Intergeneric Hybridization in Cichorieae, VII. Cytology of F_4 individuals of *Paraixeris denticulata* $\times$ *Crepidiastrum platyphyllum*¹

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Introduction

It is noteworthy that the hybrid between *Paraixeris denticulata* NAKAI and *Crepidiastrum platyphyllum* KITAMURA is actually found in nature, which taxonomists describe as a new species or a member of a new genus. The present author has undertaken to investigate the origin and the nature of this plant since 1933. He crossed these two different plants and obtained a hybrid quite similar to the plant found in nature. Further the cytological behavior of the hybrid has been studied. The F_1 of the hybrid which had a low fertility, yielded some achenes when open-pollinated between the F_1 individuals. The fertility became higher in each generation than the last. The cytological features of these offsprings up to F_3 have been reported in the preceding papers of this series (ONO and SATÔ 1935, ONO 1937, 1938, 1941). In the fall of 1933, a rather large number of F_4 individuals were obtained. Out of these individuals about one hundred were selected for investigation of their external morphology, somatic chromosomes, meiotic behaviors and fertilities. These investigations were expected to reveal the hereditary and evolutionary significance of this hybrid, and further to elucidate to some extent the nature and the consequences of the structural changes in chromosomes. Another aim of the present study was to investigate whether it might be possible by crossing any two species to produce a fully constant and viable new type, which might prove of great significance in the problem of evolution. In the present paper some results of the cytological observations will be described.

Material and Method

The origin of the present material is reported in the former papers. *Paraixeris denticulata*, being self-sterile, was selected as mother plant. Eleven F_1 plants were obtained in 1933. They were isolated in a wooden frame, and yielded only 36 achenes of F_2 in 1935. But these achenes germinated only poorly, and 15 F_2 plants were obtained. These F_2 showed

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remarkable polymorphism in the external morphology and in the chromosome constitution. Two of these F_2 were isolated and 75 achenes were put forth in 1937. Out of these achenes 8 F_3 plants were brought to maturation in 1939. These plants were again isolated in a wooden frame, and they yielded a great many achenes, and thus a rather large number of F_4 individuals were obtained. Among these about one hundred individuals were picked up at random as the material of the present investigations.

In the spring 1941 the root-tips of each individual were fixed in NAVASHIN solution, and embedded after the butyl-alcohol schedule in paraffin and stained by NEWTON's gentiana violet method.

In the autumn 1941, the flower-buds were fixed with CARNOY's solution without chloroform and mounted as aceto-carmin smear preparations after the schedule of TANAKA described in the previous paper (ONO 1943). Cytological sketches will be published elsewhere.

Observations

About half of the F_4 individuals show rather regular meiotic figures with five bivalents. But in some of these individuals slight irregularities such as loose pairing of bivalents, premature separation of bivalents or rare occurrence of one tetravalent are often observed. Cytological features of the other half individuals with rather irregular meiotic figures are as follows:—

F_4-1^1 The somatic chromosomes are ten in number. In one of them is seen the characteristic long constriction which is peculiar to Cp (*Crepidiastrum platyphyllum*). The meiotic division of this individual is characterized by the presence of one tetravalent in almost all its pollen mother cells (94.5%). The configurations of these tetravalents are somewhat variable. About 30% of them are of ring configuration, while the remaining 70% are of chain configuration. But the pairing of the adjoining components are not always found in their terminal portions, but often in interstitial and other portions. Frequently the tetravalent is constituted with two bivalents loosely attached to each other. The four or less of the components of the tetravalent are often attached to the nucleolus, but on some occasions the tetravalent is detached from the nucleolus, the four other chromosomes attached to the nucleolus. Thus their attachment or detachment must be considered to be due to the changing nature of either the components of the tetravalents or the nucleolar chromosomes. Low fertility of the pollen may be connected with the tetravalent formation, which is probably the cause of uneven distribution of the chromatin in the daughter nuclei.

¹ This indicates one individual plant of F_4

F₄-5 Ten chromosomes are counted in the root-tip cells. In the meiotic division there are found always a tetravalent and one or two heteromorphic bivalents. The component chromosomes of the tetravalent are quite different in their morphology. Such a tetravalent may be said as a heteromorphic tetravalent. One bivalent seems to separate prematurely in the metaphase. But no irregularities were encountered in the separation of the chromosomes during anaphase.

