Bothalia 29,2: 335–341 (1999)

Miscellaneous notes

POACEAE

CHROMOSOME STUDIES ON AFRICAN PLANTS. 12. THE TRIBES OF SUBFAMILY POOIDEAE

Our laboratories have presented various papers of cytogenetic data on chromosome numbers of South African representatives of the grass subfamily, Pooideae (Spies & Du Plessis 1986a, b, 1987a, b; Spies & Voges 1988; Spies *et al.* 1996a, b, 1997). In this paper chromosome numbers of specimens from the smaller tribes, as well as miscellaneous specimens that were not included in previous papers, are presented.

The aim of this study is to determine the chromosome numbers, polyploid levels and meiotic chromosome behaviour of some of the South African representatives of the Pooideae.

MATERIALS AND METHODS

For the purpose of this study, cytogenetic material of identical plants of a population was collected and fixed in the field (Table 1). Voucher specimens are housed in the Geo Potts Herbarium, Department of Botany and Genetics, University of the Orange Free State, Bloemfontein (BLFU) or in the National Herbarium, Pretoria (PRE).

Anthers were squashed in aceto-carmine and meiotically analysed (Spies *et al.* 1996a). Only gametic chromosome numbers are presented to conform to previous papers on chromosome numbers in this journal (Spies & Du Plessis 1986a). Due to the large number of chromosome number reports on some of the species included in this study, we refer to the chromosome atlas rather than to all the individual publications for a specific species.

RESULTS AND DISCUSSION

Forty-seven plants, representing 29 species and 16 genera were studied (Table 1).

Tribe Poeae

In *Catapodium rigidum* we found n = 2x = 14 (Figure 1A), which confirms previous reports of the presence of both diploid and tetraploid specimens in this species (Ornduff 1968; Fedorov 1969; Moore 1972, 1977; Goldblatt 1983, 1985; Goldblatt & Johnson 1994).

Poa binata was tetraploid (n = 2x = 14) and *P. pratensis* hexaploid (Figure 2B–D) (n = 3x = 21). Chromosome number reports on *P. pratensis* indicate a wide range of aneuploid chromosome numbers in this species (2n = 25–124) (Ornduff 1967; Fedorov 1969; Moore 1970, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1998).

A diploid chromosome number (Figure 2E, F) for *Puccinellia angusta*, confirms a previous report from our laboratory (Spies *et al.* 1997). A possible B-chromosome was present in both *P. angusta* specimens (Figure 2G). Specimens of the *Puccinellia* sp. were hexaploid (Figure 2H, I).

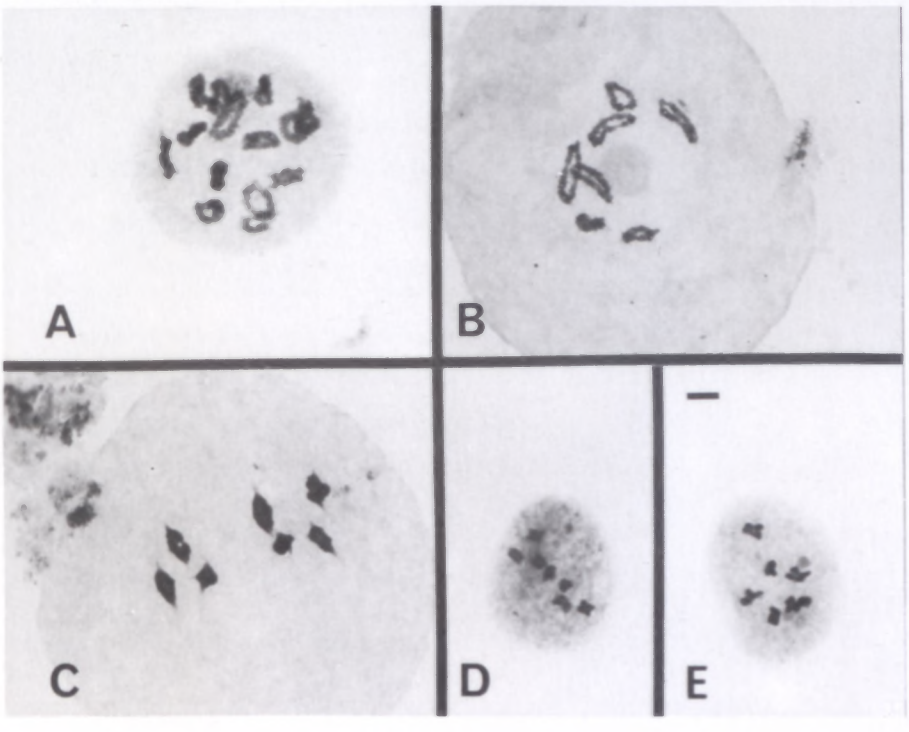

FIGURE 1.—Meiotic chromosomes in some specimens of the genera *Catapodium*, *Hainardia* and *Koeleria*. A, *Catapodium rigidum*, *Spies 4636*, n = 14, diakinesis with 14_{II}. B, C, *Hainardia cylindrica*, *Spies 5013*, n = 7: B, diakinesis; C, metaphase I, with 7_{II}. D, E, *Koeleria* sp., *Spies 5111*, n = 7: D, metaphase I; E, diakinesis, with 7_{II}. Scale bar: 6.5 µm.

