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CHROMOSOME NUMBERS OF SOME TEXAS GRASSES

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This is a second report on the chromosome numbers of native and introduced grasses. The first report (Brown, 1950) concerned the chromosome numbers of eighty species in thirty-eight genera of nine tribes of the Gramineae. The present is the result of a cytological study of forty-four species (all but two additional to the first report) in twenty-four genera of five tribes. As in the previous paper identification and nomenclature of all United States grasses are according to Hitchcock (1935), Herbarium specimens have been made of parts of the plants studied and are filed in the University of Texas Herbarium. Many of the plants are growing in the grass garden of the Plant Research Institute.

Materials and methods. Root tips of the grasses were either collected in the field or from potted plants after a period of growth in the greenhouse. After fixation in the CRAF modification of Navashin's fluid the root tips were embedded and sectioned according to standard procedures. Since nearly all species studied have small chromosomes, cross sections were cut at 8 or 10 microns. In order to have permanent slides Heidenhain's iron alum hemotoxylin was used for the stain. For studies of meiosis young inflorescences were fixed in absolute-acetic fixative and smeared in aceto-carmine.

Table 1 lists the species studied, the author's collection numbers, the chromosome numbers found and the authority for those species previously studied. In a few cases plants were furnished by the U. S. Soil Conservation Service Station at San Antonio, Texas and their numbers are used and are designated by letter prefixes. References to previous records of chromosome numbers in Table 1 are usually the latest, if more than one exists, unless there are conflicting chromosome numbers reported. The listing of $2n$ numbers indicates that counts were derived from a study of metaphase chromosomes of mitosis in root tips. The listing of n numbers indicate that the counts were made in a study of diakinesis of the first meiotic division in pollen mother cells.

Results and discussion. Many of these reported chromosome counts require little or no comment aside from their being on record whereas others, of more significance, are discussed at greater length.

Festuceae. The seeds and herbarium specimen of *Festuca arizonica* were collected at the Manitou Experimental Forest of the U. S. Department of Agriculture, Forest Service near Colorado Springs, Colorado. The plants were grown in the greenhouse and proved to be hexaploid with 42 large

