


Brassica Allotriploids Hybrids: New Way to Exceed Recombination Limits for COs Rate and Distribution



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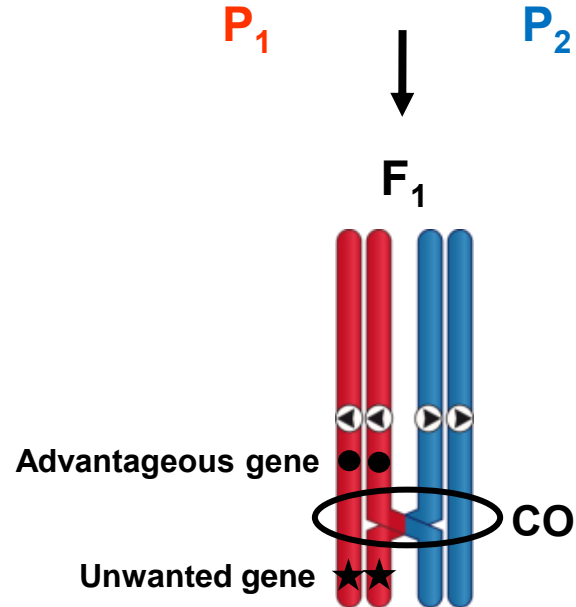
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What is the interest of Crossovers(COs)? What about their frequency and distribution?

INTEREST IN PLANT BREEDING

Essential for mixing genetic diversity

(Wijnker and De Jong, 2008)

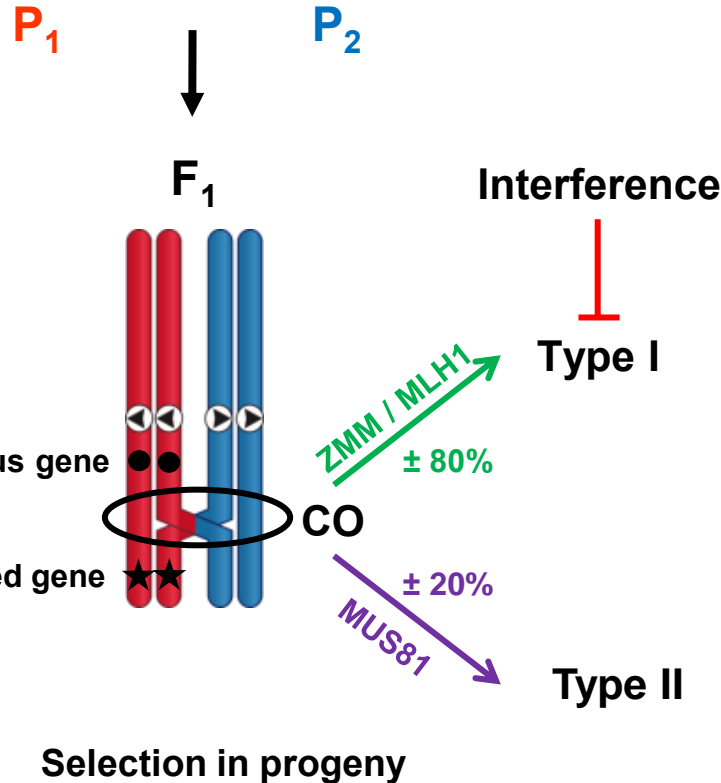


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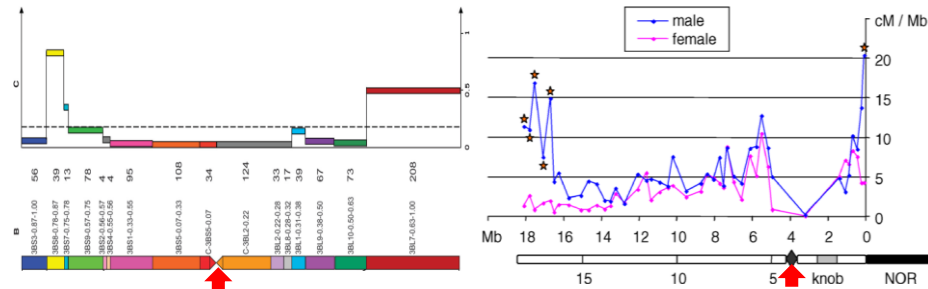
(Wijnker and De Jong, 2008)



(Mercier *et al.*, 2014)

HOWEVER:

- Rarely more than 2 COs per chromosome and per meiosis
- Non homogenously distributed along the chromosomes (Mézard *et al.*, 2007)



CO distribution along wheat 3B chromosome and Arabidopsis 4 chromosome

(Drouaud *et al.*, 2007 ; Saintenac *et al.*, 2007)

- ➔ Depends of the chromosome conformation
No CO in the vicinity of centromeric regions

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BREEDING CONSTRAINTS:

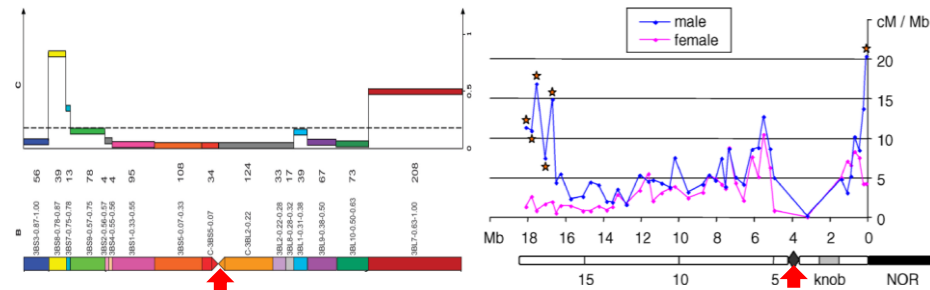
- Large progenies
- Impossibility to separate some genes

INTEREST:

To control the number and distribution of COs events

HOWEVER:

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CO distribution along wheat 3B chromosome and Arabidopsis 4 chromosome

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Progenies selection

(Mercier *et al.*, 2014)

Why oilseed rape is a good model for studying COs?



- 1st oleaginous species in Europe and 4th in the world (64,8 Mt)
 - Use for: Oil production & Seed cake
- (FAOSTAT, 2012)



***B. rapa* AA,
2n=20**

(Wang *et al.*, 2011)

X



***B. oleracea*
CC, 2n=18**

(Liu *et al.*, 2014)



***B. napus*
AACC, 2n=38**

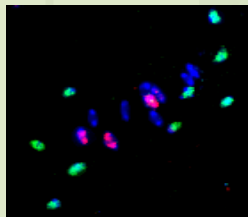
(Chalhoub *et al.*, 2014)

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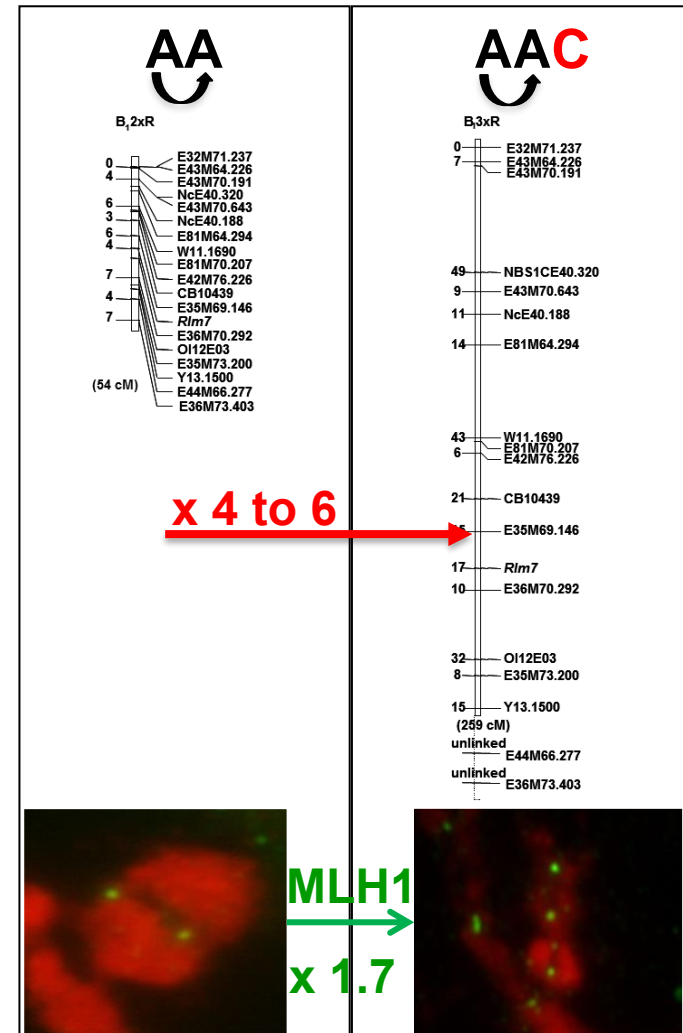
Recombination rate between homologous A07 chromosomes increase in AAC (2n=29) compare to AA (2n=20) hybrids



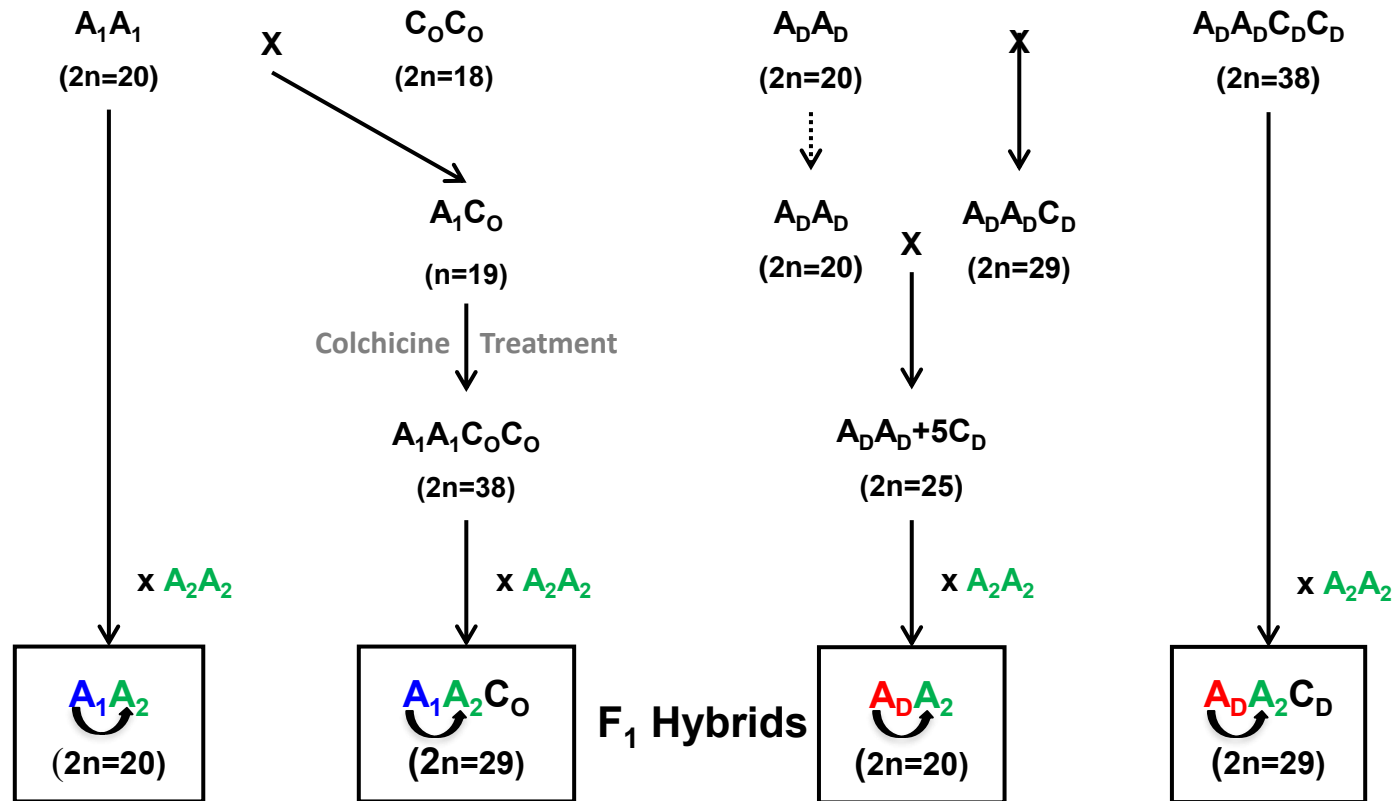
(Leflon *et al.*, 2010)

QUESTIONS

- What about the CO frequency and distribution between the 10 homologous A chromosomes?
- What the impact of male and female meiosis?