F₄-9 Ten somatic chromosomes are counted in the root-tip cells, two of them having longer constrictions. In the meiotic divisions some 40% of the pollen mother cells have 5 bivalents. The remaining 60% have one tetravalent and three bivalents. The tetravalent is in almost all occasions connecting with nucleolus. But in rare occasions nucleolar chromosomes form a bivalent. Affinities in these bivalents seem to be not so strong, and at least in one bivalent the partners detach prematurely in the metaphase. In the anaphase the separation of chromosomes seems to proceed rather regularly in spite of the presence of tetravalent and the prematurely separating bivalent. In the second division the separation of the chromosomes seems also to proceed regularly, although in some occasions retarded chromosomes are observed.

F₄-10 In the mitotic metaphase ten chromosomes are counted, one of which has a long constriction. In the meiotic division about half of the pollen mother cells have five bivalents and the remaining half have a tetravalent or a tetrapartite and three bivalents. The former is constituted of two bivalents loosely attached, and is ordinarily of ring configuration and in some cases of chain configuration. In some occasions the components of the tetravalent are connected with the nucleolus, but in other occasions not.

F₄-11 Ten chromosomes are counted in the root-tip cells. One chromosome has a long constriction. One chromosome is noteworthy because its shape is quite new. This may be one clear instance of novation following hybridization. In the meiotic division one tetravalent and three bivalents are observed in almost all pollen mother cells. One of the bivalents seems to separate prematurely at the metaphase. The tetravalent seems to include the large V-shaped chromosome which is formed by novation.

F₄-17 This individual has eleven chromosomes or one chromosome plus ordinary number of chromosomes in the somatic cells. Some chromosomes seem to have new forms caused by crossing-over between the non-homologous chromosomes. The most clear novation is observed in one chromosome which is long V-shaped. In the meiotic divisions several different configurations are observed, the somatic chromosome number being odd. The mode of pairing is shown in the following table.

$1V + 1IV + 1II$	2	$1III + 4II$	6
$1V + 3II$	3	$1I + 5II$	4
$1IV + 1III + 2II$	3	$1IV + 2III + 1I$	4
$2IV + 1II + 1I$	2	$1IV + 3II + 1I$	1
$2III + 2II + 1I$	1	$1III + 3II + 2I$	1

Pentavalents, tetravalents, trivalents and univalents are frequently observed, but anaphase separation of the chromosomes seems to be more regular than the expectation although some 3% of the pollen mother cells were observed to have laggard chromosomes.

F_4-19 Ten somatic chromosomes are counted in the root-tips. The meiotic division proceed rather normally. But about 25% of the pollen mother cells have tetravalents. When five bivalents are observed, component chromosomes of one bivalent pair quite loosely and separates prematurely. This shows the less affinity of those chromosomes, and the formation of the tetravalent may be connected with the presence of those chromosomes.

F_4-21 Ten somatic chromosomes are counted in the root-tips, one of which has the characteristic long constriction. One chromosome is clear to be newly formed one by novation. The meiotic division is quite irregular. There are no pollen mother cells which have five bivalents. The frequencies of the observed configurations are as follows:

$1IV + 3II$	47	$2IV + 1$	31
$2III + 2II$	3	$1III + 3II + 1I$	1
$1IV + 2III$	1	$1IV + 1II + 4I$	1

The most frequently observed figures are constituted with one tetravalent and three bivalents. Two of these bivalents often unite to form a tetravalent.

F_4-22 In the somatic cells ten chromosomes are observed, two of which have the characteristic long constrictions. In the diakinesis of meiotic division one trivalent and one univalent are observed beside three bivalents. It is interesting that the relative situation of them is definite. This implies that in the earlier stages of meiosis these two had united to form a tetravalent, and separated in the diakinesis. In fact two instances to indicate this condition clearly are observed. One is the case where the trivalent and the univalent is connected with a fine thread showing that these two have just separated in this stage. The other is the case where one tetravalent is observed instead of a trivalent and a univalent showing retarded separation. The presence of the trivalent or the univalent may be the cause of the lower fertility both in male and female.

