Karyotaxonomy in Poaceae I.
Chromosomes and taxonomic relations in some Japanese grasses.*

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Introduction

Of some 290 species of Poaceae found in Japan, the chromosome numbers have hitherto been reported in about 130 species. Few studies concerning chromosome morphology and behavior have been carried out in Japanese grasses, except in the cultivated plants. In Europe and the United States, various investigators (Avdulov 1931, 1933; Krishnaswami 1940; Hunter 1934; Armstrong 1937; Stebbins and Love 1941; etc.) have made cytological studies concerning both the morphology and the behavior of the chromosomes in various species, but karyotype studies in this family are comparatively few. Still less work has been done along such lines in Japanese material; the studies of the Setaria by Kisimoto (1938) and of Oryzae by Hirayosi (1937) are the chief examples. The present authors are studying the karyotypes of Japanese grasses and considering their taxonomic relationships from the karyotypic standpoint. A part of the results of these investigations is reported in this paper.

Material and Methods

All the materials used are plants found in the fields. The localities where they were obtained are Musasisakai, Kobotoketoge, Suginami, Koremasa and Meguro in Tokyo, and Kirigamine and Simosuwa in Nagano. Collections were made mostly in July and August, 1952. Karyotype studies were made throughout on the root-tip cells, which were fixed directly in the field. Navashin's solution was used in fixation. Paraffin sections were cut at 10-15 micra and Newton's gentian violet method was used for staining. All the figures were drawn with an Abbe drawing apparatus at a magnification of 20×100. The expression of the karyotypes is based on Sinoto's method (1944).

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Observations

1) *Brachypodium sylvaticum* Beauv. (Ezoyamakamojigusa) Fig. 4.

*B. sylvaticum* Beauv. var. *miserum* Koidz. (Yamakamojigusa) Fig. 5.

In both species nineteen chromosomes are found, rather small in size, and in general with median or submedian constrictions.

2) *Agropyron Turczaninovii* Drob. var. *tenuisetum* Ohwi. (Inukamojigusa) Fig. 1.

Twenty-eight chromosomes are found, and the chromosomes are comparatively large, like those of the other *Agropyron*, one of the chromosomes having a satellite. Avdulov (1931) reports the chromosome number of *A. Gmelini* to be $2n=14$, and at present *A. Gmelini* is considered as a synonym of *A. Turczaninovii*.

3) *Bromus remotiflorus* Ohwi. (Kitunegaya) Fig. 2.

*B. catharticus* Vahl. (Inumugi) Fig. 3.

In the former, fourteen chromosomes are found; and in the latter, forty-two. The chromosomes of both species are large, those of the former being a little more larger. *B. catharticus*, which is called "Inumugi" in Japan, is also ascribed to *B.*
Table 1. List of chromosome numbers reported.

<table>
<thead>
<tr>
<th>Species (Japanese name)</th>
<th>2n</th>
<th>Localities</th>
<th>Fig. n</th>
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<th>Authority</th>
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<td>Kirigamine</td>
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<td>42 Stebbins et Tobgy 1944, Oinuma 1952 (as <em>B. unioioides</em>)</td>
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Sacciolepis angusta (Trin.) Stapf. (Numerigusa) 18 Musasisakai 24
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Microstegium vimineum var. polystachyum Ohwi. (Asiboso) 40 Suginami 32
Hemarthria japonica Roschev. (Usinosippei) 18 Suginami 31a, b 9 Moriya et Kondo 1950 (as Rottboellia japonica)

unioloides. Ohwi named this plant B. catharticus. B. catharticus was studied cytologically by Stebbins and Tobgy (1944). In the genus Bromus, intraspecific polyploids are found in some species, and also in B. catharticus, Moriya and Kondo (1950; as B. unioloides) report n=14 (i.e. tetraploid), while the authors' observation and a counting by Oinuma (1952; as B. unioloides) reveal it to be hexaploid.

4) Festuca extremiorientalis Ohwi. (Ootobosigara) Fig. 6.

Twenty-eight chromosomes are found, and the chromosomes show sizes similar to those of Lolium, Agropyron, etc.

