December, 1989
Kor. J. Plant Tax.
Vol. 19, No. 4, 229-239

A cytotaxonomical study on some species of Korean *Forsythia*

Sung Chill Lim and Sung Chul Ko*
(Department of Biology, Dankook University, Seoul 140-714, Korea and
*Department of Biology, Hannam University Taejon 300-791, Korea)

韓國産 개나리屬(*Forsythia*)의 몇 種에 대한 細胞分類學的 硏究

林 星 七 · 高 聖 哲*
(檀國大學校 生物學科 · *韓南大學校 生物學科)

Abstract

On 5 species of Korean *Forsythia, F. koreana* (pin and thrum types), *F. ovata, F. densiflora, F. saxatilis* (pin and thrum types) and *F. viridissima* chromosome numbers and karyotypes were examined and their cytotaxonomical viewpoints were discussed.

All chromosome numbers of the treated taxa were $2n = 28$, and those of *F. densiflora* and *F. saxatilis* were found in this study for the first time. Putting the basic chromosome number of this genus $X = 14$, they are diploids derived from the same ancestor.

In the pin and thrum types of *F. koreana* and *F. saxatilis* karyotypes based on the relative length of chromosome were same but those based on the position of centromere were somewhat different. In addition, all chromosomes were very stable as metacentric and submetacentric ones, and then the genus *Forsythia* are thought to have maintained the very restricted distribution almost without the variation in chromosomal morphology and number.

Introduction

Approximately 6 or 7 species in the genus *Forsythia* which belongs to the tribe Forsythieae of the subfamily Jasminoideae under the family Oleaceae (Melchior, 1964) have been known

in the world (Rehder, 1927). For most of them except *F. europaea* distributed in Southeast Europe, or Albania, the region of Asia including Korea, China and Japan has been thought to be the center of their distribution.

About Korean *Forsythia* since Palibin (1900) had reported *F. viridissima* which is thought to originate from China, Nakai (1911) added *F. suspensa* and he (1917, 1919, 1942) published 4 species of *F. koreana. F. saxatilis, F. ovata* and *F. densiflora* as new ones. Finally he (1952) arranged Korean *Forsythia* into 4 species and 1 variety of *F. densiflora, F. koreana, F. koreana* var. *autumnales, F. ovata* and *F. saxatilis.* Besides Korean *Forsythia* was reported by Mori (1921) for 3 species, Park (1945) for 4 species and 1 variety, and Chung (1957) and Lee (1980) for 4 species. But all these reports fall under the above-mentioned category of Nakai (1952). Chung and Lee (1962) insisted 7 species composed of 4 species of Nakai (1952) and 3 agricultural species coming from abroad, namely, *F. viridissima, F. suspensa* and *F. japonica,* and it means that *F. japonica* was added to Korean *Forsythia* after all.

After Rehder (1891) *Forsythia* has been widely known to be heterostylous plant. But some problems in the identification of *Forsythia* had been raised because Chung (1957) described *F. saxatilis* as pin type in style, and Chung and Lee (1962) insisted *F. koreana* as thrum type and *F. saxatilis* as pin type. For such problems Lee *et al* (1982) clarified the differences between two species by the examination of characters such as flowers and leaves. In additin, Lee (1984) established two new varieties of *F. saxatilis* var. *pilosa* and *F. saxatilis* var. *lanceolata,* and recorded *F. intermedia, F. rhynchophylla* and unidentified hybrids as wild or agricultural plants in Korea. At the same time he divided Korean *Forsythia* except foreign species into two groups. i.e., *F. koreana* and the remains by the palynolgoical and floral characters, and accentuated the necessity of the cytological and the biochemical study for the research in more clear relationship between taxa.

Therefore the present study was cytotaxonomically attempted through the examination of chromosome numbers and karyotypes to the 5 species of all the known taxa of Korean *Forsythia.*

Cytotaxonomical study on this genus has been performed by O'mara (1930), Sax and Abbe (1932), and Tayler (1945) using *F. koreana, F. ovata,* and *F. viridissima* of the taxa treated in this study. According to their reports, chromosome numbers of above species are $2n = 28$ as diploid of basic chromosome number, $X = 14$ but those of *F. densiflora* and *F. saxatilis* and karyotypes of the treated 5 species have never been researched.