F₄-23 In the somatic cells ten chromosomes are counted, one of which has the characteristic long constriction. In the late diakinesis of meiotic division half of the pollen mother cells have five bivalents. In the remaining cells one or two tetravalents with variable configurations are seen. In one cell a hexavalent and two bivalents are observed.

F₄-26 Ten somatic chromosomes are counted in the root-tip cells, one of which is of new shape and is clear to be reconstructed one. In the meiotic division multivalents are frequently observed. A heptavalent, a hexavalent, a pentavalent or a tetravalent are often seen in the late diakinesis. These multivalents are often of chain configuration and rarely of ring configuration. And in some occasions branched configurations are observed. Univalents occur also frequently. In the anaphase the separation of the chromosomes proceeds rather normally inspite of the presence of multivalents. Univalents also go quickly to either pole. The pollen mother cells with laggard chromosomes in the anaphase of the first division are less than 5% in spite of the high percentage of multivalents. It is remarkable that with these meiotic irregularities, the fertility of the female gametophyte is as high as 92%, although the pollen fertility is only 64%.

F₄-27 Ten somatic chromosomes are counted. In the meiotic division a tetravalent of chain configuration and three bivalents are most frequently observed. But one of these bivalents pairs quite loosely and dissociates much earlier in the metaphase. The components of this bivalent are often found as two univalents. The chain of the tetravalent is often disjoined at the center, and in such occasion five bivalents are observed. In one case a hexavalent of a strange configuration was observed. This hexavalent consists of two trivalents connected with a fine thread. It is supposed that each trivalent is consisted of one half of the tetravalent and a component chromosome of the loosely pairing bivalent. The premature separation of this bivalent resulted in the dissociation of the hexavalent.

F₄-28 Ten somatic chromosomes are counted. In the meiotic division most of the pollen mother cells contain four bivalents and two univalents. In some cases three bivalents and four univalents are observed. The presence of these univalents or a priori lower homology of these chromosomes may be the cause of the lower fertility in the female gametophyte.

F₄-29 Ten somatic chromosomes are counted in the root-tip cells. One chromosome has the characteristic long constriction, but the length of the longer arm is very short. It is clear that there occurred a recombination of chromosomes. Ordinarily five bivalents are observed in the meiotic division. But among these five bivalents, two bivalents

are seen to pair quite loosely in the late diakinesis and metaphase. Some 30% of the pollen mother cells have a tetravalent. But the components of this tetravalent unite themselves in very minute portions. Often one component is seen to detach from the tetravalent forming a trivalent and a univalent. With all these irregularities the separation of the chromosomes in the anaphase proceeds quite regularly.

F_1 -31 Ten chromosomes are observed in the somatic cells. In the meiotic division five bivalents are regularly observed. But three of these bivalents are observed to pair quite loosely and the separation of the component chromosomes takes place prematurely in the metaphase. And especially in one bivalent among these three, pairing takes place in only a minute portion. So it may be better to denote it as two univalents loosely connected. The condition that more than half of the bivalents pair so loosely seems to be the cause of the lower rate of achene setting, and it is noteworthy that it does not affect the fertility of the pollen.

F_1 -32 Ten chromosomes are counted in the somatic cells, one of which has the characteristic long constriction. In the meiotic division about half of the pollen mother cells have one or two tetravalents. And these tetravalents are constituted with two bivalents loosely connected. In some cases these bivalents are connected with a long and, fine thread in the late diakinesis. Such tetrapartite chromosomes will afterwards be observed only as two bivalents. In such cells where only one tetravalent is observed, the pairing of the two bivalents among the remaining three bivalents is very loose, while very tight pairing is observed in the remaining one. Such bivalents in which pairing is observed to be very loose seem to form another tetravalent. And in five percent of the pollen mother cells these bivalents remain only as four univalents.

F_1 -33 Ten chromosomes are counted in the somatic cells, one of which seems to be a morphologically new chromosome. In the meiotic division two tetravalents and one bivalents are almost always observed. One tetravalent is composed of two larger and two smaller chromosomes. The larger ones pair in the portions ranging from one end to the middle part and both of the remaining half part are free. At each end of these free portions each of the smaller chromosomes is associating. In one instance this tetravalent was seen dissociated at the center to form two bivalents of extremely heteromorphic nature. The other tetravalent is of a branched configuration: one chromosome is associating at the center of a chain of three chromosomes. The bivalent pairs rather tightly.