Figs. 9-17. Somatic chromosomes. Fig. 9. Eleusine indica. Fig. 10. Sporobolus elongatus. Fig. 11. S. japonicus. Fig. 12. Muhlenber gia Hugelii. Fig. 13. M. japonica. Fig. 14. Stipa extremiorientalis. Fig. 15. Ergrostitis megastachya. Fig. 16. E. pilosa. Fig. 17. E. multicaulis.
5) *Eragrostis pilosa* Beauv. (Ooniwahokori) Fig. 16.

*E. megastachya* Link. (Suzumegaya) Fig. 15.

*E. multicaulis* Steud. (Niwahokori) Fig. 17.

In all of these three species, forty chromosomes are found, and the chromosomes are all small and V-shaped in general. In *E. megastachya*, there is one pair of chromosomes which have closely attached satellites, giving the effect of a secondary constriction.

6) *Eleusine indica* Gaert. (Ohisiba) Fig. 9.

Eighteen chromosomes are found. The chromosomes are small in size and resemble those of *Eragrostis*. This species is considered to be an ancestor of *E. coracana* Gaert. (Sikokubie), which has thirty-six chromosomes.

7) *Muhlenbergia japonica* Steud. (Nezumigaya) Fig. 13.

*M. Hugelii* Trin. (Oonezumigaya) Fig. 12.

In both species forty-two chromosomes of smaller size are found. The chromosomes of *M. Hugelii* are so much smaller than those of *M. japonica* that correct counting is difficult.

8) *Sporobolus elongatus* R. Broun. (Nezuminoo) Fig. 10.

*S. japonicus* (Steud.) Maxim. (Higesiba) Fig. 11.

In the former, thirty-six small chromosomes are found, and in the latter, forty.

9) *Stipa extremiorientalis* Hara. (Hanegaya) Fig. 14.

Twenty-four chromosomes are observed. The chromosomes are small, but larger
than those of *Muhlenbergia* and as long as those of *Sporobolus*. One pair having small and elongated satellites is observed. This species was formerly ascribed to *S. sibirica* var. *effusa* Maxim. *S. sibirica* also has the chromosome number 2n=24 (Avdulov 1928).

10) *Trisetum bifidum* Ohwi. (Kaniturigusa) Fig. 7.  
*Trisetum sibiricum* Rupr. (Tisimakanituri) Fig. 8.

In the former, twenty-eight chromosomes are found, and in the latter, fourteen. These chromosomes are comparatively large. Two varieties of *T. bifidum* are found in Japan; i.e. var. *macranthum* and var. *papillosum*. The latter was used for the present observations.

11) *Agrostis palustris* Hudson. (Konukagusa) Fig. 21.

Forty-two chromosomes are found. The chromosomes of *Agrostis, Calamagrostis, Polypogon, Alopecurus*, etc. all show polypoidy of b=7, and generally the sizes of their chromosomes are the same.

12) *Calamagrostis Pseudo-Phragmites* Koeler. (Hossugaya) Fig. 20.  
*Calamagrostis longiseta* Hack. (Higenogariyasu) Fig. 19.

In both species twenty-eight chromosomes are found. The long chromosomes of *C. longiseta* are mostly V-shaped, but some are J-shaped. The junior author also observed the chromosomes of *C. arundinacea* Roth., and its number was ca. fifty-six. *C. arundinacea* has been reported to have 2n=28 by Avdulov (1931) (cf. Nygren 1946). As *C. arundinacea* is very polytypic, intraspecific polyploidy can be expected. The material for the present observation is var. *robusta* Nakai (Oosaitogaya).

Figs. 23-28b. Somatic chromosomes. Fig. 23. *Paspalum Thunbergii*. Fig. 24. *Sassiolepis angusta*. Fig. 25. *Setaria chondrachne*. Fig. 26. *Digitaria Ischaemum* var. *asiatica*. Fig. 27a. *D. chinensis*. Fig. 27b. Schematic representation of the karyotype of the same species. Fig. 28a. *Pennisetum alopeculoides*. Fig. 28b. Schematic representation of the karyotype of the same species.
13) *Polypogon fugax* Steud. (Hiegaeri) Fig. 18.
Forty-two chromosomes are found. This species is also called *P. Higegaweri* Steud., but according to Ohwi (1941) this plant is *P. fugax*.