TABLE 1. *Chromosome numbers in the Gramineae*

Genus and Species	Collection No.	Fig.	*n*	2*n*	Previous Records 2*n*	Previous Records Authority
FESTUCEAE						
Festuca arizonica Vasey	3512	1	......	42		
Distichlis texana (Vasey) Scribn.	3516	2	......	40		
Eragrostis curtipedicellata Buckl.	3374	3	......	40		
CHLORIDEAE						
Leptochloa virgata (L.) Beauv.	3488	4	......	40	40	(Nunez in Parodi 1946)
Chloris virgata Swartz	3273	5	10	......	20	(Brown 1950)
Trichloris pleuriflora Fourn.	T-33	6	......	60		
Bouteloua hirsuta Lag.	3261	7	......	28	21, 37, 42	(Fults 1942)
AGROSTIDEAE						
Lycurus phleoides H.B.K.	3309	8	......	28		
Sporobolus poiretii (R. and S.) Hitch.	3264	9	......	36	36	(Avdulow 1931)
S. airoides (Torr.) Torr.	SA-4031	10	54	......	126	(Stebbins and Love 1941)
Piptochaetium fimbriatum (H.B.K.) Hitchc.	3326	11	......	44		
Stipa leucotricha Trin and Rupr.	3473	12	......	26	26	(Brown 1949)
S. tenuissima Trin.	3305	13	......	32		
S. eminens Cav.	3302	14	......	46	46	(Love, in Myers 1947)
Muhlenbergia porteri Scribn.	3349	15	......	20		
M. polycaulis Scribn.	3329	16	......	20		
M. monticola Buckl.	3348	17	......	40		
M. reverchoni Vasey and Scribn.	3475	18	......	40		
M. repens (Presl.) Hitchc.	3312	19	......	60		
PANICEAE						
Paspalum pubiflorum Rupr.	3518	20	30	......		
P. langei Nash.	3519	21	......	40	60	(Burton 1942)
P. distichum L.	3396	22	......	40	40 48 60	(Brown 1948) (Burton 1942) (Saura 1941)
P. dissectum (L.) L.	3263	23	......	40	25	(Krishnaswamy 1940)
Panicum hians Ell.	3268	24	......	20	18	(Brown 1948)
P. obtusum H.B.K.	3364	25	......	20		
ditto	3288	26	......	40	36	(Brown 1948)
P. geminatum Forsk.	3411	27	......	40		
P. antidotale Retz.	SA-115	28	......	18	18	(Burton 1942)
P. anceps Michx.	3436	29	......	18	18	(Brown 1948)
P. filipes Scribn.	3293	30	......	18		
P. plenum Hitchc. and Chase	T-762	31	......	54		
P. bulbosum H.B.K.	3325	32	......	54		
ditto	3315	33	......	72	70	(Krishnaswamy 1940)
Eriochloa sericea (Scheele) Munro	3508	34	......	54		
Trichachne californica (Benth) Chase	3512	35	......	36	18	(Krishnaswamy 1940)
T. insularis (L.) Nees.	SA-4051	36	......	36		
T. patens Swallen	3520	37	......	72		
Leptoloma cognatum (Schult) Chase	3371	38	......	36	36	(Brown 1948)
ditto	3466	39	......	72		
Stenotaphrum secundatum (Walt) Kuntze	3275	40	9	......	18	(Brown 1950)
Brachiaria ciliatissima (Buckl.) Chase	3235	41	......	36		
ANDROPOGONEAE						
Erianthus strictus Baldw.	3442	42	......	30		
Manisuris cylindrica (Michx.) Kuntze	3517	43	......	18	18	(Reeves and Mangelsdorf 1935)
Elyonurus tripsacoides H. and B.	3461	44	......	20		
E. barbiculmis Hack.	3318	45	......	20		
Heteropogon contortus (L.) Beauv.	SA-4310	46	......	60	20	(Darlington and Janaki Ammal 1945)
Trachypogon montufari (H.B.K.) Nees	SA-4003	47	......	20		