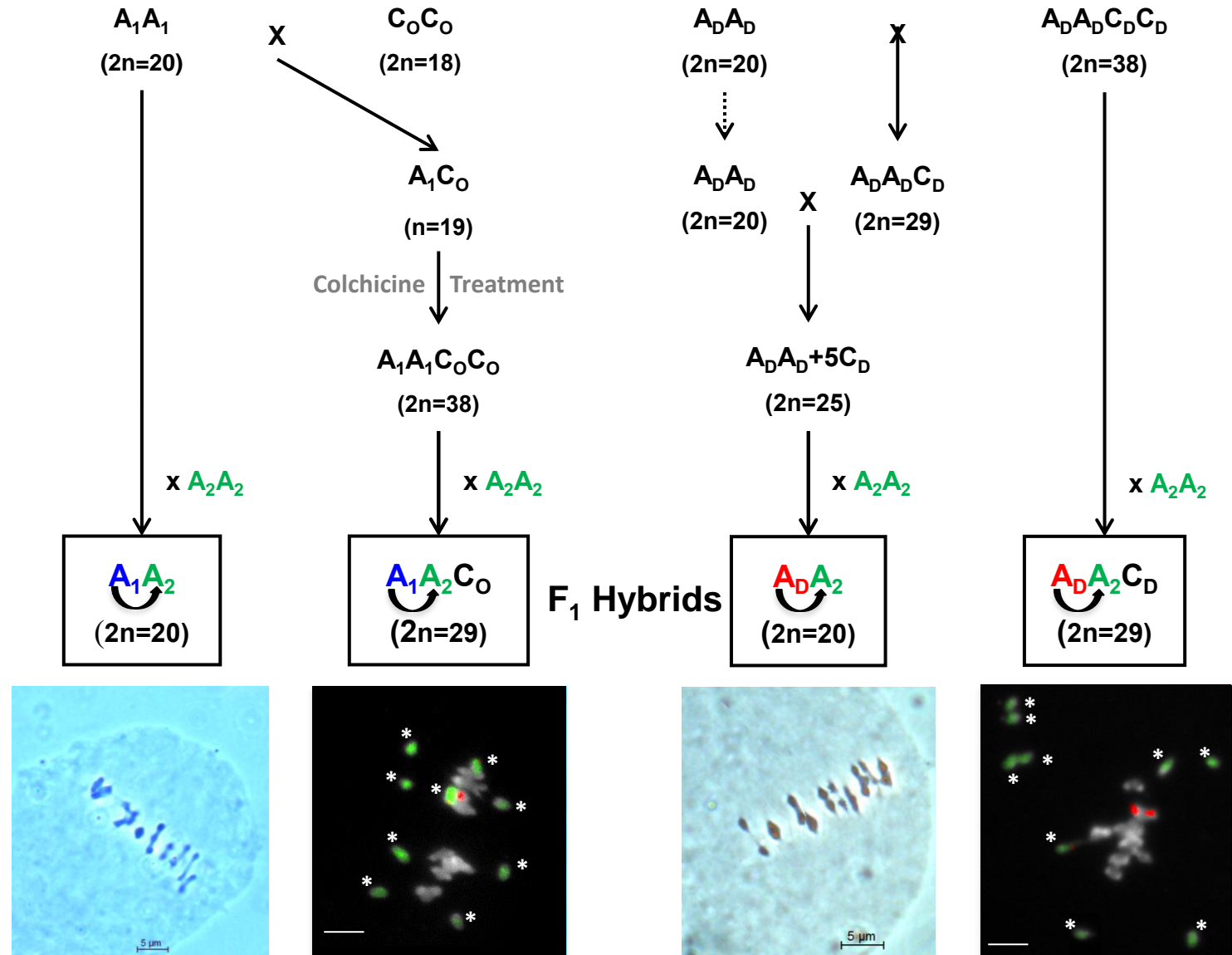


F1 hybrids production for recombination analysis on A genome in AA and AAC hybrids



A_1A_1 and A_2A_2 represent *B. rapa* cv C1.3 and Chiifu (Sequenced, Wang *et al.*, 2011), respectively. C_0C_0 designates the *B. oleracea* cv (RC34). $A_D A_D C_D C_D$ represents the *B. napus* cv Darmor.

F1 hybrids production for recombination analysis on A genome in AA and AAC hybrids



Selection of polymorphic SNP markers covering the 10 A chromosomes

60 K Illumina Array®
(52127 SNP)

- Polymorphic SNPs between A_2A_2 and A_1A_1 , $A_1A_1C_0C_0$, $A_D A_D$, $A_D A_D C_D C_D$

1980 SNPs

- SNPs Homogenously distributed along the 10 A chromosomes (Wang *et al.*, 2011)
- Adapted to KASPAR®

214 SNPs

- KASPAR® for F₁ progenies
- Genetic mapping at 2pt LOD > 3
- Genetic mapping = physical location

204 SNPs



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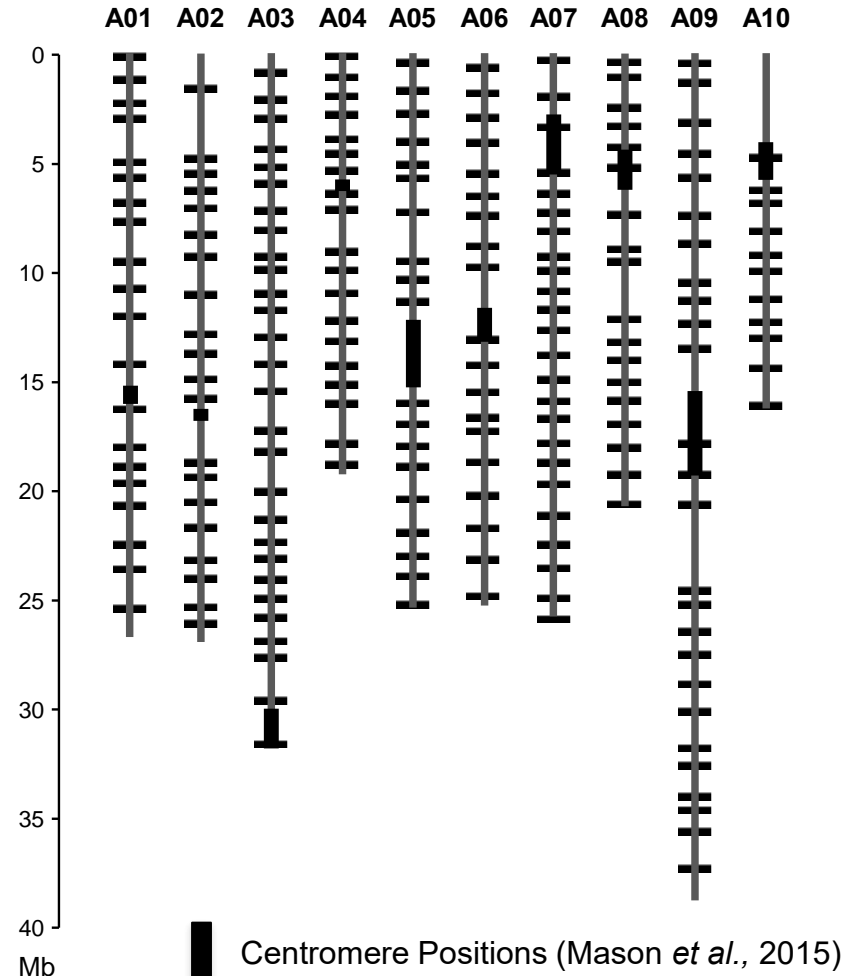
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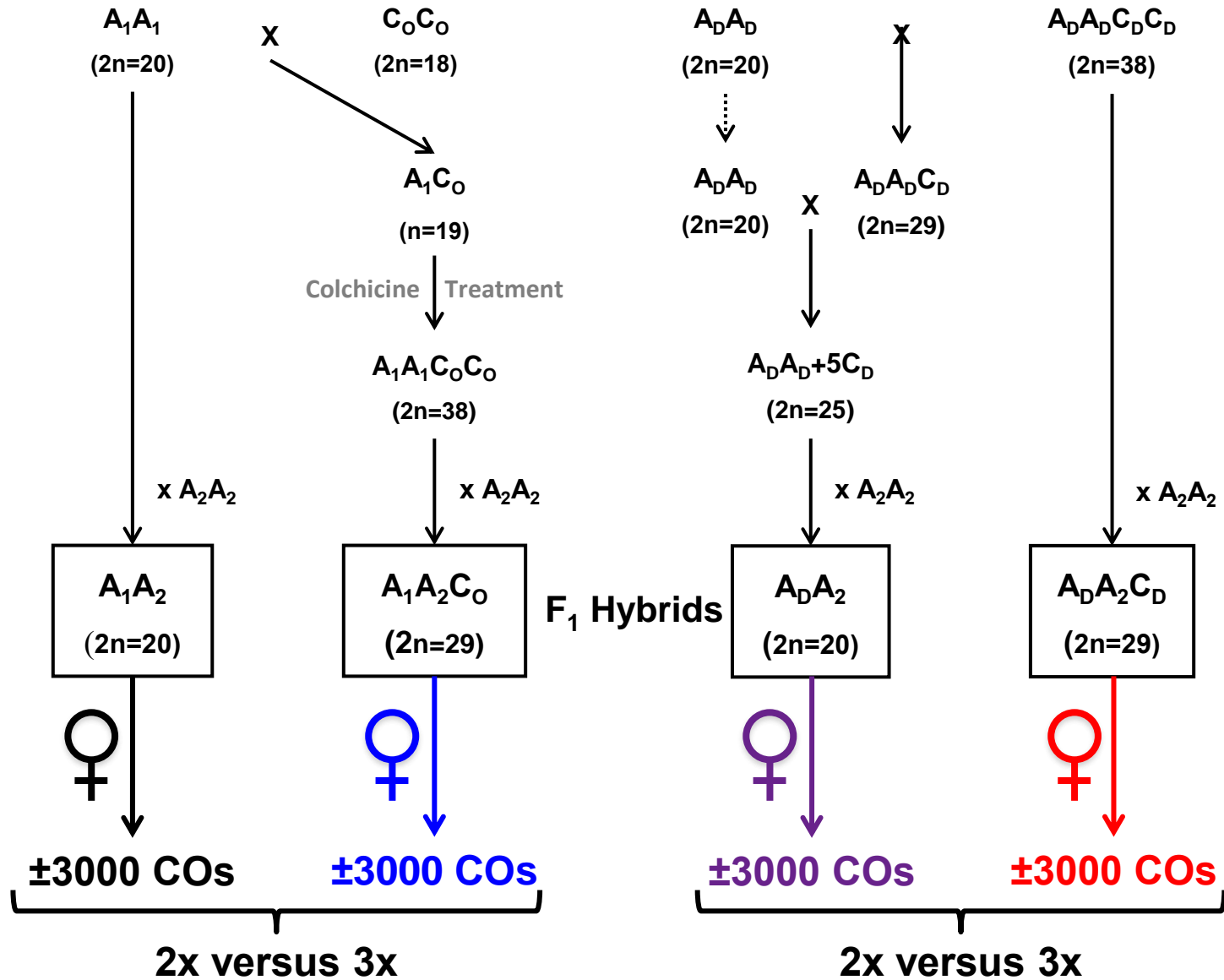
- KASPAR® for F_1 progenies
- Genetic mapping at 2pt LOD > 3
- Genetic mapping = physical location