14) *Alopecurus aequalis* Sobol. var. *amurensis* Ohwi. (Suzumenoteppo) Fig. 22a, b. The karyotype is as follows:

\[ K = 14 = 4A_1^m + 2A_1^{m'} + 2A_2^{sm} + 4A_2^{m'} + 2' A_2^{m'} \]

15) *Digitaria chinensis* Hornem. (Komehisiba) Fig. 27a, b.

*D. Ischaemum* Muhl. var. *asiatica* Ohwi. (Akimehisiba) Fig. 26.

In the former, eighteen chromosomes are observed, and in the latter, thirty-six. The karyotype of *D. chinensis* is as follows:

\[ K = 18 = 2A_m + 2A_s^m + 4B_1^m + 4B_2^m + 2C_1^m + 2'C_2 + 2C_3^m \]

The chromosomes of *D. Ischaemum* var. *asiatica* are mostly V-shaped, a few of them being J-shaped. In *D. Ischaemum* var. *asiatica* satellites were not observed. The authors also observed the chromosomes of *D. adscendens* Henr. which bears a remarkable resemblance to *D. chinensis* in the external morphology. This species has the chromosome number 2n=ca.54.

16) *Setaria chondrachne* Honda. (Inuawa) Fig. 25.

Thirty-eight chromosomes are observed; these are small and generally V-shaped.

17) *Sacciolepis angusta* (Trin.) Stapf. (Numerigusa) Fig. 24.

Eighteen chromosomes are observed, and their sizes are similar to those of the other genera of Trib. *Paniceae*.

18) *Paspalum Thunbergii* Kunth. (Suzumenohie) Fig. 23.
Forty small chromosomes are observed.

19) *Pennisetum alopeculoides* Spreng. (Tikarasiba) Fig. 28a, b.
Eighteen chromosomes are found. Its chromosomes are alike in size; one pair is J-shaped, and the others are all V-shaped.

20) *Cymbopogon tortilis* Hitchc. var. *Goeringii* Hand-Mazz. (Suzumekarukaya) Fig. 29a, b.

The karyotype of this species is as follows:

\[ K = 20 = 2A_1^m + 2A_2^m + 2B_1^m + 2C_1^m + 2C_2^m + 2D_1^m + 2D_2^m + 2E_1^m + 4E_2^m \]

21) *Ecoiopus cotifer* A. Camus. (Aburasusuki) Fig. 30.

Forty chromosomes are found. The chromosomes are small, but rather larger than those of the other species of Trib. *Andropogoneae*.

22) *Microstegium vimineum* A. Camus. var. *polystachyum* Ohwi. (Asiboso) Fig. 32.

The authors' observations are usually \( 2n=40 \), but rarely \( 2n=42 \) or \( 44 \). This plant propagates by creeping roots as well as by sexual reproduction. For this reason the occurrence of aneuploidy can be expected. Its chromosomes are small, and there is one pair having a long secondary constriction like a satellite.

23) *Hemarthria japonica* Roshev. (Usinosippei) Fig. 31a, b.

The chromosomes are relatively large, as compared with other species in Trib. *Andropogoneae*. Its karyotype is as follows:

\[ K = 18 = 4A_1^m + 2A_2^m + 2B_1^m + 2C_1^m + 2C_2^m + 2C_3^m + 4D^m \]

**Discussion**

The genus *Brachypodium* is placed at present in a subtribe of Trib. *Hordeae*, but formerly it was included in Trib. *Festuceae*. The chromosomes of the genus *Brachypodium* show a great difference from those of the remaining Trib. *Hordeae*. Nevski divides this tribe into seven subtribes, but their chromosomes, excluding those of Subtrib. *Brachypodiinae*, are large and all show polyploidy of \( b=7 \). The chromosomes of *Brachypodium* are small and their basic number is not clear because of the divergence of the numbers. On the other hand, O. Holmberg (1926) includes the genus *Bromus* with *Brachypodium* in Subtrib. *Brachypodiinae*. The authors cannot agree with this grouping, on the basis of the large size of *Bromus* chromosomes. Avdulov (1931) has proposed to group the genus *Brachypodium* with the *Phragmitiformes* of Subfam. *Sacchariferae*, although Avdulov's *Phragmitiformes* is a miscellaneous group. But it is dangerous to decide its placing by the chromosomal characteristics alone. The placing of the genus *Brachypodium* must depend on further investigations.