TABLE 1.—Gametic chromosome numbers of representatives of the subfamily Pooideae (Poaceae) in southern Africa with their voucher specimen numbers and specific localities. Species are listed alphabetically and the localities are presented according to the system described by Edwards & Leistner (1971)

Taxon	Voucher	n	Locality and voucher no.
Tribe Poeae			
Catapodium rigidum (L.) C.E.Hubb.	*Spies 4636*	14	WESTERN CAPE.—3420 (Bredasdorp): 3 km north of De Hoop Nature Reserve, (–AD).
Lolium			
multiflorum Lam.	*Spies 5613*	7	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
	Spies 2468	7	EASTERN CAPE.—3126 (Queenstown): Penhoek Pass, (–BA).
rigidum Gaudin	*Spies 5358*	7	WESTERN CAPE.—3118 (Vanrhynsdorp): 21 km from Doringbaai to Donkins Bay, (–CD).
sp.	*Spies 5005*	7	WESTERN CAPE.—3218 (Clanwilliam): on beach, Lambert's Bay, (–AB).
Poa			
binata Nees	*Spies 4666*	14	EASTERN CAPE.—3028 (Matatiele): 10 km from Rhodes to Naude's Neck, (–CC).
pratensis L.	*Spies 4720*	28	EASTERN CAPE.—3027 (Lady Grey): 30 km from Rhodes to Lundean's Neck, (–DD).
	Spies 4670	28	EASTERN CAPE.—3028 (Matatiele): 12 km from Rhodes to Naude's Neck, (–CC).
Puccinellia			
angusta (Nees) Smith & C.E.Hubb.	*Spies 3157a*	7+0–1B	NORTHERN CAPE.—2917 (Springbok): 17 km from Steinkopf to Port Nolloth, (–BD).
	Spies 3773	7+0–1B	WESTERN CAPE.—3319 (Worcester): Katbakkies turnoff, on road between Ceres and Citrusdal, (–AB).
sp.	*Spies 3364*	21	NORTHERN CAPE.—2917 (Springbok): 6 km from Kleinsee to Springbok, (–CA).
	Spies 3069	21	NORTHERN CAPE.—3018 (Kamiesberg): eastern side of Kamiesberg, (–AC).
Vulpia			
muralis (Kunth) Nees	*Spies 4309*	21	WESTERN CAPE.—3318 (Cape Town): 7 km from Yzerfontein to Darling, (–AC).
myuros (L.) S.F.Gray	*Spies 3112*	7+0–1B	WESTERN CAPE.—3017 (Hondeklipbaai): dunes at Groenrivier Mouth, (–DC).
Tribe Hainardieae			
Hainardia cylindrica (Willd.) Greuter	*Spies 5013*	7	WESTERN CAPE.—3318 (Cape Town): 2 km east of Mamre Road, (–BC).
Parapholis incurva (L.) C.E.Hubb.	*Spies 5006*	21	WESTERN CAPE.—3218 (Clanwilliam): on beach, Lambert's Bay, (–AB).
Tribe Meliceae			
Melica			
decumbens Thunb.	*Spies 4802*	9	FREE STATE.—2827 (Senekal): 6 km from Clocolan to Peka Bridge, (–DC).
	Spies 4762	9	EASTERN CAPE.—3027 (Lady Grey): 82 km from Barkly East to Lady Grey, via Joubert's Pass, (–CD).
	Spies 5221	9	EASTERN CAPE.—3323 (Willowmore): 168 km from Patensie to Willowmore, (–DA).
racemosa Thunb.	*Spies 4777*	9	FREE STATE.—2926 (Bloemfontein): 19 km from Dewetsdorp to Hobhouse, (–DB).
	Spies 5197	9	EASTERN CAPE.—3324 (Steytlerville): 25 km from Patensie to Willowmore, (–DA).
sp.	*Spies 4538*	9	WESTERN CAPE.—3420 (Bredasdorp): 30 km from Bredasdorp to Swellendam, (–CA).
Tribe Aveneae			
Agrostis sp.	*Spies 4308a*	14	NORTHERN CAPE.—3017 (Hondeklipbaai): 18 km from Kamieskroon to Leliefontein, (–BA).
Avena sativa L.	*Spies 5611*	21	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
Koeleria sp.	*Spies 5111*	7	MPUMALANGA.—2530 (Lydenburg): 5 km from Belfast to Dullstroom, (–CA).
Tribe Bromeae			
Bromus			
catharticus Vahl	*Spies 4760*	21	EASTERN CAPE.—3027 (Lady Grey): 82 km from Barkly East to Lady Grey via Joubert's Pass, (–CD).
	Spies 2505	21	EASTERN CAPE.—3027 (Lady Grey): Beestekraal, (–DC).
	Spies 4668	21	EASTERN CAPE.—3028 (Matatiele): 10 km from Rhodes in Naude's Neck, (–CC).
	Spies 4673	21	EASTERN CAPE.—3028 (Matatiele): 12 km from Rhodes on Naude's Neck, (–CC).
pectinatus Thunb.	*Spies 4280*	14	NORTHERN CAPE.—2917 (Springbok): 17 km from Springbok to Hondeklipbaai, (–DB).
rigidus Roth	*Spies 5300*	28	WESTERN CAPE.—3119 (Calvinia): 7 km from Nieuwoudtville to Clanwilliam, (–AC).
sp.	*Spies 4816*	21	FREE STATE.—2827 (Senekal): 29 km from Clocolan to Ficksburg, (–DC).
Tribe Triticeae			
Hordeum murinum	*Spies 4977*	7	WESTERN CAPE.—3319 (Worcester): 1 km south of old toll house in Mitchell's Pass, (–AD).
subsp. *murinum*	*Spies 3385*	14	WESTERN CAPE.—3418 (Simonstown): Redhill, (–AB).
subsp. *leporinum*	*Spies 4939*	7	MPUMALANGA.—2530 (Lydenburg): 18 km from Lydenburg to Weltevreden, (–AB).
	Spies 4949	7	MPUMALANGA.—2530 (Lydenburg): 6 km from Dullstroom to Goede Hoop, (–AC).
	Spies 5003	7	EASTERN CAPE.—3028 (Matatiele): 47 km from Rhodes in Naude's Neck, (–CC).
	Spies 4925	7	EASTERN CAPE.—3228 (Butterworth): on beach at Bonza Bay, (–CC).
vulgare L. subsp. *vulgare*	*Spies 5612*	14	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
Secale			
africanum Stapf	*Spies 5608*	7	NORTHERN CAPE.—3220 (Sutherland): near Sutherland, (–BC).
cereale Bieb.	*Spies 5607*	7	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
Triticum aestivum L.			
Karee	*Spies 5606*	21	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
Tugela	*Spies 5604*	21	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
Zarragossa	*Spies 5603*	21	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
durum Desf.	*Spies 5605*	14	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).
× *Triticosecale* Wittm.	*Spies 5609, 5610*	21	FREE STATE.—2926 (Bloemfontein): cultivated, UOFS campus, (–AA).