Materials and Methods

Experimental plants were collected in the field from March 1985 to May 1986 and were transplanted to the seedbed and the greenhouse of Hannam University (Table 1) and the identification of them was based on Lee (1984) and Lee *et al*(1982). The examined individuals were prepared into the voucher specimens, which were preserved in the Natural Museum of

Table 1. Materials and Localities

Species	Localities	Collector	Date
F. koreana (pin type)	CN: Taejon	Lim S.C.	1985. 3. 12
F. koreana (thrum type)	CN: Taejon	Lim S.C.	1985. 5. 7
F. ovata	Seoul: Hongneung	Lim S.C.	1985. 5. 7
F. densiflora	Seoul: Hongneung	Lim S.C.	1985. 5. 7
F. saxatilis (pin type)	KG: Mt. Pukhan	Lim S.C.	1986. 3. 16
F. saxatilis (thrum type)	KG: Mt. Pukhan	Lim S.C.	1986. 3. 16
F. viridissima	KB: Euisung	Lim S.C.	1985. 3. 27

province: CN: Chungnam; KG: Kyunggi; KB: Kyungbuk

Hannam University.

Chromosomes were observed from root tips, which were pretreated with 0.002M 8-hydroxyquinolin solution and were hydrolysed in the mixture of 45% acetic acid and 1N Hcl (1:2) at the 60°C for an estimated 12 to 13 minutes. For chromosomal observation these samples were stained with 1% aceto-orcein solution and squashed.

Well-dispersed chromosome sets of metaphase in mitosis were selected for the analysis of chromosomal morphology, and their length was calculated with standardized scale improvised for the purpose. Chromosomes were classified into very long (VL, 1.30 and more), long (L, 1.29-1.00), medium (M, 0.99-0.80) and short (S, 0.79 and less) on the basis of relative length. Arm ratio and centromeric indices as metacentric (m, 1.00-1.70), submetacentric (sm, 1.71-3.00) and subtelocentric (st, 3.01-7.00) were adopted from the method of Leven *et al* (1964).

Table 2. Chromosome number of the *Forsythia*

Species	Present study	Previous reports		
	2n	2n	Authors	Localities
F. koreana (pin and thrum types)	28	28	Tayler (1945)	?
			O'mara (1930)	?
F. ovata	28	28	O'mara (1930)	?
			Sax and Abbe (1932)	Korea
			Tayler (1945)	?
F. densiflora	28	—	———	
F. saxatilis (pin and thrum types)	28	—	———	
F. viridissima	28	28	O'mara (1930	?
			Sax and Abbe (1932)	China

Observation and Results

Somatic chromosome number of the treated 5 species were observed as $2n = 28$, diploid of $x = 14$ (Plate 1, Table 2).

Chromosomal length of them ranged from 1.25 microns to 3.79 microns. On the basis of relative length, arm ratio and centromeric indices all chromosomes of the examined 5 species were grouped into 4 kinds, alternatively very long, long, medium and short, and then diverse karyotypes could be described as stated below (Plate 2-4).

Karyotype

Very Long (1.30 and more)
Type A. Metacentric chromosomes
Type B. Submetacentric chromosomes

Long (1.29-1.00)
Type C. Metacentric chromosomes
Type D. Submetacentric chromosomes

Medium (0.99-0.80)
Type E. Metacentric chromosomes
Type F. Submetacentric chromosomes

Short (0.79 and less)
Type G. Metacentric chromosomes
Type H. Submetacentric chromosomes

Details of chromosome characters of each species are given in table 3 and 4.

Table 3. Chromosome characteristics of taxa.

Species	VL.		L.		M.		S.	
	A	B	C	D	E	F	G	H
F. koreana (pin type)		2	4	4	10	2	4	2
F. koreana (thrum type)	2		4	4	12		4	2
F. ovata		2	8		10	4	4	
F. densiflora		2	6	4	12	2	2	
F. saxatilis (pin type)	2		8		18			
F. saxatilis (thrum type)	2		6	2	18			
F. viridissima		2	6	2	10	2	6	

Table 4. Summerized Karyo-morphological features of the taxa investigated here.