F_1 -35 Ten somatic chromosomes are counted in the root-tip cells. In the meiotic division one tetravalent and three bivalents are always observed. Out of these three bivalents the association in two bivalents is quite loose, and they often remain as four univalents even in the late

diakinesis. In the metaphase, of course, these loose bivalents are seen to separate much earlier than the other. Sometimes the tetravalent and one of the loose bivalents form a hexavalent, associating together in a chain.

F₄-36 Ten somatic chromosomes are counted in the root-tips. In the meiotic division of the pollen mother cells abundant irregularities are observed as is expected from the lower fertility. About 60% of the pollen mother cells have one tetravalent and three bivalents. The shape of the tetravalent is quite polymorphic. Ordinarily a chain of various shapes are observed. But in some cases the configuration is of a chain of three chromosomes and a branch of one. Among these 60% some 3% have a tetravalent and two trivalents. About 20% of the pollen mother cells have regular five bivalents, and the remaining 20% are of various configurations. Ordinarily in these pollen mother cells one or more of univalents are observed. And also varying numbers of bivalents or trivalents are seen. In one case a hexavalent of branched configuration was observed.

F₄-38 Ten chromosomes are counted in the somatic cells. And it is noteworthy that twenty chromosomes are counted in some cells which are found in the chimera condition among those cells with ten chromosomes. In the meiotic division some cells have five bivalents and some cells have one or two tetravalents in which the association of the chromosomes is quite loose. One of these tetravalents often dissociates into one bivalent and two univalents.

F₄-41 Ten somatic chromosomes are counted. The meiotic division is quite irregular. In many pollen mother cells varying combinations of divergent configurations are observed. Ordinarily in one bivalent quite loose pairing and earlier separation are observed. And two bivalents often unite themselves to form a tetravalent in the late diakinesis. In the late metaphase this tetravalent is always observed to be dissociated into two bivalents.

F₄-42 Ten somatic chromosomes are observed in the root-tip cells. In the meiotic metaphase, two tetravalents are observed, one being of ring configuration and the other of chain one. In the anaphase of the first division many chromosome segments are seen remaining in the equatorial plate to be excluded from the daughter nuclei. Such a phenomenon is quite rarely observed in the present hybrids. In the anaphase of the second division no segments are observed remaining in the plate: division proceeding quite regularly.

F₄-43 Ten somatic chromosomes are observed in the root-tip cells. The chromosome behavior in the meiotic division is rather irregular. In nearly all the pollen mother cells one tetravalent and three bivalents are

observed. The remaining cells have two tetravalents and one bivalent. The association in these tetravalents is rather loose. In the anaphase of the first and second divisions many chromosome segments are observed remaining in the equatorial plate.

F_4 -44 Ten chromosomes are counted in the root-tip cells. In the meiotic division at least one tetravalent is observed in almost all the pollen mother cells. Often one bivalent and two tetravalents are observed. In such a case one tetravalent is of chain configuration and the other is of cross configuration. But the association of the component chromosomes is quite loose, showing that there are little affinities between these chromosomes.

F_4 -45 Ten somatic chromosomes are counted in the root-tip cells. In the meiotic division one tetravalent is always observed.

F_4 -47 Ten chromosomes are counted in the root-tips. One chromosome has the characteristic long constriction. In accordance with the low fertilities both in male and female gametophytes, the meiotic division proceeds considerably irregularly. In the most pollen mother cells, one or two tetravalents are observed. The configurations of these tetravalents are quite variable: ring, chain or cross configurations are often observed. In some cases a tetravalent and a bivalent are substituted with two trivalents. Such irregularities may cause the uneven distribution of the chromosomes in the daughter nuclei, and thus the sterility of the gametophyte.

F_4 -48 Ten chromosomes are counted in the root-tips, one of which has the long constriction. In the pollen mother cells rather regular meiosis is observed to take place and the separation of the chromosomes in the anaphase seems to be very regular. But in the late diakinesis and early metaphase one tetravalent is regularly observed. The configuration of this tetravalent is of branched one. And it is observed that this tetravalent dissociates into two bivalents, thus having less influence to the fertility of the pollen or the embryosacs.

