

Material: Cádiz. Vejer de la Frontera, 19. IV. 1978, DEVESA & PASTOR (SEV 42345), 2n = 16. Algeciras. Punta Carnero, 20. IV. 1978, DEVESA & PASTOR (SEV 42357), 2n = 16. Tarifa, 20. IV. 1978, DEVESA & PASTOR (SEV 42355), 2n = 16. Málaga. Puerto de Ojén, 20. IV. 1978, DEVESA & PASTOR (SEV 42356), 2n = 16. Casares, 28. IV. 1978, LUQUE, TALAVERA & VALDÉS (SEV 42353), 2n = 16.

The number found in mitosis has been 2n = 16. MESSERI 1931: 436 observed n = 8 in material from Italy. MENSINKAI 1939: 24, LEVAN 1935: 307 and BARROS BEVES 1973: 174 indicated 2n = 16 for cultivated material. GARBARI & TORNADORE 1970: 79 and RENZONI & GARBARI 1971: 107 observed 2n = 16 in material from Italy. JACOBSEN & OWNBEY 1977: 271 found 2n = 16 in material from Bulgaria.

The populations studied present an asymmetry of the type 2A and the idiogrammatic formula is 10m + 4sm + 2sm ^{sat} (fig. 28). The length of the chromosomes ranges from 15,7 to 22,8 μm.

Discussion

Karyotype Symmetry

On the whole, in *Allium* species the metacentric chromosomes predominate, with the centromere in the median region (m), in a proportion of 67, 78%; the metacentrics with the centromere at the medium point (M), appear in 16,38%; the submetacentrics with the centromere in the submedian region (sm) in 10,66%; the subtelocentrics with the centromere in the subterminal region (st) in 3,81%; the telocentrics, with the centromere in the terminal region (t) appear in 0,98%, and the telocentrics with the centromere at the terminal point (T) are present in 0,44%.

Most of the species have very symmetrical karyotypes, with a very high proportion of metacentric chromosomes. In the system according to STEBBINS 1971: 88 the karyotypes of these species belong to the asymmetry types 1A or 2A. This is an indication of primitiveness. Only three species have high levels of asymmetry: *A. chamaemoly* shows the 3A type, *A. triquetrum* the 2B type and *A. subvillosum* with the most asymmetrical karyotype represents the 3B type.

Structural Heterozygosity

It is a phenomenon well known in the genus *Allium*, and quoted by KURITA 1953, 1958, LEVAN 1935, EID 1956, KHOSHOO & SHARMA 1959b GIMENEZ MARTIN 1961 and BRAT 1965a, 1966. BENTZER 1972 has discussed the same fact in *Leopoldia*.

In this work it has been observed in pair 1 of the diploid karyotype of *A. sphaerocephalon* (fig. 7). The same phenomenon can be observed in two chromosomes of the group 3 of hexaploid *A. oleraceum* (fig. 15), opposed to the remaining four, and in the group 2 of tetraploid *A. schoenoprasum* (fig. 31).

Small Satellites

They are present mainly in st chromosomes, although they can also be found in sm and t. The sections *Molium*, *Briseis*, *Rhizirideum* and *Anguinum* show subtelocentric satellited chromosomes (st^{sat}); the sections *Ophioscorodon* and *Melanocrommyum* have submetacentrics with satellites (sm^{sat}), in the sect. *Schoenoprasum* telocentrics with satellites (t^{sat}) appear and in the sect. *Molium* also telocentrics have satellites (T^{sat}). The satellites are small and are situated on the shorter arm, being difficult to detect at times.

Polyploidy and Aneuploidy

Polyploidy is a very common phenomenom in this genus. For instance, TURESSON 1966: 182 found 2x and 4x levels in *A. schoenoprasum*. KOLLMANN 1973b: 113 observed these two levels in *A. paniculatum*. BOTHMER 1970, 1975 found 4x, 5x, 6x and 7x in *A. ampeloprasum*. BARROS NEVES 1973: 166 recorded 5x and 6x in *A. vineale*.

Theories related to allopolyploid and autopolyploid origin have been proposed. KHOSHOO & SHARMA 1959a indicated that a pentaploid *A. neapolitanum* was a segmental allopolyploid. RUIZ REJÓN & SAÑUDO 1976 agree with this theory. KOUL & GOHIL 1970 equally agree that the tetraploid *A. ampeloprasum* had an allopolyploid origin. MENSINKAI 1939 who studied the polyploid series of *A. cyaneum* REG., *A. deseglisei* BOR., *A. bidwelliae* WATS., *A. margaritaceum* SIBTH. & SM., *A. senescens* L. and *A. giganteum* R., arrived at the conclusion that these series were produced by allopolyploidy, by interspecific hybridization followed by duplication of chromosomes.

