CHIASMA STUDIES IN STRUCTURAL HYBRIDS. VIII. FURTHER EVIDENCES FOR CHIASMA FORMATION BY CROSSING-OVER IN RECIPROCAL TRANSLOCATIONS OF *SCILLA SCILLOIDES*

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The conformity between frequency of the chiasma formation in the heteromorphic chromosome pair and that of the equational AI separation has previously been ascertained in a heterozygote for reciprocal translocation of *Scilla scilloides* Druce (Noda 1961). The same findings were reported in the various cases of the reciprocal translocations and deficiency, in plants and animals, in serial articles of the present studies (Kayano 1960, Kayano and Nakamura 1960, Noda 1960, Zen 1961). Such close interrelation can be well interpreted on the basis of the chiasmatype hypothesis. In the present study further evidences for the chiasma formation by the crossing-over were obtained in the four cases of reciprocal translocation in *S. scilloides*.

OBSERVATIONS

A complex *S. scilloides* is an aggregate of the eight cytogenetic types constituted of two different genomes A ($x=8$) and B ($x=9$), the former being consisted of eight chromosomes a_1 to a_8 and the latter of nine chromosomes b_1 to b_9 (Haga and Noda 1958, 1963). In addition to the standard chromosomes a telocentric B-chromosome f and its isochromosome F are found to present in certain plants (Haga 1961).

Four different types of the translocation heterozygotes were found in the natural populations. The first was found in a cytogenetic type ABB and to involve a translocation between chromosome b_2 and b_4 of the genome B, the second in AABB and to involve a translocation between a_2 and a_4 of the genome A, and the third and forth in AABB; in the latter two cases chromosomes which participated in the translocations were unidentifiable (Figs. 1-3, Table 1).

Karyotypes and meiotic pairings in the plants dealt with in the present study will be described in detail elsewhere. The same cytological method were employed as described in a previous paper (Noda 1960).

Meiotic pairings of four chromosomes participated in the translocations are presented diagrammatically in Figures 1-3. In the translocations between b_2 - b_4 and between a_2 - a_4 , two chromosome pairs, I and II, were clearly distinguishable at MI as well as at AI from one another, but those pairs were unidentifiable in the third and forth transloca-

Table 1. Standard MI pairing in the heterozygotes for four types of reciprocal translocations

Cytogenetic type	Translocation between	Standard MI config.	Plant from
ABB	b_2-b_4	$\odot 4+7_{\text{I}}+8_{\text{I}}$	Usa (Kyushu)
AABB	a_2-a_4	$\odot 4+15_{\text{I}}$	Iwami (Tyugoku)
AABB	not identified	$\odot 4+15_{\text{I}}$	Yosu (Korea)
AABB	not identified	$\odot 4+15_{\text{I}}$	Isl. Izena (Ryukyus)

Figs. 1-3. Diagrammatic representation of the meiotic pairings in four types of translocation heterozygotes. 1. b_2-b_4 translocation (ABB). 2. a_2-a_4 translocation (AABB). 3. Translocations in which participated chromosome were unidentifiable (AABB).

tion heterozygotes found in cytogenetic type AABB. Homologous kinetochores appeared separated at MI without exception (Figs. 4, 6-8).

In no case was formation of more than a single chiasma observed in the interstitial segments between the kinetochore and the point of interchange. Formation and non-formation of a single chiasma in the interstitial segment are denoted as IX and OX, and equational and reductional AI separations of the pair involving this segment as E and R. In the two translocation heterozygotes involving unidentifiable pairs, the chiasma formation and AI separations were recorded in the same way as in the previous paper; OX-OX, IX-OX, and IX-IX for chiasma formation, and R-R, E-R, and E-E for AI separation (cf. Noda 1961).

In the two pairs of the translocation b_2-b_4 of cytogenetic type ABB, there were found nearly no chiasma and no equational AI separation (Figs. 1, 4-5, Table 2). On the contrary, in the case of translocation a_2-a_4 found in cytogenetic type AABB, the frequencies of chiasmata per segment conforms statistically with that of AI equational separation per pair; 0.273X and 0.176E in pair I, and 0.455X and 0.412E in pair II (Figs. 2, 6, Table 2). The same holds true of other two translocations found in cytogenetic type AABB, that is, 0.50X at MI and 0.50E at AI in one of the two, and 0.494X and 0.490E in the remaining one (Figs. 3, 7-9, Table 2).

Figs. 4a-9a. 4a, 6a-8a. MI in the translocation heterozygotes, arrows indicate a single chiasma in the interstitial segment. $\times 1200$. 5a, 9a. AI in the translocation heterozygotes, arrows indicate the equational separation. $\times 800$. 4a-5a. Translocation b_2-b_4 (ABB). 4a. $\odot 4+7_I+8_I$, OX-OX. 5a. E-E. 6a. $\odot 4+15_I$, OX-OX, in a_2-a_4 translocation (AABB). 7a-9a. Translocations in AABB in which interchanged chromosomes were unidentifiable. 7a. $1_{IV}+15_I+1f_I$, IX-OX (Yosu). 8a-9a. Translocation (Isl. Izena). 8a. $1_{IV}+15_I+1f_I+2f_I+\odot F$, IX-OX. 9a. E-R, of which reductional separation can not be identified.

Figs. 4b-9b. Line diagrams of the configurations of the photos given in Figures 4a-9a.

Table 2. Chiasma frequencies in the interstitial segments as compared with those of equational AI separation in the translocation heterozygote in which two pairs are identifiable, above, and not identifiable, below

Cytogenetic type	Translocation	Pair	MI				AI				χ^2	D. F.
			Segm. obs.	0X	1X	Xta/segm.	Pair obs.	R	E	E/pair		
ABB (Usa)	b_2-b_4	I	33	33	0	0.0	27	27	0	0.0	0.0	1
		II	33	32	1	0.030	27	27	0	0.0	0.03	1
AABB (Iwami)	a_2-a_4	I	11	8	3	0.273	17	14	3	0.176	0.80	1
		II	11	6	5	0.455	17	10	7	0.412	0.13	1

Cytogenetic type	Translocation	MI					AI					χ^2	D.F.
		Segm. obs.	0X-0X	1X-0X	1X-1X	Xta/ segm.	Pair obs.	R-R	E-R	E-E	E/pair		
AABB (Yosu)	not identified	128	6	116	6	0.50	20	0	20	0	0.50	0.56	1
AABB (Izena)	not identified	500	46	414	40	0.494	50	6	39	5	0.490	1.46	1

The χ^2 -test for the conformity between the mean chiasma frequency and the mean frequency of equational AI separation gives the value $P>0.05$ without exception.

CONCLUSION AND SUMMARY

The heterozygotes for four types of the reciprocal translocations were found in the natural populations of *S. scilloides* consisting of genome A ($x=8$) and B ($x=9$). One of those was involved in cytogenetic type ABB ($\odot 4+7_{II}+8_I$), and three in AABB ($\odot 4+15_{II}$). The frequencies of chiasmata observed at MI in the interstitial segments between kinetochore and the point of interchange conformed very well to that of equational AI separations of the pairs involving these segments.

The same parallelism has also been confirmed in the heterozygotes for pericentric inversion in *S. scilloides* (Noda 1965). Furthermore, in the same species, a single chiasma was clearly observed to be formed at the segment between two unpaired loops in the asymmetrical bivalent resulted from the intra-arm transposition (Noda 1962). These findings support the chiasmatype hypothesis accounting for the origin of the

cytological configuration chiasma (cf. Darlington 1965).

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