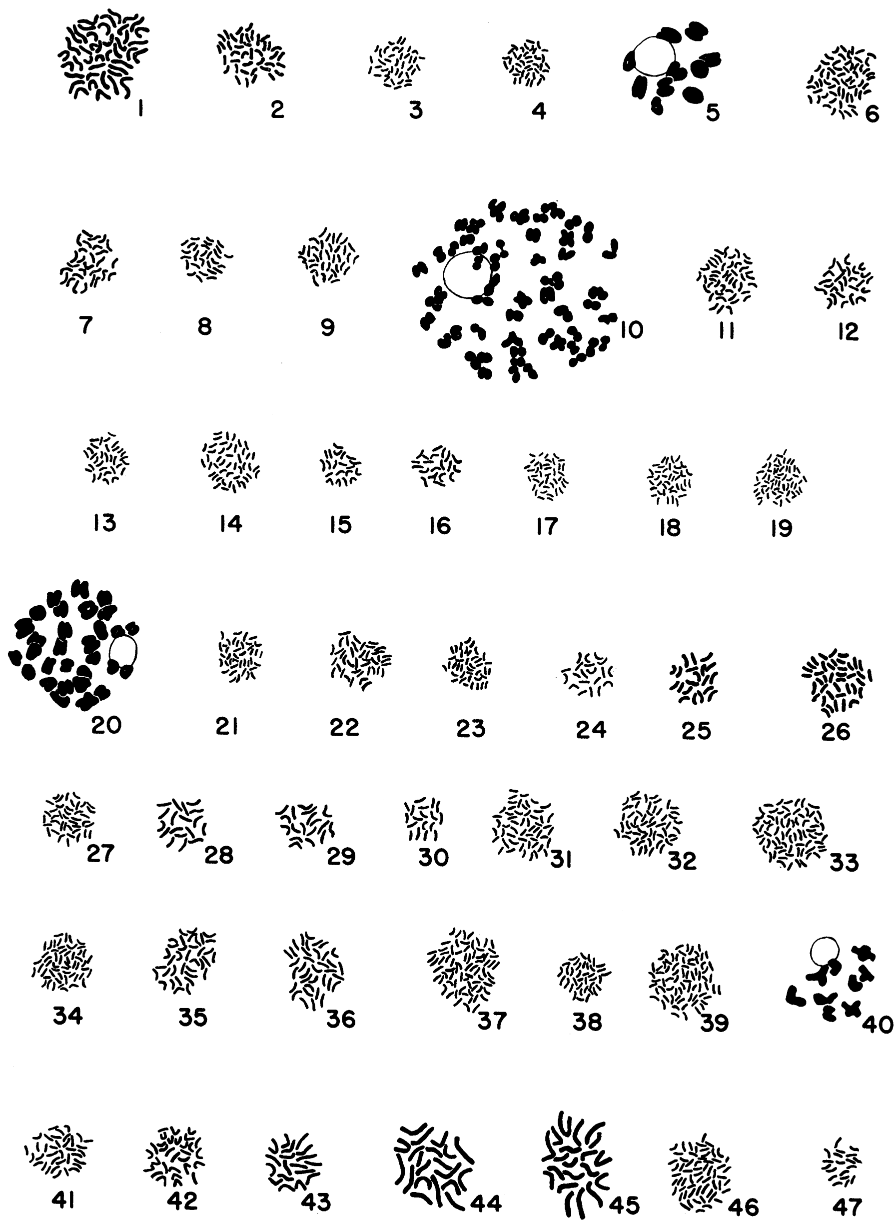

FIG. 1–47. Camera lucida drawings of chromosomes of the following Gramineae. Magnification × 1,000. FIG. 1. *Festuca arizonica,* $2n = 42$. FIG. 2. *Distichlis texana,* $2n = 40$. FIG. 3. *Eragrostis curtipedicellata,* $2n = 40$. FIG. 4. *Leptochloa virgata,* $2n = 40$. FIG. 5. *Chloris virgata,* $n = 10$. FIG. 6. *Trichloris pleuriflora,* $2n = 60$. FIG. 7. *Bouteloua hirsuta,* $2n = 28$. FIG. 8. *Lycurus phleoides,* $2n = 28$. FIG. 9. *Sporobolus poiretii,* $2n = 36$. FIG. 10. *S. airoides,* $n = 54$. FIG. 11. *Piptochaetium fimbriatum,* $2n = 44$. FIG. 12. *Stipa*

chromosomes (fig. 1) and a basic number of 7, typical of *Festuca* and related genera. *Distichlis texana* also in the Festuceae has, however, a basic number $x = 10$ and the chromosomes are small (fig. 2). Cytologically this species agrees with two other species of that dioecious genus in chromosome number and size, all three having $2n = 40$ small chromosomes. *D. spicata* (L.) Greene and *D. stricta* (Torr.) Rydb. are widespread in North America but *D. texana* is restricted to northern Mexico and two known locations in western Texas It is a much larger and more robust plant with stolons many feet in length that produce roots and erect plants at the nodes. The plant studied is staminate and was collected in a roadside ditch in Limpia Canyon of the Davis Mountains of west Texas.[1] Another genus with $x = 10$ small chromosomes is *Eragrostis* with *E. curtipedicellata,* a tetraploid species, having $2n = 40$ (fig. 3).