204 SNPs



1 SNP / 1.25 Mb
(Var = 0.35 ; σ = 0.59)
Recovering 94% of A genome

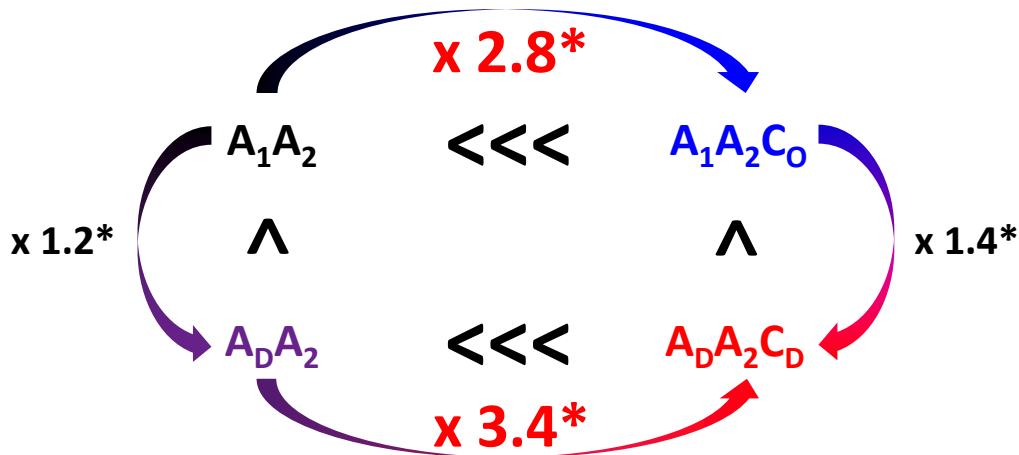
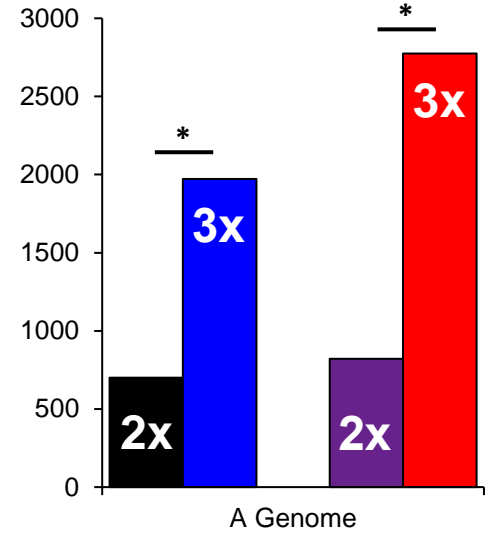
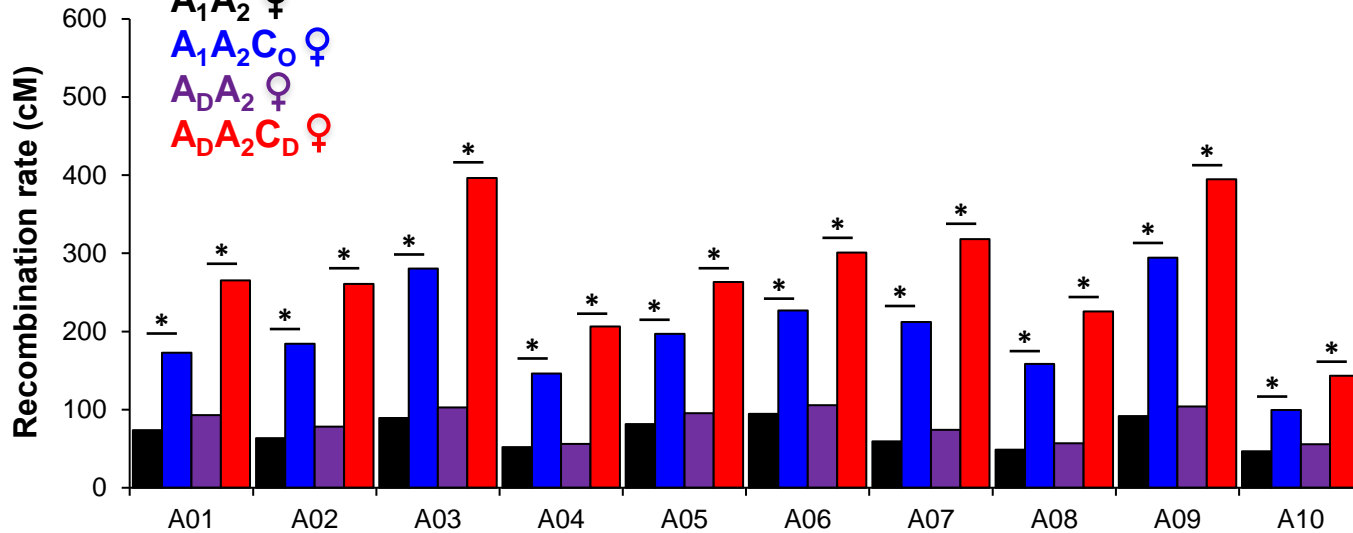
What about frequency and distribution of COs in AA vs AAC hybrids?



What about **frequency** and distribution of COs in AA vs AAC hybrids?

* χ^2 test ($\alpha=0.01$)

A_1A_2 ♀
 $A_1A_2C_0$ ♀
 $A_D A_2$ ♀
 $A_D A_2 C_D$ ♀

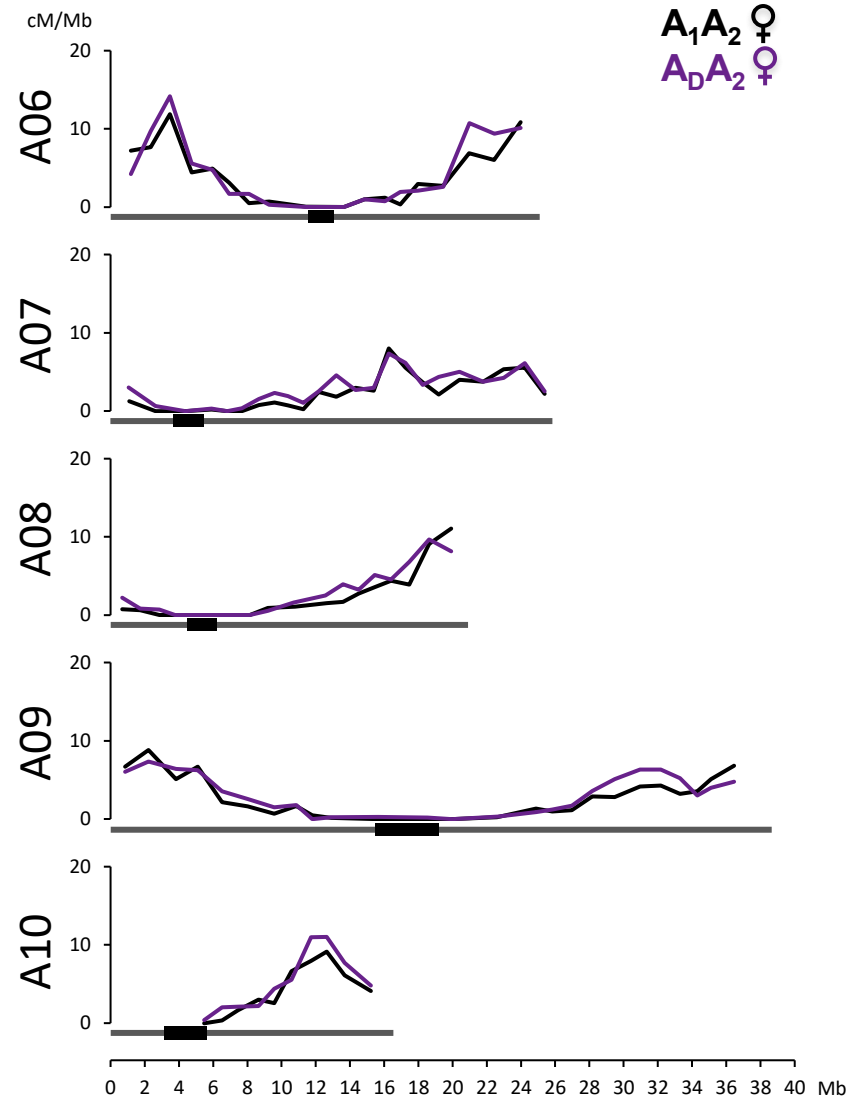
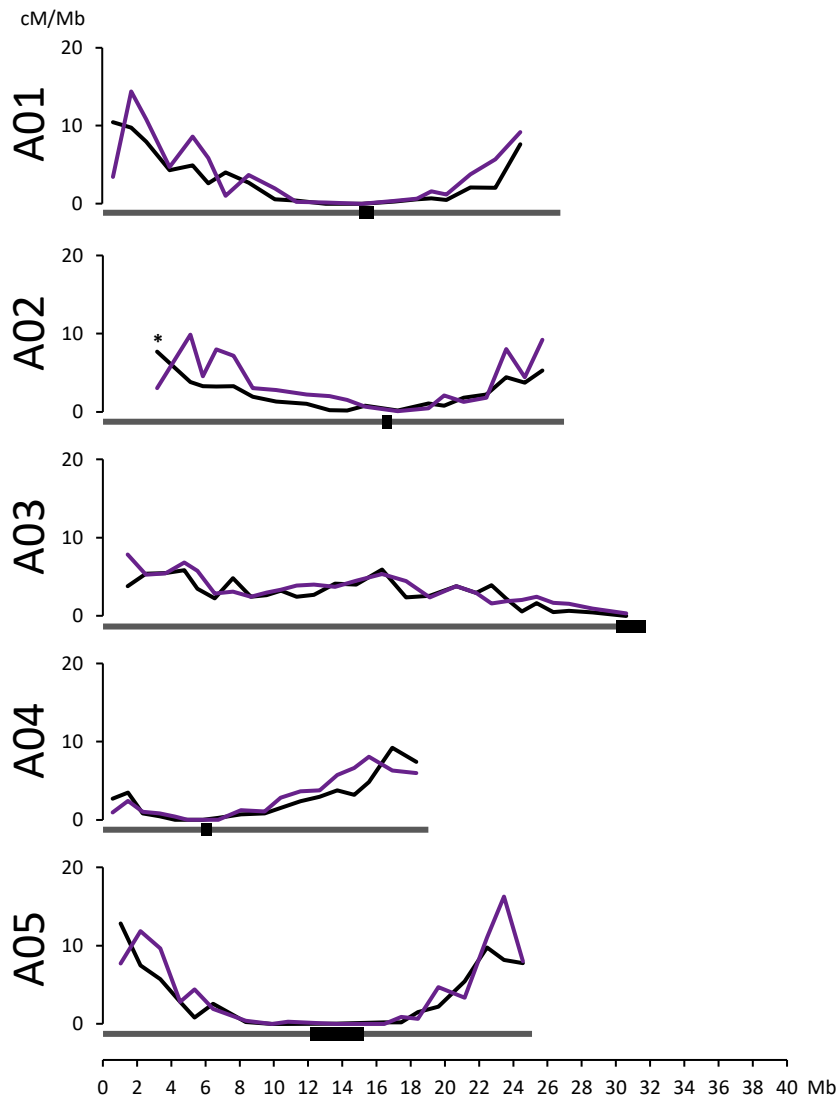


CO frequency always AAC >>> AA between all homologous A chromosomes

Genetic background can affect recombination rate, particularly in AAC hybrids

What about frequency and **distribution** of COs in AA vs AAC hybrids?