F_4 -49 The number of the somatic chromosomes is counted as ten in the root-tip cells. The meiotic division of this individual reveals much irregularities in the pairing of the chromosomes. In the late diakinesis the chromosomes are assembling into only two groups, one with four chromosomes and the other with six. These chromosomes associate ordinarily in their terminal portions. In the metaphase, occasionally only two configurations, one of tetravalent and the other of hexavalent are observed, but ordinarily more configurations with fewer component chromosomes are observed. The tetravalent is seen to separate into two bivalents, one bivalent and two univalents or one trivalent and one univalent. The hexavalent is also observed to separate into one tetravalent and one bivalent, one tetravalent and two univalents or one pentavalent

and one univalent.

F₄-50 In the root-tips ten somatic chromosomes are counted, two of which have the long constrictions. In the meiotic division at least one tetravalent is regularly observed. Some 30% of the pollen mother cells have two tetravalents. But one of these tetravalents seems to separate earlier into two bivalents.

F₄-52 Ten somatic chromosomes are counted in the root-tip cells. One chromosome has the characteristic long constriction. The meiotic division is characterized by the presence of a hexavalent or strictly hexapartite chromosomes. Rarely this hexapartite decomposes into three bivalents or into one bivalent and one tetravalent. One of the bivalents often separates into two univalents. These conditions may be the proof that the affinity between the component chromosomes is quite small and may also be one of the causes of the extremely low fertility in male and female gametophytes.

F₄-53 Ten somatic chromosomes are counted in the root-tip cells. Some cells are observed to have 20 chromosomes. In the majority of the pollen mother cells two tetravalents and a bivalent are observed. The types of these tetravalents are much variable: chain, cross or branched configurations are seen. Sometimes one of the tetravalents decomposes into two bivalents and in rare occasions the bivalent associates with one of the tetravalents forming a hexavalent.

F₄-54 In the somatic cells ten chromosomes are observed ordinarily. Some chimera cells with forty chromosomes are observed. Some cells must have twenty chromosomes, but no such were observed owing perhaps to the smallness of the material. In the meiotic division one tetravalent of chain configuration is observed. Rarely two of the remaining bivalents associate into a tetravalent and thus two tetravalents and a bivalent are observed. In the telophase some laggard chromosomes or chromosome segments are observed remaining in the equatorial plates. Such a condition may be the cause of the lower fertility of the pollen.

F₄-55 Ten somatic chromosomes are counted in the root-tips, two of which have long constrictions. In the meiotic division one or two tetravalents are observed. One of the tetravalents is constituted with two bivalents, one of which pairs very loosely and often separates earlier at metaphase. The component chromosomes of the other tetravalent associate very loosely in a chain or rarely in a ring. But occasionally these four chromosomes dissociate into four univalents.

F₄-56 Ten somatic chromosomes are observed in the root-tip cells, two of which have characteristic long constrictions. In the meiotic division at least one tetravalent is observed. The shape of this tetravalent is of chain configuration, and the paired portions are very small. The

affinity between the component chromosomes seems to be very low. One of the bivalents is very capricious. It often associates with the tetravalent forming a hexavalent and sometimes with another bivalent forming another tetravalent. But the association in these hexavalent and tetravalent is quite loose. These are more frequently observed in diakinesis, showing the decomposition in the metaphase.

F₄-57 The somatic chromosome number is ten, one of which has a long constriction. In the meiotic division at least one tetravalent is observed and often there are two tetravalents. The shapes of these tetravalents are of chain configuration.

F₄-60 The somatic chromosomes are ten in number, one of which having the characteristic long constriction. The behavior in the meiotic division is quite peculiar. It is characterized by the presence of a hexapartite. It is clear from the observed configurations that this hexapartite is constituted with a chain of four chromosomes and a semihomologous bivalent, the homologous end is connected with one end of the chain of four. Occasionally a configuration of three bivalents to form a hexapartite is observed.