Chlorideae. A plant identified by the author as *Leptochloa virgata* collected near the coast of Texas has $2n = 40$ (fig. 4) and agrees with the count of that species made by Nunez (Parodi 1946) for Argentine material. This plant, however, has larger florets and longer awns than indicated in the description for *L. virgata.* The count of $n = 10$ in *Chloris virgata* (fig. 5) confirms the count of $2n = 20$ by Brown (1950) in contrast to $2n = 14$ and $2n = 30$ reported by previous authors. A plant of *Trichloris pleuriflora* that was acquired from the San Antonio station of the Soil Conservation Service is hexaploid with $2n = 60$ (fig. 6). Fults (1942) reported $2n = 21$, 37 and 42 in *Bouteloua hirsuta.* The present material has clearly $2n = 28$ (fig. 7).

Agrostideae. Species of certain genera in this tribe are abundant in Texas and some are of considerable forage value. *Lycurus phleoides,* abundant in the Davis Mountains, is such a species. In its basic number $x = 7$ (fig. 8) it agrees with related genera, although its presence in a hot

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leucotricha, $2n = 26$. FIG. 13. *S. tenuissima,* $2n = 32$. FIG. 14. *S. eminens,* $2n = 46$. FIG. 15. *Muhlenbergia porteri,* $2n = 20$. FIG. 16. *M. polycaulis,* $2n = 20$. FIG. 17. *M. monticola,* $2n = 40$. FIG. 18. *M. reverchoni,* $2n = 40$. FIG. 19. *M. repens,* $2n = 60$. FIG. 20. *Paspalum pubiflorum,* $n = 30$. FIG. 21. *P. langei,* $2n = 40$. FIG. 22. *P. distichum,* $2n = 40$. FIG. 23. *P. dissectum,* $2n = 40$. FIG. 24. *Panicum hians,* $2n = 20$. FIG. 25. *P. obtusum* $2n = 20$. FIG. 26. *Ditto,* $2n = 40$. FIG. 27. *P. geminatum,* $2n = 40$. FIG. 28. *P. antidotale,* $2n = 18$. FIG. 29. *P. anceps,* $2n = 18$. FIG. 30. *P. filipes,* $2n = 18$. FIG. 31. *P. plenum,* $2n = 54$. FIG. 32. *P. bulbosum,* $2n = 54$. FIG. 33. *Ditto,* $2n = 72$. FIG. 34. *Eriochloa sericea,* $2n = 54$. FIG. 35. *Trichachne californica,* $2n = 36$. FIG. 36. *T. insularis,* $2n = 36$. FIG. 37. *T. patens,* $2n = 72$. FIG. 38. *Leptoloma cognatum,* $2n = 36$. FIG. 39. *Ditto,* $2n = 72$. FIG. 40. *Stenotaphrum secundatum,* $n = 9$. FIG. 41. *Brachiaria ciliatissima,* $2n = 36$. FIG. 42. *Erianthus strictus,* $2n = 30$. FIG. 43. *Manisuris cylindrica,* $2n = 18$. FIG. 44. *Elyonurus tripsacoides,* $2n = 20$. FIG. 45. *E. barbiculmis,* $2n = 20$. FIG. 46. *Heteropogon contortus,* $2n = 60$. FIG. 47. *Trachypogon montufari,* $2n = 20$.

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[1] The author is much indebted to Dr. Barton Warnock of Sul Ross State Teachers College in Alpine, Texas, whose knowledge of the plants of Trans-Pecos Texas made the collection of this species and many others possible.