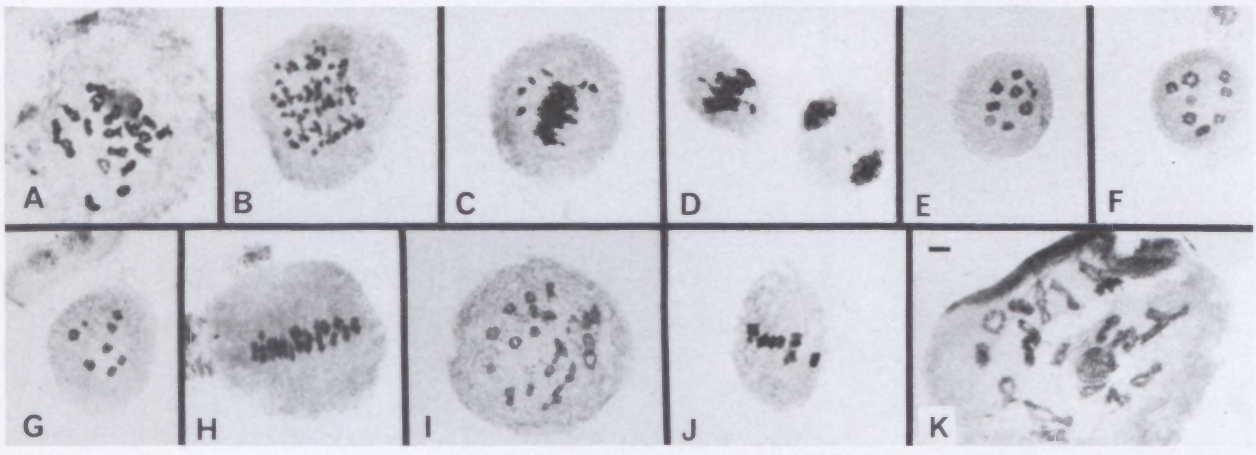

FIGURE 2.—Meiotic chromosomes. A, *Parapholis incurva*, *Spies 5006*, n = 21, diakinesis with 21_{II}; B, *Poa pratensis*, *Spies 4670*, n = 28, early anaphase I; C, D, *Spies 4720*, metaphase I cells with univalents; E, F, *Puccinelia angusta*, *Spies 3157a*, *3773*, n = 7, diakinesis with 7_{II}; G, n = 7+1B, diakinesis with 7_{II} 1_{I} — the univalent is probably a B-chromosome. H, I, *Puccinellia* sp.: H, *Spies 3069*, n = 21, metaphase I with 21_{II}; I, *Spies 3364*, n = 21+0–4B, diakinesis with 21_{II} and 3–4 B-chromosomes; J, *Vulpia myuros*, *Spies 3112*, n = 7+1B, metaphase I with 7_{II} and a B-chromosome; K, *V. muralis*, *Spies 4309*, n = 21, diakinesis with 21_{II}. Scale bar: 6.5 µm.