F₄-63 Ten somatic chromosomes are counted. In the meiotic division one tetravalent and three bivalents are ordinarily observed. Pairing is quite loose in these bivalents, only minute portions of the chromosomes being connected. The tetravalent is composed of a chain of three chromosomes and a branch chromosome attaching to the center chromosome of the chain. Often one of the bivalents is connected to the tetravalent forming a chain of five chromosomes with one branch chromosome. It is noteworthy that this individual is a little self-fertile. Six achenes are obtained after the isolation of five flower heads in paper bags.

F₄-64 Ten somatic chromosomes are counted. In the meiotic division one tetravalent of a chain configuration and three bivalents are observed. Among these bivalents two bivalents pair quite loosely and often dissociate into univalents. The presence of such irregularities may be one of the causes of the extremely low fertility both in male and female gametophyte.

F₄-68 The number of somatic chromosomes is ten, among which one chromosome has the characteristic long constriction. In the meiotic division one or two tetravalents are always observed. These tetravalents pair in rings or in chains, but often decompose into two bivalents showing that the affinity of the component chromosomes is not so strong.

F₄-70 The number of somatic chromosomes is ten. In the meiotic division one tetravalent of Y-type configuration is ordinarily observed, and sometimes two of the bivalents associate to form a tetrapartite chromosomes. The Y-type tetravalent often dissociates into a bivalent and

two univalents. Such a irregularity may cause the low fertility of the pollen.

F₄-71 Ten somatic chromosomes are counted, among which one has the characteristic long constriction. In the meiotic division one tetravalent of ring configuration and three bivalents are ordinarily observed. In one of the bivalents pairing is very loose, and instead of this bivalent there remain two univalents unpaired. They may disturb the even distribution of the chromosomes and may be the main cause of the low fertility and the size fluctuation of the pollen.

F₄-73 Ten somatic chromosomes are counted. In the meiotic division one bivalent and two tetravalents of chain configuration are observed. But the affinity of the component chromosomes of these tetravalents is very small. Some components often remain unpaired as univalents. Sometimes the bivalent and one of the tetravalents are united to form a hexavalent. In the anaphase and telophase many chromosome segments are remaining in the equatorial plate.

F₄-76 Ten somatic chromosomes are observed, one of which has a long constriction. In the meiotic division two tetravalents and a bivalent are observed. In some of the pollen mother cells, one or both of the tetravalents are dissociated into a univalent and a bivalent, showing the small affinity of the component chromosomes. The anaphase separation of the chromosomes seems to proceed rather regularly, and thus the pollen fertility is rather high in spite of the presence of the two tetravalents.

F₄-77 Ten somatic chromosomes are counted. In the half of the pollen mother cells five bivalents are observed and the remaining half cells contain one or two tetravalents. The presence of these tetravalents seems to be the cause of the low fertility of the pollen.

F₄-78 There are ten somatic chromosomes. The meiotic division proceeds rather irregularly as is expected from the low fertilities. In almost all the cells one tetravalent is observed. This tetravalent is ordinarily of chain configuration and is often associated with a bivalent forming a hexavalent or hexapartite chromosomes. Sometimes one of the remaining bivalents dissociates into two univalents. The examination of earlier diakinesis reveals that more chromosomes are associated in a chain in the earlier stages. At metaphase these multivalents are dissociated into tetravalents and bivalents.

F₄-79 Ten somatic chromosomes are counted. In the meiotic division one tetravalent and three bivalents are regularly observed. In one or two of these bivalents very loose pairing is observed.

F₄-80 Ten somatic chromosomes are counted in the root-tips. In the meiotic division a tetrapartite or a tetravalent is always observed.

The configuration of it shows that the homology of the component chromosomes is quite low.

F_4 -86 Ten somatic chromosomes are counted, one of which has a long constriction. In some part of the root-tips chimeral cells with twenty chromosomes are observed. In the meiotic division a hexavalent or a tetravalent is often observed. And in these multivalents the association of the component chromosomes is very loose and sometimes several chromosomes remain unpaired as univalents. The presence of these univalents may be one of the causes of the low fertility of the pollen.

F_4 -87 In the somatic cells ten chromosomes are counted, one of which has a long constriction. In the meiotic division one or two tetravalents are observed. Ordinarily these tetravalents are of chain configuration. The affinities of the component chromosomes in these tetravalents and the bivalents seem to be very weak, paired portions being very minute in every configuration. And they often dissociate into univalents prematurely in the later diakinesis.