dry habitat is in sharp contrast to other genera of the tribe with $x = 7$ which are grasses chiefly of cool moist regions. Most species of Agrostideae native to Texas are in genera with basic numbers other than $x = 7$. A few examples follow. A count of $2n = 36$ for *Sporobolius poiretii* (fig. 9) confirms that of Avdulow (1931). The plant of *Sporobolus airoides* studied has $n = 54$ chromosomes (fig. 10). This plant is 12-ploid with $x = 9$ and is evidently a different cytological strain from the California material studied by Stebbins and Love (1941) which was 14-ploid with $2n = 126$. The first determination of the chromosome number in the genus *Piptochaetium* was $2n = 22$ in 6 species and three varieties by Covas and Bocklet as well as Valencia (see Parodi 1946). *P. fimbriatum,* the only species native to United States, also has $2n = 22$ (fig. 11). The basic number $x = 11$ is also found in *Stipa Brachyelytrum* and *Aristida,* genera that show morphological evidences of interrelationship. From the cytological study of the genus *Stipa* by Stebbins and Love (1941) it is known that aneuploidy is prevalent in the North American species of *Stipa* although most South American species investigated have $x = 11$. Additional aneuploidy found in the genus by the present study is $2n = 26$ in *Stipa leucotricha,* (fig. 12), 32 in *S. tenuissima* (fig. 13) and 46 in *S. eminens* (fig. 14). This last determination confirms the count of Love (see Myers 1947) for *S. eminens.* All species of *Muhlenbergia* so far studied (18 species) have a basic number $x = 10$ except for *M. filiformis* which is reported to have $2n = 18$ (Myers 1947).The present investigation includes five of these eighteen species (fig. 15 to 19).

Paniceae. Of the four species of *Paspalum* studied, three have chromosome numbers different from those previously reported. Two of these, *P. langei* and *P. distichum,* are examples of intraspecific variation in polyploidy that is so common in many genera of the Gramineae. *Paspalum pubiflorum* $n = 30$ (fig. 20) is reported for the first time. This species is a weedy type in central Texas and, unlike most species of the genus, is able to survive dry hot summers. As indicated in Table 1 three chromosome numbers have been reported for *P. distichum,* 40, 48 and 60. The present study agrees with that of Brown (1948) rather than Burton (1942). Saura (1941) found his South American material of this species to be hexaploid with the basic number $x = 10$ characteristic of this genus. Krishnaswamy (1940) reported $2n = 25$ for *P. dissectum* but Texas material clearly shows $2n = 40$ (fig. 23). The very large genus *Panicum* is characterized by the basic number $x = 9$, although $x = 7$ has been found in one species (Brown 1950) and $x = 10$ in some South American species (Nunez. in Parodi 1946). The present study reports $x = 10$ in three United States species. Brown (1948) reported P. *hians* and *P. obtusum* to have $2n = 18$ but in the present study Texas material of these two species show $2n = 20$ (fig. 24 and 25) as well as one tetraploid plant of *P. obtusum* with $2n = 40$ (fig. 26). *P. geminatum* also has $2n = 20$ (fig. 27) which may indicate a relationship with *Paspalum*. The five other species of the genus studied have $x = 9$ (fig. 28 to 32). Krishnaswamy (1940) found $2n = 70$ in *P. bulbosum* but the present material has $2n = 54$ (fig. 32) and $2n = 72$ (fig. 33). Of the three species studied of *Trichachne, T. californica* and *T. insularis* have $2n = 36$ (fig. 35 and 36) while *T. patens* has $2n = 72$ (fig. 37). The present study reports a teraploid plant of *T. californica* whereas Krishnaswamy (1940) reported a diploid, $2n = 18$, in that species called by him *Panicum californicum* Benth. *Leptoloma cognatum* reported by Brown (1948) to have $2n = 36$ was found to have also $2n = 72$ in Texas material (fig. 38 and 39). Brown (1950) reported *Stenotaphrum secundatum* to have $2n = 18$. This has been corroborated by a study of meiotic chromosomes which shows $n = 9$ (fig. 40) for the same plant previously investigated.

