Allocation of *Triticum timopheevi* chromosomes I. Karyotypic comparison between Emmer and Timopheevi Wheats by C-banding

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Abstract

Somatic chromosomes of *Triticum turgidum* (2n=28, AABB) and *T.timopheevi* (2n=28,AAGG) were studied by C-banding. Since there was a close resemblance between the C-banded karyotypes of *T.turgidum* and the A and B genomes of common wheat, every chromosome of *T.turgidum* was correctly identified. Nine chromosomes of *T.timopheevi* had prominent bands and the rest had faint bands. Although seven heavily banded chromosomes of *T. timopheevi* were assumed to constitute the G genome and the remaining seven the A genome, no decisive allocation to wheat homeologous group was possible. A method of allocating the *T.timopheevi* chromosomes was discussed.

I. Introduction

Tetraploid wheats are divided into two groups, the Emmer group and the Timopheevi group. The Emmer species share the A and B genomes with hexaploid common wheats (Kihara 1924), whereas, as suggested by Lilienfeld and Kihara (1934) and others, the Timopheevi species has the A genome in common with the Emmer and common wheats and the second genome is partially homologous to the B genome. Lilienfeld and Kihara (1934) designated the genome constitution of *T.timopheevi* as AAGG, suggesting a diphyletic origin of the Emmer group and the Timopheevi group. By contrast, many workers proposed a monophyletic origin of the tetraploid wheats through differentiation in chromosome structure (Sachs 1953, Tanaka et al.1979) or through mutations of genes causing asynapsis in a heterozygous condition (Wagenaar 1961,1966). Studying the chromosome pairing of F_1 hybrids between telocentric lines of *T. aestivum* cv. 'Chinese Spring' and the amphidipoid *T.timopheevi-T.tauschii* (*Ae.squarrosa*), Feldman (1966) concluded that although the B genome chromosomes more often failed in pairing with the chromosome of the corresponding genome (G genome) of *T.timopheevi* than the A genome chromosomes, the G genome is sufficiently closely related to the B genome to be designated as B^t. As to the

origin of the G genome, Shands and Kimber (1973) found a high level of homologous pairing in hybrids of *T. timopheevi* and *Aegilops speltoides*, suggesting that *Ae. speltoides* is the donor of the second genome of *T. timopheevi*.

In addition to the studies of the chromosome pairing in meiosis, a different approach to the origin of the tetraploid wheats was attempted in characterizing the chromosomes at the mitotic metaphase, by *in situ* hybridization (Gerlach et al. 1978) or by chromosome banding (Chen and Gill 1983, Noda 1983). Although these studies produced suggestive results concerning the origin of the B and G genomes, more detailed chromosome banding works would be required for determination of the homology or homoeology of each of the *T. timopheevi* chromosomes to the chromosome of the Emmer and common wheats, and for further understanding of the phylogenetic differentiation in the tetraploid wheats.

In this study, karyotypes of an Emmer wheat and a Timopheevi wheat were studied in detail by C-banding, as a basis of an investigation to allocate the chromosomes of *T. timopheevi* to the wheat homeologous groups. The method of the allocation will be discussed in this paper.

II. Materials and Methods

Triticum turgidum L. var. *nigro-barbatum* and *T. timopheevi* zhuk. var. *typicum* were used in this study as representatives of the Emmer group and the Timopheevi group, resepectively. The seed stocks of both of the species were kindly provided by Dr.I.Ohtsuka, Kanagawa University, Yokohama, Japan, and the strain of the latter species was the same as was used as a tester strain (KU-107-1) in the study by Kawahara and Tanaka (1977) on chromosomal interchanges in the Timopheevi group.

Somatic chromosomes of these species were studied in root-tip cells at metaphase by the C-banding technique modified by Endo (1986).

III. Results and Discussion

A. *C-banded karyotypes*

Both species had two pairs of SAT-chromosomes, and the rest of the chromosomes were metacentric or submetacentric, with constrictions sporadically observd in regions other than centromere and satellite (Fig. 1). It was impossible to distinguish between the *T. turgidum* and *T. timopheevi* chromosomes stained in an ordinary way with acetocarmine.