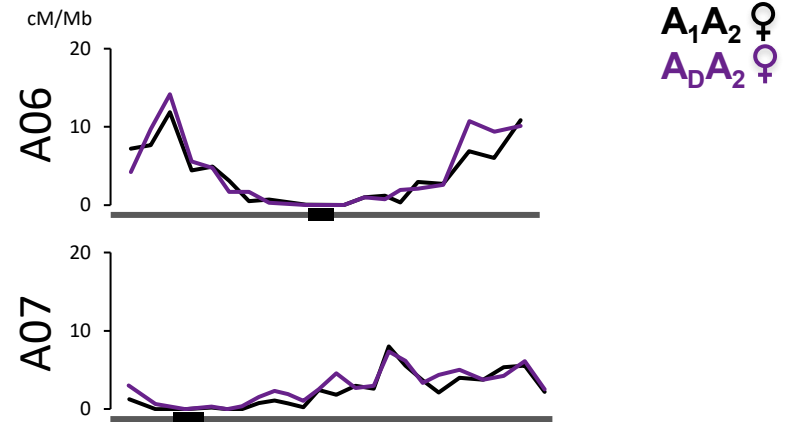
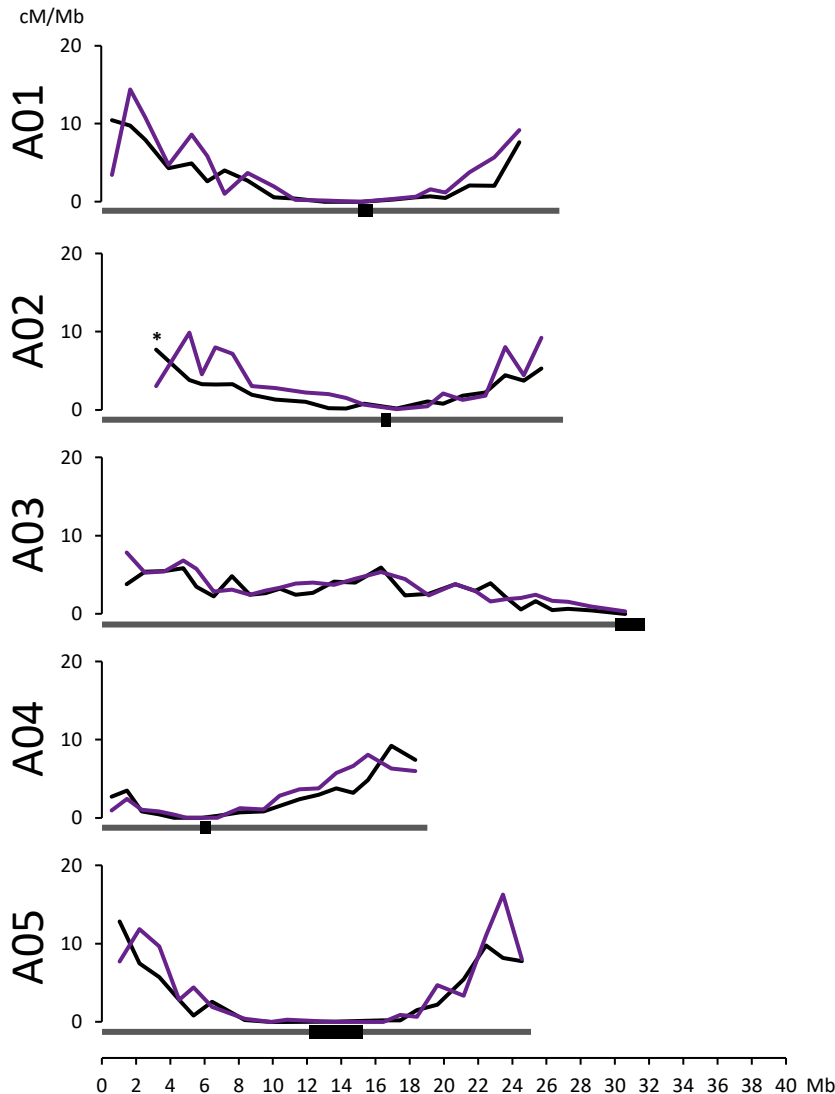
* χ^2 test (0.05)



A_1A_2 ♀
 $A_D A_2$ ♀

What about frequency and **distribution** of COs in AA vs AAC hybrids?

* χ^2 test (0.05)



Expected Recombination profile along each homologous A chromosome in AA hybrids

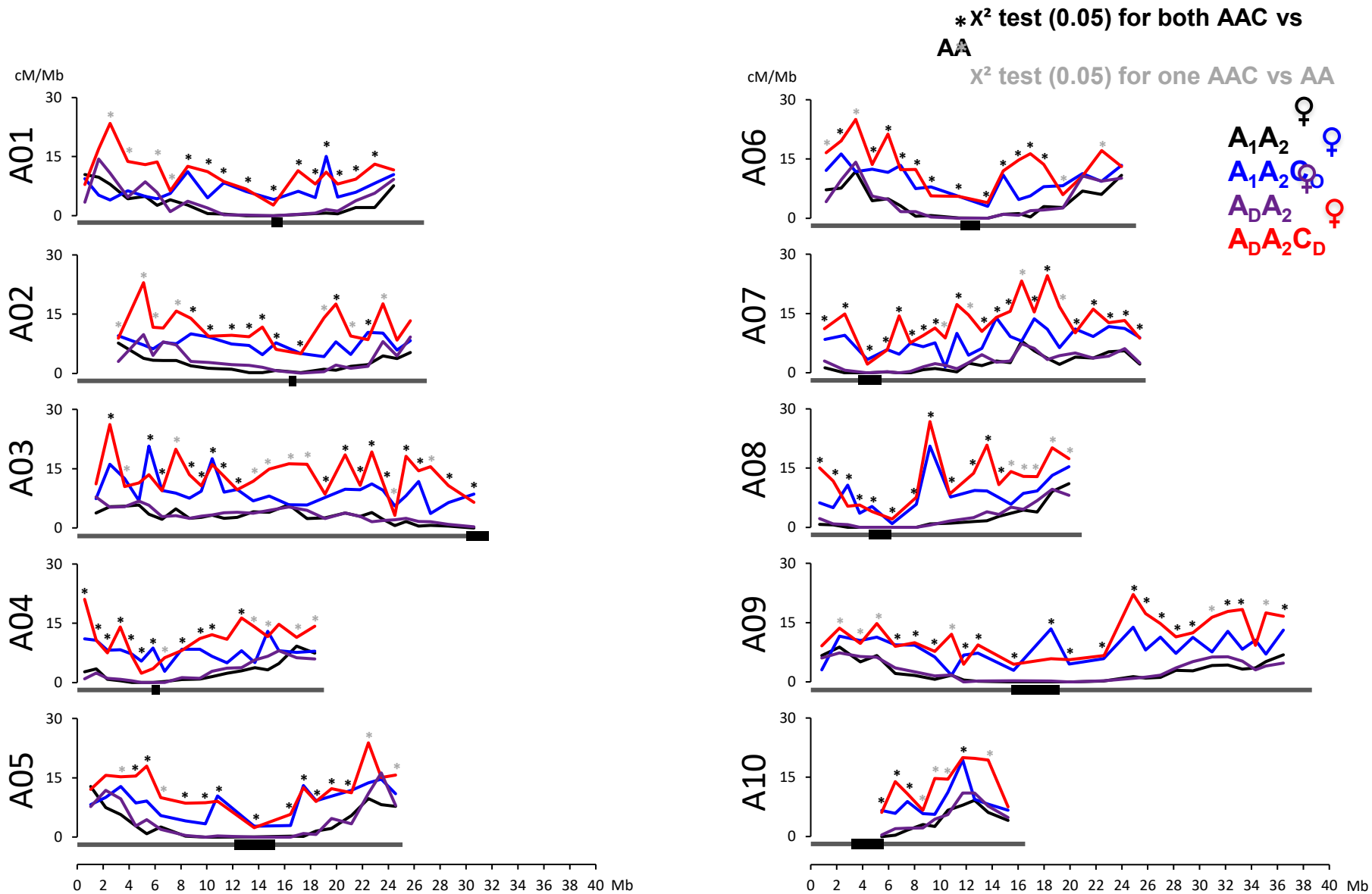
Depending on chromosome conformation

- No CO in pericentromeric regions
- Gradient for CO rate along chromosome arms (Linear regression; $0.4 < R^2 < 0.98$; $p\text{-value} < 0.05$)