Ohwi (1941) points out that the difference between Trib. *Agrostideae* and Trib. *Avenae* lies only in the numbers of florets of their spikelets and that they are related to each other. The chromosome numbers of Trib. *Avenae* generally show polyploidy of \( b=7 \), and in Trib. *Agrostideae*, except *Phleum echinatum*, no number
other than those with the basic number of seven has been reported. Also they resemble each other in their chromosome sizes. Ohwi’s opinion is thus supported from a cytological point of view.

*Agrostis, Calamagrostis, Polypogon, Sporobolus, Alopecurus, Muhlenbergia, Stipa*, etc. were formerly included together in Trib. Agrostideae. *Sporobolus, Stipa, Muhlenbergia*, etc. are separated from it at present and also Honda (1930) makes an independent tribe of the genera *Alopecurus* and *Phleum*. The chromosomes of the genera *Stipa, Muhlenbergia*, etc. are clearly different from those of *Agrostis, Calamagrostis, Alopecurus, Polypogon*, etc. It seems to be right from the cytological point of view that the genus *Stipa*, with the other genera, should be grouped into an independent tribe at present by Roshevitz, C. E. Hubbard, etc.

The genus *Digitaria* is distributed over the world (mainly the tropical part) and presents many taxonomical difficulties. In Japanese *Digitaria*, also, different scientific names are brought forward by various investigators and unification is lacking. It is difficult sometimes to differentiate between poor individuals of “Mehisiba”, i.e. *Digitaria adscendens*, which we find everywhere in Japan, and “Komehisiba”, i.e. *D. chinensis*. The authors’ observations show, however, that there is a difference in chromosome number between the two species. That is, “Mehisiba” has the number $2n=ca.54$, but the number of *D. chinensis* is $2n=18$. “Mehisiba” was formerly ascribed to *D. sanguinalis*. The difference between *D. adscendens* and *D. sanguinalis* depends on the size and shape of their spikelets (Nash), but Tuyama (1942) points out that this definition is not always applicable, and there are many species which resemble them. On the other hand, *D. sanguinalis* is reported as $2n=36$ by Avdulov (1931). The authors believe that adjustment can be made in this group to some extent from a chromosomal study.

The genus *Setaria*, as well as *Digitaria*, belongs to Subtrib. Panicinae. Japanese *Setaria* are divided into three sections. All of the species hitherto reported in *Setaria* are included in the Sect. *Setariotypus* and show polyploidy of $b=9$. *S. chondrachne* Honda is a member of Sect. *Panicatrix* and is characterized by the presence of creeping roots. The chromosome number, i.e. $2n=38$, which is reported by the authors, is considered to be a consequence of aneuploidy and not to indicate a difference in the basic number.

**Summary**

The chromosome numbers and morphologies were studied in 32 species of Japanese grasses, which belong to the genera *Brachypodium, Agropyron, Bromus, Festuca, Eragrostis, Eleusine, Muhlenbergia, Sporobolus, Stipa, Trisetum, Agrostis, Calamagrostis, Polypogon, Alopecurus, Digitaria, Setaria, Paspalum, Pennisetum, Cymbopogon, Eccoilopus, Microstegium, Hemarthria* (Table 1). The taxonomic placing of the genus *Brachypodium* was considered, as well as the systematical relations between
Trib. *Agrostideae* and Trib. *Aveneae*; Trib. *Agrostideae* and the genera *Stipa*, *Muhlenbergia*, etc. A karyotaxonomical point of view of the genus *Digitaria* was mentioned.

It is a pleasure to record here a debt of gratitude to Messrs. H. Kasaki, B. Sakai, and T. Takemaru for their kindness during the course of the present investigations.

**Literature cited**