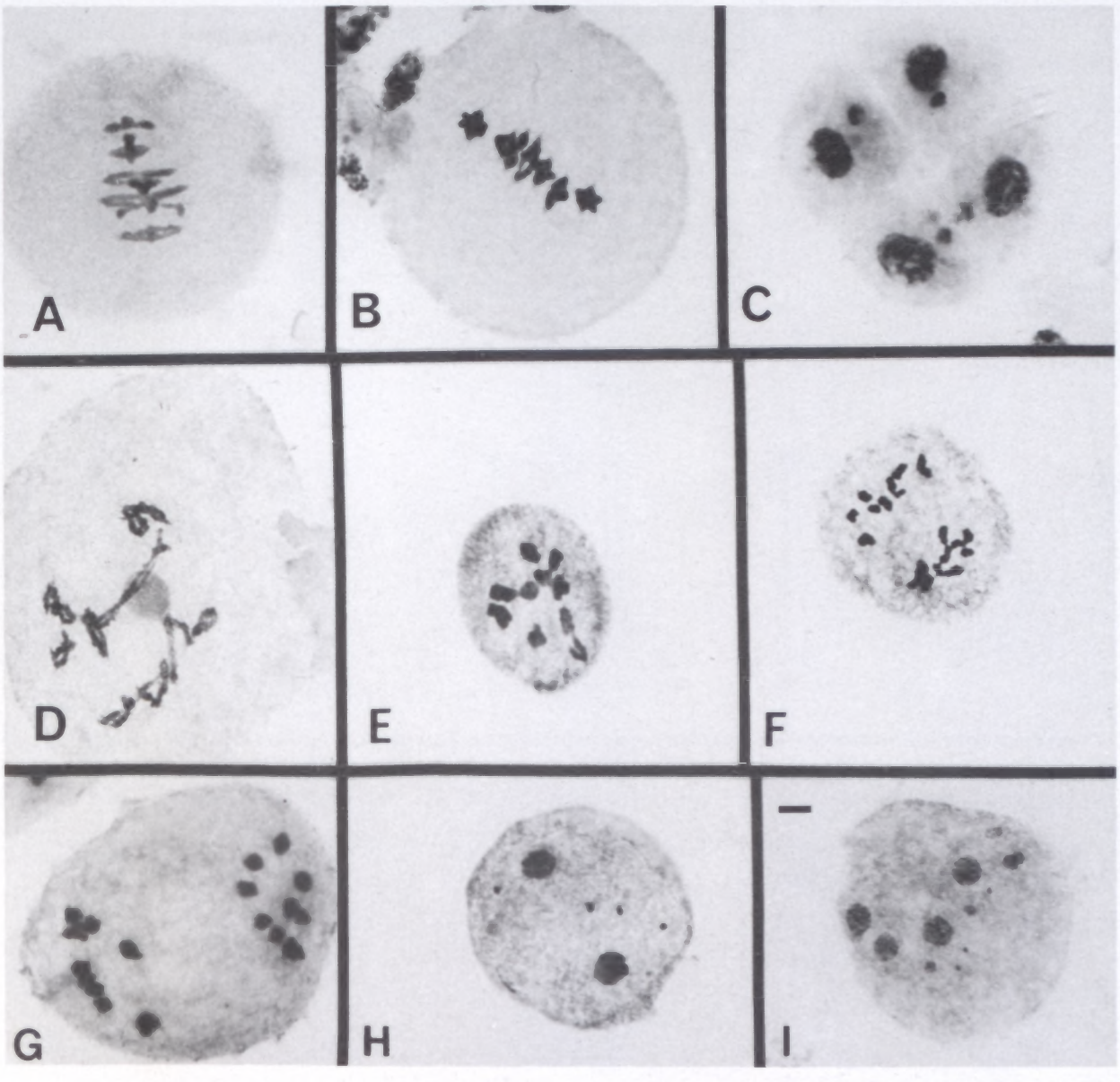

FIGURE 3.—Meiotic chromosomes. A, C, *Lolium rigidum*, *Spies 5358*: A, n = 7, metaphase I with 7_{II}; C, telophase II with micronuclei in all cells of tetrad. B, *Lolium* sp., *Spies 5005*, n = 7, metaphase I with 7_{II}. D, E, *Melica decumbens*: D, *Spies 5221*, n = 9, diplotene with 9_{II}; E, *Spies 4802*, n = 9, diakinesis with 9_{II}. F, G, *M. racemosa*, n = 9, anaphase I with 9-9 chromosome segregation: F, *Spies 5197*; G, *Spies 4777*. H, I, *Melica* sp., *Spies 4583*: H, telophase I with four micronuclei; I, telophase II with various micronuclei and no cytokinesis. Scale bar: A–H, 6.5 µm; I, 27.3 µm.