F_4 -89 Ten somatic chromosomes are observed, one of which has a long constriction. In the meiotic division two tetravalents of chain configuration are frequently observed. Often one of the tetravalents dissociates into two bivalents. In some occasions these bivalents dissociated are seen connected with a fine thread forming a tetrapartite chromosomes. And rarely one tetravalent and one bivalent are associated together to form a hexavalent.

F_4 -92 Ten somatic chromosomes are counted, one of which has a long constriction. In the meiotic division one or two tetravalents are observed. They are ordinarily of chain configuration and are apt to dissociate into bivalents. The presence of these tetravalents may be one of the causes of the lower fertility of the pollen.

F_4 -96 Ten somatic chromosomes are counted, one of which has a long constriction. In the meiotic division various types of chromosome associations are observed, but the tetravalent is apt to dissociate into two bivalents and the trivalents into one bivalent and one univalent. Possible combinations of such tetravalents, trivalents, bivalents and univalents are observed and each cell has a different combination from the other. The separation of chromosomes at anaphase seems to proceed rather irregularly, some laggard chromosomes are observed in the equatorial plate.

F_4 -97 Ten somatic chromosomes are counted. In the meiotic division one tetravalent is always observed. The remaining six chromosomes ordinarily form three bivalents. Sometimes one or two of these bivalents are dissociated into univalents.

F_4 -102 In the root-tip cells eleven chromosomes are observed. This

individual is one of the rare instances of hyperploids among these hybrids. One very small chromosome has a long constriction. This chromosome is clearly of a new type. In the meiotic division two tetravalents and a trivalent are ordinarily observed. One of the tetravalent is of ring configuration and the other a chain one. The chain tetravalent is rarely dissociated into a trivalent and a univalent, or into two bivalents. At anaphase laggard chromosomes or chromosome segments are often observed in the equatorial plate. In the second division such irregularities are frequently observed.

Somatic chromosomes

The somatic chromosomes in the root-tip cells are, in general, ten in number. Only three individuals had 11 chromosomes, while no individuals had the smaller number than ten. The fact that the most individuals have ten chromosomes indicates that the mechanism of preservation of the chromosome number is adequately equipped. As no hyposomic individuals are observed, it may be said that the deficiency of chromatin is more fatal than its duplication. In the previous paper dealing with F_2 individuals each chromosome was distinguished morphologically and identified with any of the parental chromosomes. Individuals with unbalanced combinations of chromosomes were surviving. But it was considered to be questionable that really unbalanced types can still survive. But when many individuals of F_4 were examined, it became clear that the chromosomes of these individuals are not always possible to be identified with any of the parental chromosomes. Some chromosomes are quite new in their morphology. These facts suggest that it is not sufficient enough to identify the chromosomes only from the morphological stand point. Such new chromosomes must be derived from the parental chromosomes by the crossing-over between the semihomologous chromosomes in the heteromorphic bivalents observed in the meiosis of the hybrids. These are apparently observed in the F_4 -2, -11, -16, -21, -26, -29, -46, -47, -90 and -101 plants.

In some individuals certain cells in the root-tip have doubled chromosome numbers. F_4 -38, -53, -54 and 186 are observed to have such chimeral cells. Especially in F_4 -54, beside those with 10 chromosomes one cell was observed to have 40 chromosomes. In these observations no special effort has been made to find such chimeral cells. Although only four individuals were observed by chance to have such irregularity, more individuals with such chimeral cells were expected to be discovered when an intended observations had been made. It is noteworthy that all of these individuals show low fertility of the pollen. But it is not clear that the low fertility is caused by the chimeral condition.

Plant	F_4-38	F_4-53	F_4-54	F_4-86
Pollen fertility (%)	43	69	62	47
The rate of achene setting (%)	84	67	90	91

It may be said rather safely that the chromosome doubling is observed somewhat frequently in these individuals. It seems probable that the genic double nature of the somatic nucleus is apt to recover by the chromosome doubling in such hybrids.