The C-banding produced a distinctive band or bands in all but one of the chromosomes of *T. turgidum*. The banding patterns closely resembled the already identified N- or C-banding patterns of the A and B genome chromosomes in common wheats and a different Emmer species (Endo 1986, Endo and Gill 19 83, 1984). Therefore, it may safely be said that the identification of the *T. turgidum* chromosoes was absolutely correct, as shown in Fig. 2a. Although the allocation of the chromosomes 4A and 4B was reverse in the previous studies,

the revised designation proposed by Dvořák (1983) and Chen and Gill (1983) was adopted in this study.

Prominent bands appeared in nine of the C-banded chromosomes of *T.timopheevi*. The remaining five chromosomes had some faint bands that were seen only in well stained cells. Thus, all the chromosomes of *T.timopheevi* were distiguished from one another and from all of the chromosomes of *T.turgidum*. These chro.nosomes were designated as a to n(Fig. 2b) because a complete allocation corresponding to the A and B genome chromosomes of the Emmer and common wheat species was impossible on the basis of the banding pattern.

Seven heavily banded chromosomes of *T.timopheevi*, h to n were rether similar in banding pattern to the B genome chromosomes and therefore were attempted to be placed in the corresponding positions. These chromosomes probably constitute the G genome, this genome is demonstrated to be partially homologous to the B genome (Lilienfeld and Kihara 1934, and others), and is considerd to have originated from *Ae.speltoides* whose seven chromosomes all have many heterochromatic bands (Shands and Kimber 1973, Chen and Gill 1983, Noda 1983). Consequently, the A genome of *T.timopheevi* is postulated to consist of the chromosomes a to g, but it is hardly possible to find any resemblance in banding patten between the two A genomes of the different groups of tetraploid wheats.

It is worth noticing that there was only one SAT-chromosome in the supposed G genome, whose banding pattern seems to correspond to that of the 6B chromosome of *T.turgidum*. The other SAT-chromosome, designated as a, was not like chromosome 1B at all and placed in the assumed A genome of *T. timopheevi*. This fact agrees with the observation by Feldman (1966) that the chromosome of *T.timopheevi* which paired with the 1BL of 'Chinese Spring' was not satellited. The satellite region of a G genome chromosome corresponding to chromosome 1B may have been translocated into a A genome chromosome during the evolutivn of *T.timopheevi*. Anyway, there is a limit to the discussion based on only the banding characteristics, and the homology or homoeology between the chromosomes of the Emmer wheat and the Timopheevi wheat must be identified.

B. *Allocation of the chromosomes of T.timopheevi*

The F_1 hybrid between *T.turgidum* and *T.timopheevi* shows a high level of chromosome pairing and female fertility, although it is male sterile, and the backrossed offspring are mostly 28-chromosome plants(Ohtsuka personal communication). This fact enables us to study the homology or homoeology of the chromosomes of *T.timopheevi* to those of *T.turgidum*.

Because of the high level of pairing homology between the parental species, translocated chromosomes involving chromosomes of the two species are expected to occur in the B_1· plants. Therefore, identification of the chromosomes involved in a translocation will help identify the homology or homoeology between the chromosomes.

Also, complete observations on the chromosome constitution of a sufficient number of the B_1 plants will help determine the homology or homoeology between the chromosomes of the parental species. Suppose the F_1 hybrid is backcrossed with *T.turgidum*. When a *T.timopheevi* chromosome is found in a B_1 plant with normal growth, its homologous or homoeologous *T.turgidum* chromosome is expected to exist in the monosomic condition, never in the disomic condition, in the same plant. On the other hand, when both homologues of a *T.turgidum* chromosome are present in a B_1 plant, its homologous or homoeologous *T.timopheevi* chromosome is expected not to be found in the same plant. Thus, most of the *T.timopheevi* chromosomes will be able to be allocated successfully.