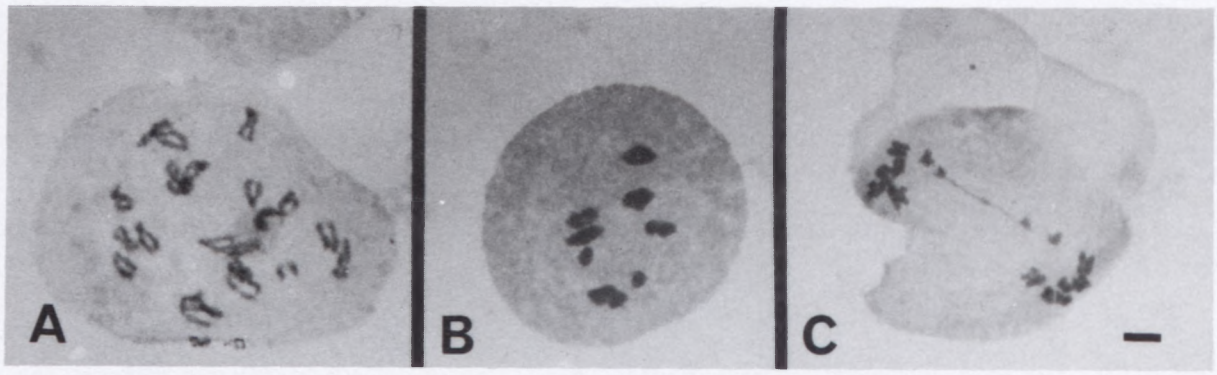

FIGURE 4.—Meiotic chromosomes in some specimens of the genera *Avena* and *Lolium*. A, *Avena sativa*, *Spies 5611*, n = 21, diakinesis with 21_{II}; B, C, *Lolium multiflorum*, *Spies 5613*, n = 7+0–2B: B, early metaphase I with 7_{II} and two unpaired B-chromosomes; C, anaphase I with a bridge. Scale bar: A, 27.3 µm; B, C, 6.5 µm.

Vulpia myuros was diploid (Figure 2J, K), thus confirming various previous results which stated that diploid, tetraploid and hexaploid specimens had been observed (Ornduff 1967, 1968; Fedorov 1969; Moore 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996).

Diploid chromosome numbers (n = x = 7) were observed for all the *Lolium* specimens studied (Figure 3A–C). These observations for *L. multiflorum*, *L. rigidum* and *Lolium* sp. confirm previous results (Ornduff 1968; Fedorov 1969; Moore 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998). Some metaphase I cells contained univalents (Figure 4B) and an anaphase I bridge was observed (Figure 4C).

Tribe Hainardieae

An interesting observation during this study is the diploid chromosome number of n = x = 7 for *Hainardia cylindrica* (Figure 1B, C). The literature indicates a basic chromosome number of x = 13 (Goldblatt 1981; Goldblatt & Johnson 1994). Further studies of this rare representative of the tribe Hainardieae are needed to determine whether the South African representative deviates in other aspects from its Mediterranean counterparts.

The hexaploid *Parapholis incurva* specimen (Figure 2A) confirms previous reports on this species (Fedorov 1969; Goldblatt 1981, 1983). However, another ploidy level (2n = 28), including aneuploidy (2n = 24, 36 & 38), has also been reported (Fedorov 1969; Moore 1972,