LEVAN 1931 differs from this idea, and observed that in tetraploid populations of various species of *Allium*, in the meiosis quadrivalents are formed. He proved that in populations of diploid ($2n = 16$) *A. shoenoprasum* often no reduced gametes are formed in cold days.

KHOSHOO & SHARMA 1959b indicate that triploid populations of *A. rubellum* BIEB. have the same origin. MURIN 1964: 577 who studied tetraploid plants of *A. porrum* with chromosomes that can be grouped in fours, considers also that these plants have an autopolyploid origin.

The results obtained in this work indicate that the polyploidy is of autopolyploid nature in most of the studied species of *Allium*. This opinion is based, above all, on the comparison of the Karyotypes of the different ploidy levels studied in each species; as in *A. ampeloprasum* (figs. 1—3), *A. pyrenaicum* (fig. 6), *A. guttatum* (figs. 9 & 10), *A. vineale* (figs. 11 & 12), *A. oleraceum* var. *oleraceum* (figs. 14 & 15), *A. scorzonerifolium* (figs. 23 & 24), *A. senescens* subsp. *montanum* (figs. 29 & 30), *A. schoenoprasum* (fig. 31) and *A. schmitzii* (fig. 32).

In every species, the plants of different ploidy levels do not show any morphological differences, so it is impossible to determine a priori, morphologically, the ploidy level. This is a normal situation in autopolyploid series.

Probably the species *A. baeticum* and *A. pardoi* may not be autopolyploids. The dubled chromosome number in *A. chamaemoly* and *A. subvillosum* probably has not originated through polyploidy but through fragmentation (see the following chapter "Basic number evolution").

The presence of aneuploidy has been indicated in *A. neapolitanum* (Barros neves 1973: 180), *A. carinatum* (Tschermak-Woess 1947: 72) and *A. pulchellum* (Tschermak-Woess & Schiman 1960, sec. Bothmer 1970: 525).

Supernumerary Chromosomes

Bothmer 1970: 532 indicated that species of most of the *Allium* sections contain supernumerary chromosomes; they correspond to two types: "type 1", of a size equivalent to half, or somewhat more, of a normal chromosome, and "type 2" of less than half that size. Both types are present in the sect. *Allium*, but in the sections *Rhizirideum* and *Codonoprasum* there are only "type 1".

"Type 1" supernumerary chromosomes have been detected only in *A. sphaerocephalon* in this work.

The Presence of Bulbils in the Inflorescence

In the genus *Allium* bulbils in the inflorescence are frequent, or all the flowers are substituted by bulbils.

This fact is related to the increasing of the ploidy level. So, for instance, the specimens of *A. carinatum* with bulbils have 2n = 16 & 3n = 24 and the specimens which only have flowers show 2n = 16. In *A. roseum* plants with bulbils in the inflorescence have 2n = 40 and 2n = 48, according to a previous study in individuals with 2n = 32 bulbils were present or not; in 2x plants (2n = 16) bulbils are lacking always. In *A. moly* there is no relation between the presence of bulbils and increase of the ploidy level, because specimens, with and without bulbils in the inflorescence have 2n = 14. In *A. scorzonerifolium* the specimens studied with flowers only have 2n = 14, and the specimens with bulbils show 2n = 21. *A. vineale* without bulbils has 2n = 16 and the specimens with flowers and bulbils or only bulbils present 2n = 32, 2n = 40 and 2n = 48.

Basic Number Evolution

In *Allium* the chromosome basic numbers x = 7, 8, 9, 10 are present. According to FEINBRUM 1954: 1037, 82,5% of the species have x = 8, 14% x = 7 and 3,5% x = 9. The basic number x = 10 is present in *A. chelotum* from Iran (PEDERSEN & WENDELBO 1966: 309), in *A. negevense* from Israel (KOLLMANN 1973a: 105) and in the Russian species *A. kujukense* and *A. decipiens* (VAKHTINA, sec. BOTHMER 1970: 524), although MENSINKAI 1939: 5 recorded n = 8 for the last species. MARCHI & al. 1974: 306 and GARBARI 1975: 541 recorded n = 11 for *A. chamaemoly* L.

There are three theories about the evolution of the basic number:

— LEVAN 1932 & 1935 considers that x = 7 is the most primitive number, from which all the others have originated.

— MENSINKAI 1939: 38 considers that x = 8 is the earliest because it is the most common, x = 7 and x = 9 could be derived from it.

— BRAT 1965a: 496 considers that each taxonomic group has evolved in a different way, the basic number being x = 8 in some or x = 7 in others.