Andropogoneae. In *Erianthus* most species studied have $x = 10$ with counts of $2n = 20$, 40 and 60. *E. strictus,* however, has $2n = 30$ (fig. 42). This indicated either a basic number of $x = 5$ or a derived basic number of $x = 15$. This is the first American species of the genus to be studied cytologically. Reeves and Mangelsdorf (1935) reported *Manisuris cylindrica* to have $n = 9$ and $2n = 18$ chromosomes. This number was confirmed in the present study (fig. 43). Avdulow (1931) reported *Rotboellia glandulosa* Trin. (a closely related genus) to have $2n = 54$, also with a basic number $x = 9$. It was unexpected, therefore to find in two species of *Elyonurus,* another genus close to *Manisuris,* that $x = 10$, both species having $2n = 20$ (fig. 44 and 45). A striking feature of the chromosomes of *Elyonurus* is their large size. In general the chromosomes of the Andropogoneae are small compared to the large chromosomes typical of Festuceae and Hordeae. However, in the case of *Elyonurus* the chromosomes of the two species studied were longer and thicker than those of *Festuca arizonica* and *Bromus catharticus,* representing Festuceae, but shorter than those of *Elymus interruptus* and *Sitanion hystrix,* representing the Hordeae, in approximately the length ratio of Festuceae 8 : *Elyonurus* 10 : Hordeae 13. The chromosomes of *Elyonurus* are nearly twice the length of those of *Manisuris* and much thicker. In spite of this cytological difference between *Manisuris* and *Elyonurus* the morphological similarities are sufficient to justify their present taxonomic relationship. Darlington and Janaki Ammal (1945) report *Heteropogon contortus* to have $2n = 20$. The Texas material studied is hexaploid with $2n = 60$ (fig. 46). In the related genus *Trachypogon* the species *T. montufari* is diploid with $2n = 20$ (fig. 47). The chromosomes of these last two genera are of the size characteristic of the Andropogoneae.

It is apparent from this and other cytological studies of grasses that basic chromosome number and chromosome size are not constant throughout many of the large tribes. Genera with a basic number $x = 7$ almost always have large chromosomes but genera with $x = 8$, 9, 10, 11, 12, etc. have small chromosomes. *Elyonurus* is an exception to this since it has a basic number $x = 10$ but the chromosomes are large. It seems evident from morphological, cytological and anatomical data that most of the commonly recognized tribes are unnatural and should be divided into subtribes or into a larger number of tribes. This has been proposed in some systematic treatments of grasses such as Hubbard's (1934) treatment. Anatomical and cytological studies are in general agreement in pointing out these natural groups that are, nevertheless, delimited basically by morphological characteristics. Further examples of different basic chromosome numbers in the commonly accepted tribes are: *Festuca* $x = 7$ large chromosomes in contrast to *Distichlis* and *Eragrostis* $x = 10$ small chromosomes; *Chloris* and others $x = 10$ (or 5), *Bouteloua* $x = 7$; *Lycurus* $x = 7$, *Sporobolus* $x = 9$, *Muhlenbergia* $x = 10$ and Aneuploidy in *Stipa;* in *Panicum* $x = 7$, 9 and 10; and in the Andropogoneae $x = 9$ in *Manisuris* but $x = 10$ in other genera.

SUMMARY

1. The chromosome numbers of 44 species in 24 genera of Gramineae are reported. Of these the chromosome numbers of 25 species are reported for the first time.

2. The very restricted species *Distichlis texana* agrees with the wide-spread species *D. spicata* and *D. stricta* in having $2n = 40$ small chromosomes.

3. *Piptochaetium fimbriatum,* the only species of the genus in the United States, agrees with South American species in having $2n = 44$ and this chromosome number shows the relationship of this genus to *Stipa, Aristida* and *Brachyelytrum.*

4. *Stipa tenuissima* is aneuploid in a genus that is typically aneuploid.

5. The basic number in *Panicum hians, P. obtusum* and *P. geminatum* is $x = 10$. *Erianthus strictus,* the first American species in this genus to be studied cytologically has $2n = 30$ indicating a basic number of 5 or 15.

6. The basic number in *Elyonurus* and *Trachypogon* is $x = 10$, with *Elyonurus* having, perhaps, the largest chromosomes in the Andropogoneae.

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