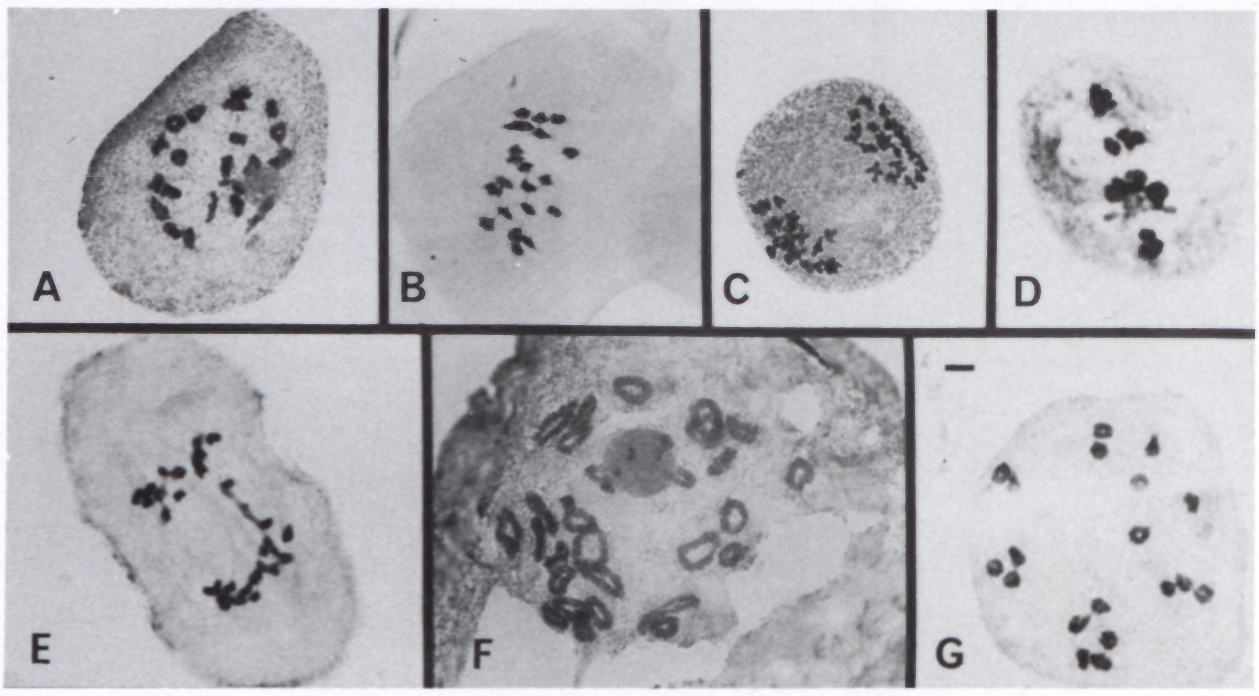

FIGURE 5.—Meiotic chromosomes in specimens of genus *Bromus*. A–C, *B. catharticus*: A, C, *Spies 2505*; B, *Spies 4668*, n = 21. A, diakinesis with 21_{II}; B, metaphase I with 21_{II}; C, anaphase I with 21-21 segregation of chromosomes. D, E, *B. pectinatus*, *Spies 4280*, n = 14: D, metaphase I; E, anaphase I, with one chromosome segregating late. F, *B. rigidus*, *Spies 5300*, n = 28, diakinesis with 28_{II}; G, *Bromus* sp., *Spies 4816*, n = 21, diakinesis with 21_{II} (3_{II} are out of focus). Scale bar: 6.5 µm.

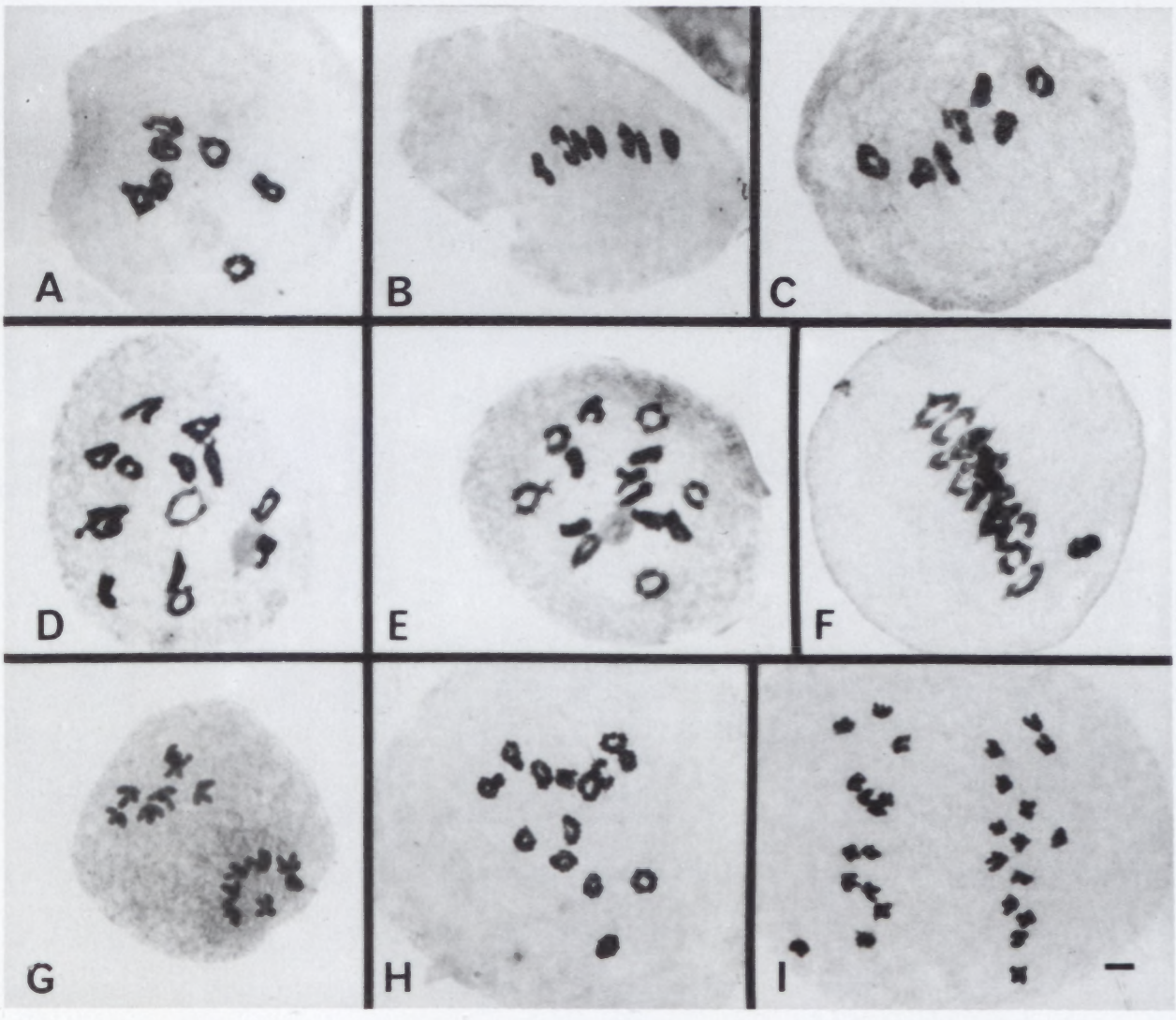

FIGURE 6.—Meiotic chromosomes in specimens of genus *Hordeum*. A, B, *H. murinum*, *Spies 4977*, n = 7: A, diakinesis with 7_{II}; B, metaphase I with 7_{II}. C–G, *H. murinum*: C, subsp. *leporinum*, *Spies 4939*, n = 7, early metaphase I with 7_{II}; D–G, subsp. *murinum*, *Spies 3385*, n = 14: D, E, diakinesis with 14_{II}; F, metaphase I; G, anaphase I with a 7-7 segregation of chromosomes, indicating a cell with n = 7 in same individual. H, *H. vulgare* subsp. *vulgare*, *Spies 5612*, n = 14, diakinesis with 14_{II}; I, anaphase I with 14-14 segregation. Scale bar: 6.5 µm.