References

Chen, P.D. and Gill, B.S.1983. The origin of chromosome 4A, and genomes B and G of tetraploid wheats. Proc. 6th Int. Wheat Genet. Symp.,Kyoto, Japan:39-48.

Dvořák, J. 1983. The origin of wheat chromosomes 4A and 4B and their genome reallocation. Can J. Genet. Cytol.25:210-214.

Endo, T. R. 1986. Complete identification of common wheat chromosomes by means of the C-banding technique. Jpn. J. Genet. 61:89-93.

Endo, T.R. and Gill, B. S. 1983. Identification of wheat chromosomes by N-banding. Proc. 6th Int. Wheat Genet. symp. ,kyoto, Japan:355-359.

Endo,T. R. and Gill,B. S. 1984. Somatic karyotype, heterochromatin distribution, and nature of chromosome differentiation in common wheat, *Triticum aestivum* L. em Thell. Chromosoma (Berl) 89:361-369.

Feldman, M.1966. Identification of unpairld chromosomes in F_1 hybrids involving *Triticum aestivum* and *T.timopheevii*. Can. J. Genet. Cytol. 8:144-151.

Gerlach, W. L., Appels, R., Dennis, E. S., and Peacock, W.J. 1978. Evolution and analysis of wheat genomes using highly repeated DNA sequences. Proc. 5th Int. Wheat Genet. Symp., New Delhi, India:81-91.

Kawahara, T. and Tanaka, T. 1977. Six chromosome types in *Triticum araraticum* Jakubz. differing with reciprocal translocations. Jpn. J. Genet. 52:261-267.

kihara, H. 1924. Cytologische und genetische Studien bei wichtigen Getreidearten mit besonderer Rucksicht aur das Verhalten der Chromosomen und die Sterilitat in den Bastarden. Mem. Coll. Sci. Kyoto Imp. Univ. Ser. B. 1:1-200.

Lilienfeld, F.and kihara, H. 1934. Genomanalyse bei *Triticum* und *Aegilops*. V. *Triticum timopheevi* zhuk. Cytologia 6:87-122.

Noda, K. 1983. Chromosome mosaic of the B genome of wheat. Proc. 6th. Int. wheat Genet. symp., Kyoto, Japan:1089-1094.

Sachs, L. 1953. Chromosome behaviour in species hybrids with *Triticum timopheevi*. Heredity 7:49-58.

Shands, H. and Kimber, G. 1973. Reallocation of the genomes of *Triticum timopheevii* zhuk. Proc. 4th Int. Wheat Genet. Symp., Columbia, USA:101-108.

Tanaka, M, Kawahara, T., and Sano, J. 1979. The origin and the differentiation of the B and G genomes of the tetraploid wheats. Rep. Plant Germ-Plasm Inst. Kyoto Univ. No. 4:1-11.

Wagenaar, E. B. 1961. Studies on the genome constitution of *Triticum timopheevi* Zhuk. I.Evidence for genetic control of meitic irregularities in tetrapoid hybrids. Can. J. Genet. Cytol. 3:47-60.

Wagenaar, E. B. 1966. Studies on the genome constitution of *Triticum timopheevi* Zhuk. II. The *T.timopheevi* complex and its origin. Evolution 20:150-164.