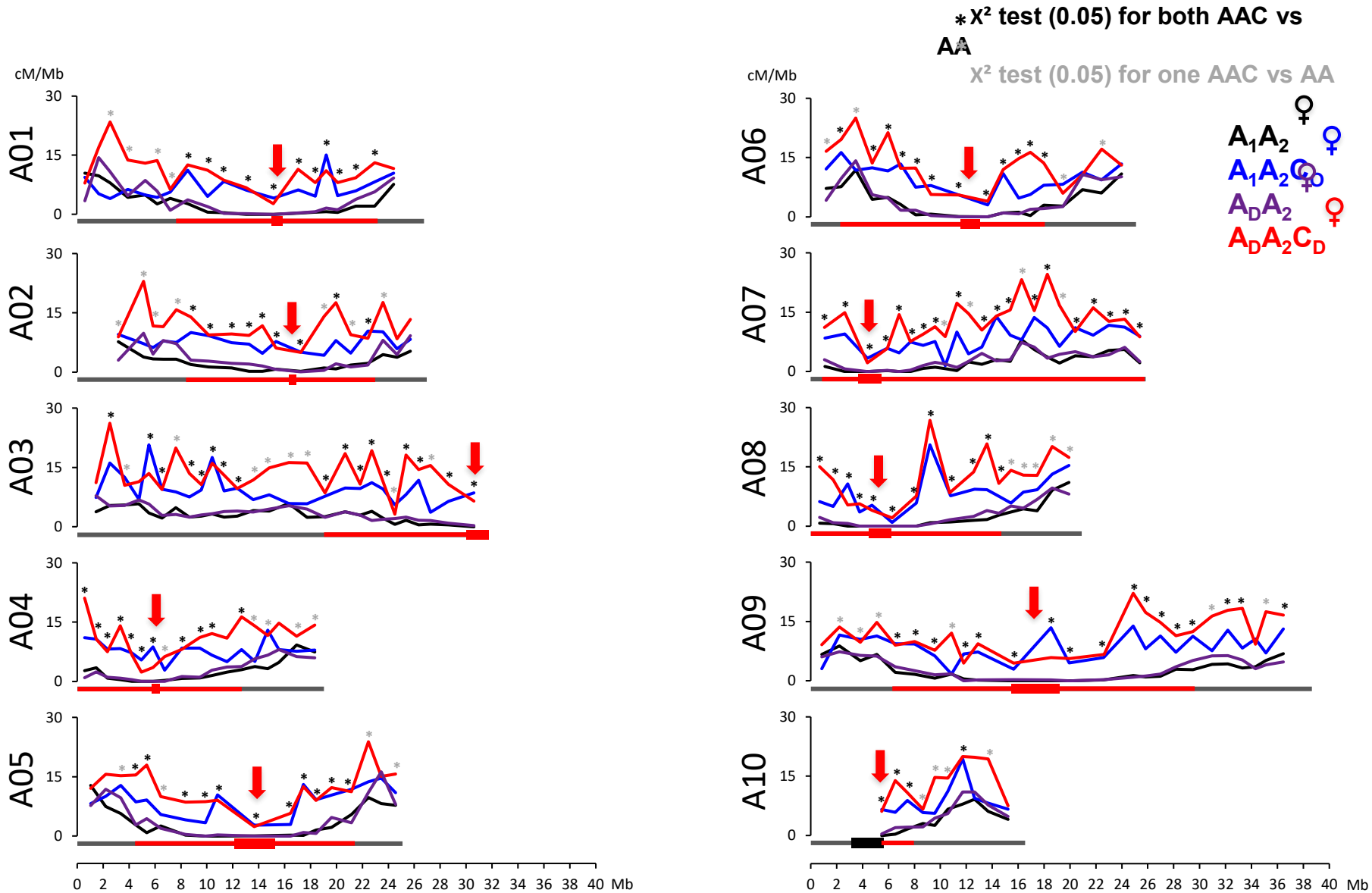
No variation with genetic background

What is going on in AAC hybrids?

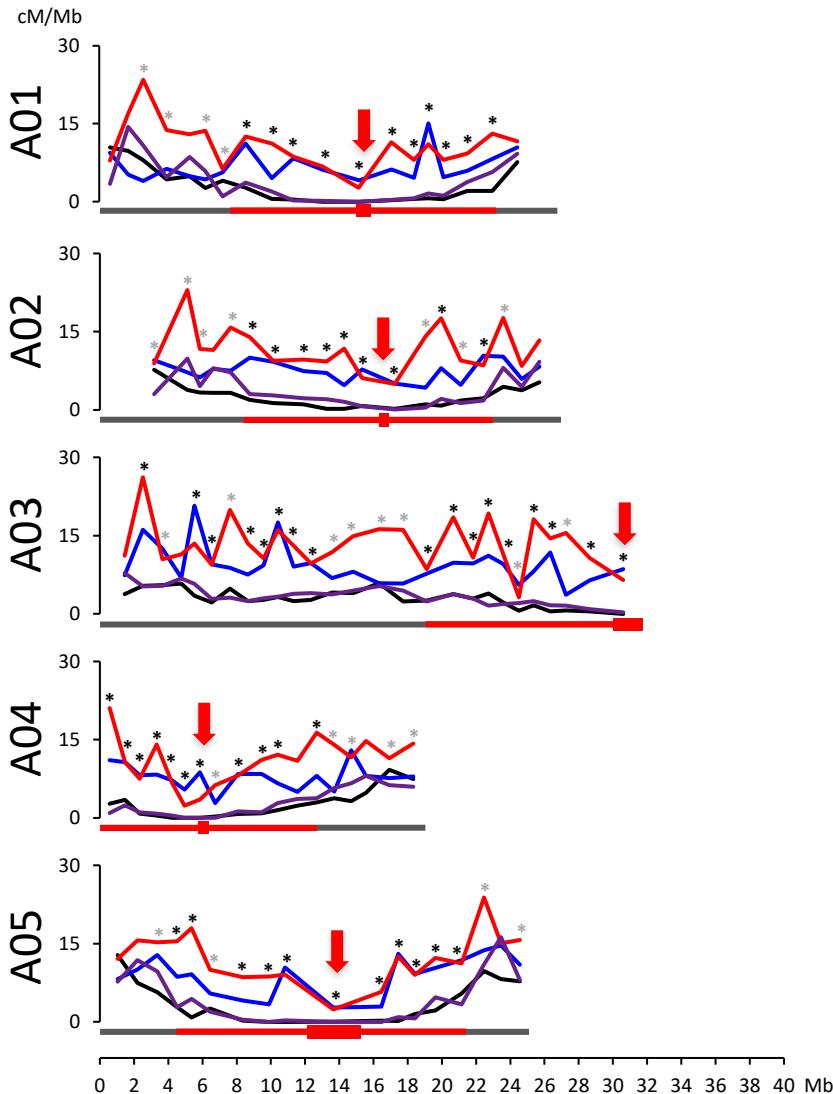
What about frequency and **distribution** of COs in AA vs AAC hybrids?



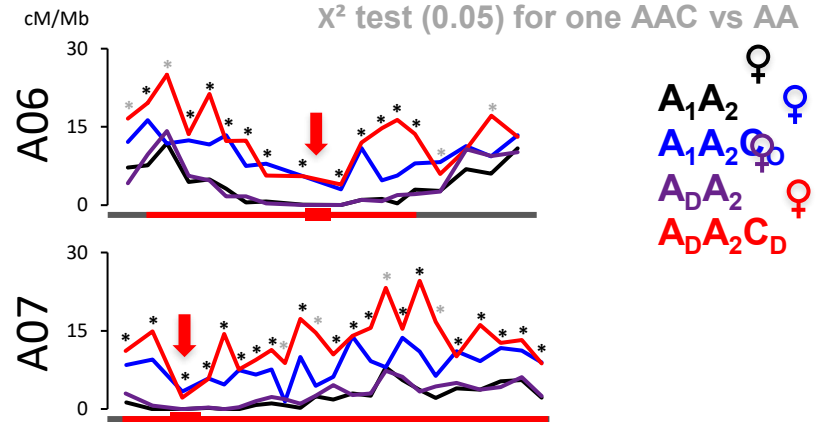
What about frequency and **distribution** of COs in AA vs AAC hybrids?



What about frequency and **distribution** of COs in AA vs AAC hybrids?



* χ^2 test (0.05) for both AAC vs AA



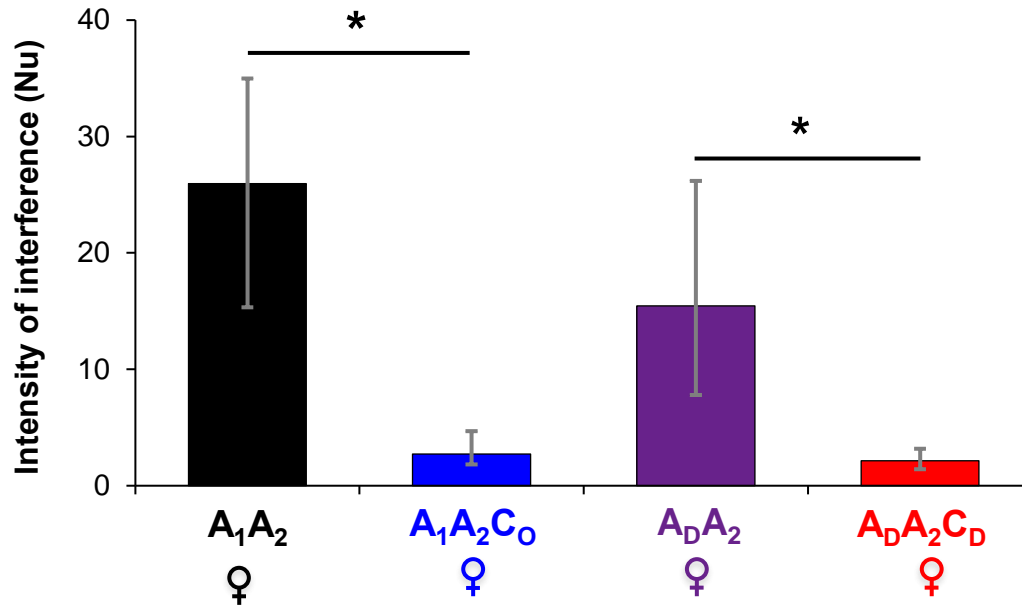
Recombination profiles always AAC \neq AA between each homologous A chromosome

NOT Depending of chromosome conformation

- CO in pericentromeric regions
- No Gradient for CO rate along chromosome arms

Variation between AAC genetic backgrounds, particularly in telomeric regions

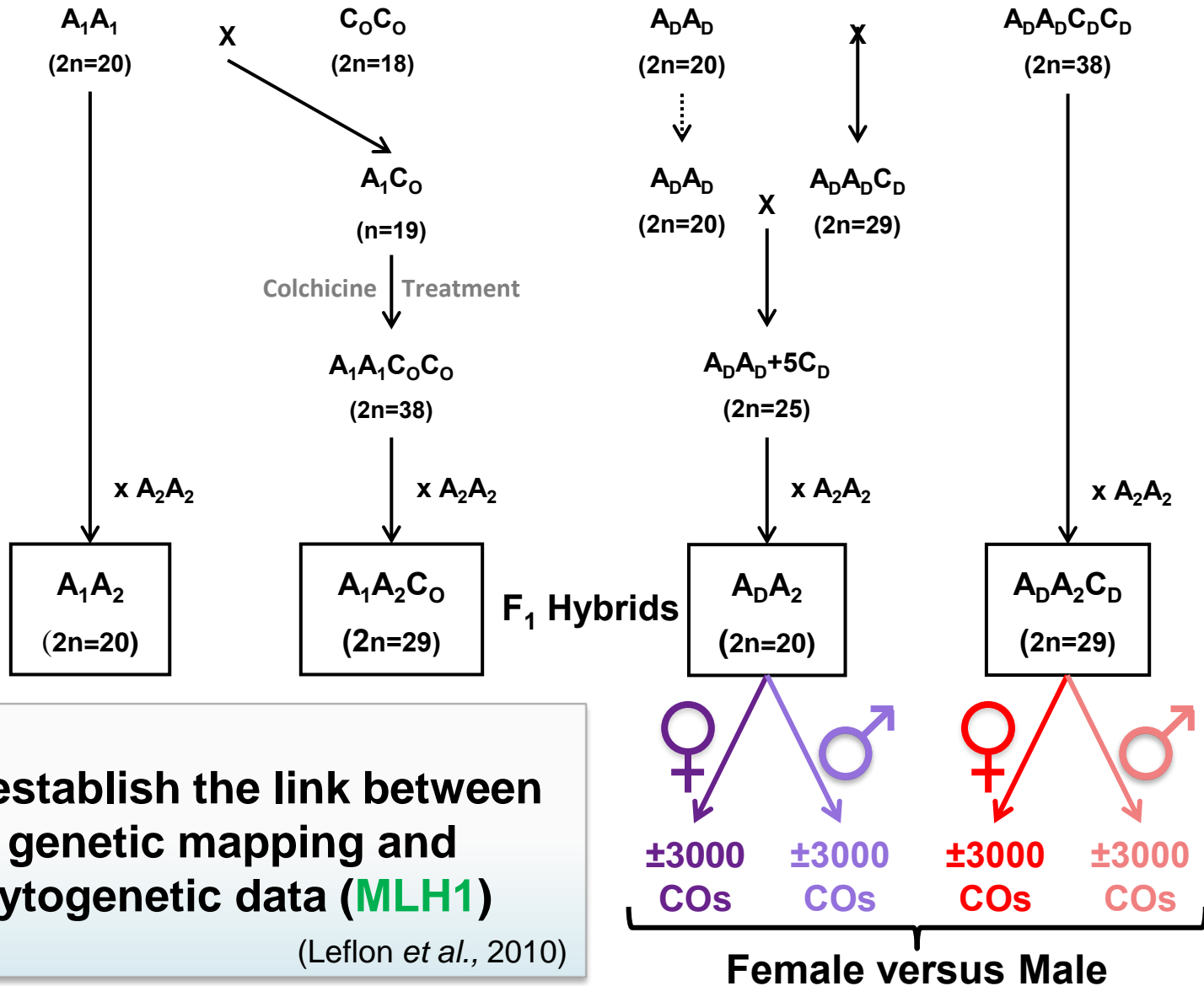
What about **interference** in AA vs AAC hybrids?



