Supplemental material 4.5. Three meiotic models explaining how multiple cross-over events within a homeologous chromosome arms may have led to secondary tetrasomic segregation and double-reduction observed in female Rbt-Yct F1 hybrid gametes. A homeologous chromosome pair (chromosome 1 in light and dark blue shades and chromosome 2 in light and dark orange shades) derived from a rainbow trout (solid line and lighter color shades) and cutthroat trout (dashed line and darker color shades) are shown in an individual. Centromeres are indicated by an ellipse (R = rainbow trout, Y = cutthroat trout). Locus subscripts indicate chromosome origin and species phase. The model incorporates empirical data from F1 hybrids.
5a. Meiotic model explaining the occurrence of three double-reduction gametes that had recombinant centromere pairs: two crossover events within a homeologous chromosome arm followed by adjacent disjunction

1. Homologs pair first and recombine

1. Two rainbow trout (R₁ and R₂) and two cutthroat trout (Y₁ and Y₂) chromosomes are shown. Chromosome arms containing locus C and D are homeologs; the region inside dashed boxes are undifferentiated (locus D is duplicated) and the region between the centromere and dashed box are differentiated (locus C is duplicated). Locus A and B are non-duplicated and reside on chromosome arms that are not usually homeologs. Homologs (Rᵅ/Y₁ and Rᵅ/Y₂) pair first and may recombine anywhere. Homologous R₁ and Y₁ chromatids cross-over between the centromere and the duplicated locus C₁ within the homeologous chromosome arm.

2. Pairing of homeologs and recombination

2a. Homeologs pair in distal chromosome regions. The preferential pairing of homeologs occurs between the Y₁ chromatid that crossed-over in panel 1 and the Y₁ homeolog, and occurs between the R₁ chromatid that crossed-over in panel 1 and the R₅ homeolog.

2b. Homeologs recombine. Our empirical data for three female gametes having double-reduction at the homeologous pairing RYHyb12q-RYHyb13q is consistent with this series of cross-over events within the homeologous chromosome arms.

3. Adjacent disjunction of homologous paired centromeres

3a. Two meiosis I daughter cells from panel 2b are shown following adjacent disjunction.

3b. One gamete, 4a.3, has the double-reduction Dᵅ/Dᵅ at the duplicated locus D. This gamete is representative of three female gametes having double-reduction at distal duplicated loci non-parental centromere pairs at the homeologous pairing RYHyb12q-RYHyb13q. In gamete 4a.3, two recombination events have occurred on chromosome Y₁ within the homeologous arm; one event resulted in a homologous exchange with R₁ and the second event resulted in a homologous exchange with R₂.

The model presented here indicates that one daughter cell can produce four gametes that each have distinct inheritance patterns for undifferentiated distal duplicated loci. Locus D exhibits disomic segregation in 4a.1, secondary tetrasomic segregation in 4a.2, double-reduction in 4a.3, and gamete 4a.4 has a homeologous exchange on each chromosome (locus Dᵅ has crossed over to chromosome Y₁ and locus Dᵅ has crossed over to chromosome R₂).
5b. Meiotic model explaining the occurrence of one double-reduction gamete that had a recombinant centromere pair: two crossover events within a homeologous chromosome arm followed by alternate disjunction.

1. Two rainbow trout (R₁ and R₂) and two cutthroat trout (Y₁ and Y₂) chromosomes are shown. Chromosome arms containing locus C and D are homeologs; the region inside dashed boxes are undifferentiated (locus D is duplicated) and the region between the centromere and dashed box are differentiated (locus C is duplicated). Locus A and B are non-duplicated and reside on chromosome arms that are not usually homeologs. Homologs (R₁/Y₁ and R₂/Y₂) pair first and may recombine anywhere. Homologous R₁ and Y₂ chromatids cross-over between the centromere and the duplicated locus C₂ within the homeologous chromosome arm.


3. Alternate disjunction of homologous paired centromeres

4. Sister chromatids assort into gametes

4a. Four possible gamete types for panel 3a daughter cell. Gamete 4a.4 has the double-reduction D₁₁/D₂₂ at the duplicated locus D. This gamete is representative of one female gamete having double-reduction at distal duplicated loci non-parental centromere pairs at the homeologous pairing RYHyb12q-RYHyb13q.

In gamete 4a.4, one recombination event has occurred on each chromosome within the homeologous arm pair. Chromosome Y₁ shows a distal homeologous exchange involving duplicated locus D and chromosome R₁ shows one homologous exchange between the centromere and the duplicated locus C.

Under this model, daughter cell 3a also produces one gamete showing secondary tetrasomic segregation at duplicated locus D (4a.3, D₁₁/D₂₂) and two gametes that exhibit disomic segregation at locus D (4a.1 and 4a.2).
5c. Meiotic model explaining the occurrence of two gametes showing secondary tetrasomic segregation that had three crossover events within a homeologous chromosome arm pair followed by alternate disjunction

1. Two rainbow trout (R₁ and R₂) and two cutthroat trout (Y₁ and Y₂) chromosomes are shown. Chromosome arms containing locus C and D are homeologs; the region inside dashed boxes are undifferentiated (locus D is duplicated) and the region between the centromere and dashed box are differentiated (locus C is duplicated). Locus A and B are non-duplicated and reside on chromosome arms that are not usually homeologs. Homologs (R₁/Y₁ and R₂/Y₂) pair first and may recombine anywhere. R₁ and Y₁ homologous chromatids cross-over between the centromere and the duplicated locus C₁, and R₂ and Y₂ homologous chromatids cross-over between the centromere and the duplicated locus C₂ within the homeologous chromosome arm.


2a. Preferential pairing occurs between the homeologous Y₁ and Y₂ chromatids that experienced a homologous crossover in panel 1. The homeologous R₁ and R₂ chromatids that experienced a homologous crossover in panel 1 also preferentially pair.

2b. Homeologs recombine. Our empirical data for one female gamete showing secondary tetrasomic segregation at the homeologous pairing RHYyb12q-RHYyb13q is consistent with this series of crossover events within the homeologous chromosome arm.

3. Alternate disjunction of homologous paired centromeres

3a. Two meiosis I daughter cells from panel 2b are shown following alternate disjunction.

4. Sister chromatids assort into gametes

4a.1. Four possible gamete types for each panel 3a daughter cell. Gamete 4a.3 exhibits secondary tetrasomic segregation at the duplicated locus D (D₁/D₂). This gamete is representative of two female gametes exhibiting secondary tetrasomic segregation at distal duplicated loci at the homeologous pairing RHYyb12q-RHYyb13q. In gamete 4a.3, three recombination events have occurred within the homeologous chromosome arm pair. Chromosome R₁ shows one homologous exchange and chromosome Y₂ shows one homologous and one homeologous exchange. Under this model, daughter cell 3a also produces one gamete having double-reduction at the duplicated locus D (4a.4, D₁/D₂) and two gametes that exhibit disomic segregation at locus D (4a.1 and 4a.2).