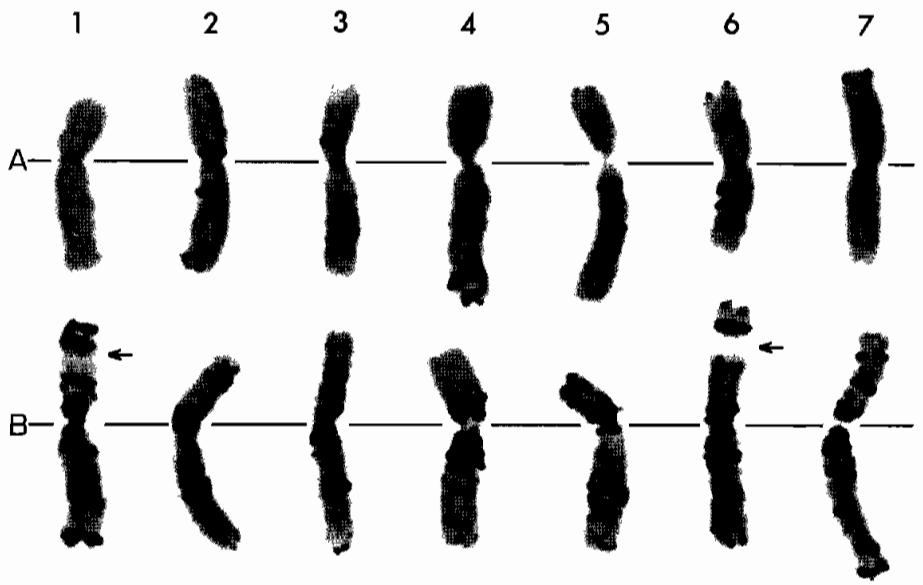
Figure Legends

Fig. 1. Somatic metaphase chromosomes of (a) *T.turgidum* and (b) *T.timopheevi*. The chromosomes were identified on the basis of heterochromatic bands appearing in the same cells treated by C-banding after being taken these photographs (cf.Fig.2). Sinceit was difficult to distingush among chromosomes c to g of *T. timopheevi*, because of their faint bands, they were not designated in Fig. 1b. Bars=10μm.

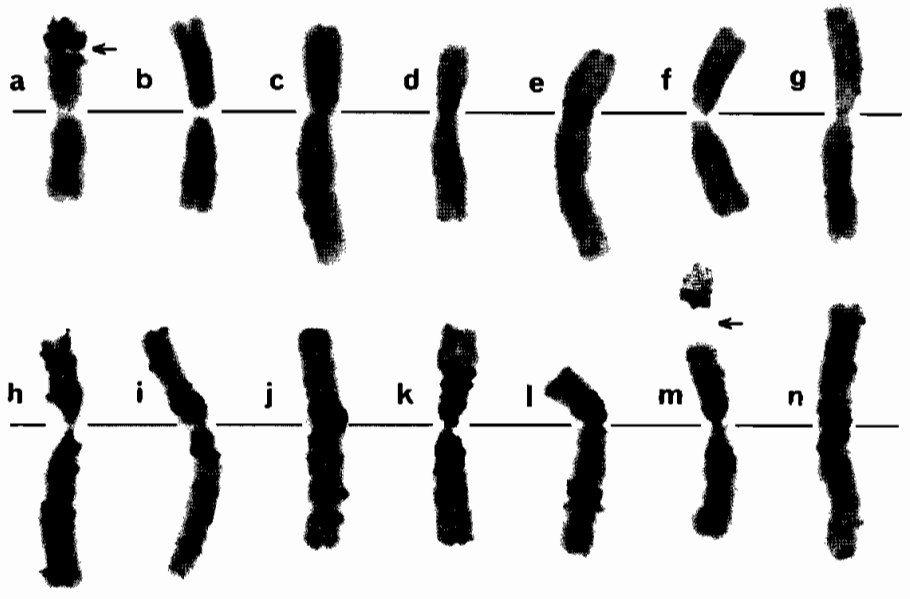
Fig. 2. C-banded karyotypes of (a) *T.turgidum* and (b) *T.timopheevi*. In Fig.2a, A and B represent the genomes and 1 to 7 homoeologous groups of *T.turgidum*. The chromosomes of *T.timopheevi* were rather arbitrarily designated as a to n in Fig. 2b. The chromosome sizes in these figures do not correctly show the actual relative sizes because the chromosomes were collected from different cells. The horizontal lines indicate the centromere regions and the arrows the secondary constrictions.


a
4B
7B
6B
1A
6B
6A
1A
5A
3B
3B
1
2A
4A
4A
6A
7A
7A
2B
5B
3A
5B
7B
5A
2B
2A
1B
4B
3A
b
i
b
h
h
i
m
l
l
a
a
k
k
n
j
n
b
m
j

Fig 1



a



b

Fig 2