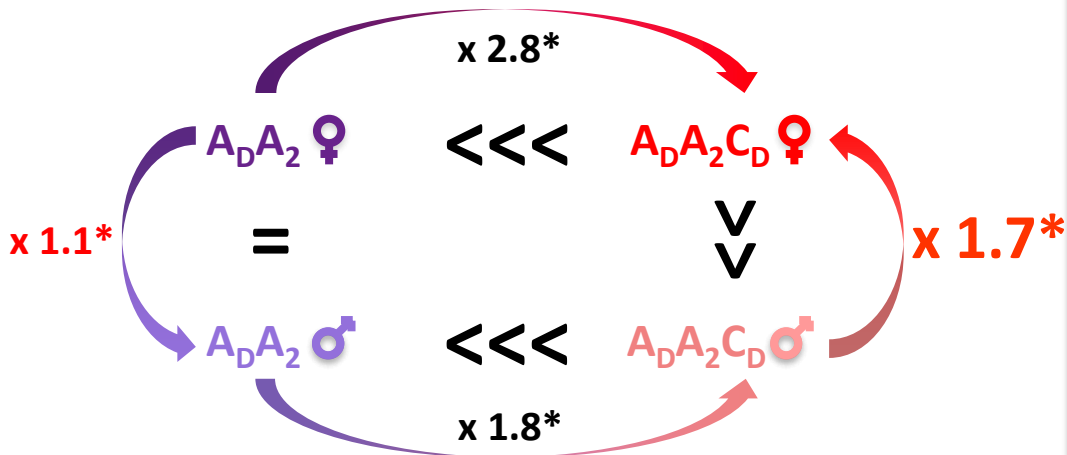
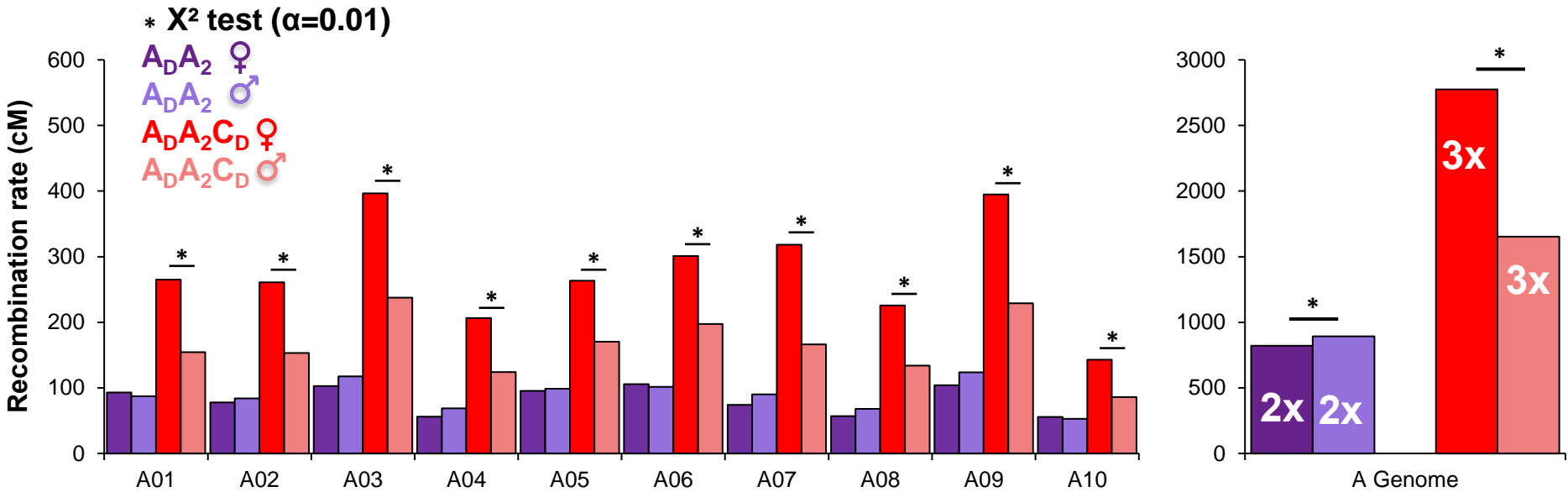
Intensity of interference :
AA >>> AAC
for each homologous A
chromosome

Are the data equal after female or male meiosis?

What about frequency and distribution of COs in male and female meiosis in AA vs AAC hybrids?



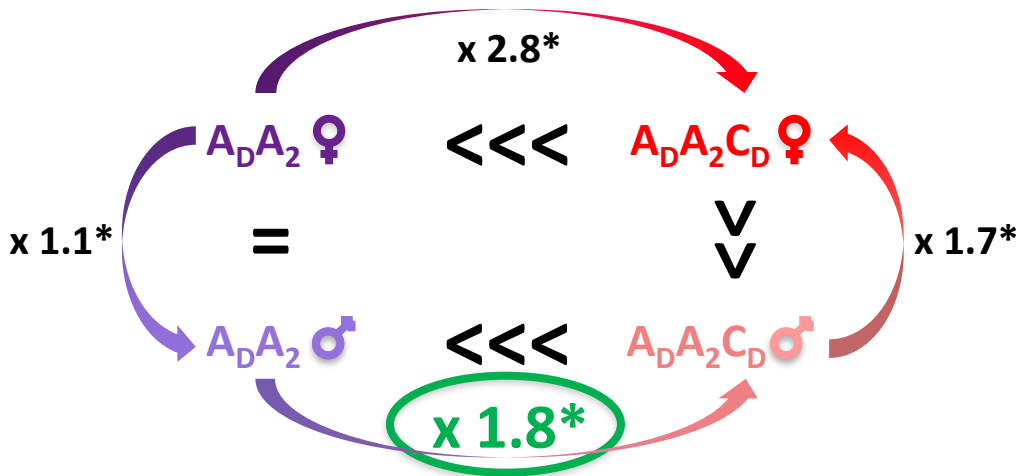
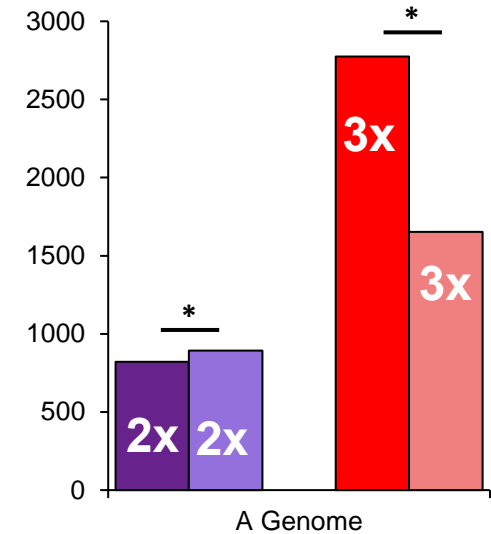
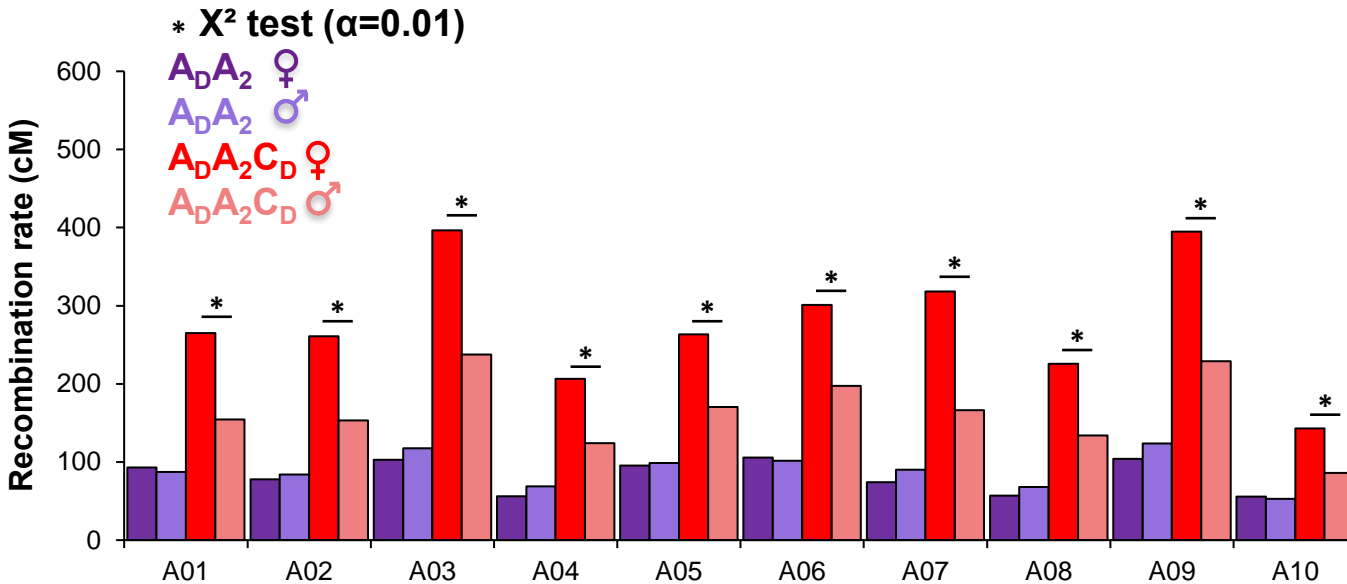
What about **frequency** and distribution of COs in male and female meiosis in AA vs AAC hybrids?



CO frequency:
 AAC male << AAC female
 AA male ~ AA female
 for all homologous A chromosomes

But always AAC >>> AA

What about **frequency** and distribution of COs in male and female meiosis in AA vs AAC hybrids?