Meiotic division

Although meiotic division proceeds quite regularly in the F_1 individuals of the present hybrids, many meiotic irregularities are met with in the present F_4 material. In 25 individuals that is about one fourth of the material plants used, meiotic division proceeds quite regularly as in the F_1 individuals. In the metaphase of the first division of these individuals five tightly paired bivalents are always observed. The second division also proceeds quite regularly with no lagging chromosomes or no uneven distribution of chromosomes. These individuals have very high fertility, both the percentage of good pollen and the rate of the achene setting being more than 90%. In 16 individuals, five bivalents are observed normally in diakinesis. But at metaphase the partners of one or two of these bivalents are separated prematurely. This separation takes place after the bivalent has been brought to the equatorial plate or when it is quite close to the plate. Therefore the separation of chromosomes at anaphase shows no irregularity at all. Thus no uneven distribution of chromosomes may take place.

Such premature separation indicates that there is less affinity between the partners of this bivalent. It is noteworthy that the pollen fertility of such individuals is not influenced so much by this irregularity, but on the contrary the rate of the achene setting is very much influenced.

When the partners of the bivalents have less affinity than in the above mentioned bivalents, they may remain as two univalents instead of forming the prematurely separating bivalent. Two individuals had univalents as early as in middle diakinesis. These univalents may become the causes of uneven distribution of chromosomes, and seem to reduce the fertility of both pollens and embryosacs. They give influences especially to the pollen fertility as the multivalents do. In 8 individuals, some chromosomes were observed to have no affinity at all with other chromosomes among the somatic sets, and thus they are compelled to remain as univalents from the beginning and cause meiotic irregularities in abundance.

About one third of the F_4 individuals are found to have many multivalents such as tetravalents, hexavalents or trivalents. The components of such multivalents are by no means homologous chromosomes considering from their external morphology, but as they pair they seem to be homologous in some small portions. The configuration of such multivalents seems to be very variable. The positions of connection and the constitution of the configuration are very variform. Chains are observed most frequently. Cross configurations with interstitial chiasmata, ring configurations with terminal chiasmata or branched configurations are often observed. Some of such multivalents cause uneven distribution of chromosomes and will surely cause the low fertility especially of the pollen.

A more complicated type is observed in such individuals where both multivalents and loose bivalents are observed. In the pollen mother cells which contain multivalents pairing of the component chromosomes is very loose. As a rule the remaining chromosomes form loose bivalents. In ten individuals the pairing is so loose that irregularities in the chromosome separation are caused.

As mentioned above irregularities of several types are observed in the metaphase of the first division, but in the anaphase of the first and in the second division there are much less irregularities. Even in the individual in which tetravalents, hexavalents are observed abundantly in diakinesis, many of these multivalents are dissociated into bivalents in metaphase and later stages. And thus the later stages become more regular. In rare occasions several laggard chromosomes or chromosome segments remaining in the equatorial plate are observed in the anaphase of the first and second division. But the frequency of irregularities in the later stages is much lower than that in diakinesis or metaphase of the first division. Micronuclei are rarely formed. Even in such occasions where the sizes of the pollen is various, the tetrad is formed rather normally and the size difference of the pollen seems to be determined during the course of their development.

It is noted especially concerning the mode of chromosome pairing. We can distinguish pairing types described above but the frequencies of the multivalents or univalents are markedly variable even in one individual. And the component chromosomes of the multivalent are often exchanged e.g. in some cases the sat-chromosome is a component of a tetravalent but in the other cases not. The paired portions of these multivalents also vary with the configuration. This gives impression as if the homologous segments lie scattered in several other parts of the same or other chromosomes.

The consideration on the relation between these irregularities and the fertilities and also the full discussion on all the results described above

will be given in the following papers.

Summary

1) Somatic chromosomes and meiotic divisions of 97 F_1 individuals of *Paraixeris denticulata* and *Crepidiastrum platyphyllum* were examined.

2) In many individuals the somatic chromosome number was 10. Only three had 11 chromosomes. In the root-tips of four individuals polyploid cells were observed besides the diploid ones. In some individuals new types of chromosomes were observed.

3) In the meiotic division some individuals had bivalents only. But in the others multivalents or prematurely separating bivalents were observed in abundance. The forms of the multivalents and the component chromosomes of them were quite variable even in one individual. More multivalents were observed in the earlier diakinesis than in the metaphase.

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