1977; Goldblatt 1981, 1983; Goldblatt & Johnson 1994, 1998).

Tribe Meliceae

Melica decumbens (Figure 3D, E), *M. racemosa* (Figure 3F, G) and *Melica* sp. have basic chromosome numbers of nine, thus confirming previous reports (Ornduff 1967, 1968, 1969; Fedorov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998). Various meiotic abnormalities were observed during this study, particularly micronuclei during telophase I (Figure 3H, I).

Tribe Aveneae

In *Agrostis* sp. both the basic chromosome number of seven and the tetraploid level (n = 2x = 14) conform with previous reports on this genus (Ornduff 1967, 1968, 1969; Fedorov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998).

The specimen of *Koeleria* sp. was diploid, n = x = 7 (Figure 1D, E) with normal meiosis.

The hexaploid chromosome number observed for *Avena sativa* (Figure 1A) conforms with numerous reports on this species (Ornduff 1967, 1968, 1969; Fedorov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998). Only bivalents were formed and meiosis was normal.

Tribe Bromeae

The genus *Bromus* consists of 150 species worldwide (Clayton & Renvoize 1986), and 15 species are present in South Africa (Gibbs Russell *et al.* 1990). Three of these species were included in this study (Table 1), all specimens have x = 7 (Figure 5) and tetraploid to octaploid specimens were observed. The hexaploid (n = 3x = 21) counts for *B. catharticus* (Figure 5A–C) confirm

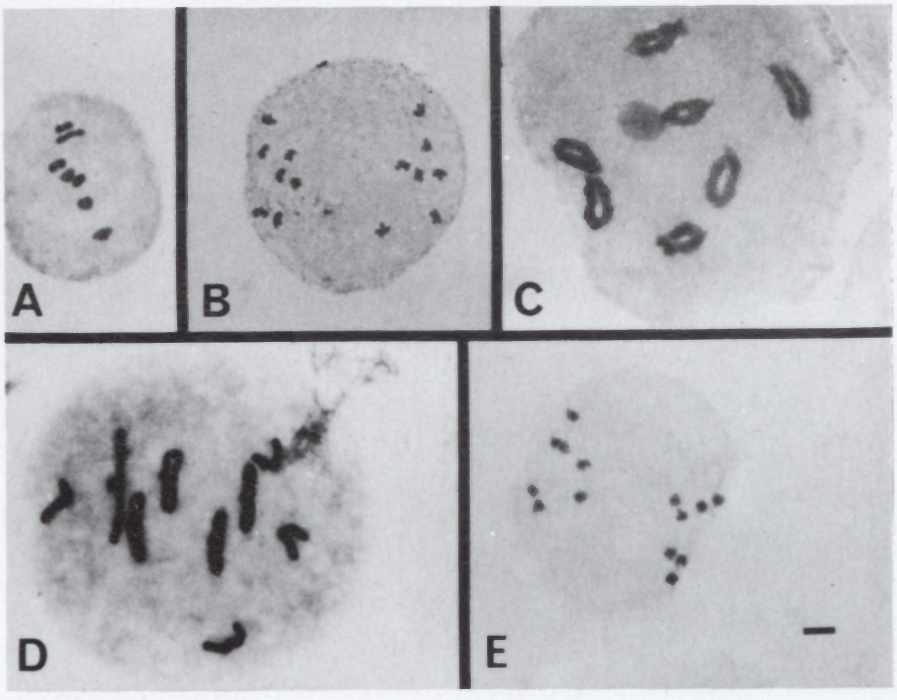

FIGURE 7.—Meiotic chromosomes in specimens of genus *Secale*. A, B, *S. africanum*, *Spies 5608*, n = 7: A, metaphase I with 7_{II}; B, anaphase I with a 7-7 segregation. C–E, *S. cereale*, *Spies 5607*, n = 7: C, diakinesis with 7_{II}; D, metaphase I with $5_{II}4_{I}$; E, anaphase I with a 7-7 segregation. Scale bar: A, B, E, 27.3 µm; C, D, 6.5 µm.

numerous previous reports (Fedorov 1969; Moore 1972; Goldblatt 1983, 1985, 1988; Goldblatt & Johnson 1994) and this ploidy level is far more frequent than diploid (Goldblatt 1983), tetraploid (Fedorov 1969; Spies & Du Plessis 1986a) or octaploid (Fedorov 1969; Spies & Du Plessis 1986a). All the hexaploid plants in this study showed bivalent formation during meiosis (Figure 5A, B) suggesting an alloploid origin for this species.

The *B. pectinatus* (Figure 5D, E) specimen studied was tetraploid (n = 2x = 14), thus confirming previous reports which indicated the presence of both diploid and tetraploid specimens (Fedorov 1969; Moore 1970, 1971, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1996). *Bromus rigidus* is octaploid, confirming previous reports (Moore 1974; Goldblatt 1981). The presence of bivalents only (Figure 5F, G) indicates an alloploid origin for this species. Tetraploid, hexaploid, octaploid and decaploid specimens are also known (Fedorov 1969; Moore 1971, 1972, 1977; Goldblatt & Johnson 1994).