AA **BUT!** **AAC**

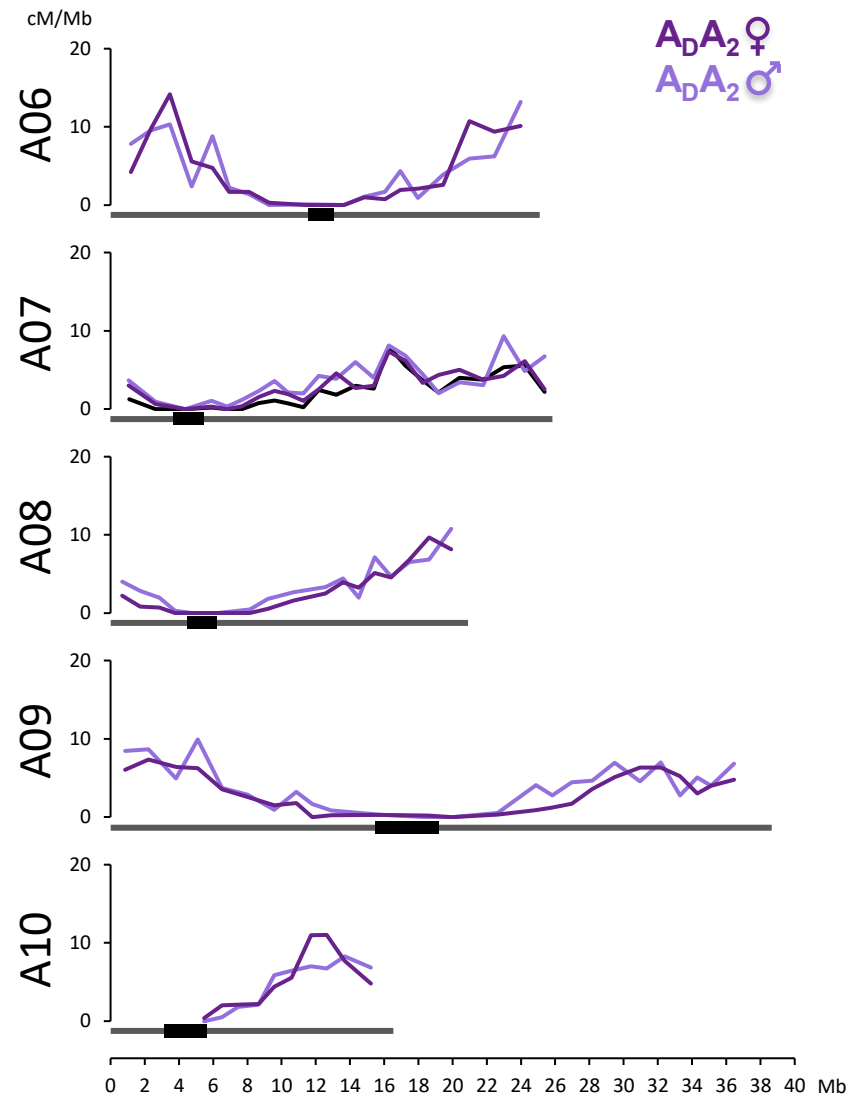
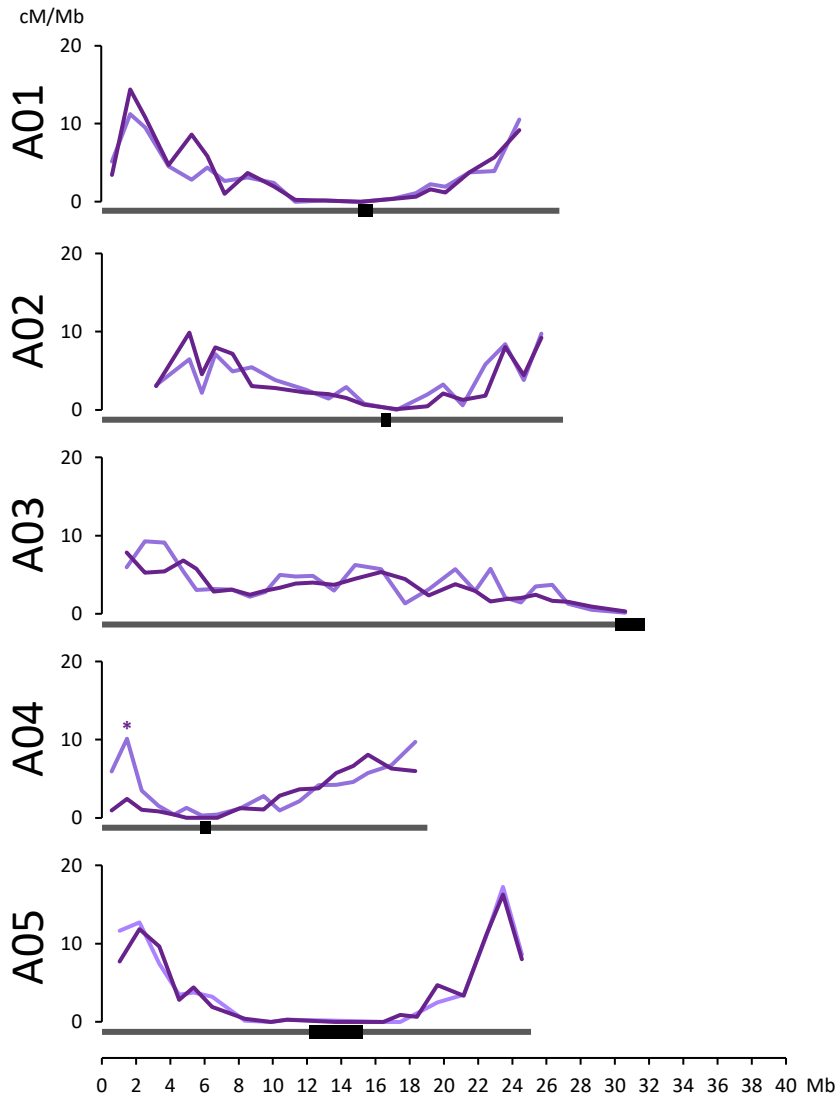
MLH1
x 1.7

(Leflon *et al.*, 2010)

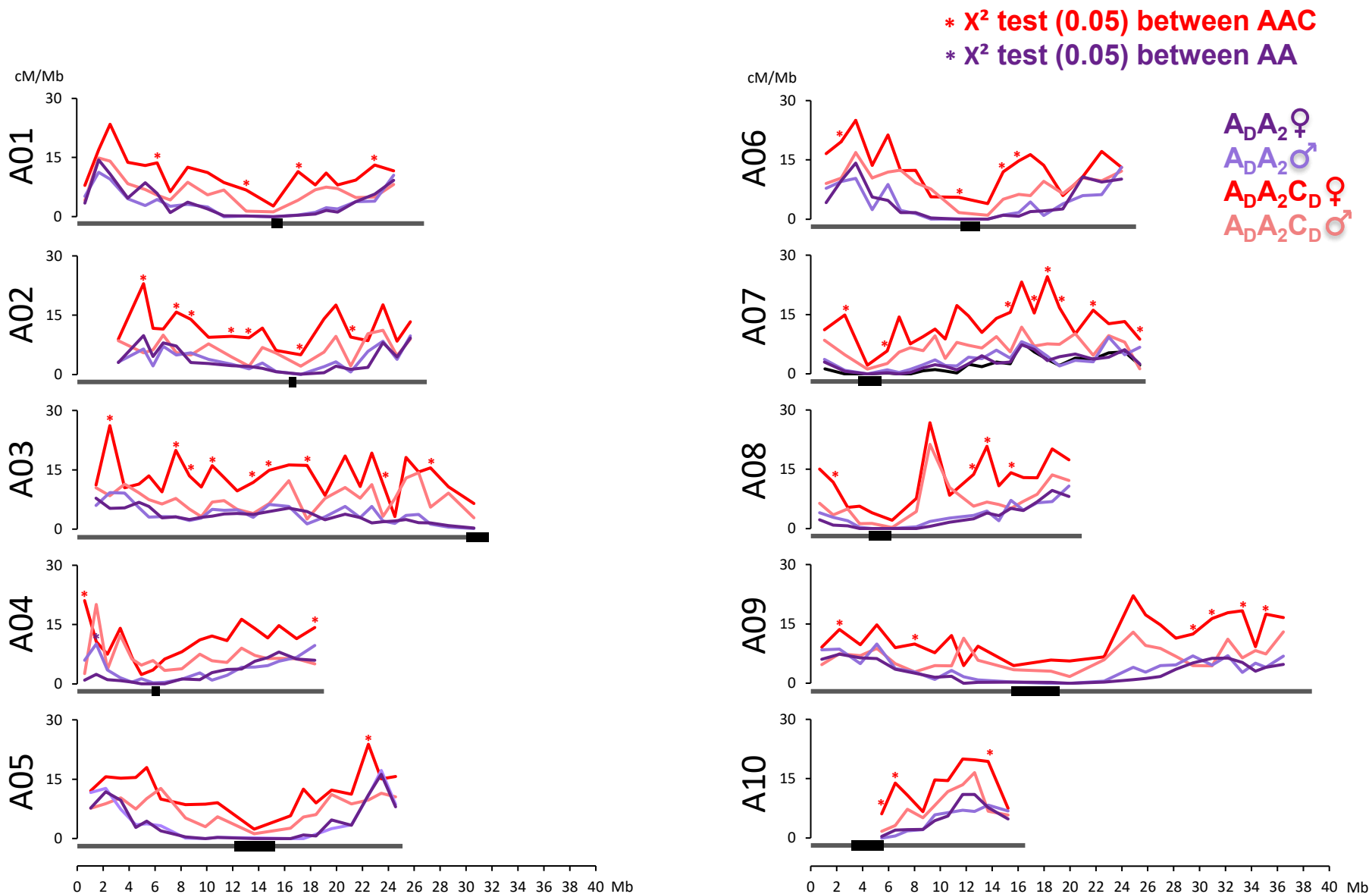
In AAC male hybrids, the increase of COs rate is mainly due to Type I CO !

What about frequency and **distribution** of COs in male and female meiosis in AA vs AAC hybrids?

