Change in the magnitude of meiotic drive due to increased temperature

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Change in the magnitude of meiotic drive due to increased temperature

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Purpose
According to the Mendel’s first law, the Law of Segregation, allele pairs segregate randomly with the chance of 50–50. However, a precedent research showed that there are preferences meiosis in D. americana by favoring the X-4 fused arrangement over the unfused arrangement. X-4 chromosome has remained polymorphic. In particular, it is found in a latitudinal gradient along the Mississippi River. The more north the population is, the more the fused arrangement, and the more south the population is, the more unfused. Therefore, this study is intended to identify the effect of temperature on the meiotic drive phenotype. The flies in this study were performed in 24°C, while the previous studies were all done at 22°C.

Meiotic Drive
Meiotic drive is a mechanism of the meiotic process preferring one allele or chromosome to another. This significantly impacts the diversity by increasing or decreasing specific strains of species. This breaks the Law of Segregation because the allele does not segregate randomly.

Chromosomal Centromeric orientation
- Fig. 1. Acrocentric and metacentric chromosome’s centromere orientation
- Chromosomes can be classified by the position of centromere.
- Acrocentric: located near the end of the chromosome
- Metacentric: located to the middle of the chromosome

Metacentric chromosomes can be formed by the centromeric fusion between two acrocentric chromosomes.

Acrocentric chromosomes can be formed by a centromeric fusion within a metacentric chromosome.

Meiotic drive can influence Centromeric Orientation
- Males have a transmission rate of 50% to get either acrocentric or metacentric chromosomes.
- Human and Chicken females have a meiotic drive towards acrocentric chromosomes.
- Mouse females have a meiotic drive towards metacentric chromosomes.

X-4 chromosome is found in a latitudinal gradient
- D. americana is found along the Mississippi river.
- The more north the population is found, the more the X-4 fused chromosomes present.
- The more south the population is found, the more the unfused X and 4th chromosomes are present.

Meiotic drive favors the X-4 arrangement
- Offspring of heterozygous females with respect to X4 arrangement inherited the fused X-4 chromosome roughly 52-60% of the time.
- Offspring from F1
- D. americana/noxamexicana hybrid females show the same pattern.

Possible Outcomes
With the meiotic drive favoring the X-4 chromosome, it should overcome the unfused arrangement entirely. But the unfused arrangement is being maintained. To explain this, there are two leading hypotheses explaining the polymorphic nature of the X-4 fused chromosome.

1) Meiotic drive is only activated in times of stress, which is more consistent within the Northern United States
2) Meiotic drive occurs in all flies, but selection against the fused X-4 chromosome at high levels in climates that are more associated with the Southern United States.

If 1) is correct we expect to see the loss of meiotic drive in our study. The transmission of the X-4 arrangement will reverse back to 50/50 as predicted by Mendel.
If 2) is correct, we expect to see meiotic drive for X-4 fused chromosomes to be maintained. The fused X-4 chromosome will be transmitted to 65-69% of our collected offspring.

Methodology

Heterozygous females were crossed in 24°C with D. noxamexicana males. (Fig. 5)

Offspring were collected and their DNA was extracted. Master mix was made. (Fig. 6)

Polymerase Chain Reaction (PCR)

Gel electrophoresis (Fig. 7, 8)

Fig. 5 Loci near the centromere on the X and 4th chromosomes that different in the presence of a deletion was identified. These deletions could be tracked by molecular tools.

Possible Outcomes

Future Studies
Test the viability of drosophila at the different temperatures.
• If there is a selective advantage for the unfused arrangements at higher temperature. Then homozygous unfused flies will be more fit at higher temperatures.
• We can analyze this by observing survivability and hatch rates of individuals having the different arrangements.

Investigate more environmental factors other than temperature.
• There are many environmental factors other than temperature that are different between the northern and southern United States.
• Factors such as humidity, daylength, pollution could cause stress and may influence the meiotic drive phenotype.

References

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Fig. 3 Divergence graph of Drosophila

Wish you success in biological research!