Tribe Triticeae

All *Hordeum* specimens had a basic chromosome number of 7 (Figure 6). Diploid and tetraploid specimens have been observed. Both ploidy levels showed normal meiosis and the formation of only bivalents in the tetraploid

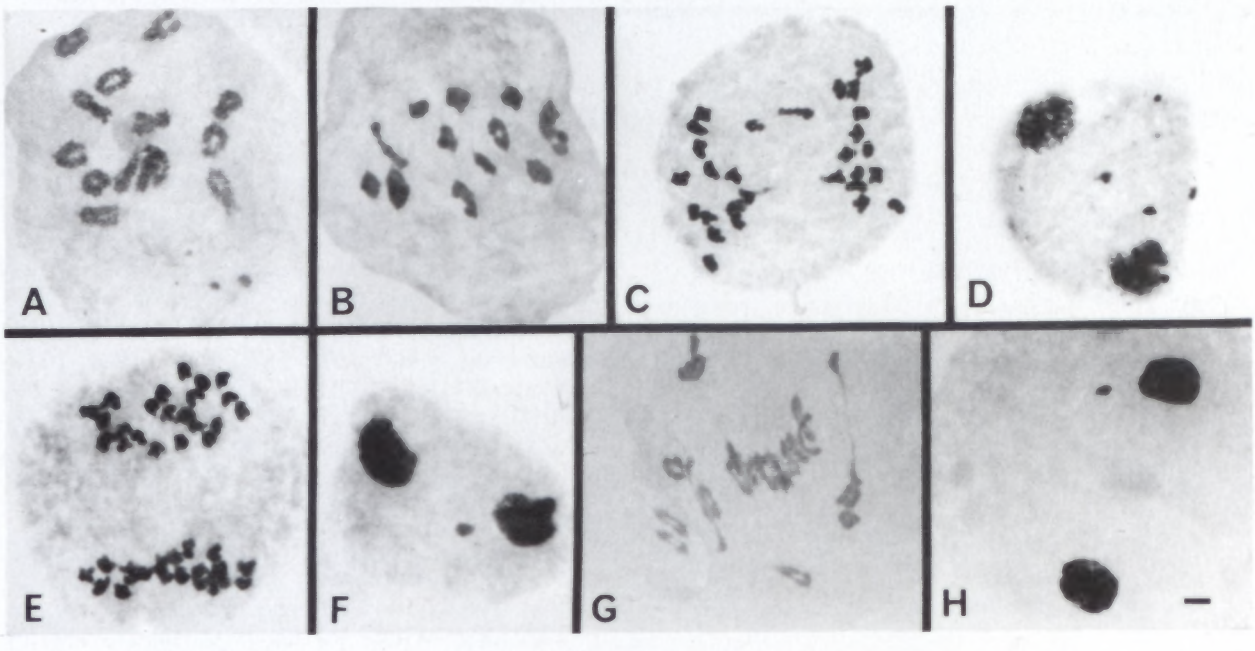

FIGURE 8.—Meiotic chromosomes in specimens of genus *Triticum* and × *Triticosecale*. A–D, *Triticum durum*, *Spies 5605*, n = 14: A, diakinesis with 14_{II}; B, early metaphase I with 14_{II}; C, anaphase I with a 14-14 segregation (one bivalent segregating late); D, telophase I with two micronuclei. E, F, *T. aestivum*, *Spies 5606*, n = 21: E, anaphase I with 21 chromosomes in each pole; F, one dyad with a micronucleus. G, H, × *Triticosecale*, *Spies 5610*, n = 21: G, metaphase I with bivalents; H, telophase I with a micronucleus. Scale bar: 6.5 µm.

specimens indicate an alloploid origin. The results of this study conform with previous results for these species (Ornduff 1967, 1968, 1969; Fedorov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998).

Both *Secale* species studied proved to be diploid (Figure 7) with normal meiosis in most cells. In one metaphase cell of *S. cereale* four univalents were observed. The results of this study confirm previous reports on this genus (Ornduff 1967, 1968, 1969; Fedorov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998).

This study confirmed a tetraploid status for *T. durum* (Figure 8A–D) and that both *T. aestivum* (Figure 8E, F) and × *Triticosecale* are hexaploids (Figure 8G, H) (Ornduff 1967, 1968, 1969; Fedorov 1969; Moore 1970, 1971, 1972, 1974, 1977; Goldblatt 1981, 1983, 1985, 1988; Goldblatt & Johnson 1990, 1991, 1994, 1996, 1998).

CONCLUSIONS

This study once again confirms the basic chromosome number of x = 7 for the tribes Poeae, Hainardieae, Aveneae, Bromeae and Triticeae, as well as the basic chromosome number of x = 9 for the tribe Meliceae. Further studies should be done to determine the degree of chromosome homology between the Meliceae and other representatives of the subfamily Pooideae, in order to establish the position of the Meliceae in this tribe. The basic number of x = 7 for the Hainardieae should also be investigated further to determine whether the South African plants differ from their Mediterranean counterparts in this respect.

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