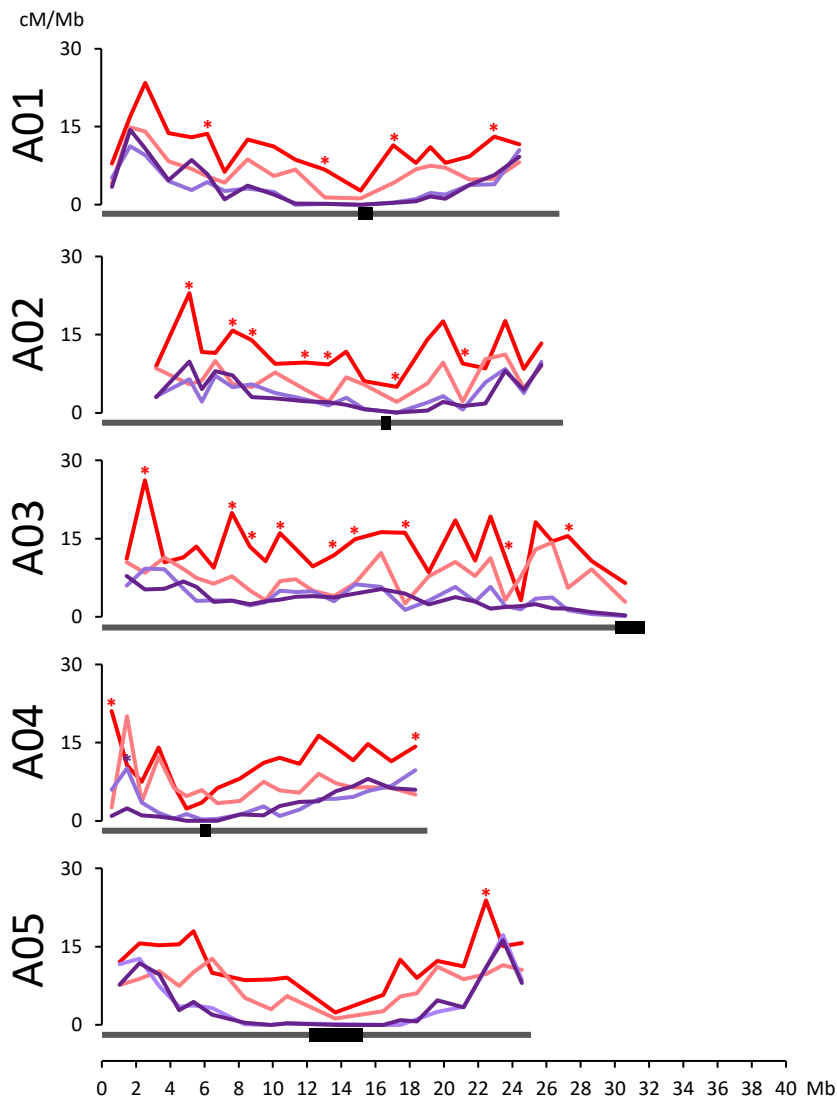
* χ^2 test (0.05) between AA



What about frequency and **distribution** of COs in male and female meiosis in AA vs AAC hybrids?

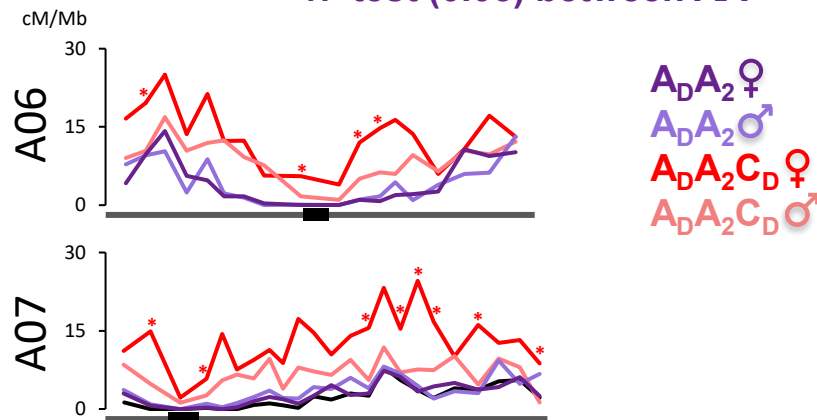


What about frequency and **distribution** of COs in male and female meiosis in AA vs AAC hybrids?



* χ^2 test (0.05) between AAC

* χ^2 test (0.05) between AA

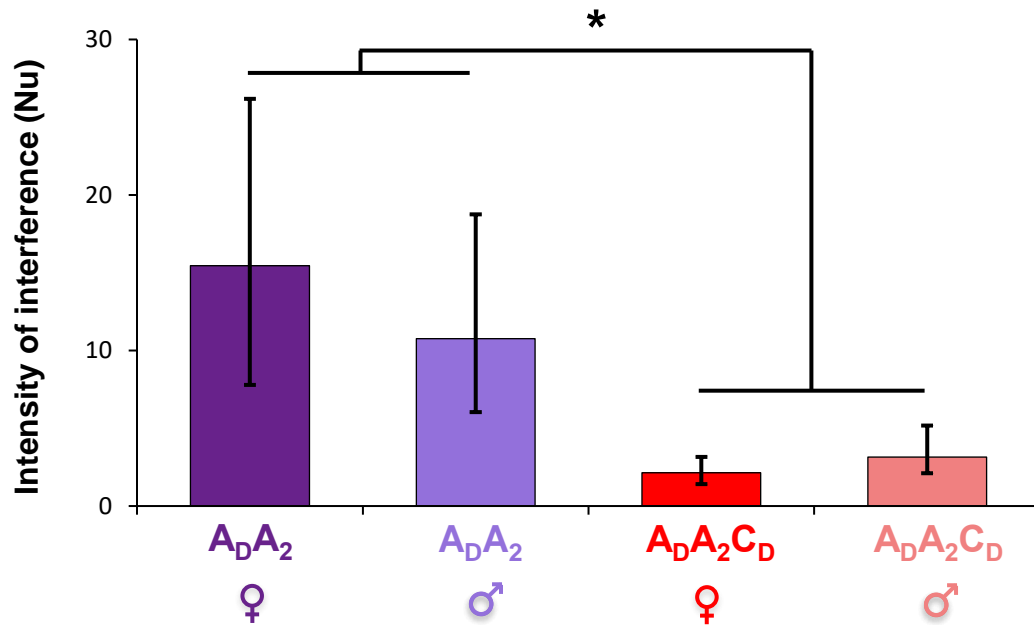


Recombination profiles between each A homologous chromosome in male and female meiosis is:

- Equal between AA hybrids
- Similar between AAC hybrids but frequently female > male

Always AAC \neq AA hybrids

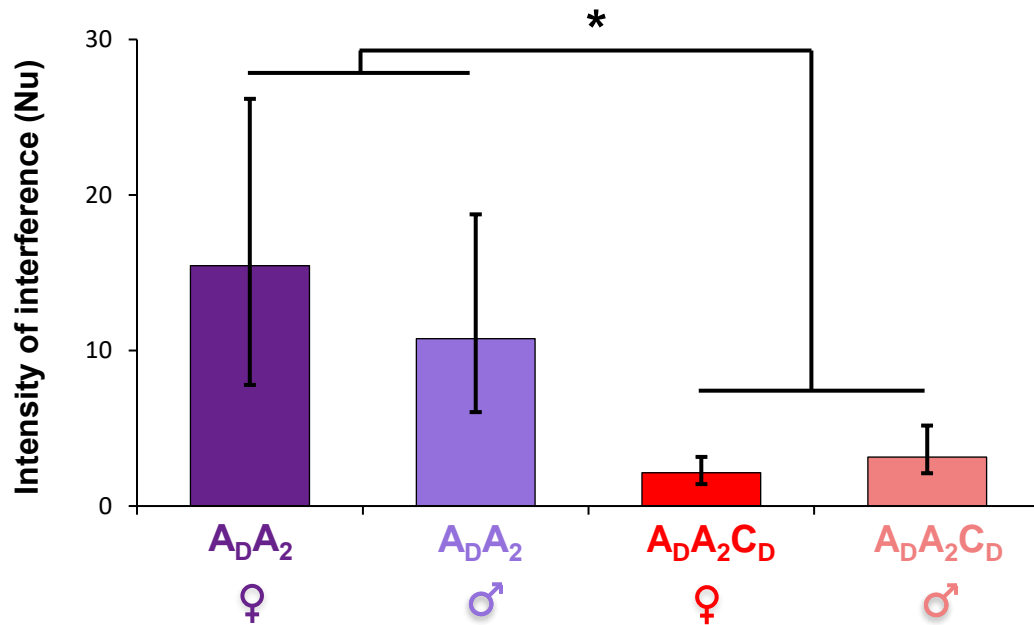
What about **interference** in male and female meiosis in AA vs AAC hybrids?



**Intensity of interference in AA and AAC hybrids:
male ~ female
for each homologous A
chromosome**

But always AA >>> AAC

What about **interference** in male and female meiosis in AA vs AAC hybrids?



**Intensity of interference in AA and AAC hybrids:
male ~ female
for each homologous A
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But always AA >>> AAC



Conclusion

❖ AAC vs AA hybrids, whatever genetic background and male/female meiosis:

- Increase of CO rate
- Change of CO distribution
- Decrease in interference intensity



By using AAC hybrids, we can break the linkage disequilibrium

❖ AAC male vs female hybrids:

- Variation in CO rate (female > male)
- Similar CO distribution
- Similar interference intensity



The increase of recombination rate in AAC male is due to Type I CO probably non interfering

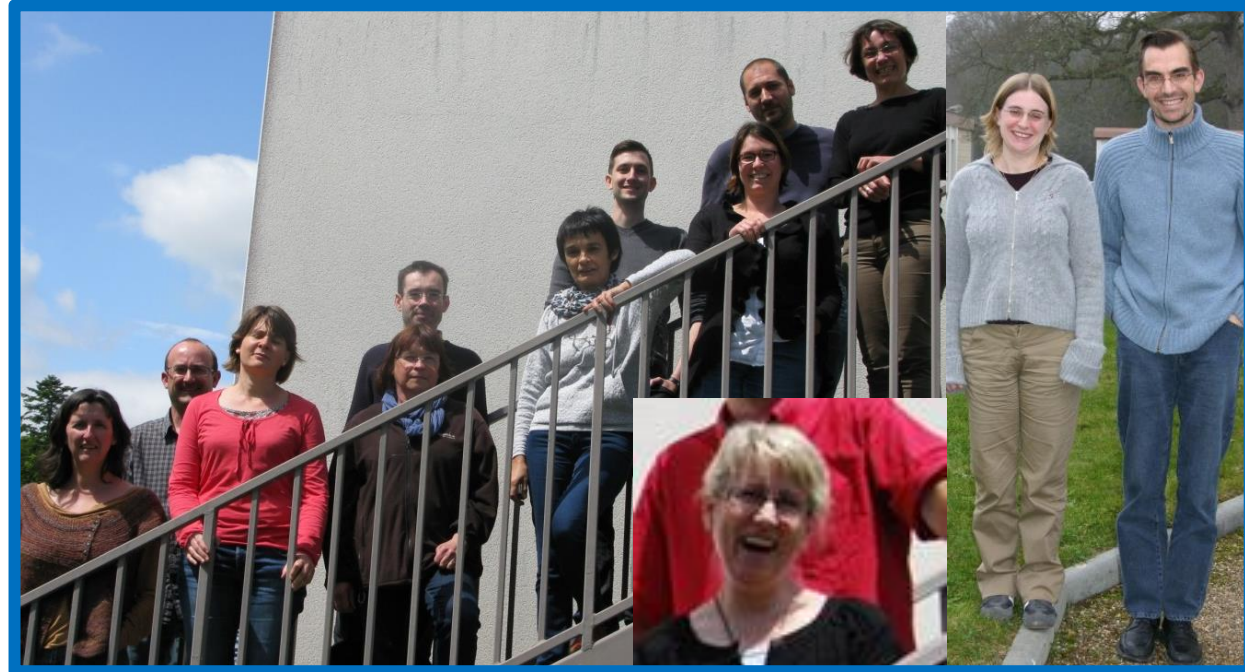
Prospect:

- What are the mechanisms responsible for modifications of CO rate and distribution? **Epigenetics?** (Melamed-Bessudo and Levy, 2012 ; Kim *et al.*, 2005 ; Gaut *et al.*, 2007 ; Kirik *et al.*, 2008; Tsai *et al.*, 2008; Mirouze *et al.*, 2012; Yelina *et al.*, 2012; Jahns *et al.*, 2014)
- Use in breeding programs

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