Taxa	1	2	3	4	5	6
F. koreana (pin type)	28	1.90-3.59	9 (18)	5 (10)	2.56	35.84
F. koreana (thrum type)	28	1.71-3.29	11 (22)	3 (6)	2.51	35.14
F. ovata	28	1.67-3.43	12 (24)	2 (4)	2.23	31.22
F. densiflora	28	1.25-2.20	10 (20)	4 (8)	1.61	22.54
F. saxatilis (pin type)	28	1.57-2.32	14 (28)	—	1.86	26.04
F. saxatilis (thrum type)	28	1.37-2.32	13 (26)	1 (2)	1.70	23.80
F. viridissima	28	1.99-3.79	13 (26)	1 (2)	2.64	36.96

1 = Chromosome number (2n)
2 = Size range in microns.
3 = Number of metacentric chromosomes.
4 = Number of submetacentric chromosomes.
5 = Average chromosome length in microns.
6 = Absolute chromosome length in microns.

Discussion

Chromosome numbers of *F. koreana* (Fig. 1,2), *F. ovata* (Fig. 3), and *F. viridissima* (Fig. 7) were 2n = 28, which is correspondent with the results of O'mara (1930), Sax and Abbe (1932) and Tayler (1945), and those of *F. densiflora* (Fig. 4) and *F. saxatilis* (Fig. 5,6) were also found as 2n = 28 in the present study for the first time (Table 1). In spite that *Forsythia* has been widely known to be heterostylous plant after Rehder (1891), Chung (1957), and Chung and Lee (1962) erroneously described *F. koreana* having thrum type only and *F. saxatilis* having pin type only. But about this problem Lee *et al* (1982) and Lee (1984) illustrated that both species are heterostylous. Therefore, in this study both pin and thrum types of two species were examined and appeared as 2n = 28 (Table 2, Fig. 1,2,5,6). Putting the basic chromosome number of *Forsythia*, X = 14 which had been already reported by O'mara (1930), Sax and Abbe (1932), Tayler (1945), Darington and Wylie (1955), and so forth, the 5 species of Korean *Forsythia* treated in this study are thought to be derivatives from the same ancestor from the cytological viewpoint.

On the basis of relative length, arm ratio and centromeric indices all chromosomes of the examined 5 species were grouped into 4 kinds, namely VL, L, M and S groups, and then 8 karyotypes from type A to type H could be classified. Lee (1984) pointed out the minute differences between pin and thrum types in *F. koreana* and *F. saxatilis* morphologically. For the former the lobes of corolla are somewhat overlapped in the pin type compared with those

in the thrum type, and for the latter trichomes exist only on the leaf vein of abaxial surface in the pin type compared with those all over the abaxial surface of leaf in the thrum type. But in the present study any chromosomal differences between the above 2 types in each species could not be found from the viewpoint of relative length (Fig. 8,9,12,13), while some minute differences could be found from the viewpoint of centromeric indices (Table 3). This result seems to support that of Lee (1984) cytologically.

All chromosomes of the treated 5 species were metacentric and submetacentric (Table 4) and such a chromosomal simplicity is thought to suggest the cytotaxonomical stability of these taxa. This opinion is correspondent with Tayler (1945) who recorded cytological stability of the genus *Forsythia* from the fact that chromosome number of all taxa examined such as species, varieties and hybrids in the *Forsythia* were 2n = 28, diploid of X = 14. Also the genera under the family Oleaceae are generally known not to form intergeneric hybrids except the genera of *Osmanthus* and *Phillyrea* (Sax and Abbe, 1932). Accordingly the genus *Forsythia* are thought to have maintained the very restricted distribution almost without the variation in chromosomal morphology and number.

摘 要

韓國産 *Forsythia*屬 *F. koreana, F. saxatilis, F. ovata, F. densiflora, F. viridissima*의 5種에 대한 體細胞染色體와 核型分析을 통한 細胞分類學的 接近을 試圖한 結果 이들의 體細胞染色體는 모두 2n=28이었고, *F. densiflora*와 *F. saxatilis*는 本 硏究에서 2n=28로 처음 밝혀진 것이다.

*Forsythia*屬의 染色體基本數가 X=14인 點으로 미루어보아 取扱된 모든 分類群은 共通의 祖上으로부터 由來된 二倍數性植物로 생각된다.

染色體의 相對的 길이(R. L)에서 보면, *F. koreana, F. saxatilis*內의 長柱花(Pin)와 短柱花(Thrum)는 各各 같았으나 動原體의 位置에서 보면 若干의 差異를 나타내었다. 또한 核型은 metacentric 및 submetacentric chromosomes으로서 매우 安定되었으며 결국 *Forsythia*屬의 分類群들은 染色體의 形態나 數的인 變化를 겪지않고 매우 制限된 地理的 分布를 維持해온 것으로 생각된다.