From the comparison of karyograms, one arrives at the conclusion that those with x = 7 are more symmetrical than the others with x = 8, x = 9 or x = 14. So in the section *Molium*, most of the species have the basic number x = 7 and metacentric chromosomes; however, the tetraploid populations of *A. roseum* with x = 8 show 4 telocentric chromosomes (fig. 17). *A. chamaemoly* (fig. 18) and *A. subvillosum* (fig. 19), with x = 14, contain a high proportion of submetacentric and subtelocentric chromosomes. An *A.* sect. *Briseis*, *A. pendulinum* (x = 7) presents a pair of subtelocentric chromosomes (RENZONI & GARBARI, 1970) though *A. triquetrum* (x = 9) has three pairs of subtelocentric chromosomes (fig. 25).

We can conclude that x = 7 is the most primitive basic number, and from it the numbers x = 8, x = 9, x = 10 and x = 14 (as secondary basic number) have been originated by fragmentation. See fig. 33.

These conclusions are in agreement with LEVAN 1932, 1935 and EID 1963 (sec. BRAT 1965a), and with the chemical and anatomical data from SAGHIR 1964 (sec. TRAUB 1968) and the phytogeographical studies of TRAUB 1968. One is not in agreement, therefore, with the theories of MENSINKAI 1939 and BRAT 1965a.

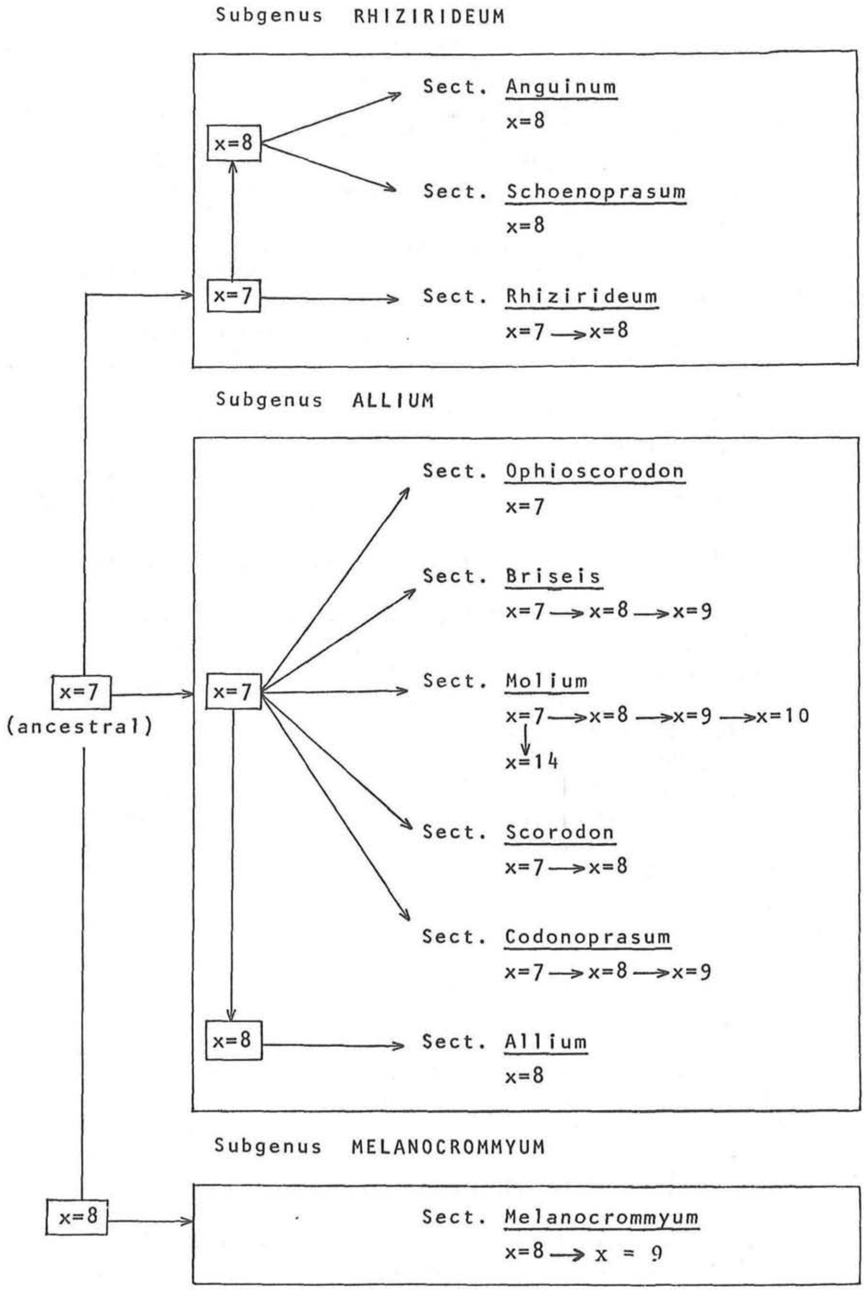


Fig. 33. Evolution of the chromosome basic numbers of *Allium* based on data from the sections represented in the Iberian Peninsula

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