References

Chung, T.H. 1957. Korean Flora I. Shinzisa. Seoul.

_____ and W. C. Lee. 1962. On the *Forsythia* in Wui Sung. Kor. Jour. Bot. 5:37-38.

Darlington, C.D. and A.P. Wylie. 1955. Chromosome atlas of Flowering Plant. George Allen & Uniwin, London.

Lee, S.T. 1984. A systematic study of Korean *Forsythia* species. Kor. Jour. Pl. Tax. 14:87-107.

_____, M.Y. Kim. and S.P. Hong. 1982. A taxonomic study of *Forsythia koreana* Nakai and

F. saxatilis Nakai. Kor. Jour. Pl. Tax. 12:15-62.
Lee, T.B. 1979. Illustrated Flora of Korea. Hyangmoonsa, Seoul.
Leven, A., K. Fredga and A.A. Sandberg. 1964. Nomenclature for centromeric position on chromosomes. Hereditas 52:201-220.
Melchior, H. 1964. Syllabus der Pflanzenfamilien II.
Mori, T. 1921. An Enumeration of Plant Hither to Know from Corea. Gov. Gen. Chos.
Nakai, T. 1911. Flora Koreana II. J. Coll. Sci. Imp. Tokyo 31:89.
_____. 1917. *Forsythia ovata.* 日本植物管見.
_____. 1919. *Forsythia japonica* var. *saxatilis.* Bot. Mag. Tokyo 161:33.
_____. 1942. *Forsythia saxatilis, F. densiflora.* Icon. Pl. As. Orient. 4
_____. 1952. A Synoptical Sketch of Korea Flora. Bull. Sci. Tokyo 31:91.
O'mara, J. 1930. Chromosome number in the genus *Forsythia*. Jour. Arn. Arb. 11:14-15.
Palibin, J. 1900. *Forsythia viridissima*. Conspectus Flora Koreae. Vol 2.
Park, M.K. 1949. An Enumeration of Korean Plant. pp. 191-192.
Rehder, J. 1891.Über Dimorphismus bei *Forsythia*. Gartenflora 40:395-400.
_____. 1927. Manual of cultivated trees and shrubs. McMillan Co. New York. pp. 749-750.
Sax, K. and E.C. Abbe. 1932. Chromosome number and the anatomy of the secondary xylem in the Oleaceae. Jour. Arn. Arb. 13:37-47.
Tayler, H. 1945. Cyto-taxonomy and phylogeny of the Oleaceae. Brittonia 5:337-367.

Explanation of Plates

Plate 1. Photomicrographs of the somatic chromosomes
Fig. 1. *F. koreana* (pin type)
2. *F. koreana* (thrum type)
3. *F. ovata*
4. *F. densiflora*
5. *F. saxatilis* (pin type)
6. *F. saxatilis* (thrum type)
7. *F. viridissima*

Plate 2. Karyotypes of somatic chromosomes
Fig. 8. *F. koreana* (pin type)
9. *F. koreana* (thrum type)
10. *F. ovata*
11. *F. densiflora*
12. *F. saxatilis* (pin type)
13. *F. saxatilis* (thrum type)
14. *F. viridissima*

PLATE 1

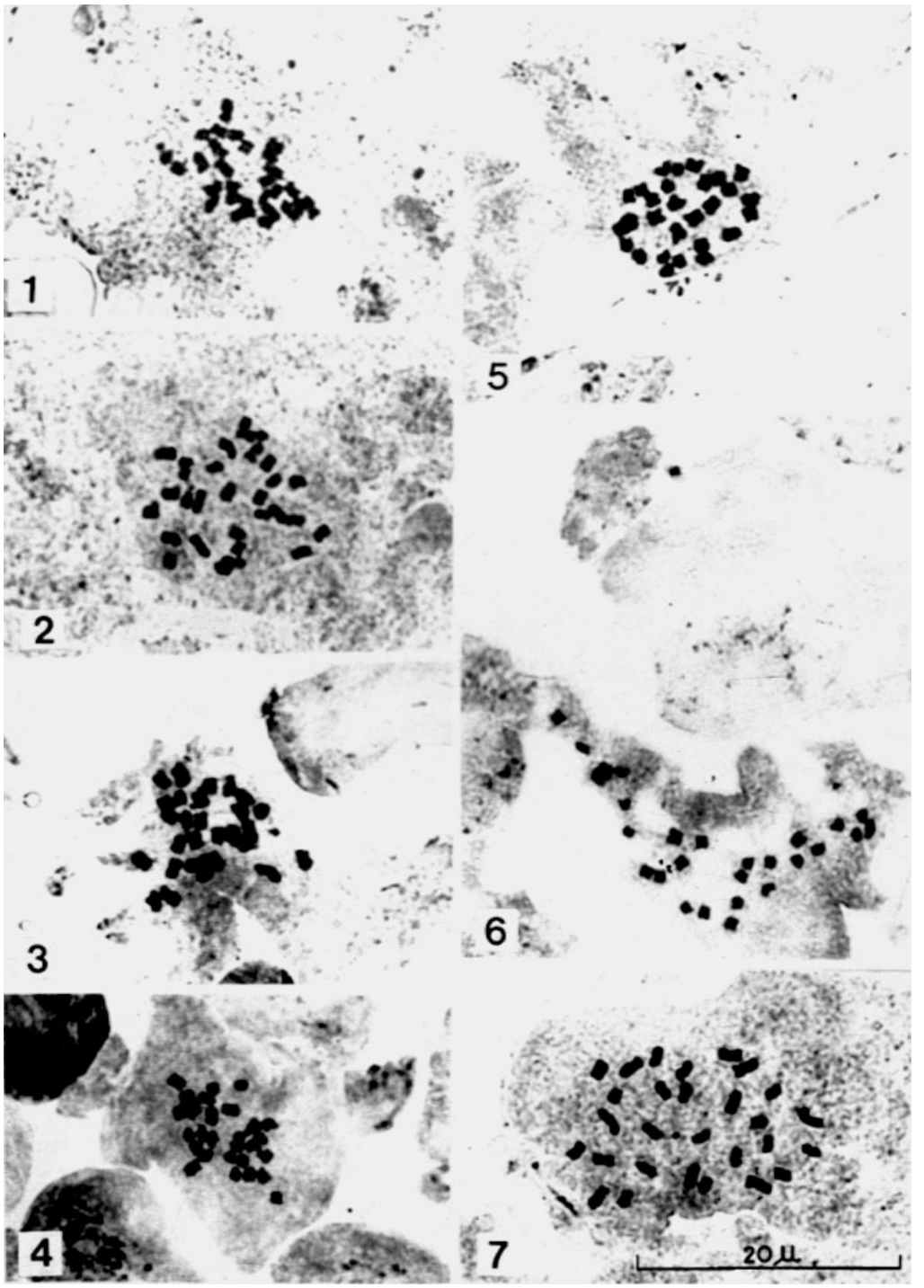
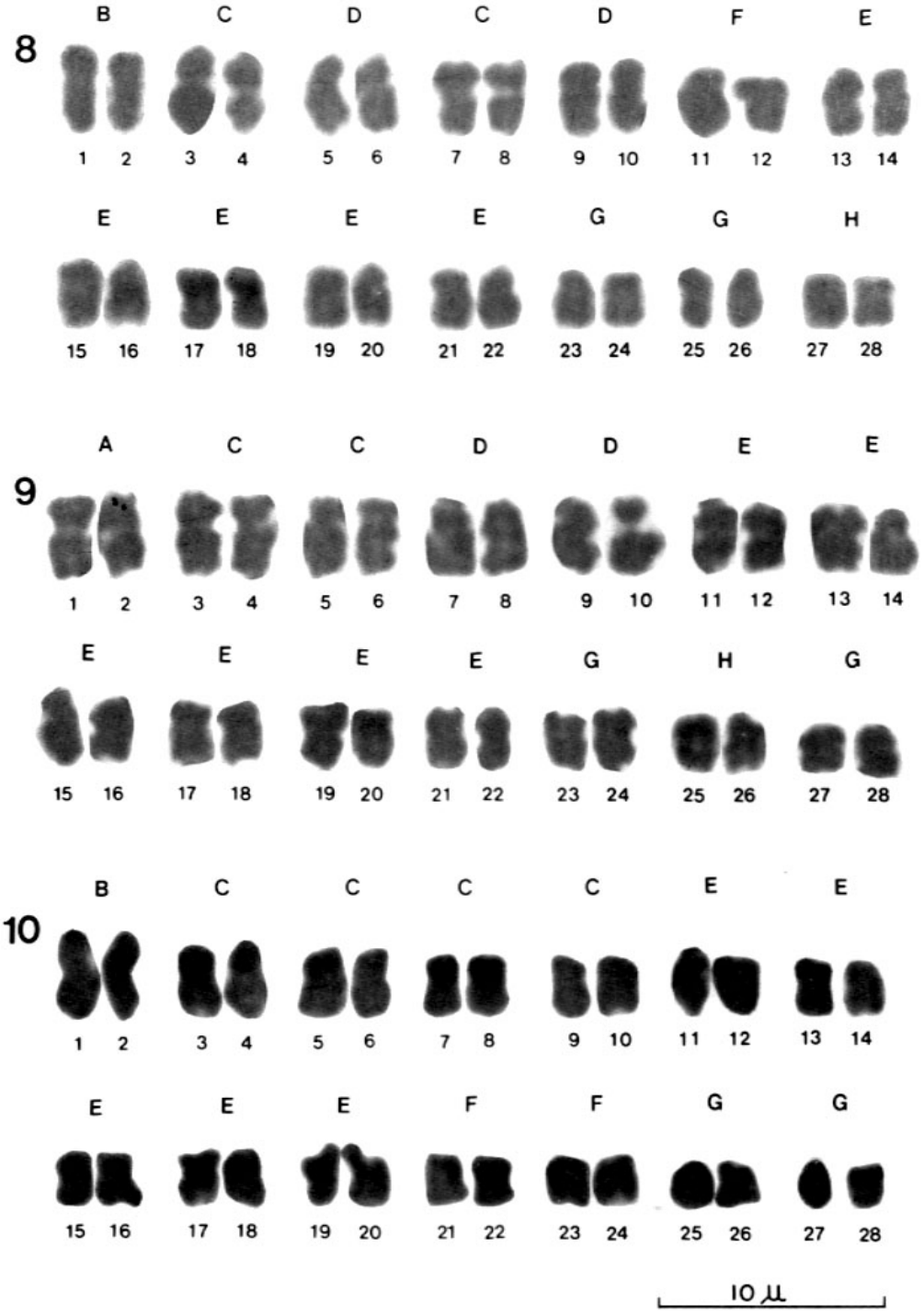
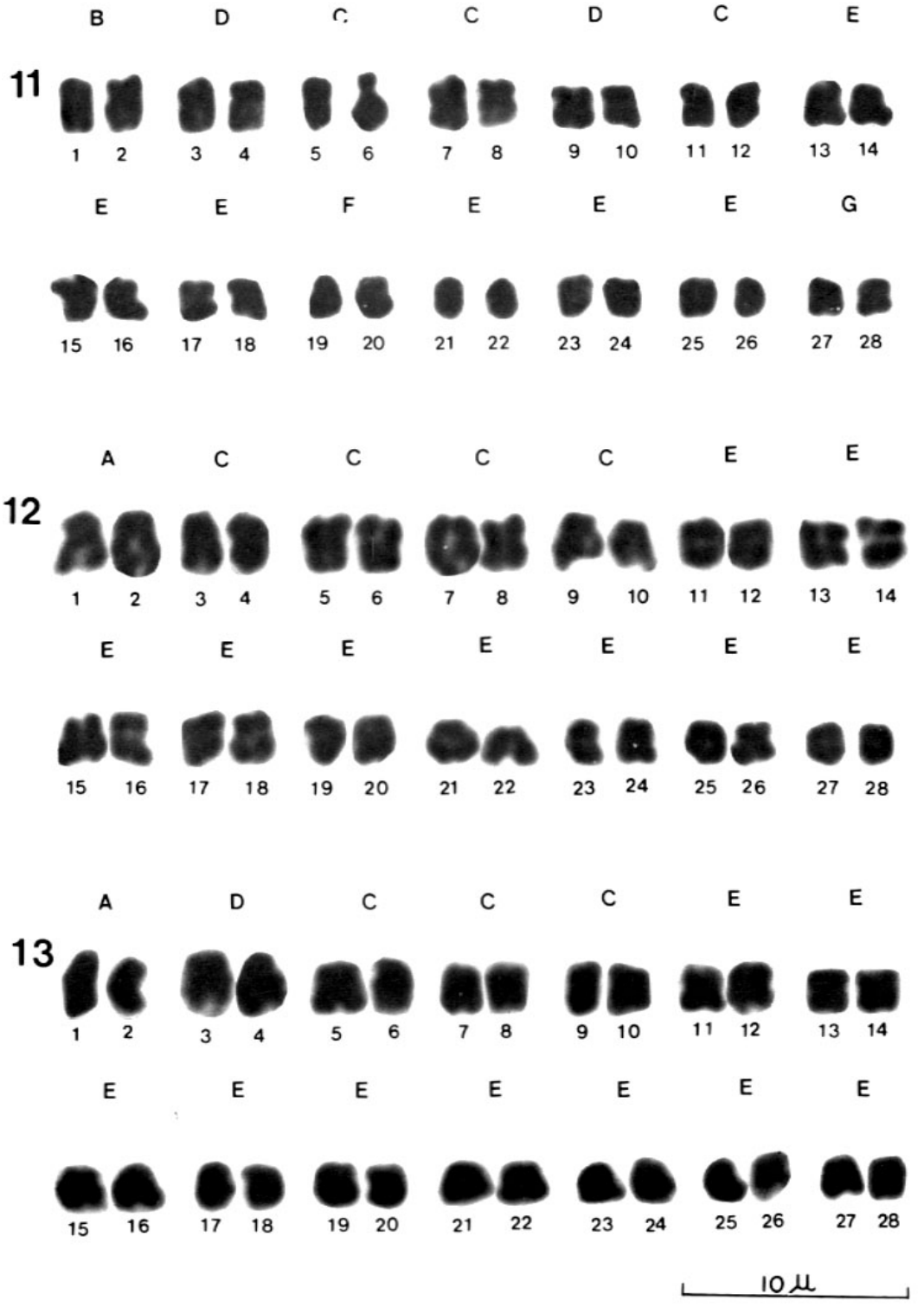
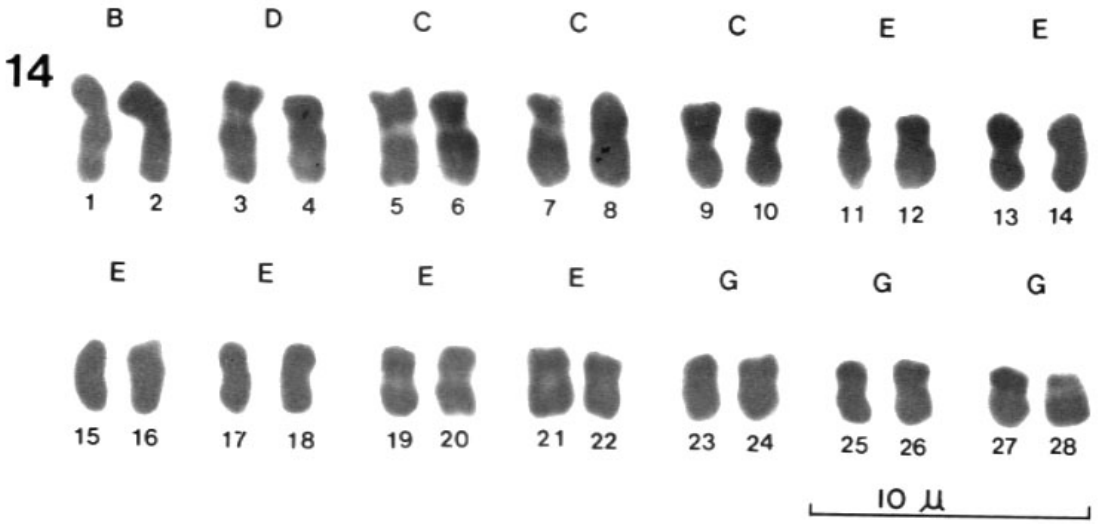


PLATE 2


8
B C D C D F E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E E E G G H
15 16 17 18 19 20 21 22 23 24 25 26 27 28
9
A C C D D E E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E E E G H G
15 16 17 18 19 20 21 22 23 24 25 26 27 28
10
B C C C C E E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E E F F G G
15 16 17 18 19 20 21 22 23 24 25 26 27 28
10 μ


11
B D C C D C E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E F E E E G
15 16 17 18 19 20 21 22 23 24 25 26 27 28
12
A C C C C E E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E E E E E E
15 16 17 18 19 20 21 22 23 24 25 26 27 28
13
A D C C C E E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E E E E E E
15 16 17 18 19 20 21 22 23 24 25 26 27 28
10μ


14
B D C C C E E
1 2 3 4 5 6 7 8 9 10 11 12 13 14
E E E E G G G
15 16 17 18 19 20 21 22 23 24 25 26 27 28
10 μ